ASM Drivetrain Basic

Reference

For ASM Drivetrain Basic Blockset 5.4.1 and ASM Drivetrain Basic Operator Blockset 5.4.1

Release 2021-A – May 2021

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Important Notice

This publication and the contents hereof are subject to change without notice.

Contents

About This Reference

Content

This reference introduces you to the features provided by the ASM Drivetrain Basic Library. It describes the structure and parts of the model, its physical background, and the data required for parameterization.

Symbols

dSPACE user documentation uses the following symbols:

Symbol	Description
⚠ DANGER	Indicates a hazardous situation that, if not avoided, will result in death or serious injury.
⚠ WARNING	Indicates a hazardous situation that, if not avoided, could result in death or serious injury.
⚠ CAUTION	Indicates a hazardous situation that, if not avoided, could result in minor or moderate injury.
NOTICE	Indicates a hazard that, if not avoided, could result in property damage.
Note	Indicates important information that you should take into account to avoid malfunctions.
Tip	Indicates tips that can make your work easier.
⍰	Indicates a link that refers to a definition in the glossary, which you can find at the end of the document unless stated otherwise.
🕮	Precedes the document title in a link that refers to another document.

Naming conventions

dSPACE user documentation uses the following naming conventions:

%name% Names enclosed in percent signs refer to environment variables for file and path names.

< > Angle brackets contain wildcard characters or placeholders for variable file and path names, etc.

Special folders

Some software products use the following special folders:

Common Program Data folder A standard folder for application-specific configuration data that is used by all users.

%PROGRAMDATA%\dSPACE\<InstallationGUID>\<ProductName>

or

%PROGRAMDATA%\dSPACE\<ProductName>\<VersionNumber>

Documents folder A standard folder for user-specific documents.

%USERPROFILE%\Documents\dSPACE\<ProductName>\<VersionNumber>

Local Program Data folder A standard folder for application-specific configuration data that is used by the current, non-roaming user.

%USERPROFILE%\AppData\Local\dSPACE\<InstallationGUID>\<ProductName>

Accessing dSPACE Help and PDF Files

After you install and decrypt dSPACE software, the documentation for the installed products is available in dSPACE Help and as PDF files.

dSPACE Help (local) You can open your local installation of dSPACE Help:

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To access the Web version, you must have a *mydSPACE* account.

PDF files You can access PDF files via the icon in dSPACE Help. The PDF opens on the first page.

Overview of the Drivetrain Basic Library

Drivetrain Basic Library

Introduction

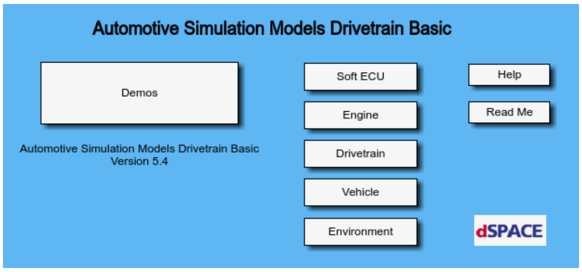
This topic gives you an overview of the ASM Drivetrain Basic Library.

Opening the library

You can open the library in MATLAB/Simulink. Refer to How to Open an ASM Library (ASM Drivetrain Basic Model Description 📖) or .

Contents

The following illustration shows the first level of the library.



The library has the following main subsystems.

Soft ECU The Soft ECU subsystem contains all the subsystems that allows you to use the engine model offline or if a real ECU is not available. Refer to Soft ECU on page 109.

Engine The Engine subsystem contains all the Simulink blocks necessary to model a basic engine. Refer to Engine on page 69.

Drivetrain The Drivetrain subsystem contains the blocks to model the vehicle drivetrain. Refer to Drivetrain on page 13.

Vehicle The Vehicle subsystem contains the blocks used for simulating a basic vehicle behavior. Refer to Environment on page 73.

Environment The Environment subsystem contains the blocks to simulate the vehicle environment. Refer to Environment on page 73.

Demos The Demos subsystem contains ready-to-use demo models that you can use to start modelling. Refer to Demos on page 163.

Drivetrain

Where to go from here

Information in this section

Hydraulics

Where to go from here

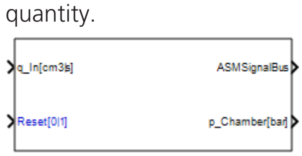
Information in this section

Chambers

Chamber

Description

The CHAMBER block builds up a hydraulic capacity with fixed volume and compressible fluid. The chamber pressure is calculated depending on the flow quantity.



The chamber describes the pressure state as a function of the flow quantity into and out of the chamber. Based on the continuity law, the differential equation for the chamber pressure can be written as the following equation:

$$\dot{p} = \frac{E}{V}\Sigma_i q_i$$

where:

- E is the bulk modulus
- V is the chamber volume
- q is the flow rate

In this model, the change of the pressure due to the change of the chamber volume (elasticity of the chamber walls) is neglected.

Inports

The following table shows the inports:

Name	Unit	Description
q_In	[cm^3|s]	Flow quantity into the chamber
Reset	[0|1]	Reset of states

Outports

The following table shows the outports:

Name	Unit	Description
ASMSignalBus	[]	Signal bus containing signals of ASM components, refer to ASMSignalBus (ASM User Guide 🕮).
p_Chamber	[bar]	Pressure inside the chamber

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_V_Chamber	[cm^3]	Chamber volume
ItNum	[-]	Iteration number
StepSize	[s]	Simulation step size

Related topics

References

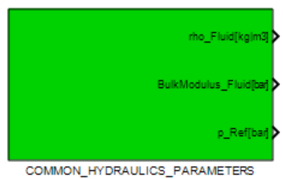
Chamber (ModelDesk Parameterizing 🕮)

Common Parameters

Common Hydraulics Parameters

Description

The COMMON_HYDRAULICS_PARAMETERS block provides all the hydraulics parameters, which are used by several other subsystems in the model. This is required to achieve a central access point to these parameters for online access. A modification will influence all model parts that use these parameters for a real-time and an offline simulation.



Outports

The following table shows the outports:

Name	Unit	Description
BulkModulus_Fluid	[bar]	Bulk modulus of the hydraulic fluid
p_Ref	[bar]	Reference pressure
rho_Fluid	[kg/m^3]	Density of the hydraulic fluid

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_BulkModulus_Fluid	[bar]	Bulk modulus of hydraulic fluid
Const_p_Ref	[bar]	Reference pressure
Const_rho_Fluid	[kg/m^3]	Hydraulic fluid density

Related topics

References

Common Hydraulics Parameters (ModelDesk Parameterizing)

Cylinders

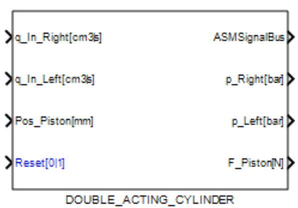
Where to go from here

Information in this section

Double Acting Cylinder

Description

This block simulates a double-acting hydraulic cylinder with two flow-in ports. The fluid flows into the cylinder chambers and generates a pressure on each side of the piston.



Depending on the pressure difference between both cylinder piston sides, there is a resulting force on the piston. The movement of the piston must be calculated externally, so the block needs the current piston position as an input signal. The external calculation can be universally used to implement additional forces from springs, dampers and conditions. The chamber pressures mainly change due to the fluid flow. Thus, the pressure difference over the cylinder piston is given by the following equation:

$$\Delta p = E \cdot \left(\int \frac{1}{V_{A0} + \Delta V_A} \cdot q_A \, dt - \int \frac{1}{V_{B0} + \Delta V_B} \cdot q_B \, dt \right)$$

where:

- E is the bulk modulus.
- V_{A0}, ΔV_A are the initial and the delta volume of the chamber A.
- V_{B0}, ΔV_B are the initial and the delta volume of the chamber B.
- q_A is the flow quantity through port A.
- q_B is the flow quantity through port B.

Each chamber volume is calculated according to the cylinder piston position as follows:

$$\Delta V_A = x \cdot A_{piston}$$

$$\Delta V_B = -x \cdot A_{piston}$$

where:

- x
- A_{piston}

The influence of these volume changes on the pressure of the elastic fluid in the chambers is neglected. It is assumed that the piston will not significantly move as long as there is no connection to a large volume (e.g. tank) on at least one side of the double-acting cylinder, which allows a flow out of the chamber. This influence can therefore be considered as part of the damping of the piston movement.

Inports

The following table shows the inports:

Name	Unit	Description
Pos_Piston	[mm]	Position of the cylinder piston
q_In_Left	[cm^3|s]	Flow quantity into the left chamber of the cylinder
q_In_Right	[cm^3|s]	Flow quantity into the right chamber of the cylinder
Reset	[0|1]	Reset of states

Outports

The following table shows the outports:

Name	Unit	Description
ASMSignalBus	[]	Signal bus that contains signals of ASM components. Refer to ASMSignalBus (ASM User Guide 🕮).
F_Piston	[N]	Force from the hydraulic pressures to the cylinder piston
p_Left	[bar]	Pressure inside the left chamber of the cylinder
p_Right	[bar]	Pressure inside the right chamber of the cylinder

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_A_Piston	[cm^2]	Piston cross-sectional area
Const_V_Left_Init	[cm^3]	Left chamber volume when the piston is centered
Const_V_Right_Init	[cm^3]	Right chamber volume when piston is centered
ItNum	[-]	Iteration number
StepSize	[s]	Simulation step size

Related topics

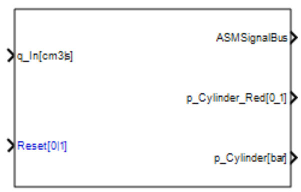
References

Double Acting Cylinder (ModelDesk Parameterizing 📖)

Single Acting Cylinder

Description

The SINGLE_ACTING_CYLINDER block simulates a single-acting cylinder with a pre-loaded spring and damping.



It assumes an incompressible fluid to determine a theoretical piston position according to the flow into the chamber of the cylinder.

$$x_{piston,preloaded} = \frac{1}{A_{piston}} \cdot \int q_{flow}\, dt$$

This theoretical position does not yet consider the required prefill of the cylinder to overcome the pre-loaded spring. Therefore, there is a piston position offset which is equivalent to the pre-load to determine the actual piston position.

$$x_{piston} = x_{piston,preloaded} - x_{preload-equivalent}$$

This equivalent offset results from the pre-load force and the pre-load stiffness, which generally is the spring stiffness at the initial position.

$$x_{preload-equivalent} = \frac{F_{preload}}{k_{preload}}$$

The spring force from the actual piston movement is determined by a map as a function of the actual piston position to allow any spring characteristics. Finally, the chamber pressure can be calculated from the sum of forces and the piston area:

$$p_{chamber} = \frac{F_{spring} + F_{damping} + F_{preload}}{A_{piston}}$$

$$p_{chamber} = \frac{F_{spring}\left(x_{piston}\right) + D \cdot \dot{x}_{piston} + k_{preload} \cdot x_{preload-equivalent}}{A_{piston}}$$

Inports

The following table shows the inports:

Name	Unit	Description
q_In	[cm^3/s]	Flow quantity into the chamber
Reset	[0|1]	Reset of states

Outports

The following table shows the outports:

Name	Unit	Description
ASMSignalBus	[]	Signal bus containing signals of ASM components, refer to ASMSignalBus (ASM User Guide 📖).
p_Cylinder	[bar]	Pressure inside of the chamber of the cylinder
p_Cylinder_Red	[0_1]	Normalized cylinder pressure

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_A_Piston	[cm^2]	Piston cross-sectional area
Const_Damping_Coeff	[Ns/cm]	Damping coefficient of the piston movement
Const_Pos_Piston_Preload	[mm]	Equivalent piston position at the pre-load
Const_Stiffness_Coeff_Preload	[N/mm]	Equivalent stiffness at the pre-load
Const_p_Max_Cylinder	[bar]	Maximum cylinder pressure
ItNum	[]	Iteration number
Map_F_Spring	[N]	Map of the spring force acting against the piston movement = f(Pos_Piston[mm])
StepSize	[s]	Simulation step size

Related topics

References

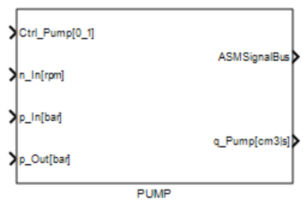
Single Acting Cylinder (ModelDesk Parameterizing 📖)

Pumps and Motors

Pump

Description

The pump delivers the hydraulic fluid from the tank to a hydraulic system. It uses an input speed signal and gear train ratio to determine the pump speed. The used modeling approach is based on a look-up-table, which calculates the delivered fluid quantity from the pump speed and the pressure drop over the pump.



Inports

The following table shows the inports:

Name	Unit	Description
Ctrl_Pump	[0_1]	Control signal to actuate the pump flow
n_In	[rpm]	Pump gear input speed
p_In	[bar]	Pressure at input side
p_Out	[bar]	Pressure at output side

Outports

The following table shows the outports:

Name	Unit	Description
ASMSignalBus	[]	Signal bus that contains signals of ASM components. Refer to ASMSignalBus (ASM User Guide 📖).
q_Pump	[cm^3/s]	Flow quantity provided by the pump

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_i_Pump	[-]	Gear ratio of the gear train between the input speed and the pump speed
Map_Displ_Pump	[l/min]	Pump displacement = f(n_Pump[rpm], p_Delta[bar])

Related topics

References

Pump (ModelDesk Parameterizing 📖)

Utils

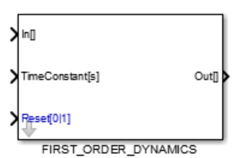
Where to go from here

Information in this section

First Order Dynamics

Description

The block models a first-order-dynamics behavior. The block can be used in an over-sampled subsystem.



For more information about the local oversampling method refer to Local Subsystem Oversampling (ASM User Guide 📖).

The calculations are based on the following equation:

$$\tau \cdot \dot{Out} + Out = In$$

where:

In	is the input signal
Out	is the output signal
τ	is the time constant of the first-order-dynamics system

Inports

The following table shows the inports:

Name	Unit	Description
In	[]	Input signal
Reset	[0|1]	Reset of states
TimeConstant	[s]	Time constant of the first-order-dynamics system

Outports

The following table shows the outports:

Name	Unit	Description
Out	[]	Integrated input signal

Parameters

The following table shows the parameters:

Name	Unit	Description
x0	[]	Integrator initial condition
ItNum	[-]	Iteration number
StepSize	[s]	Simulation step size

Related topics

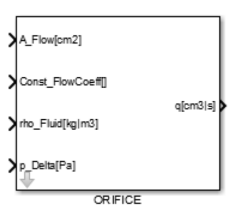
Basics

Local Subsystem Oversampling (ASM User Guide)

Orifice

Description

The block models a sharp-edged orifice.



It is calculated using the orifice equation:

$$q = A \cdot \alpha \cdot \sqrt{\frac{2}{\rho}(p_{in} - p_{out})}$$

where:

A is the orifice passage area as a function of the controller signal

α is the flow discharge coefficient

p is the hydraulic fluid density

Inports

The following table shows the inports:

Name	Unit	Description
A_Flow	[cm^2]	Orifice cross-sectional flow area
Const_FlowCoeff	[]	Flow coefficient
p_Delta	[Pa]	Pressure drop over the orifice
rho_Fluid	[kg/m^3]	Fluid density

Outports

The following table shows the outports:

Name	Unit	Description
q	[cm^3/s]	Flow rate through the orifice

Valves

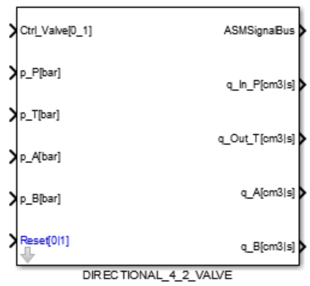
Where to go from here

Information in this section

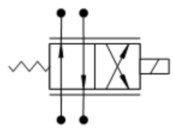
4/2 Directional Valve

Description

This block simulates a 4-2-way valve. It can be used for on/off valves as well as continuous valves, whose connection orifice areas correspond to the control signal level.



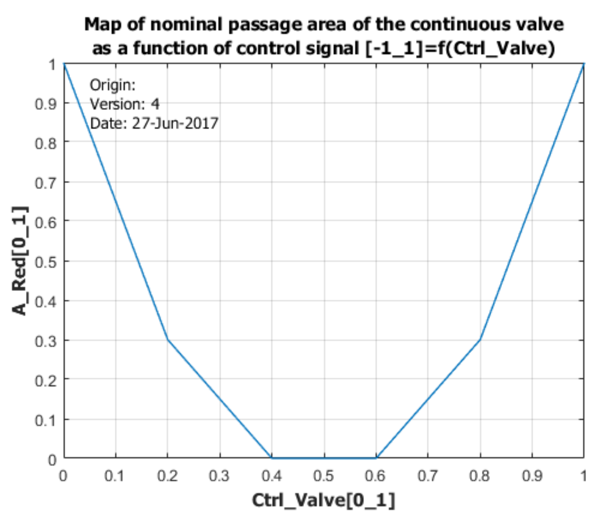
The following illustration shows a 4-2-way valve:



The valve type is determined by the following parameters:

- Map_A_Red represents the orifice area as a function of the control signal
- Const_Ctrl_Valve_OnOff defines the switch point of the valve ways, which determines which valve connection the orifice area is applied to.

The following figure shows an example map of a continuous valve opening characteristic:



For this example, the switch point defined by Const_Ctrl_Valve_OnOff should be between 0.4 and 0.6 to apply the sections of the passage area map to the corresponding valve way. In case of an on/off valve Map_A_Red should be constant, so it would only switch directions at the switch point defined by Const_Ctrl_Valve_OnOff.

The flow quantity for each connection is then calculated using the orifice equation:

$$q = A \cdot \alpha \cdot \sqrt{\frac{2}{\rho}(p_{in} - p_{out})}$$

where:

A is the orifice passage area
α is the flow discharge coefficient
p is the hydraulic fluid density

Moreover, the block can be combined with multiplexer and demultiplexer blocks in Simulink in order to switch a higher number of port connections analogously.

Inports

The following table shows the inports:

Name	Unit	Description
Ctrl_Valve	[0_1]	Description Control signal to actuate the valve
p_InPort_1	[bar]	Pressure at inport 1 of the valve
p_InPort_2	[bar]	Pressure at inport 2 of the valve
p_OutPort_1	[bar]	Pressure at outport 1 of the valve
p_OutPort_2	[bar]	Pressure at outport 2 of the valve
Reset	[0|1]	Reset of states

Outports

The following table shows the outports:

Name	Unit	Description
ASMSignalBus	[]	Signal bus that contains signals of ASM components. Refer to ASMSignalBus (ASM User Guide 📖).
q_In_InPort_1	[cm^3/s]	Flow quantity into inport 1 of the valve
q_In_InPort_2	[cm^3/s]	Flow quantity into inport 2 of the valve
q_Out_OutPort_1	[cm^3/s]	Flow quantity out of outport 1 of the valve
q_Out_OutPort_2	[cm^3/s]	Flow quantity out of outport 2 of the valve

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_A_Max	[cm^2]	Maximum passage area
Const_Ctrl_Valve_OnOff	[0_1]	Nominal control signal switch point to switch the flow direction
Const_FlowCoeff	[]	Flow discharge coefficient
Const_t_ValveDynamics	[s]	Time constant of the valve opening dynamics
ItNum	[]	Iteration number

Name	Unit	Description
Map_A_Red	[0_1]	Map of nominal passage area of the continuous valve as a function of control signal = f(Ctrl_Valve)
StepSize	[s]	Simulation step size
Sw_ValveDynamics	[0|1]	Switch to activate the valve opening dynamics ▪ 0: Off ▪ 1: On

Related topics

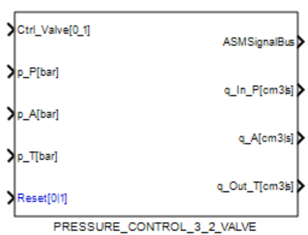
References

Directional 42 Valve (ModelDesk Parameterizing 📖)

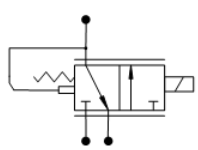
3/2 Pressure Control Valve

Description

The pressure control valve is a 3/2-way valve, which is used to regulate a defined input or output pressure.

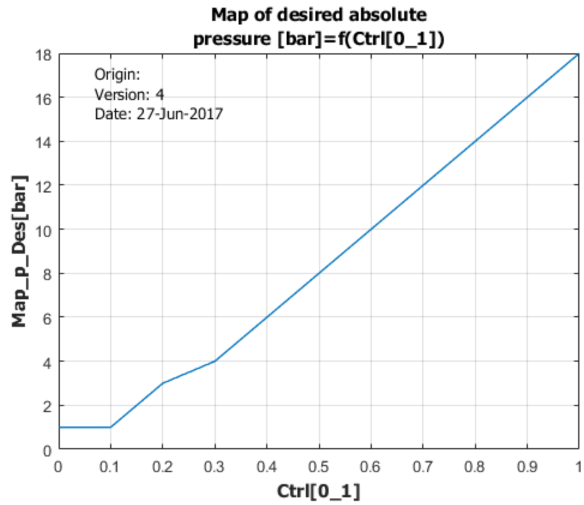


The following illustration shows the pressure control valve.



The control signal corresponds to a desired pressure. The actual pressure is fed back to regulate the valve position until the desired pressure is reached. This self-controlling behavior is reached with a PI controller which controls two orifices, i.e. flow-in (P-A) and flow-out (A-T). The difference between the desired and the actual pressure is used as a reference signal to calculate the flow passage area for both valve orifices.

The following figure shows an example of the desired pressure as a function of the nominal control:



The controller signal is determined by the following equation:

$$e = p_{in} - p_{des}(ctrl_{valve})$$

$$ctrl_{PI} = K_p \cdot e(t) + K_i \cdot \int_0^t e(\tau)\, d\tau$$

where:

p_{in}	is the valve input pressure which equals the system line pressure
$p_{des}(ctrl_{valve})$	is the desired pressure as a function of the valves nominal control
K_p	is the P gain of the self-controlling behavior
K_i	is the I gain of the self-controlling behavior

Since only one orifice can be open at a time, the positive and negative controller signal correspond to either flow-in or flow-out depending on the type of pressure feedback. For output side pressure feedback, the flow-in and flow-out orifice passage areas are calculated as follows:

$$A_{PA} = \begin{cases} ctrl_{PI} \cdot A_{PA\_max} & ctrl > 0 \\ 0 & otherwise \end{cases}$$

$$A_{AT} = \begin{cases} -ctrl_{PI} \cdot A_{PA\_max} & ctrl < 0 \\ 0 & otherwise \end{cases}$$

where:

A_{in_max}	is the maximum flow-in orifice passage area
A_{out_max}	is the maximum flow-out orifice passage area

For input side pressure feedback the control signals are inverted. The flow quantity through each orifice is then calculated using the orifice equation:

$$q = A\left(ctrl_{PI}\right) \cdot \alpha \cdot \sqrt{\frac{2}{\rho}(p_{in} - p_{out})}$$

where:

$A(ctrl_{PI})$	is the orifice passage area as a function of the controller signal
α	is the flow discharge coefficient
p	is the hydraulic fluid density

Inports

The following table shows the inports:

Name	Unit	Description
Ctrl_Valve	[0_1]	Control signal to actuate the valve
p_A	[bar]	Pressure at outport A of the valve
p_P	[bar]	Pressure at inport P of the valve
p_T	[bar]	Pressure at inport T of the valve
Reset	[0|1]	Reset of states

Outports

The following table shows the outports:

Name	Unit	Description
ASMSignalBus	[]	Signal bus containing signals of ASM components, refer to ASMSignalBus (ASM User Guide 📖).
q_A	[cm^3/s]	Flow quantity out of outport A of the valve
q_In_P	[cm^3/s]	Flow quantity into inport P of the valve
q_Out_T	[cm^3/s]	Flow quantity out of inport T of the valve

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_A_Max_FlowIn	[cm^2]	Maximum passage area of the flow-in (Orifice P-A)
Const_A_Max_FlowOut	[cm^2]	Maximum passage area of the flow-out (Orifice A-T)
Const_FlowCoeff_FlowIn	[]	Flow discharge coefficient of the flow-in (Orifice P-A)
Const_FlowCoeff_FlowOut	[]	Flow discharge coefficient of the flow-out (Orifice A-T)
Const_I_Ctrl	[]	I gain of the pressure feedback control
Const_P_Ctrl	[]	P gain of the pressure feedback control
ItNum	[]	Iteration number
Map_p_Des	[bar]	Map of desired absolute pressure = f(Ctrl[0_1])
StepSize	[s]	Simulation step size
Sw_p_Ctrl	[0|1]	Pressure feedback switch for valve self-control ▪ 0: Input side ▪ 1: Output side

Related topics

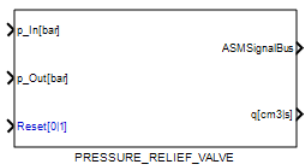
References

Pressure Control 32 Valve (ModelDesk Parameterizing)

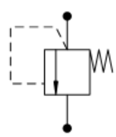
Pressure Relief Valve

Description

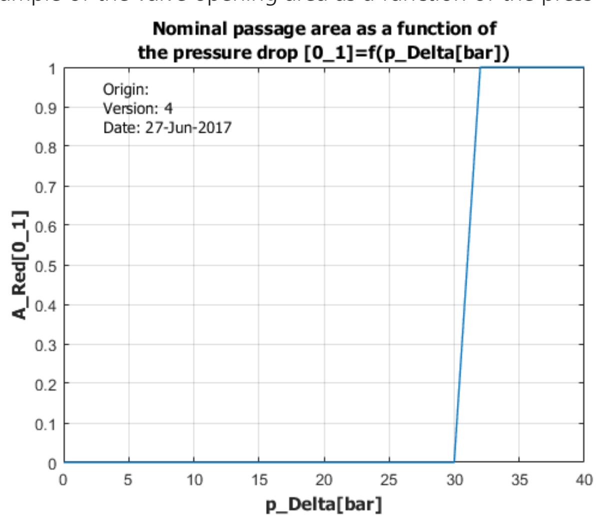
A pressure relief valve is used to control or limit pressure in a hydraulic system. It allows flow to the drain to reduce the system pressure, when the pressure drop is bigger than a certain value.



The following illustration shows a pressure relief valve.



The used modeling approach is based on a variable cross-sectional area of the valve port as a function of the pressure drop. The following figure shows an example of the valve opening area as a function of the pressure drop.



In this example, the valve starts to open, when the pressure drop exceeds 30 bar. In open state, the valve behaves like an orifice and the flow quantity is calculated as follows:

$$q = A\left(\Delta p\right) \cdot \alpha \cdot \sqrt{\frac{2}{\rho}(p_{in} - p_{out})}$$

where:

$A(\Delta p)$	is the cross-sectional area of the valve output port as a function of the pressure drop over the valve is the flow discharge coefficient
α	is the flow discharge coefficient
p	is the hydraulic fluid density

Inports

The following table shows the inports:

Name	Unit	Description
p_In	[bar]	Pressure at input side
p_Out	[bar]	Pressure at output side
Reset	[0|1]	Reset of states

Outports

The following table shows the outports:

Name	Unit	Description
ASMSignalBus	[]	Signal bus containing signals of ASM components, refer to ASMSignalBus (ASM User Guide 📖).
q	[cm³/s]	Flow quantity through the pressure relief valve

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_A_Max	[cm^2]	Maximum passage area
Const_FlowCoeff	[]	Flow discharge coefficient
Const_t_ValveDynamics	[s]	Time constant of the valve opening dynamics
ItNum	[]	Iteration number
Map_A_Red	[0_1]	Nominal passage area as a function of the pressure drop = f(p_Delta[bar])
StepSize	[s]	Simulation step size
Sw_ValveDynamics	[0|1]	Switch to activate the valve opening dynamics: ▪ 0: Off ▪ 1: On

Related topics

References

Pressure Relief Valve (ModelDesk Parameterizing 📖)

Mechanics

Where to go from here

Information in this section

Clutches

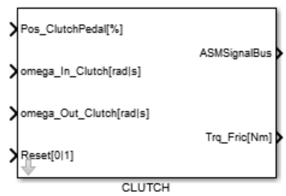
Where to go from here

Information in this section

Clutch

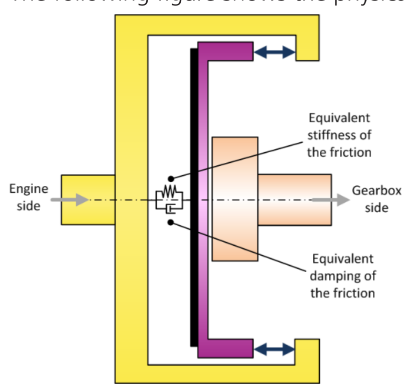
Description

The function of the clutch is to connect and disconnect the engine to the rest of the drivetrain in vehicles that have a manual gearbox.



The clutch is modeled as two plates, where the torque is transferred via friction between them. The idea of this bristle friction model is used to model the friction torque arising between the plates. The model is based on the assumption that the contact between the two surfaces acts like elastic bristles. Each bristle can deflect because of the exerted torque. This deflection torque can be described by a damper and a spring.

The following figure shows the physical model of the clutch:



The friction torque can be formulated in this equation:

$$T_{Fric} = K_{Fric} \Delta\ \theta_{Clutch} + C_{Fric} \Delta\ \Omega_{Clutch}$$

where:

K_{Fric}	is the equivalent stiffness coefficient of the friction model
C_{Fric}	is the equivalent damping coefficient of the friction model
$\Delta\theta_{Clutch}$	is the twist angle difference between the input and output side of the clutch
$\Delta\Omega_{Clutch}$	is the relative velocity between the input and output side of the clutch

The dependence of the friction torque on the normal exerted force or the command is considered as a linear relationship. The resulting friction torque is limited by the maximum transferable torque, which depends on the clutch geometry parameters and is scaled by the position of the clutch pedal, i.e.:

$$|T_{Fric}| \leq T_{Fric,\,Limit}$$

or

$$T_{Lim} = f(100 - P_{Clutch}[\%]) \cdot T_{Max}$$

where:

$P_{Clutch}[\%]$	is the clutch pedal position
T_{Max}	is the maximum transferable clutch torque
$f()$	is a scaling function which describes the nominal clutch torque capacity

Inports

The following table shows the inports:

Name	Unit	Description
omega_In_Clutch	[rad/s]	Clutch input speed
omega_Out_Clutch	[rad/s]	Clutch output speed
Pos_ClutchPedal	[%]	Clutch pedal position
Reset	[0|1]	Reset of states

Outports

The following table shows the outports:

Name	Unit	Description
Trq_Fric	[Nm]	Friction torque

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_Friction_Damping	[Nm/(rad/s)]	Torsion damping of the friction model
Const_Friction_Stiffness	[Nm/rad]	Torsion stiffness of the friction model
Const_Torque_Max	[Nm]	Maximum transferable clutch friction torque
Map_Trq_Clutch_Red	[0_1]	Clutch nominal torque capacity
StepSize	[s]	Simulation step size

Related topics

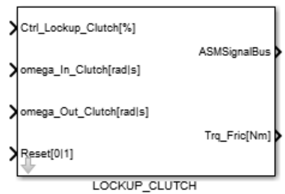
References

Clutch Basic (ModelDesk Parameterizing 📖)
History of the CLUTCH Block..278

Lock-Up Clutch

Description

The lock-up clutch is mounted parallel to the torque converter.



It connects the crankshaft and the transmission input shaft at higher vehicle speed to avoid constant slipping so that the torque converter can transfer torque between the two shafts. The modeling approach is similar to the approach for the Clutch (refer to Clutch on page 33) model.

Inports

The following table shows the inports:

Name	Unit	Description
Ctrl_Lockup_Clutch	[%]	Lockup clutch control signal
omega_In_Clutch	[rad/s]	Lockup clutch input speed
omega_Out_Clutch	[rad/s]	Lockup clutch output speed
Reset	[0|1]	Reset of states

Outports

The following table shows the outports:

Name	Unit	Description
Trq_Fric	[Nm]	Friction torque

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_Friction_Damping	[Nm|(rad/s)]	Torsion damping of the friction model
Const_Friction_Stiffness	[Nm/rad]	Torsion stiffness of the friction model
Const_Torque_Max	[Nm]	Maximum transferable lockup clutch friction torque
Map_Trq_Clutch_Red	[0_1]	Description: Lockup clutch nominal torque capacity
StepSize	[s]	Simulation step size

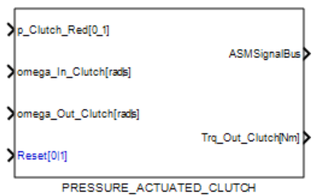
Related topics

References

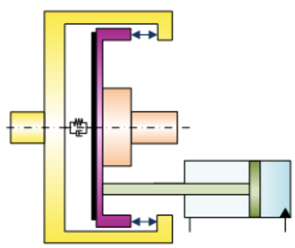
Pressure Actuated Clutch

Introduction

The function of the clutch is to connect and disconnect the engine to the rest of the drivetrain.



The following illustration shows a pressure actuated clutch:



The block builds up the friction torque depending on the clutch cylinder pressure and the relative velocity over the clutch. It is modeled as two plates, where the clutch torque is transferred via friction between them. The model is based on the assumption that the contact between the two surfaces acts as elastic bristles. Each bristle can deflect because of the exerted torque. This deflection torque can be described by a damper and a spring.

The clutch friction torque can be formulated in this equation:

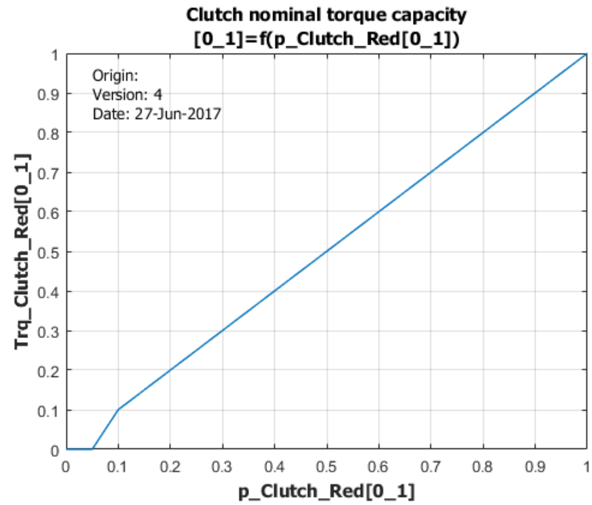
$$T_{Fric} = K_{Fric} \cdot \Delta\theta_{Clutch} + C_{Fric} \cdot \Delta\omega_{Clutch}$$

where:

K_{Fric}	is the equivalent stiffness coefficient of the friction model
C_{Fric}	is the equivalent damping coefficient of the friction model
$\Delta\theta_{Clutch}$	is the twist angle difference between the input and output side of the clutch
$\Delta\omega_{Clutch}$	is the relative velocity between the input and output side of the clutch

The relationship between the maximum transferable friction torque and the normal exerted pressure is defined as a parameter, which describes the clutch torque capacity, i.e., $T_{max} = f(p_{Cylinder,normalized})$

The following illustration shows an example how the clutch torque capacity can look like:



In this example, there is almost no torque transferred until 5% of maximum cylinder pressure. This point can be expressed as the kiss point of the clutch. The output clutch torque is then limited to the maximum transferable torque, i.e.,

$|T_{Fric}| \leq T_{max}(p_{Cylinder,normalized})$.

Inports

The following table shows the inports:

Name	Unit	Description
omega_In_Clutch	[rad/s]	Angular speed at the input side of the clutch
omega_Out_Clutch	[rad/s]	Angular speed at the output side of the clutch
p_Clutch_Red	[0_1]	Normalized clutch cylinder pressure
Reset	[0|1]	Reset of states

Outports

The following table shows the outports:

Name	Unit	Description
ASMSignalBus	[]	Signal bus that contains signals of ASM components. Refer to ASMSignalBus (ASM User Guide 📖).
Trq_Out_Clutch	[Nm]	Clutch output torque

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_Damping_Coeff	[Nm/(rad/s)]	Torsional damping coefficient of the friction plates
Const_Fric_Coeff	[Nm/rad]	Torsional stiffness coefficient of the friction plates
Const_Trq_Max_Clutch	[Nm]	Maximum transferable clutch friction torque
ItNum	[]	Iteration number
Map_Trq_Clutch_Red	[0_1]	Clutch nominal torque capacity = f(p_Clutch_Red[0_1])
StepSize	[s]	Simulation step size

Related topics

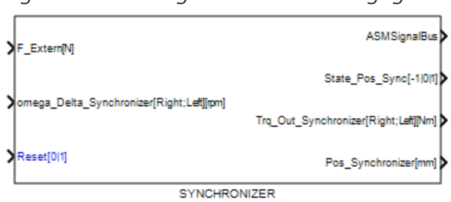
References

Pressure Actuated Clutch (ModelDesk Parameterizing 📖)

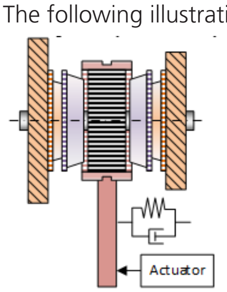
Synchronizer

Description

The **SYNCHRONIZER** block contains the mechanical part of a gear selector. It consists of a shift collar which can be moved from center position to the left or right side of the gear selector to engage the respective gear.

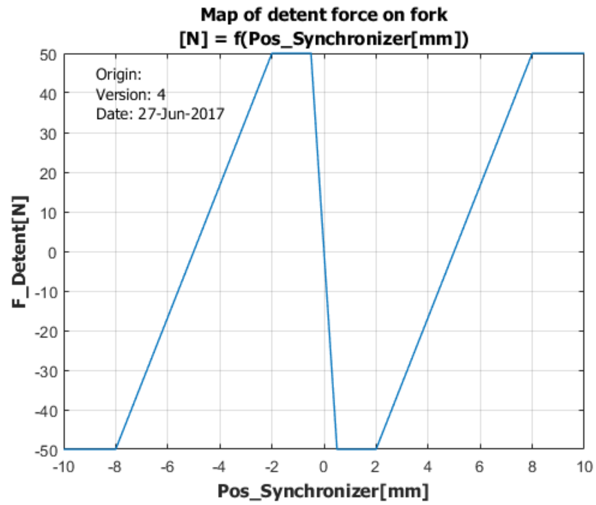


The following illustration figuratively shows the synchronizer:



It needs an externally calculated force from an actuation system, e.g. hydraulics. The external actuation force moves the shift collar to synchronize and engage gears. The gear selector movement is also encountered by a non-linear spring, which builds the synchronizer detent spring force. This force builds a mechanical lock to keep the gear selector at the end positions. The force also ensures the re-centering of the gear selector to the middle position when disengaging.

The illustration below shows an example of the detent spring force as a function of the gear selector piston position.



The dynamics of the gear selector is given in the following equation:

$$m \cdot \ddot{x} = -D \cdot \dot{x} + F_{Spring}(x) + F_{Actuation}$$

where:

x	is the gear selector position
m	is the mass of the moving parts of the synchronizer and actuation system
D	is the damping coefficient of the movement
$F_{Actuation}$	is the external actuation force
F_{Spring}	is the spring detent force

The model also considers the synchronization positions as parameters, at which the gear selector piston is held until the synchronization process ends and the desired gear completely engages to its end position.

From the resulting synchronizer force, the model calculates the friction torque of the synchronizer according to:

$$T_{Sync} = \mu(\Delta\omega) \cdot F_{Sync} \cdot r_{mean} \cdot n \cdot \sin(\alpha)$$

where:

T_{Sync}	is the torque between the synchronizer and the gear wheel
$\mu(\Delta\omega)$	is the friction coefficient as a function of the slipping speed
F_{Sync}	is the resulting synchronizer force
r_{mean}	is the mean friction radius
n	is the number of friction surfaces
α	is the cone angle of the synchronizer

Inports

The following table shows the inports:

Name	Unit	Description
F_Extern	[N]	External actuation force to the synchronizer piston
omega_Delta_Synchronizer[Right;Left]	[rpm]	Vector containing the angular relative velocity between gear wheel and shaft for right and left side of the synchronizer
Reset	[0|1]	Reset of states

Outports

The following table shows the outports:

Name	Unit	Description
ASMSignalBus	[]	Signal bus that contains signals of ASM components. Refer to ASMSignalBus (ASM User Guide).
Pos_Synchronizer	[mm]	Position of the synchronizer piston
State_Pos_Sync	[-1|0|1]	Synchronizer position state: ▪ -1: Left gear engage position ▪ 0: Not engaged ▪ 1: Right gear engage position
Trq_Out_Synchronizer[Right;Left]	[Nm]	Vector containing the slipping torque for right and left side of the synchronizer

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_Angle_Left	[deg]	Cone angle of friction surface of left side
Const_Angle_Right	[deg]	Cone angle of friction surface of right side
Const_Damping_Coeff	[Ns/cm]	Damping coefficient of the synchronizer movement
Const_Pos_Left_Engage	[mm]	Engagement position at the synchronizer left side
Const_Pos_Left_Sync	[mm]	Synchronizing start position at the synchronizer left side
Const_Pos_Right_Engage	[mm]	Engagement position at the synchronizer right side
Const_Pos_Right_Sync	[mm]	Synchronizing start position at the synchronizer right side
Const_m_GearSelector	[kg]	Mass of the gear selector piston and fork
Const_num_Fric_Left	[]	Number of friction surfaces at the synchronizer left side
Const_num_Fric_Right	[]	Number of friction surfaces at the synchronizer right side
Const_omega_Delta_Sync_UpLim	[rpm]	Slipping speed threshold of synchronized gear
Const_r_Mean_Left	[m]	Mean radius of the friction contact area of left side
Const_r_Mean_Right	[m]	Mean radius of the friction contact area of right side
ItNum	[]	Iteration number
Map_F_Detent	[N]	Map of detent force on fork = f(Pos_Synchronizer[mm])

Name	Unit	Description
Map_Fric_Coeff	[]	Map of the synchronizer friction coefficient as a function of the absolute relative velocity = f(abs(omega_Delta)[rpm])
StepSize	[s]	Simulation step size

Related topics

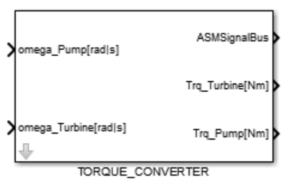
References

Synchronizer (ModelDesk Parameterizing 📖)

Torque Converter

Description

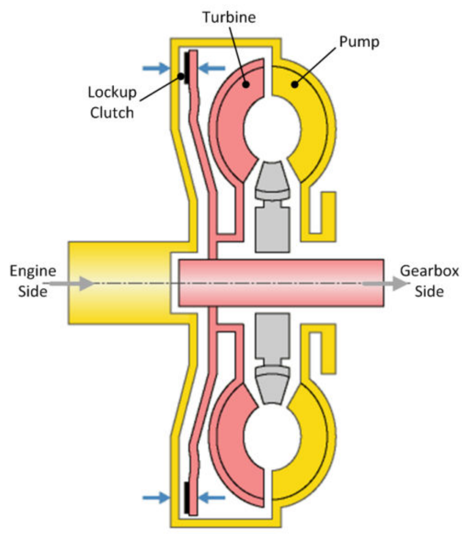
The torque converter is used in the automatic transmission drivetrain to transfer the engine torque to the transmission system.



The torque converter consists of the following elements:

- Pump
- Turbine
- Stator

The following illustration shows a schematic of a torque converter



The pump is mounted on the engine crankshaft and accelerates the oil flowing to the turbine inside the converter. From the turbine, the oil flows through the stator back to the pump. If the pump speed is greater than turbine speed, the torque converter increases the turbine torque. If the pump speed is nearly equal to the turbine speed, the converter works as a hydraulic clutch and transmits the pump torque to the turbine shaft.

The pump torque is modeled with the following equation, where the function f is a look-up table (Map_Eta_Slip):

$$T_p = f\left(\frac{\omega Turbine}{\omega Pump}\right) \cdot \omega_p{}^2$$

The turbine torque is calculated with the next equation, where the function g is a look-up table (Map_Rel_Trq_PumpTurb):

$$T_T = T_P \cdot g\left(\frac{\omega Turbine}{\omega Pump}\right)$$

Inports

The following table shows the inports:

Name	Unit	Description
omega_Pump	[rad/s]	Pump shaft speed
omega_Turbine	[rad/s]	Turbine shaft speed

Outports

The following table shows the outports:

Name	Unit	Description
Trq_Pump	[Nm]	Pump torque
Trq_Turbine	[Nm]	Turbine torque

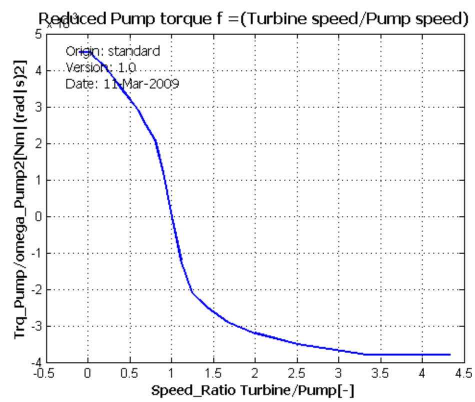
Parameters

The following table shows the block parameters:

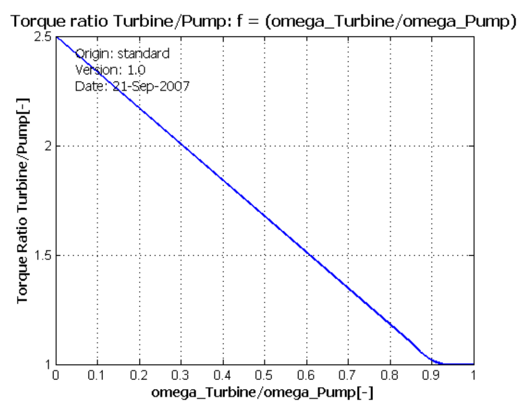
Name	Unit	Description
Map_Eta_Slip	[Nm/(rad/s)^2]	Map reduced pump torque = f(Turbine speed/Pump speed)
Map_Rel_Trq_PumpTurb	[]	Map torque ratio = f(Turbine speed/Pump speed)

Processing information

This illustration shows an example of pump torque calculation.



This illustration shows an example of turbine torque calculation.



Related topics

References

Crankshaft and Starter

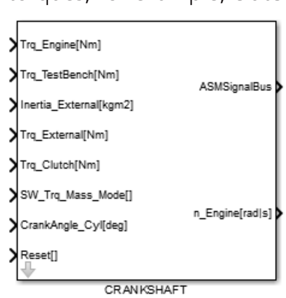
Where to go from here

Information in this section

Crankshaft

Description

The crankshaft calculates the engine speed by integration of the different drive torques, for example, clutch torque, mean effective torque of the engine.



Newton's first law is used to calculate the engine speed.

$$\left(J_{\text{Engine}} + J_{\text{External}}\right)\dot{\omega}_{\text{Engine}} = T_{\text{MeanEff,Engine}} + T_{\text{Clutch}} + T_{\text{External}} + T_{\text{TestBench}}$$

The effect of the moving piston and conrod is included as an additional mass torque. This is implemented as a look-up table depending on the crank angle. The cylinder-specific crank angle is calculated separately and provided by a signal line. The model uses a vector summation to calculate the mass torque for the entire crankshaft according to cylinder.

The mass torque look-up table is calculated from the following equation

$$T_{\text{mosz}} = \omega^2 f(\varphi)$$

where the function f is calculated with

$$f(\varphi) = m_{\text{osz}}\, r^2\left(\frac{1}{4}\lambda\sin\varphi - \frac{1}{2}\sin 2\varphi - \frac{3}{4}\lambda\sin 3\varphi - \frac{1}{4}\lambda^2\sin 4\varphi\right)$$

where:

λ is the ratio of crankshaft radius to conrod length
r is the crankshaft radius
φ is the crank angle
m_{osz} is the oscillating mass

Inports

The following table shows the inports:

Name	Unit	Description
CrankAngle_Cyl	[deg]	Individual cylinder crank angle
Inertia_External	[kg m²]	Additional external inertia, for example, from the starter
Reset	[]	Reset all integrators to their initial conditions
SW_Trq_Mass_Mode	[]	Enable for modulated mass torque
Trq_Clutch	[Nm]	Clutch torque
Trq_Engine	[Nm]	Mean effective engine torque
Trq_External	[Nm]	Additional external torque, for example, from the starter
Trq_TestBench	[Nm]	Test bench torque

Outports

The following table shows the outports:

Name	Unit	Description
n_Engine	[rad/s]	Engine speed

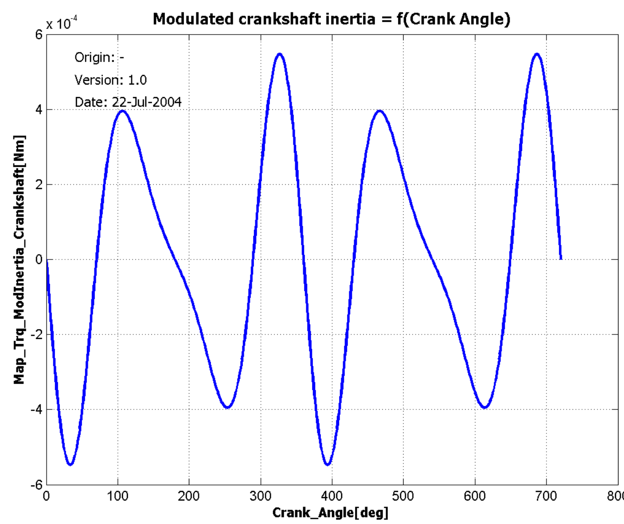
Parameters

The following table shows the block parameters:

Name	Unit	Description
Const_Inertia_Crankshaft	[kgm²]	Engine inertia (including all connected parts like camshaft, generator, first part of clutch/torque converter, rotating part of the connecting rods, mean value of the piston mass and so on with it's reduced inertia)
Const_n_Engine_Max	[rad/s]	Maximum engine speed
Const_n_Engine_Min	[rad/s]	Minimum engine speed
Map_Trq_ModInertia_Crankshaft	[Nm/(rad/s)^2]	Table of modulated crankshaft inertia [Nm/(rad/s)^2] = f(CrankAngle)
StepSize	[s]	Simulation step size

Processing information

The crankshaft mass torque is calculated during the parameterization process.



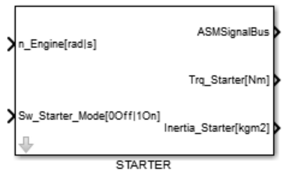
Related topics

References

Starter

Description

A combustion engine requires an initial crankshaft speed before the combustion process starts.



Therefore an external torque needs to be generated in order to accelerate the crankshaft. This is done by the starter, which initially speeds up the engine to its starting speed. When the engine reaches the startup speed, the electronic control unit starts fuel injection and ignition.

Inports

The following table shows the inports:

Name	Unit	Description
n_Engine	[rad/s]	Engine speed
Sw_Starter_Mode	[0|1]	Switch for enable or disable starter model ▪ 0: Off ▪ 1: On

Outports

The following table shows the outports:

Name	Unit	Description
Inertia_Starter	[kg m^2]	Starter inertia
Trq_Starter	[Nm]	Starter torque

Parameters

The following table shows the block parameters:

Name	Unit	Description
Const_Inertia	[kg m^2]	Starter inertia
Const_n_Starter_Max	[rpm]	Maximum starter speed
Const_Trq_init	[Nm]	Maximum starter torque

Related topics

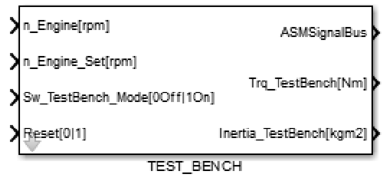
References

History of the STARTER Block..298
Starter Basic (ModelDesk Parameterizing 📖)

Test Bench

Description

The TEST_BENCH block can be used to simulate an engine test bench. It generates torque to follow a reference engine speed. This is comparable to an engine test bench and can be used to examine the engine at a fixed engine speed.



The test bench model is implemented as a PI controller.

Inports

The following table shows the inports:

Name	Unit	Description
n_Engine	[rpm]	Engine speed
n_Engine_Set	[rpm]	Engine speed setpoint
Reset	[0|1]	Reset
Sw_TestBench_Mode	[0|1]	Switch to enable or disable test bench model: ▪ 0: Off ▪ 1: On

Outports

The following table shows the outports:

Name	Unit	Description
ASMSignalBus	[]	Signal bus that contains signals of ASM components. Refer to ASMSignalBus (ASM User Guide 🕮).
Inertia_TestBench	[kgm^2]	Test bench inertia
Trq_TestBench	[Nm]	Test bench torque

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_I_Gain	[1/s]	I gain of the dynamometer controller
Const_Inertia_TestBench	[kg m^2]	Dynamometer inertia
Const_P_Gain	[]	P gain of the dynamometer controller
Const_Trq_Max_TestBench	[Nm]	Maximum dynamometer torque

Related topics

References

History of the TEST_BENCH Block 299
Test Bench (ModelDesk Parameterizing 🕮)

Switches Crankshaft

Description

The SWITCHES_CRANKSHAFT block collects the switches of the crankshaft.

Outports

The following table shows the outports:

Name	Unit	Description
Const_LoadTorque	[Nm]	Load torque on crankshaft
Sw_LoadTorque	[0|1]	Switch to activate load torque ▪ 0: Clutch ▪ 1: Constant
Sw_Trq_Mass_Mode	[1|2]	Switch to activate modulated mass torque ▪ 1: On ▪ 2: Off

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_LoadTorque	[Nm]	Load torque on crankshaft
Sw_LoadTorque	[0|1]	Switch to activate load torque ▪ 0: Clutch ▪ 1: Constant
Sw_Trq_Mass_Mode	[1|2]	Switch to activate modulated mass torque ▪ 1: On ▪ 2: Off

Gears

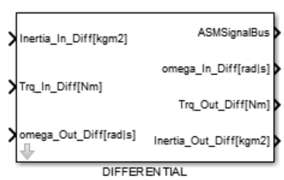
Where to go from here

Information in this section

Differential

Description

The differential converts the torque and speed between the gearbox and tires. It transmits, for example, the torque from the gearbox to the tires using a fixed ratio.



The differential model uses a simple ratio, i.e. the final drive ratio, between the input and output. No efficiency and no speed differences between the two output shafts are considered.

Inports

The following table shows the inports:

Name	Unit	Description
Inertia_In_Diff	[kg m^2]	Inertia of the differential input shaft
Trq_In_Diff	[Nm]	Differential input torque
omega_Out_Diff	[rad/s]	Differential output speed

Outports

The following table shows the outports:

Name	Unit	Description
Inertia_Out_Diff	[kg m^2]	Inertia reduced to the differential output shaft
omega_In_Diff	[rad/s]	Differential input speed
Trq_Out_Diff	[Nm]	Differential output torque

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_Diff_Ratio	[]	Final drive ratio

Related topics

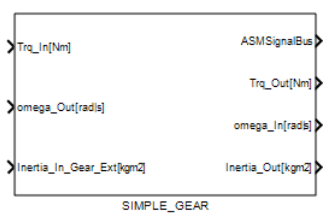
References

Differential Basic (ModelDesk Parameterizing)
History of the DIFFERENTIAL Block..281

Simple Gear

Description

The SIMPLE_GEAR block contains a simple gear train of two gear wheels.



It calculates output torque and input speed according to input torque, output speed and gear ratio:

$$T_{\text{out}} = i \times T_{\text{in}}$$

$$\omega_{\text{in}} = i \times \omega_{\text{out}}$$

Additionally, the following equation is used for the transmission output inertia:

$$J_{\text{Out}} = i^2 \times J_{\text{InputGear}} + J_{\text{OutputGear}}$$

The inertia of the input gear can be switched to an external input to consider the inertia of connected transmission components.

Inports

The following table shows the inports:

Name	Unit	Description
Inertia_In_Gear_Ext	[kg m^2]	Additional inertia at the input side
omega_Out	[rad/s]	Angular speed of the output shaft
Trq_In	[Nm]	Input torque

Outports

The following table shows the outports:

Name	Unit	Description
ASMSignalBus	[]	Signal bus that contains signals of ASM components. Refer to ASMSignalBus (ASM User Guide 🕮).
Inertia_Out	[kg m^2]	Inertia seen by the output shaft
omega_In	[rad/s]	Input shaft speed
Trq_Out	[Nm]	Output torque

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_Inertia_In_Gear	[kg m^2]	Inertia of the input gear
Const_Inertia_Out_Gear	[kg m^2]	Inertia of the output gear
Const_i_Gear	[-]	Gear ratio
Sw_Inertia_In_Gear	[1|2]	Switch of the inertia source of the input gear ▪ 1: Internal ▪ 2: External

Related topics

References

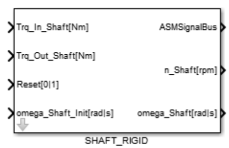
Simple Gear (ModelDesk Parameterizing 🕮)

Inertias

Rigid Shaft

Description

The SHAFT_RIGID block can be used as a general shaft. It calculates the shaft speed from the shaft inertia and the applied torques.



The shaft speed is calculated by integrating the following equation:

$$J_{\mathrm{Shaft}}\, \dot{\omega}_{\mathrm{Shaft}} = (T_{\mathrm{In}} - T_{\mathrm{Out}}) - D\, \omega$$

where:

J_{Shaft}	is the shaft inertia
$\dot{\omega}_{\mathrm{Shaft}}$	is the angular acceleration of the shaft
D	is the damping coefficient of the shaft rotation
T_{In}	is the applied torque on the shaft input side
T_{Out}	is the applied torque on the shaft output side

Inports

The following table shows the inports:

Name	Unit	Description
omega_Shaft_Init	[rad/s]	Initial shaft speed
Reset	[0|1]	Reset of states
Trq_In_Shaft	[Nm]	Applied torque on the shaft input side
Trq_Out_Shaft	[Nm]	Applied torque on the shaft output side

Outports

The following table shows the outports:

Name	Unit	Description
ASMSignalBus	[]	Signal bus that contains signals of ASM components. Refer to ASMSignalBus (ASM User Guide 📖).
n_Shaft	[rpm]	Shaft speed in [rpm]
omega_Shaft	[rad/s]	Shaft speed in [rad/s]

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_Damping_Coeff_Shaft	[Nm/(rad/s)]	Damping coefficient of the shaft rotation
Const_Inertia_Shaft	[kg m^2]	Shaft inertia
StepSize	[s]	Simulation step size

Related topics

References

Transmissions

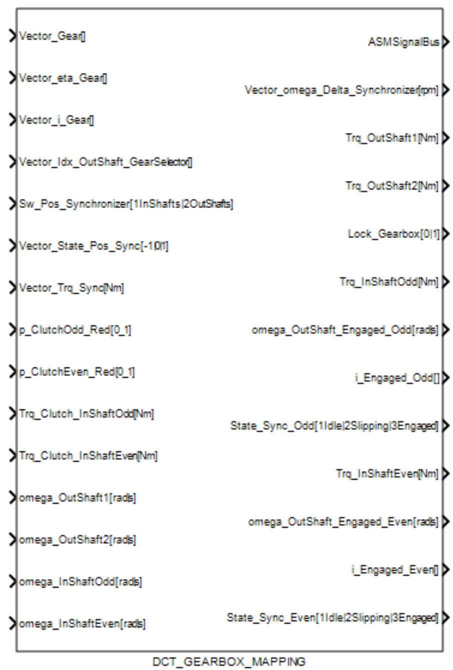
Where to go from here

Information in this section

DCT Gearbox Mapping

Description

The DCT_GEARBOX_MAPPING block maps clutches and synchronizers torques to the input and output shafts of a dual clutch transmission depending on a user-defined topology of the transmission. It also considers the gear ratios and gear mesh efficiency.



Moreover, it provides the current transmission ratio, efficiency and output shaft speeds for odd and even transmission according to the current engaged gears. It also calculates the speed differences for both sides of every gear selector.

The torque to the input shafts is determined by:

$$T_{InShaft} =$$

$$\begin{cases} T_{Clutch} + \sum T_{Synchronizer} \cdot i_{Gear}^{-1} & \text{for synchronizers on output shafts} \\ T_{Clutch} + \sum T_{Synchronizer} & \text{for synchronizers on input shafts} \end{cases}$$

The torque to the output shafts is calculated by:

$$T_{OutShaft} =$$

$$\begin{cases} T_{Clutch} \cdot i_{Gear,Engaged} + \sum T_{Synchronizer} & \text{for synchroniz. on output shafts} \\ T_{Clutch} \cdot i_{Gear,Engaged} + \sum T_{Synchronizer} \cdot i_{Gear} & \text{for synchroniz. on input shafts} \end{cases}$$

The torques are mapped according to the transmission topology, i.e., the distribution of the gear selectors to the output shafts.

The block requires several vector input signals. The order of the vector entries is fixed. All vectors except Vector_State_Pos_Sync are related to the gears. They consist of pairs of values for each gear selector with each one value for the right and the left gear selector side. There are five pairs of values for five odd gear selectors and another five pairs for even gear selectors. The resulting order of entries is as follows:

[Odd1 Right, Odd1 Left, Odd2 Right (...) Odd5 Left, Even1 Right, Even1 Left, Even2 Right…]

The vector Vector_State_Pos_Sync relates to the gear selectors and therefore must use the following order:

[Odd1, Odd2 (…) Odd5, Even1, Even2 (…) Even5]

Inports

The following table shows the inports:

Name	Unit	Description
omega_InShaftEven	[rad/s]	Angular speed of the even gears input shaft
omega_InShaftOdd	[rad/s]	Angular speed of the odd gears input shaft
omega_OutShaft1	[rad/s]	Angular speed of output shaft 1
omega_OutShaft2	[rad/s]	Angular speed of output shaft 2
p_ClutchEven_Red	[0_1]	Normalized even clutch cylinder pressure
p_ClutchOdd_Red	[0_1]	Normalized odd clutch cylinder pressure
Sw_Pos_Synchronizer	[1|2]	Switch to set the position of the synchronizers: ▪ 1: On the input shafts ▪ 2: On the output shafts
Trq_Clutch_InShaftEven	[Nm]	Torque from the even clutch to the even input shaft
Trq_Clutch_InShaftOdd	[Nm]	Torque from the odd clutch to the odd input shaft
Vector_eta_Gear	[]	Vector containing the gear efficiencies ordered by their position in the DCT topology [Odd1 Right; Odd1 Left; Odd2...]
Vector_Gear	[]	Vector containing the gear numbers ordered by their position in the DCT topology [Odd1 Right; Odd1 Left; Odd2...]
Vector_i_Gear	[]	Vector containing the gear ratios ordered by their position in the DCT topology [Odd1 Right; Odd1 Left; Odd2...]
Vector_Idx_OutShaft_GearSelector	[]	Vector containing the outshaft index of the gears ordered by their position in the DCT topology [Odd1 Right; Odd1 Left; Odd2...]
Vector_State_Pos_Sync	[-1|0|1]	Vector containing the synchronizer position state ordered by the DCT topology [Odd 1-5; Even 1-5]
Vector_Trq_Sync	[Nm]	Vector containing the slipping torque of the gears ordered by their position in the DCT topology [Odd1 Right; Odd1 Left; Odd2...]

Outports

The following table shows the outports:

Name	Unit	Description
ASMSignalBus	[]	Signal bus containing signals of ASM components, refer to ASMSignalBus (ASM User Guide 📖).
i_Engaged_Even	[]	Gear ratio of the engaged even gear
i_Engaged_Odd	[]	Gear ratio of the engaged odd gear
omega_OutShaft_Engaged_Even	[rad/s]	Angular speed of the output shaft which is connected to the engaged even gear
omega_OutShaft_Engaged_Odd	[rad/s]	Angular speed of the output shaft which is connected to the engaged odd gear
State_Sync_Even	[1|2|3]	Synchronizer position state of the even synchronizers: ▪ 1: Idle ▪ 2: Slipping ▪ 3: Engaged
State_Sync_Odd	[1|2|3]	Synchronizer position state of the odd synchronizers: ▪ 1: Idle ▪ 2: Slipping ▪ 3: Engaged
Trq_InShaftEven	[Nm]	Torque to the even input shaft
Trq_InShaftOdd	[Nm]	Torque to the odd input shaft
Trq_OutShaft1	[Nm]	Torque to output shaft 1
Trq_OutShaft2	[Nm]	Torque to output shaft 2
Vector_omega_Delta_Synchronizer	[rpm]	Vector containing the angular speed differences between gear wheels and shafts ordered by their position in the DCT topology [Odd1 Right; Odd1 Left; Odd2...]

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_p_Clutch_Red_LowLim	[0_1]	Lower clutch nominal pressure threshold to detect clutch as closed

Related topics

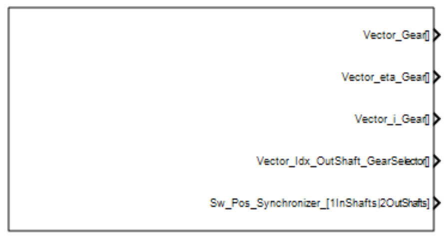
References

DCT Gearbox Mapping (ModelDesk Parameterizing 📖)

DCT Gearbox Topology

Description

This block describes the dual clutch transmission topology. It offers you the possibility to freely choose the gear selectors location and assign the related gears.



DCT_GEARBOX_TOPOLOGY

According to the selected transmission topology, the gear ratios and efficiency are also provided. The block, therefore, creates four vectors containing the following information for maximum 20 gears on 10 gear selectors:

- Gear number
- Gear ratio
- Gear efficiency
- Index of connected output shaft

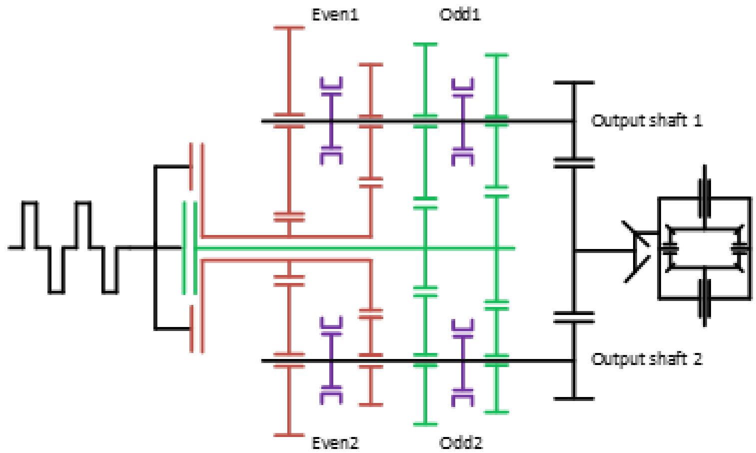
The order of the vector entries is fixed. A vector consists of pairs of values for each gear selector with each one value for the right and the left gear selector side. There are five pairs of values for five odd gear selectors and another five pairs for even gear selectors. The resulting order of entries is as follows:

[Odd1 Right, Odd1 Left, Odd2 Right (...) Odd5 Left, Even1 Right, Even1 Left, Even2 Right…]

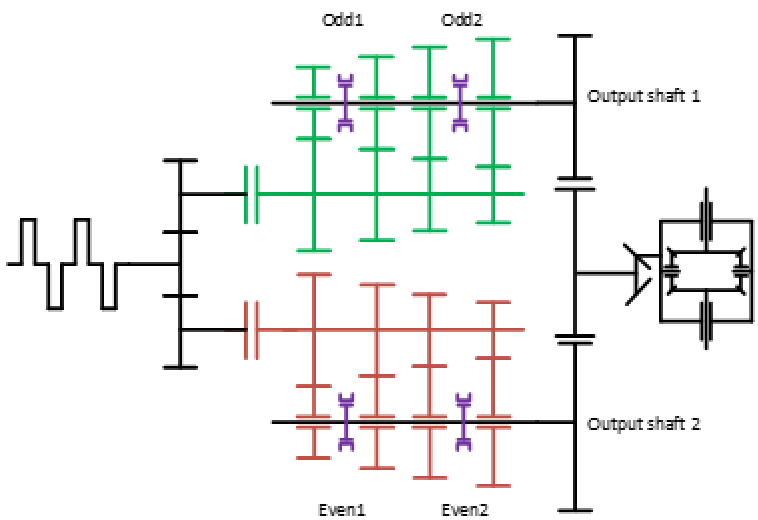
The following illustrations show exemplary mechanical layouts of DCTs with each four gear selectors. They use two odd and two even gear selectors. The main difference is the vector configuration of the index of the connected output shaft.

Mechanical layout of a DCT with hollow and rigid input shaft This example has a rigid and a hollow input shaft. As a consequence, there are one odd and one even gear selector mixed on each output shaft. The gear selectors

Odd1 and Even1 must be set to output shaft index 1, Odd2 and Even2 must be set to 2.



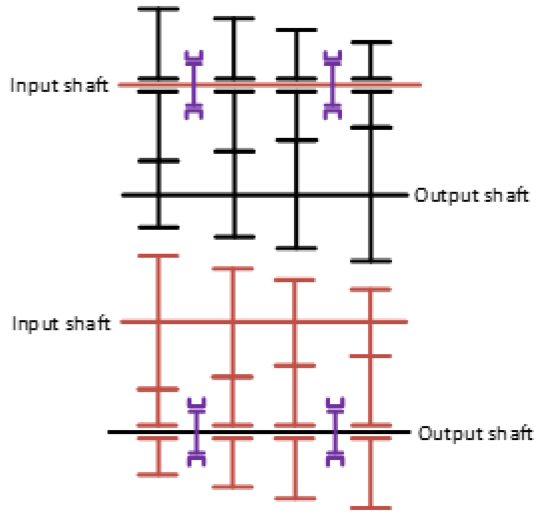
Mechanical layout of a DCT with parallel input shafts This example has two parallel input shafts. The first shaft holds the odd gear selectors, the second one holds the even gear selectors. The gear selectors Odd1 and Odd2 must be set to output shaft index 1, Even1 and Even2 must be set to 2.



Positions of the synchronizers Additionally, the block contains a switch to configure the synchronizer positions (Sw_Mode_SynchronizerPosition):

- 1: Inshafts: Synchronizers are situated on the input shafts
- 2: Outshafts: Synchronizers are situated on the output shafts

The following illustration shows the settings of the switch:



Outports

The following table shows the outports:

Name	Unit	Description
Sw_Pos_Synchronizer	[1|2]	Switch to set the position of the synchronizers: ▪ 1: On the input shafts ▪ 2: On the output shafts
Vector_eta_Gear	[]	Vector containing the gear efficiencies ordered by their position in the DCT topology [Odd1 Right; Odd1 Left; Odd2...]
Vector_Gear	[]	Vector containing the gear numbers ordered by their position in the DCT topology [Odd1 Right; Odd1 Left; Odd2...]
Vector_i_Gear	[]	Vector containing the gear ratios ordered by their position in the DCT topology [Odd1 Right; Odd1 Left; Odd2...]
Vector_Idx_OutShaft_GearSelector	[]	Vector containing the outshaft index of the gears ordered by their position in the DCT topology [Odd1 Right; Odd1 Left; Odd2...]

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_Gear_Left_GearSelectorEven1	[]	Gear on the left side of even gear selector #1
Const_Gear_Left_GearSelectorEven2	[]	Gear on the left side of even gear selector #2
Const_Gear_Left_GearSelectorEven3	[]	Gear on the left side of even gear selector #3
Const_Gear_Left_GearSelectorEven4	[]	Gear on the left side of even gear selector #4
Const_Gear_Left_GearSelectorEven5	[]	Gear on the left side of even gear selector #5
Const_Gear_Left_GearSelectorOdd1	[]	Gear on the left side of odd gear selector #1
Const_Gear_Left_GearSelectorOdd2	[]	Gear on the left side of odd gear selector #2

Name	Unit	Description
Const_Gear_Left_GearSelectorOdd3	[]	Gear on the left side of odd gear selector #3
Const_Gear_Left_GearSelectorOdd4	[]	Gear on the left side of odd gear selector #4
Const_Gear_Left_GearSelectorOdd5	[]	Gear on the left side of odd gear selector #5
Const_Gear_Right_GearSelectorEven1	[]	Gear on the right side of even gear selector #1
Const_Gear_Right_GearSelectorEven2	[]	Gear on the right side of even gear selector #2
Const_Gear_Right_GearSelectorEven3	[]	Gear on the right side of even gear selector #3
Const_Gear_Right_GearSelectorEven4	[]	Gear on the right side of even gear selector #4
Const_Gear_Right_GearSelectorEven5	[]	Gear on the right side of even gear selector #5
Const_Gear_Right_GearSelectorOdd1	[]	Gear on the right side of odd gear selector #1
Const_Gear_Right_GearSelectorOdd2	[]	Gear on the right side of odd gear selector #2
Const_Gear_Right_GearSelectorOdd3	[]	Gear on the right side of odd gear selector #3
Const_Gear_Right_GearSelectorOdd4	[]	Gear on the right side of odd gear selector #4
Const_Gear_Right_GearSelectorOdd5	[]	Gear on the right side of odd gear selector #5
Map_Idx_OutShaft_GearSelector	[]	Output shaft index map for gear selector position = f(Idx_GearSelector[-])
Map_eta_Gear	[0_1]	Gearbox efficiency map = f(Gear[-])
Map_i_Gear	[]	Gear ratio map = f(Gear[-])

Related topics

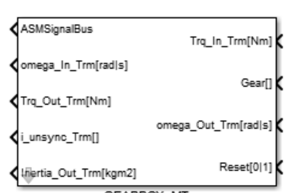
References

DCT Gearbox Topology (ModelDesk Parameterizing)

Gearbox Manual Transmission

Description

The function of the gearbox is to expand the gear ratio from the engine to the rest of the drivetrain, thereby extending the working range.



The gearbox inertia at the output shaft is parameterized with a look-up table which has the current gear as input.

The gear efficiency is also considered in the model as a function of the selected gear and is built using look-up tables. There are two tables used to differentiate between the forward and reverse efficiency. One for when the transferred torque is positive (the engine drives the vehicle), and one for when the transferred torque is negative (the vehicle drags the engine).

The following equations are used to calculate the torque, speed and inertia of the gearbox:

$$T_{Gear,Out} = \eta_{Gear} \, i_{Gear} \, T_{Gear,In}$$

$$\Omega_{Gear,In} = i_{Gear} \, \Omega_{Gear,Out}$$

$$\Theta_{Gear,Out} = f(gear)$$

where:

η_{Gear} is the gearbox transmission efficiency

i_{Gear} is the gearbox transmission ratio

The synchronization during the shift process is represented by a first-order delay element. This can be described using the following equation:

$$t_{sync} \, \dot{i}_{Gear} + i_{Gear} = i_{Gear,set}$$

where:

t_{sync} is the synchronization time constant

If the neutral gear is selected, the gearbox input speed is calculated as a new degree of freedom. For this special handling the input shaft inertia and damping of the gearbox is used as a parameter.

Inports

The following table shows the inports:

Name	Unit	Description
Gear	[]	Gear
omega_Out_Trm	[rad/s]	Transmission output speed
Reset	[0|1]	Reset of states
Trq_In_Trm	[Nm]	Transmission input torque

Outports

The following table shows the outports:

Name	Unit	Description
i_unsync_Trm	[]	Unsynchronized transmission ratio
Inertia_Out_Trm	[kg m^2]	Inertia reduced to the transmission output shaft
omega_In_Trm	[rad/s]	Transmission input speed
Trq_Out_Trm	[Nm]	Transmission output torque

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_Damping_Gear_In	[Nm/(rad/s)]	Damping coefficient of the gearbox input shaft
Const_Inert_Gear_In	[kg m^2]	Inertia of the gearbox input shaft
Const_SyncTime	[s]	Synchronization time constant
Map_Forward_Efficiency	[]	Map forward efficiency of the transmission = f(Gear)
Map_i_Ratio	[]	Map gear ratio = f(Gear)
Map_Inertia_Out	[kg m^2]	Map of transmission inertia reduced to the output shaft = f(Gear)
Map_Reverse_Efficiency	[]	Map reverse efficiency of the transmission = f(Gear)
StepSize	[s]	Simulation step size

Related topics

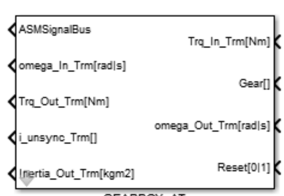
References

History of the GEARBOX_MT Block..287
Manual Transmission Basic (ModelDesk Parameterizing 📖)

Gearbox Automatic Transmission

Description

The model of the gearbox in automatic transmission is identical to the model in manual transmission (see Gearbox Manual Transmission on page 61).



GEARBOX_AT

The significant difference is that the gear in automatic transmission is set by the transmission control unit, which can be a real ECU or a soft ECU.

Inports

The following table shows the inports:

Name	Unit	Description
Gear	[]	Gear
omega_Out_Trm	[rad/s]	Transmission output speed
Reset	[0|1]	Reset of states
Trq_In_Trm	[Nm]	Transmission input torque

Outports

The following table shows the outports:

Name	Unit	Description
i_unsync_Trm	[]	Unsynchronized transmission ratio
Inertia_Out_Trm	[kg m^2]	Inertia reduced to the transmission output shaft
omega_In_Trm	[rad/s]	Transmission input speed
Trq_Out_Trm	[Nm]	Transmission output torque

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_Damping_Gear_In	[Nm|(rad/s)]	Damping coefficient of the gearbox input shaft
Const_Inert_Gear_In	[kg m^2]	Inertia of the gearbox input shaft
Const_SyncTime	[s]	Synchronization time constant
Map_Forward_Efficiency	[]	Map forward efficiency of the transmission = f(Gear)
Map_i_Ratio	[]	Map gear ratio = f(Gear)
Map_Inertia_Out	[kg m^2]	Map of transmission inertia reduced to the output shaft = f(Gear)
Map_Reverse_Efficiency	[]	Map reverse efficiency of the transmission = f(Gear)
StepSize	[s]	Simulation step size

Related topics

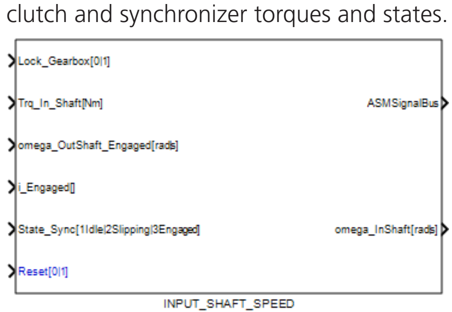
References

Automatic Transmission Basic (ModelDesk Parameterizing 📖)
History of the GEARBOX_AT Block.. 286

Input Shaft Speed

Description

The block determines the angular speed of the gearbox input shaft according to clutch and synchronizer torques and states.



The main input shaft speed calculation considers the input torque to determine angular acceleration, which can be integrated to angular speed.

$$J_{Eff} \cdot \dot{\omega}_{InShaft} = T_{In} - K_d \cdot \omega_{InShaft}$$

where:

J_{Eff}	is the effective inertia reduced to the input shaft
T_{In}	is the torque to the shaft
K_d	is the damping coefficient of the shaft rotation

As soon as a synchronizer of the connected gearbox has engaged a gear, its join will be form-locked. Therefore, no slip between input and output shaft is possible anymore. The input shaft speed will be calculated from the corresponding output shaft speed and the engaged gear ratio.

$$\omega_{InShaft} = i_{Gear} \cdot \omega_{OutShaft}$$

Inports

The following table shows the inports:

Name	Unit	Description
i_Engaged	[]	Gear ratio of the engaged gear
Lock_Gearbox	[0|1]	Indicates if gearbox is locked
omega_OutShaft_Engaged	[rad/s]	Angular speed of the output shaft connected to the engaged gear
Reset	[0|1]	Reset of states
State_Sync	[1|2|3]	Synchronizer position state Synchronizer position state ▪ 1: Idle ▪ 2: Slipping ▪ 3: Engaged
Trq_In_Shaft	[Nm]	Torque to the input shaft

Outports

The following table shows the outports:

Name	Unit	Description
ASMSignalBus	[]	Signal bus that contains signals of ASM components. Refer to ASMSignalBus (ASM User Guide 📖).
omega_InShaft	[rad/s]	Angular speed of the input shaft

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_Damping_Coeff	[Nm/(rad/s)]	Damping coefficient of the shaft rotation
Const_Inertia_Eff_In_InShaft	[kg m^2]	Effective inertia reduced to the input shaft

Name	Unit	Description
Const_t_Transition	[s]	First-order-dynamics time constant of the change to engaged state calculation
ItNum	[]	Iteration number
StepSize	[s]	Simulation step size

Related topics

References

Input Shaft Speed (ModelDesk Parameterizing 📖)

Switches

Switches Drivetrain Basic

Description

The SWITCHES_DRIVETRAINBASIC block collects the switches of the drivetrain basic.

Parameters

The following table shows the parameters:

Name	Unit	Description
Sw_Transmission_Mode	[1|2]	Switch to select transmission mode ▪ 1: Manual ▪ 2: Automatic

Related topics

References

Crankshaft Basic (ModelDesk Parameterizing 🕮)

Engine

Where to go from here

Information in this section

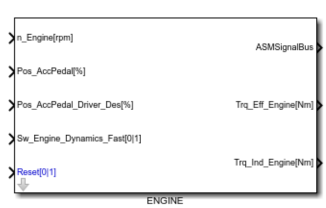
Engine

Description

A 2-D look-up table is used to describe the engine torque as a function of the engine speed and the accelerator pedal position.

The engine dynamics are approached by first-order dynamics. The model distinguishes between the dynamics for the torque increase and torque decrease. Therefore, two related time constants are used as parameters. In addition, a third time constant is used to describe the dynamics of the fast torque intervention.

The following illustration shows the Simulink representation of the engine model:



Inports

The following table shows the inports:

Name	Unit	Description
n_Engine	[rpm]	Engine speed
Pos_AccPedal	[%]	Accelerator pedal position
Pos_AccPedal_Driver_Des	[%]	Driver accelerator pedal position
Reset	[0|1]	Reset of states
Sw_Engine_Dynamics_Fast	[0|1]	Switch to activate the fast engine dynamics: ▪ 0: Standard dynamics ▪ 1: Fast dynamics

Outports

The following table shows the outports:

Name	Unit	Description
ASMSignalBus	[]	Signal bus that contains signals of ASM components. Refer to ASMSignalBus (ASM User Guide 📖).
Trq_Eff_Engine	[Nm]	Mean effective engine torque
Trq_Ind_Engine	[Nm]	Mean indicated engine torque

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_TimeConst_Decrease	[s]	Engine dynamics time constant for torque decrease
Const_TimeConst_Fast	[s]	Fast engine dynamics time constant
Const_TimeConst_Increase	[s]	Engine dynamics time constant for torque increase
Map_Torque	[Nm]	Map of effective engine torque [Nm]=f(n_Engine[rpm], Pos_AccPedal[%])
StepSize	[s]	Simulation step size

Related topics

References

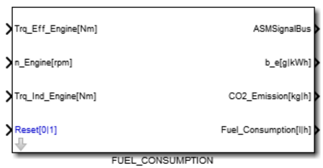
History of the ENGINE Block 283

Fuel Consumption

Description

The FUEL_CONSUMPTION model computes fuel consumption and carbon dioxide emissions. This approach is only an approximation and can be used with Engine on page 69.

The following illustration shows the Simulink representation of the model:



The calculation is based on the brake-specific fuel consumption, which is a measure of fuel efficiency. However, this measure is valid only for positive values of the effective engine torque. From the lower heating value of the fuel, the minimum brake-specific fuel consumption is calculated by using the following equation:

$$b_{e,min} = \frac{T_{ind}}{T_{eff} \cdot Q_{LHV}}$$

where:

Q_{LHV} is the lower heating value of the fuel at reference temperature

T_{ind} is the indicated engine torque

T_{eff} is the effective engine torque

The fuel mass flow rate is then computed by multiplying the brake-specific fuel consumption with the effective engine power:

$$\dot{m}_{driving} = T_{eff} \cdot n \cdot b_e$$

In the case of coasting, i.e., non-positive values of the effective engine torque, the fuel mass flow is extrapolated based on the indicated engine torque:

$$\dot{m}_{coasting} = \frac{T_{ind}}{T_{fric,idle}} \cdot \dot{m}_{idle}$$

where:

$\dot{m}_{idle}$ is the fuel mass flow rate at engine idle speed

$T_{fric,idle}$ is the engine friction torque at engine idle speed

From the current fuel mass flow rate and the fuel properties, the resulting carbon dioxide emission can be obtained:

$$CO2_{em} = \frac{\dot{m}}{\rho} \cdot CO2_{em,sp}$$

where:

$\dot{m}$ is the current fuel mass flow rate

ρ is the fuel density

$CO2_{em,sp}$ is the specific carbon dioxide emissions of the fuel

The fuel consumption is the quotient of fuel flow divided by fuel density. By integrating this value over the time, the total fuel consumption is obtained. The total carbon dioxide emissions are calculated in a similar way.

Inports

The following table shows the inports:

Name	Unit	Description
n_Engine	[rpm]	Engine speed
Reset	[0|1]	Reset of states
Trq_Eff_Engine	[Nm]	Effective engine torque
Trq_Ind_Engine	[Nm]	Indicated engine torque

Outports

The following table shows the outports:

Name	Unit	Description
ASMSignalBus	[]	Signal bus that contains signals of ASM components. Refer to ASMSignalBus (ASM User Guide 📖).
b_e	[g/kWh]	Brake-specific fuel consumption
CO2_Emission	[kg/h]	Carbon dioxide emission
Fuel_Consumption	[l/h]	Fuel consumption

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_i	[]	Factor for a four-stroke engine (0.5) or two-stroke engine (1)
Const_mdot_Fuel_Idle	[g/h]	Fuel mass flow rate at engine idle speed
Const_Q_LHV	[J/kg]	Lower heating value of the fuel at reference temperature
Const_rho_Fuel	[kg/m^3]	Fuel density
Const_Specif_Emission_CO2	[kg/l]	Specific carbon dioxide emissions of the fuel
Const_Trq_Fric_Engine_Idle	[Nm]	Engine friction torque at engine idle speed
Const_V_Displ	[m^3]	Engine displacement
Map_Specif_FuelConsumption	[bar]	Map of brake-specific fuel consumption [g|kWh]=f(n_Engine[rpm], p_Eff_Mean[bar])
StepSize	[s]	Simulation step size

Environment

Where to go from here

Information in this section

Driver

Where to go from here

Information in this section

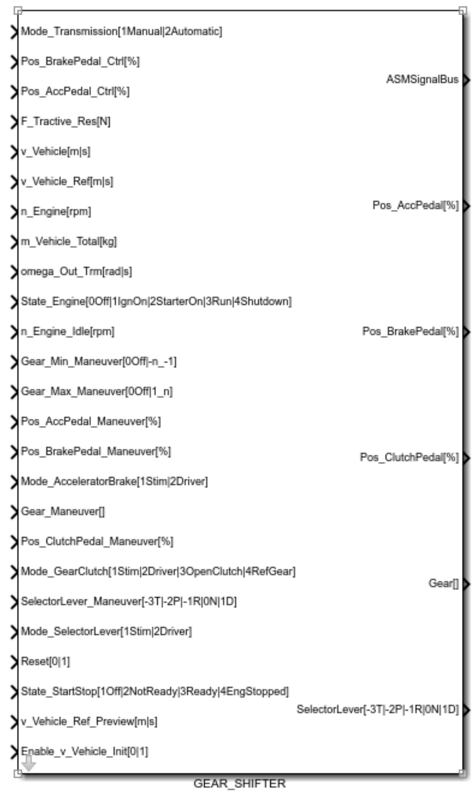
Gear Shifter

Description

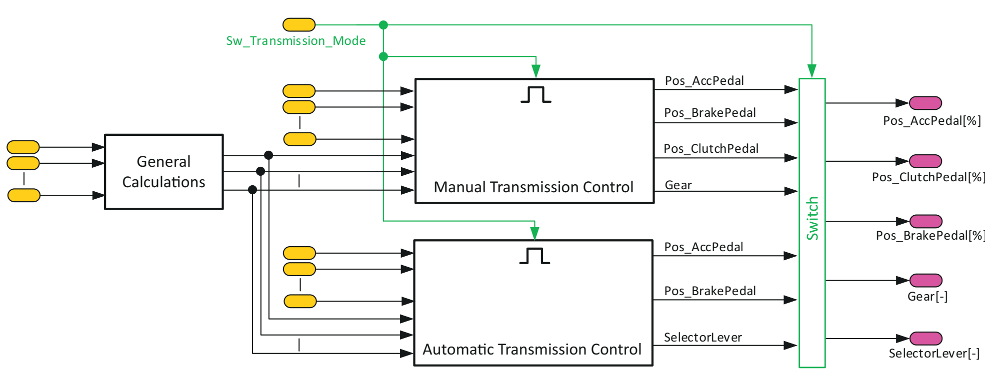
The **GEAR_SHIFTER** block simulates a part of the longitudinal driver and can be used with vehicle models equipped with manual and automatic transmissions.

In case of manual transmission, the block shifts the gear and controls the clutch pedal. Additionally, it ensures that the vehicle starts smoothly and prevents the engine from being stalled.

If it is used with automatic transmission, it controls the selector lever. The gearshift itself is performed by the SOFT_ECU_TRANSMISSION block.



The GEAR_SHIFTER block is divided into two main control subsystems. One subsystem builds the longitudinal behavior of the driver with manual transmission and the other the driver with automatic transmission. The following illustration shows the first level of the GEAR_SHIFTER block:



The Sw_Trm_Mode[1Manual|2Automatic] inport can be used to switch between the two control subsystems.

For more information on the two control subsystems, refer to the following topics:

- Gear Shifter - Manual Transmission Control on page 78
- Gear Shifter - Automatic Transmission Control on page 87

Inports

The following table shows the inports:

Name	Unit	Description
Enable_v_Vehicle_Init	[0|1]	Drivetrain initialization flag for scenarios with non-zero vehicle initial velocity
F_Tractive_Res	[N]	Tractive resistance
Gear_Maneuver	[]	Stimulus gear from maneuver
Gear_Max_Maneuver	[0Off|1_n]	Maximum allowed gear from maneuver
Gear_Min_Maneuver	[0Off|-n_-1]	Minimum allowed gear from maneuver
m_Vehicle_Total	[kg]	Total vehicle mass
Mode_AcceleratorBrake	[1|2]	Mode signal for accelerator and brake pedal: ▪ 1: Stimulus ▪ 2: Driver
Mode_GearClutch	[1|2|3|4]	Mode signal for gear and clutch pedal: ▪ 1: Stimulus ▪ 2: Driver ▪ 3: Open clutch ▪ 4: Reference gear
Mode_SelectorLever	[1|2]	Mode signal for selector lever: ▪ 1: Stimulus ▪ 2: Driver
n_Engine	[rpm]	Engine speed
n_Engine_Idle	[rpm]	Engine idle speed
omega_Out_Trm	[rad/s]	Transmission output speed
Pos_AccPedal_Ctrl	[%]	Calculated accelerator pedal position from the longitudinal controller
Pos_AccPedal_Maneuver	[%]	Accelerator pedal position from maneuver
Pos_BrakePedal_Ctrl	[%]	Calculated brake pedal position from the longitudinal controller
Pos_BrakePedal_Maneuver	[%]	Brake pedal position from maneuver
Pos_ClutchPedal_Maneuver	[%]	Clutch pedal position from maneuver
Reset_States	[0|1]	Reset of states
SelectorLever_Maneuver	[-3|-2|-1|0|1]	Selector lever position from maneuver: ▪ -3: TipShift ▪ -2: Park ▪ -1: Reverse ▪ 0: Neutral ▪ 1: Drive
State_Engine	[0|1|2|3|4]	Engine state: ▪ 0: Engine off

Name	Unit	Description
		▪ 1: Ignition on ▪ 2: Ignition on and starter activated ▪ 3: Engine is running ▪ 4: Ignition is switched off, shutdown active
State_StartStop	[1|2|3|4]	State of start-stop system: ▪ 1: Switched off ▪ 2: Not ready (conditions are not fulfilled) ▪ 3: Ready (waiting for driver action) ▪ 4: Engine actively stopped by the system
Sw_Trm_Mode	[1|2]	Switch for manual or automatic transmission: ▪ 1: Manual ▪ 2: Automatic
v_Vehicle	[m/s]	Vehicle velocity
v_Vehicle_Ref	[m/s]	Reference vehicle velocity
v_Vehicle_Ref_Preview	[m/s]	Preview reference vehicle velocity

Outports

The following table shows the outports:

Name	Unit	Description
ASMSignalBus	[]	Signal bus that contains signals of ASM components. Refer to ASMSignalBus (ASM User Guide 📖).
Gear	[]	Gear
Pos_AccPedal	[%]	Accelerator pedal position
Pos_BrakePedal	[%]	Brake pedal position
Pos_ClutchPedal	[%]	Clutch pedal position
SelectorLever	[-3|-2|-1|0|1]	Selector lever position: ▪ -3: TipShift ▪ -2: Park ▪ -1: Reverse ▪ 0: Neutral ▪ 1: Drive

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_a_Tractive_Res_UpLim	[m/s^2]	Tractive resistance acceleration threshold for startup
Const_a_x_Vehicle_LowLim	[m/s^2]	Hard braking threshold for gear hold
Const_a_x_Vehicle_UpLim	[m/s^2]	Acceleration threshold for startup
Const_D_Gain_StartUp	[s]	D gain of accelerator pedal startup controller
Const_I_Gain_ClutchPedal	[1/s]	I gain of clutch pedal controller
Const_I_Gain_StartUp	[1/s]	I gain of accelerator pedal startup controller

Name	Unit	Description
Const_n_Engine_StartUp_Set	[rpm]	Engine speed setpoint during startup
Const_P_Gain_ClutchPedal	[]	P gain of clutch pedal controller
Const_P_Gain_StartUp	[]	P gain of accelerator pedal startup controller
Const_t_Gear_Neutral	[s]	Time of gear passing through neutral during gear change
Const_t_Hold_ClutchPedal	[s]	Disengaged clutch hold time
Const_v_x_Vehicle_LowLim	[m/s]	Low velocity threshold
Map_Gear_StartUp	[]	Startup gear
Map_i_Ratio	[]	Gear ratio = f(gear)
Map_n_Engine_Downshift_Lim	[rpm]	Down shift engine speed limit = f(Pos_AccPedal)
Map_n_Engine_Upshift_Lim	[rpm]	Up shift engine speed limit = f(Pos_AccPedal)
Map_omega_Out_Trm_Shift_Bias	[rpm]	Transmission output speed shift bias = f(Tractive resistance acceleration)
Map_Pos_AccPedal	[0_1]	Accelerator pedal factor during gear change = f(Pos_ClutchPedal)
Map_Pos_ClutchPedal_Disenagement	[%]	Clutch pedal disengagement position not during startup = f(t)
Map_Pos_ClutchPedal_Disenagement_StartUp	[%]	Clutch pedal disengagement position during startup = f(t)
Map_Pos_ClutchPedal_Enagement	[%]	Clutch pedal engagement position not during startup = f(t)
Map_Pos_ClutchPedal_Enagement_StartUp	[%]	Clutch pedal engagement position during startup = f(t)
StepSize	[s]	Simulation step size
Sw_ClutchPedal_EngineOff	[0|1]	Switch to disengage the clutch if engine is not running
Sw_Upshift_Gear_Skipping	[1|2]	Switch for gear skipping: ▪ 1: On ▪ 2: Off

Related topics

References

Gear Shifter - Manual Transmission Control

Description

In the Control_ManualTransmission subsystem, the gearshift process and the clutch pedal are controlled according to the driving situation.

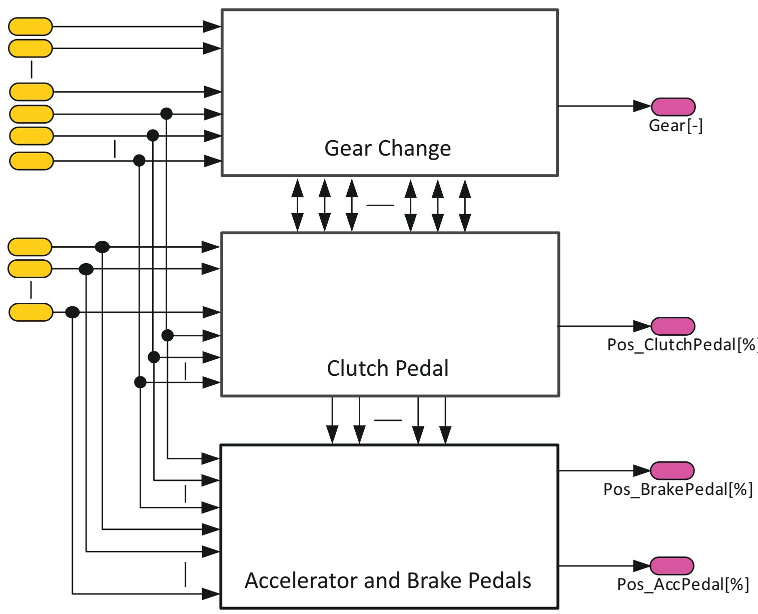
The Control_ManualTransmission subsystem ist part of the GEAR_SHIFTER block. Refer to Gear Shifter on page 74.

The driving situation is analyzed and a gear is calculated. This gear is sent as a request for clutch disengagement. When the clutch is completely disengaged, the requested gear is set and the clutch is engaged afterwards.

The manual transmission control is implemented in three subsystems:

- Clutch_Pedal: controls the clutch pedal
- Gear_Change: simulates the gearshift
- Accelerator_And_Brake_Pedals: controls the accelerator pedal during startup

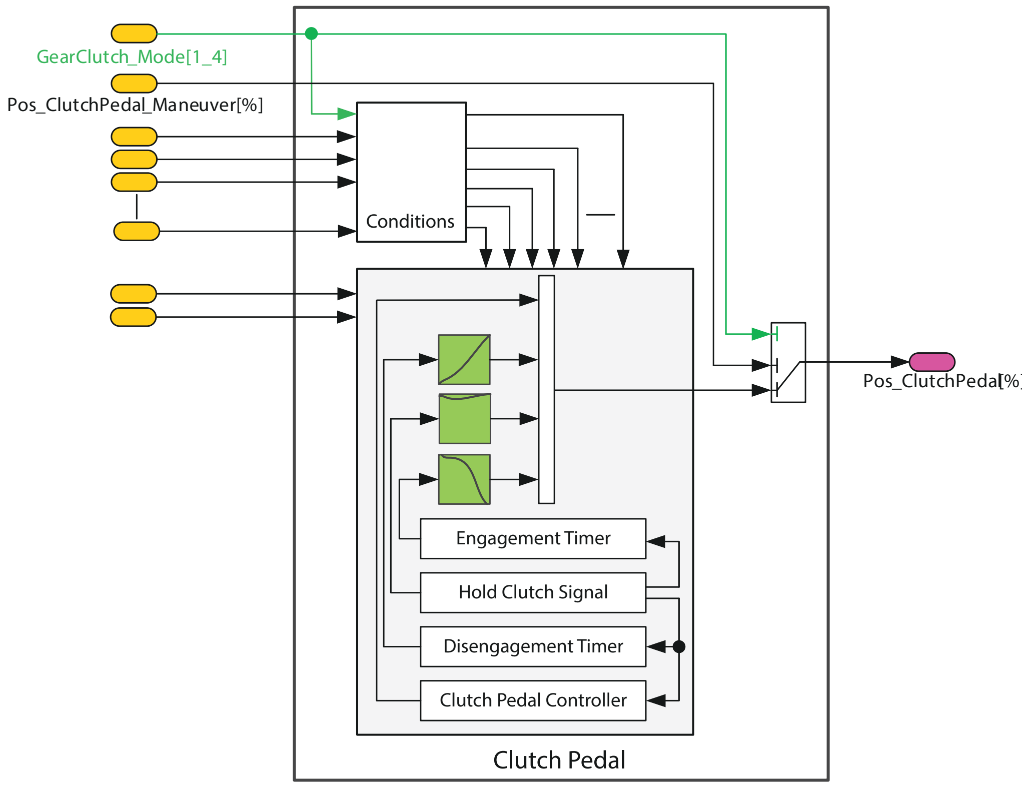
The following illustration shows how these subsystems are interconnected:



The calculations inside each subsystem are described below.

Clutch_Pedal subsystem

In the Clutch_Pedal subsystem, the clutch pedal activation and deactivation are triggered according to the requested gear and other conditions. The clutch pedal position during actuation is defined via look-up tables. It can also be controlled in special driving situations. Furthermore, the clutch pedal position can be stimulated by using external maneuver signals. The following figure illustrates this subsystem:



In addition to the gearshifting request, there are several conditions that control the actuation of the clutch pedal. Most of these conditions are related to user-defined parameters. Refer to the following table:

Condition Name	Description
Low_Engine_Speed	Indicates whether a low engine speed has been reached. Parameter: none Calculation unit: [rpm] True: {engine speed} ≤ {current engine idle speed + 100} False: {engine speed} ≥ {current engine idle speed + 500}
Engine_On	Indicates whether the engine is on. Parameter: none Calculation unit: [] The signal is calculated from the State_Engine[0|1|2|3|4] input signal and is active if the engine state equals 3. Otherwise, it is inactive.
Hard_Braking	Indicates whether the driver is braking hard. Parameter: Const_a_x_Vehicle_LowLim Calculation unit: [m/s^2] True: {reference vehicle acceleration} < {parameter} False: otherwise
Small_Velocity	Indicates whether there is a small reference vehicle velocity. Parameter: Const_v_x_Vehicle_LowLim Calculation unit: [m/s]

Condition Name	Description
	True: {reference vehicle velocity} ≤ {parameter} False: { reference vehicle velocity} ≥ {parameter + 0.4167}
Startup	Indicates whether there is a startup. Parameter: none Calculation unit: [m/s] True: ({vehicle reference velocity} > {0.05}) & (gear = neutral) False: otherwise
Standstill	Indicates whether the vehicle is standing still. Parameter: none Calculation unit: [m/s] True: {vehicle reference velocity} ≤ {0.05} False: otherwise
Initial_Velocity	Indicates whether the maneuver is defined with initial vehicle velocity. Parameter: none Calculation unit: [m/s] True: {vehicle velocity change in one simulation step} ≥ {3} False: otherwise
Big_Acceleration	Indicates whether a high acceleration is required during the startup to follow the reference vehicle velocity. Parameter: Const_a_x_Vehicle_UpLim Calculation unit: [m/s^2] True: {reference vehicle acceleration} > {parameter} False: otherwise
Big_Tractive_Resistance_Acceleration	Indicates whether a high driving resistance has to be overcome during startup. Parameter: Const_a_Tractive_Res_UpLim Calculation unit: [m/s^2] True: {tractive resistance acceleration} > {parameter} False: otherwise

The actuation of the clutch pedal can be divided into three phases:

1. Clutch pedal activation: clutch disengagement
2. Clutch pedal hold: clutch hold
3. Clutch pedal deactivation: clutch engagement

These phases are normally carried out in succession. However, clutch pedal activation always has the highest priority. It means the clutch pedal can be activated at any time regardless of its current position.

Each phase is activated if certain conditions are fulfilled.

Clutch pedal activation The clutch pedal is activated in the following cases:

- A gear change is requested.
- The reference vehicle velocity becomes low (`Small_Velocity` condition is true).

- The driver is braking hard (`Hard_Braking` condition is true) and a low engine speed has been reached (`Low_Engine_Speed` condition is true).

Clutch pedal hold The clutch pedal is held down after the clutch pedal activation ended and as long as at least one of the following conditions is fulfilled:

- A small reference vehicle velocity is tracked (`Small_Velocity` condition is true).
- The driver continues to brake hard (`Hard_Braking` condition is true) and the engine speed is low (`Low_Engine_Speed` is true).
- There is a startup with slipping clutch where no high acceleration is required (`Big_Tractive_Resistance_Acceleration` condition and `Big_Acceleration` condition are false).

If the clutch pedal activation ended and none of the above conditions is true, then the clutch pedal is held down while the gear is being changed for a user-defined time, i.e., with the Const_t_Hold_ClutchPedal parameter.

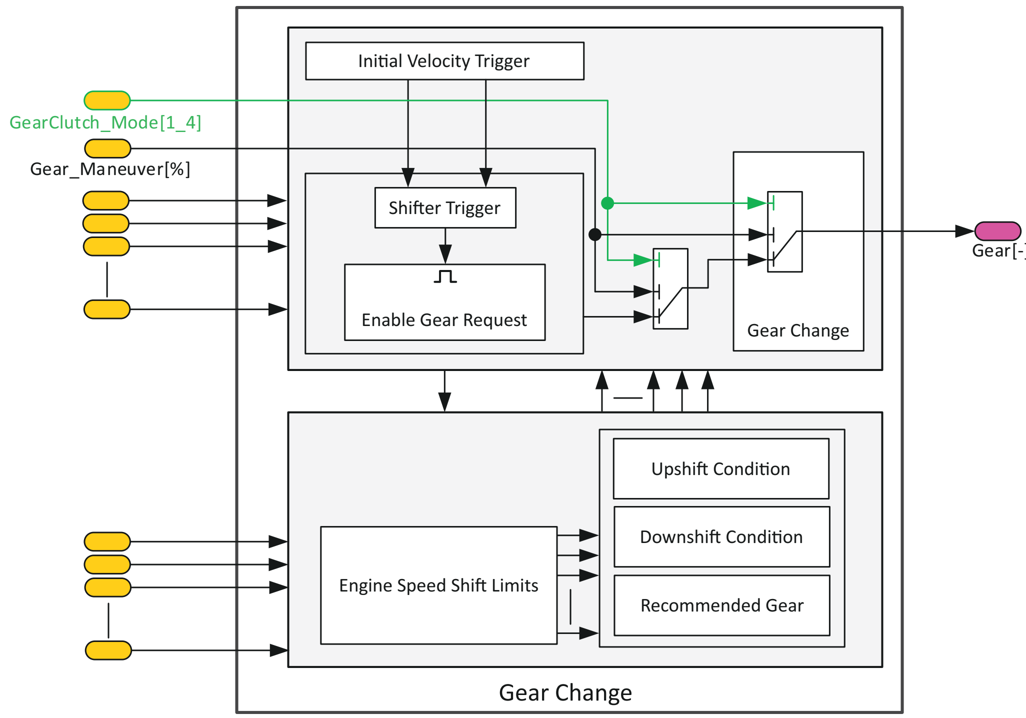
Clutch pedal deactivation After the clutch pedal hold ends, the clutch pedal is deactivated and the clutch is engaged.

The clutch pedal position is sometimes also controlled by a PI controller. The controller is active during the hold and deactivation phases of the clutch pedal after the activation phase ended and if at least one of the following conditions is fulfilled:

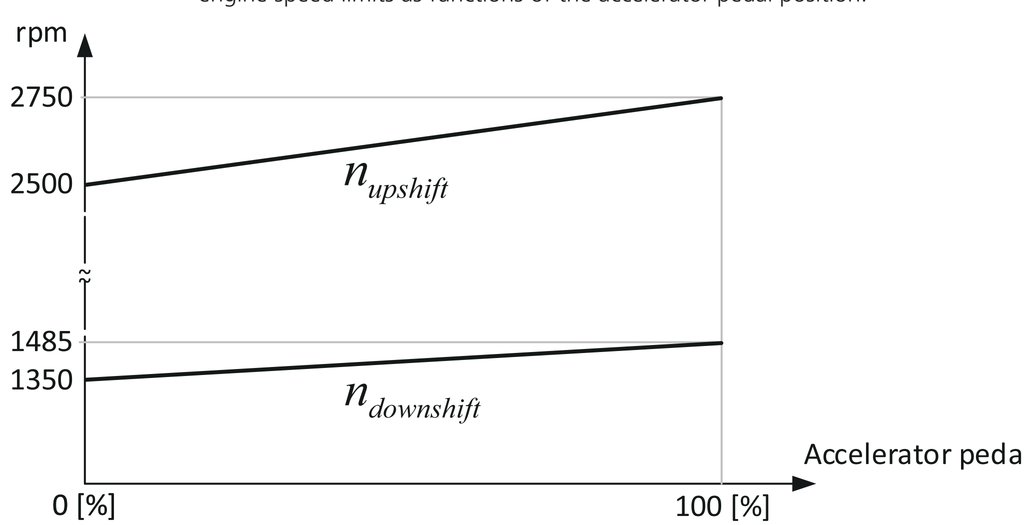
- A small reference vehicle velocity is tracked (`Small_Velocity` condition is true).
- There is a startup with slipping clutch where no high acceleration is required (`Big_Tractive_Resistance_Acceleration` condition and `Big_Acceleration` condition are false).

Gear_Change subsystem

The Gear_Change subsystem simulates the requested gear as well as the gearshift process. The requested gear can be externally stimulated or calculated according to the driving situation. The following illustration shows the subsystem.



First, the engine speed limits for the shift process and the ideal engine speed for the current and possible gears are calculated. The engine speed limits are parameterized via look-up tables as functions of the accelerator pedal position (Map_n_Engine_Upshift_Lim and Map_n_Engine_Downshift_Lim parameters). The following illustration shows exemplary values of the diesel engine speed limits as functions of the accelerator pedal position:



To calculate the ideal engine speed, the gearbox ratios and the transmission output speed are needed, with:

$$n_{current,\,ideal} = i_{current}\,\omega_{Gear,\,Out}$$

$$\overline{n}_{possible,\,ideal} = \overline{i}_{possible}\,\omega_{Gear,\,Out}$$

where:

$n_{current,\,ideal}$	is the ideal engine speed of the current gear
$i_{current}$	is the gearbox ratio of the current gear
$\omega_{Gear,\,Out}$	is the transmission output speed
$\overline{n}_{possible,\,ideal}$	is a vector of ideal engine speeds of all possible gears
$\overline{i}_{possible}$	is a vector of gearbox ratios of all possible gears

By using the user-defined engine speed limits for the shift process, the ideal engine speeds of the possible gears are filtered so only certain allowed gears are considered for the further calculations. The ideal engine speeds of the allowed gears have to fulfill the following condition:

$$n_{upshift} \geq \overline{n}_{allowed,\,ideal} \geq \left(n_{downshift} + n_{shift,\,bias}\right)$$

where:

$n_{upshift}$	is the up shift engine speed limit
$n_{downshift}$	is the down shift engine speed limit
$\overline{n}_{allowed,\,ideal}$	is a vector of the ideal engine speeds of the allowed gears
$n_{shift,\,bias}$	is the engine speed shift bias

The engine speed shift bias is a function of the tractive resistance acceleration and is defined in a look-up table. The value is used to avoid oscillations in the calculated allowed gears. The transmission output speed is being dropped as the driver disengages the clutch pedal, causing a drop in the calculated ideal engine speed as shown in the equations above.

Moreover, in the mentioned look-up table, the engine speed drop after the change to a lower gear is also considered, i.e., the look-up table delivers nonzero values for zero tractive resistance acceleration.

Afterwards, the recommended gear for the current driving situation is calculated from the allowed gears. That is, it is checked whether the current driver behavior indicates accelerating or braking demand. In the case of acceleration demand, the maximum allowed gear is selected. In the case of braking demand, the minimum allowed gear is selected. Thus, this calculation provides the optimal use of the available gears in many situations.

The up shift request is triggered if the ideal engine speed of the current gear becomes greater than or equals the up shift limit, as illustrated in the following equation:

$$request_{upshift} = \begin{cases} 1, & n_{current,\,ideal} \geq n_{upshift} \\ 0, & otherwise \end{cases}$$

The down shift request is triggered if the ideal engine speed of the current gear becomes smaller than or equals the down shift limit, as illustrated in the following equation:

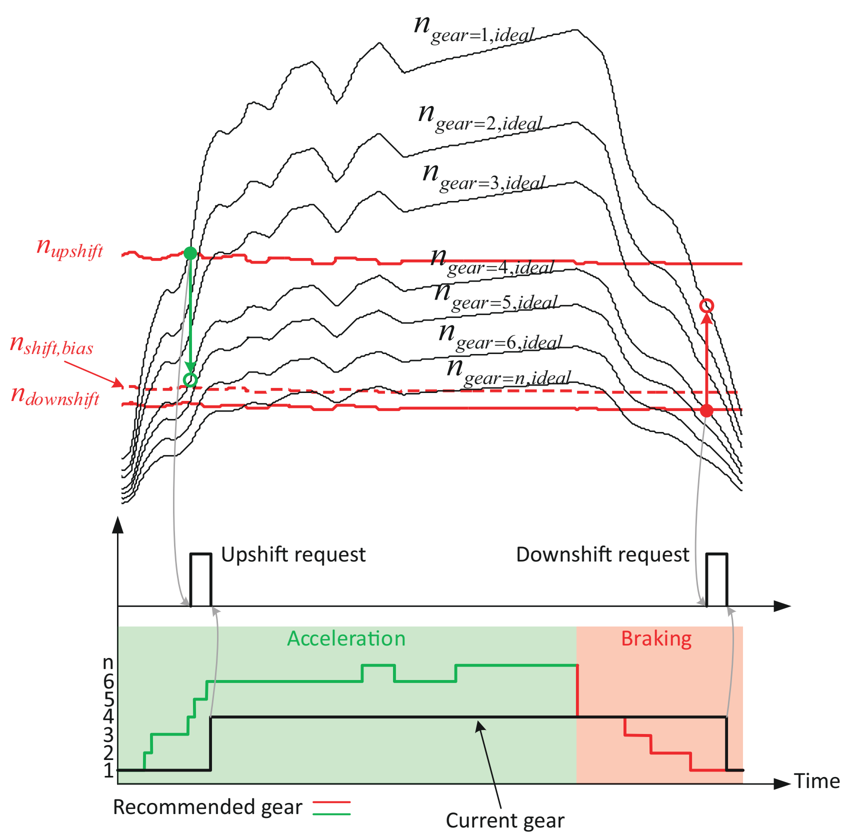
$$request_{downshift} = \begin{cases} 1, & n_{current,\,ideal} \leq n_{downshift} \\ 0, & otherwise \end{cases}$$

The up shift or down shift request triggers a gear change request which is sent to demand clutch disengagement. However, depending on the driving situation, these requests might be disabled. This can be the case, if the driver is braking hard (`Hard_Braking` condition is true). In this case, the gear is not changed and a shift request is sent once a low engine speed has been reached (`Low_Engine_Speed` condition is true), as if there was a real driver in the vehicle.

The gear change request then causes the clutch to be disengaged. Once the clutch is completely disengaged, a gearshift occurs.

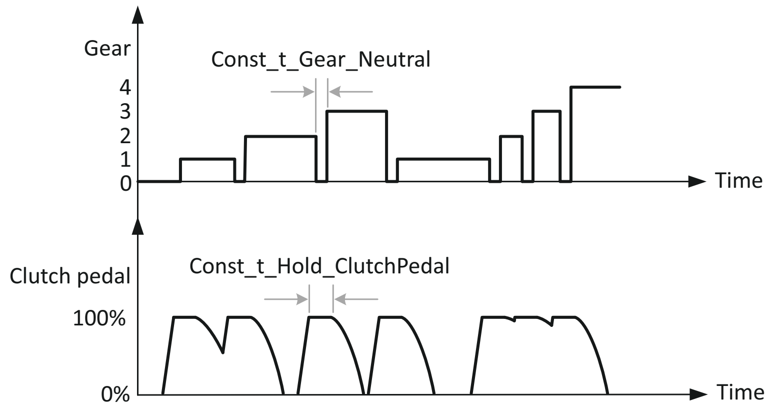
In the gear down shift process, it is also allowed to skip gears. This can happen, for example, in braking maneuvers. However, during the gear up shift, you can activate or deactivate this feature by using the Sw_Upshift_Gear_Skipping parameter.

Refer to the following illustration for a visualization of the gear calculation:



During the gearshift, you can activate the feature of passing the gear through neutral by using the Const_t_Gear_Neutral parameter. This parameter defines the time for which the gear passes through neutral during the gearshift process, thus simulating a realistic gearshifting behavior. If the parameter is zero, this feature is inactive.

Because the gear passes through neutral only when the clutch is completely open, the Const_t_Gear_Neutral parameter should always be less than or equal the time the clutch pedal remains completely depressed, i.e., less then or equal to the Const_t_Hold_ClutchPedal parameter. If this condition is not fulfilled, the minimum time of both parameters is used. The following illustration shows the feature of passing the gear through neutral during the gearshift process for both parameters.

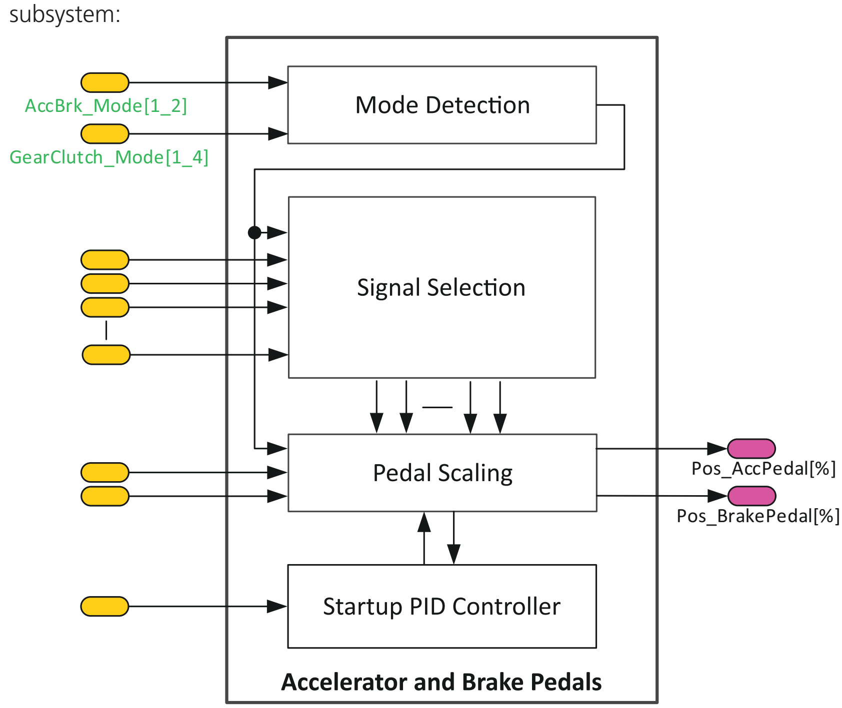


You can also force the driver to select a certain gear value at any time. This is done via the GearClutch_Mode[1Stim|2Driver|3OpenClutch|4RefGear] and Gear_Maneuver[] inports.

- If GearClutch_Mode is set to 1, the Gear_Maneuver value is used as the current gear.
- If GearClutch_Mode is set to 2, the calculated gear is used.

Accelerator_And_Brake_Pedals subsystem

The following illustration shows the Accelerator_And_Brake_Pedals subsystem:



The Accelerator_And_Brake_Pedals subsystem implements the startup functionality and the contribution of the gearshift to the accelerator and brake pedals. A PID controller is used to modify the accelerator pedal position to reach a user-defined engine speed (Const_n_Engine_StartUp_Set parameter) during vehicle startup.

The startup controller is activated during startup only if at least one of the following conditions is fulfilled:

- There is high tractive resistance (`Big_Tractive_Resistance_Acceleration` condition is true)
- The maneuver is defined with initial velocity (`Initial_Velocity` condition is true)
- High acceleration is needed to follow the reference vehicle velocity (`Big_Acceleration` condition is true)

The brake pedal position is disabled if the startup controller is active.

Because this block ensures a correct startup, you might need to change the defined engine speed during startup if, for example, the vehicle is to start on a steep hill.

The accelerator pedal position is scaled during clutch actuation. For the scaling, a user-defined look-up table is used as a function of the clutch pedal position (Map_Pos_AccPedal parameter).

If the accelerator and brake pedals are stimulated via external signals, they are routed out without intervention.

Related topics

References

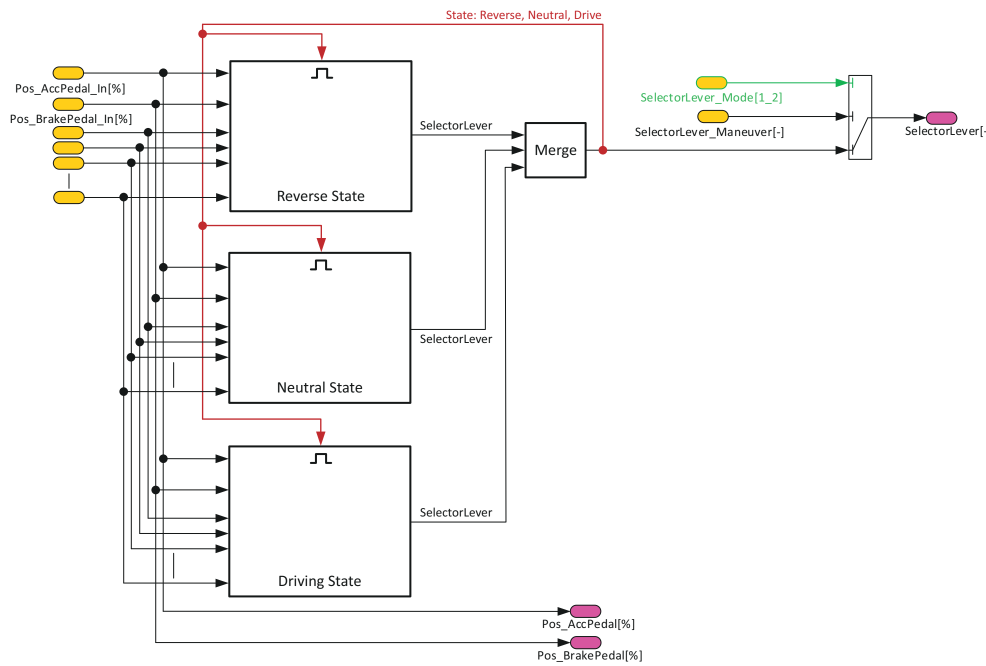
Gear Shifter....................74
Gear Shifter - Automatic Transmission Control....................87

Gear Shifter - Automatic Transmission Control

Description

In the Control_AutomaticTransmission subsystem, the selector lever is simulated for automatic transmission. The following illustration shows the structure of the block.

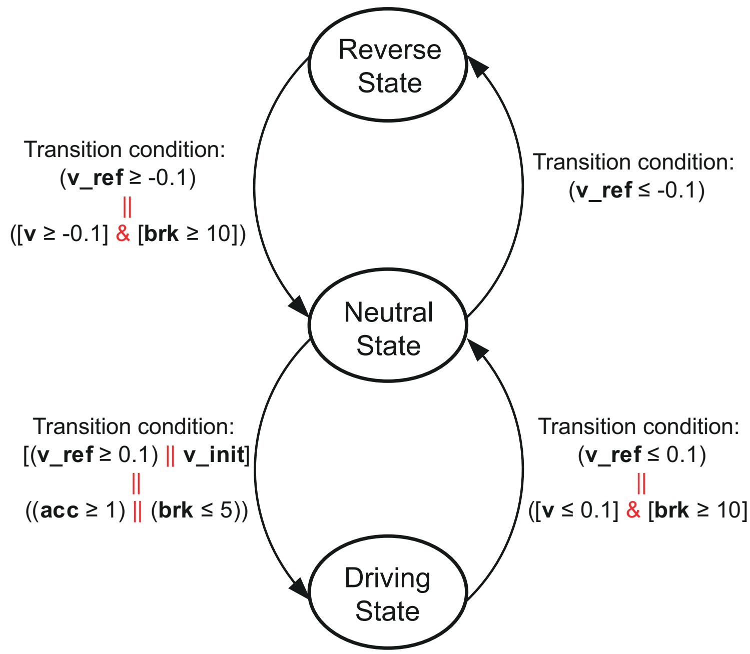
The Control_AutomaticTransmission subsystem is part of the Gear_Shifter block. Refer to Gear Shifter on page 74.



A state machine is implemented to continuously check the driving situation and set selector lever to the right position. Only one state can be active at a time. The transition from one state to another is conditionally driven and only occurs in a rational manner. The selector lever can also be stimulated via external signals, i.e., gear or selector lever. The stimulated gear can force the selector lever to change position. If the selector lever is externally stimulated, the calculated value is overwritten.

The following illustration displays the simulated states as well as the transitions between them:

Where,	
||	: logical OR
&	: logical AND
~	: logical NOT
v	: vehicle speed [m|s]
v_ref	: reference vehicle speed [m|s]
brk	: brake pedal position [%]
acc	: accelerator pedal position [%]
v_init	: initial velocity condition [0|1]



While the selector lever is set in this block, the shift itself is performed by the SOFT_ECU_TRANSMISSION block.

Related topics

References

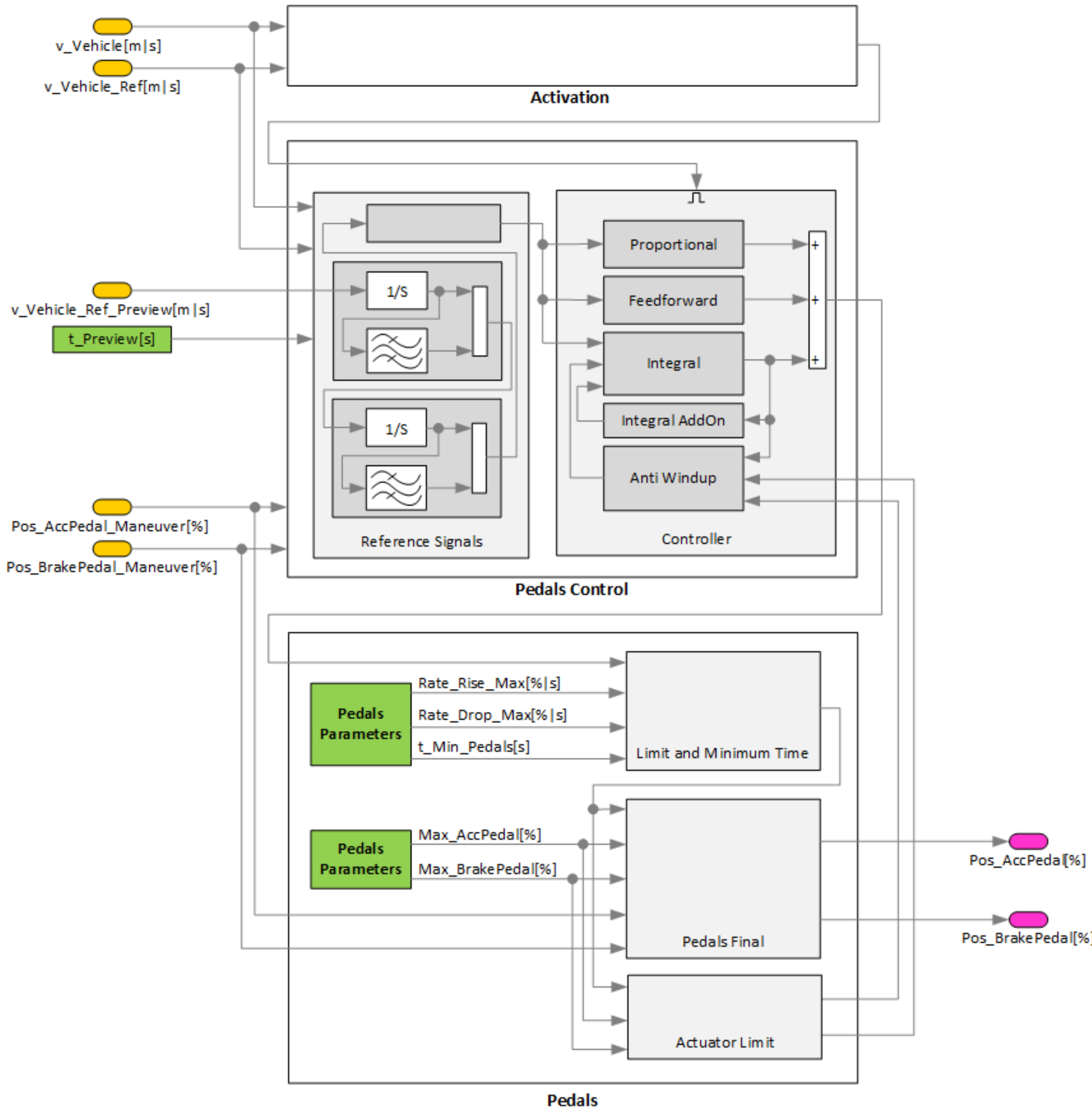
Longitudinal Control

Description

The LONGITUDINAL_CONTROL block controls the accelerator pedal and the brake pedals to follow a specified reference velocity.

The block is mainly modeled as a PI plus feed-forward controller. User parameters, preview information of the reference velocity, and the conditions of the speed course significantly influence the controller.

The following illustration shows the schematic of the block.



The model can simulate realistic pedal behavior. It lets you define parameters, such as the minimum time to switch between different pedals, the maximum and the minimum allowed pedal actuation rate, etc.

Inports

The following table shows the inports:

Name	Unit	Description
Enable_v_Vehicle_Init	[0|1]	Drivetrain initialization flag for scenarios with non-zero vehicle initial velocity
Mode_AcceleratorBrake	[1|2]	Mode signal for accelerator and brake pedal ▪ 1: Stimulus ▪ 2: Driver
Pos_AccPedal_Maneuver	[%]	Accelerator pedal position stimulus from the maneuver scheduler
Pos_BrakePedal_Maneuver	[%]	Brake pedal position stimulus from the maneuver scheduler
Reset	[0|1]	Reset of states
State_Engine	[0|1|2|3|4]	Engine state ▪ 0: Engine off ▪ 1: Ignition on ▪ 2: Ignition on and starter activated ▪ 3: Engine is running ▪ 4: Ignition is switched off, shutdown active
v_Vehicle	[m/s]	Vehicle velocity
v_Vehicle_Ref	[m/s]	Reference vehicle velocity
v_Vehicle_Ref_Preview	[m/s]	Preview reference vehicle velocity

Outports

The following table shows the outports:

Name	Unit	Description
ASMSignalBus	[]	Signal bus that contains signals of ASM components. Refer to ASMSignalBus (ASM User Guide 🕮).
Pos_AccPedal	[%]	Accelerator pedal position
Pos_BrakePedal	[%]	Brake pedal position
t_Preview	[s]	Preview time on reference vehicle velocity

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_Max_AccPedal	[%]	Maximum value of accelerator pedal
Const_Max_BrakePedal	[%]	Maximum value of brake pedal
Const_P_FeedForward_aCtrl	[]	Feed-forward P gain of reference acceleration
Const_Pos_BrakePedal_Standstill	[%]	Brake pedal actuation in standstill
Const_Rate_Drop_Max_AccPedal	[%/s]	Minimum drop rate of accelerator pedal
Const_Rate_Drop_Max_BrakePedal	[%/s]	Maximum drop rate of brake pedal
Const_Rate_Rise_Max_AccPedal	[%/s]	Maximum rise rate of accelerator pedal

Name	Unit	Description
Const_Rate_Rise_Max_BrakePedal	[%/s]	Minimum rise rate of brake pedal
Const_t_Min_Pedals	[s]	Minimum time needed to switch between different pedals
Const_t_Preview	[s]	Reference speed preview time
Map_I_vCtrl	[]	I gain of velocity controller = f(v_Vehicle)
Map_P_vCtrl	[]	P gain of velocity controller = f(v_Vehicle)
StepSize	[s]	Simulation step size

Related topics

References

Longitudinal Control (ModelDesk Parameterizing 📖)
Longitudinal Control... 89

Maneuver

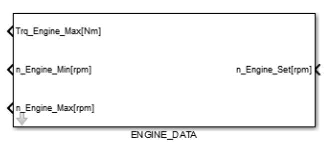
Where to go from here

Information in this section

Engine Data

Description

The ENGINE_DATA block provides the engine speed and torque characteristics. It is used in combination with the TEST_CYCLE block to simulate engine-dynamometer test cycles.



Inports

The following table shows the inports:

Name	Unit	Description
n_Engine_Set	[rpm]	Engine speed setpoints

Outports

The following table shows the outports:

Name	Unit	Description
n_Engine_Max	[rpm]	Maximum engine speed
n_Engine_Min	[rpm]	Minimum engine speed
Trq_Engine_Max	[Nm]	Maximum engine torque

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_n_Engine_Max	[rpm]	Maximum engine speed
Const_n_Engine_Min	[rpm]	Minimum engine speed
Map_Trq_Engine_Max	[Nm]	Maximum engine torque f(n_Engine_Set)
StepSize	[s]	Simulation step size

Related topics

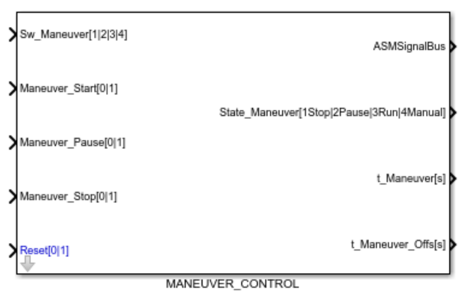
References

Engine Data (ModelDesk Parameterizing 📖)
History of the ENGINE_DATA Block..283

Maneuver Control

Description

The MANEUVER_CONTROL block controls the maneuver time and provides the maneuver status. It is used with stimulus and driver maneuvers.

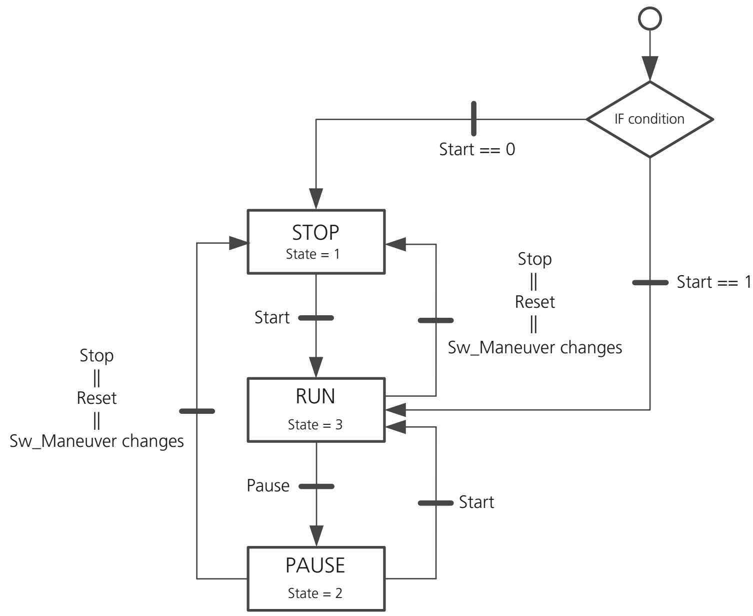


You can start, pause and stop the maneuver via inputs to the block. Inside the block, there is a state machine that changes the maneuver state in a certain logical sequence.

The block is active only during stimulus and driver maneuver, i.e., `Sw_Maneuver` = 2 or 3. In other cases, the maneuver state is set to Manual and no time is calculated.

At the beginning of the simulation, the initial maneuver state is determined according to the Maneuver_Start and Maneuver_Stop inports. The maneuver is initialized in RUN state, but only if `Maneuver_Start` = `1` and `Maneuver_Stop` = `0`. In all other cases, the maneuver is initialized in STOP state.

The following illustration shows the state machine.



The transitions between the different states are rising edge-triggered. This means that a transition occurs only if the corresponding signal goes from low to high, e.g., from `0` to `1`.

Inports

The following table shows the inports:

Name	Unit	Description
Maneuver_Pause	[0|1]	Switch to pause maneuver
Maneuver_Start	[0|1]	Switch to start maneuver
Maneuver_Stop	[0|1]	Switch to stop maneuver
Reset	[0|1]	Reset of states
Sw_Maneuver	[1|2|3|4]	Switch to select the maneuver type: ▪ 1: Offline manual (Simulink) ▪ 2: Online manual (dSPACE hardware) ▪ 3: Stimulus maneuver (time-dependent stimuli) ▪ 4: Driver maneuver (test cycles)

Outports

The following table shows the outports:

Name	Unit	Description
ASMSignalBus	[]	Signal bus that contains signals of ASM components. Refer to ASMSignalBus (ASM User Guide 📖).
State_Maneuver	[1|2|3|4]	Maneuver state: ▪ 1: Maneuver stopped ▪ 2: Maneuver paused

Name	Unit	Description
		▪ 3: Maneuver running ▪ 4: Manual state
t_Maneuver	[s]	Maneuver time
t_Maneuver_Offs	[s]	Maneuver time with offset

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_Key_Time_Offset	[s]	Offset time before maneuver starts
Const_Start_Time	[s]	Initial time when maneuver starts
StepSize	[s]	Simulation step size

Related topics

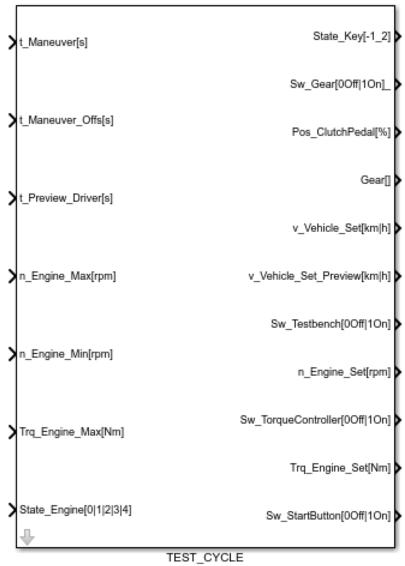
References

History of the MANEUVER_CONTROL Block... 294
Maneuver Control (ModelDesk Parameterizing 📖)

Test Cycle

Description

The TEST_CYCLE block provides the necessary data to simulate engine as well as chassis-dynamometer test cycles. It can be parameterized by the asm_eng_drivingcycles.m M file in your installation, asm_eng_drivingcycles (ASM User Guide 📖). Several standard emission test procedures are included and can be used in combination with ASM demos.



For an engine-dynamometer test cycle, the block provides the engine speed and torque setpoints. This data is used in combination with a test bench to control the engine.

For a chassis-dynamometer test cycle, the block provides the vehicle speed setpoints. These setpoints are used as a reference for the longitudinal driver model.

The following standard emission test procedures are included in the installation:

Name	**Description**
AC	Aachen city cycle
ESC	European Stationary Cycle
ETC	New transient cycle for truck and bus engines
EUDC	Extra-urban driving cycle for low-powered vehicles without additional gear information
EUDC with 5 gears	Extra-urban driving cycle for low-powered vehicles including additional gear information for five gears
EUDC with 6 gears	Extra-urban driving cycle for low-powered vehicles including additional gear information for six gears
FFE_City	City cycle
FTP75	Federal test procedure
FTP75_short	Federal test procedure without pause
FTP75_transient	Engine dynamometer schedule for heavy-duty diesel engines
HIGHWAY	Highway fuel economy test driving cycle
Jap_10-15	Japanese 10-15 exhaust emission and fuel economy driving schedule
JP_JC05	The JE05 cycle (also known as the ED12) is a transient test based on Tokyo driving conditions.
JP_JC05 with 5 gears	The JE05 cycle (also known as the ED12) is a transient test based on Tokyo driving conditions. This data also includes gear information for a five-gear transmission.
JP_JC08	Japanese chassis dynamometer test cycle for light vehicles (< 3500 kg GVW)

Name	Description
US06	Supplemental FTP driving schedule
SC03	Supplemental FTP driving schedule
WHTC	Engine dynamometer schedule for truck and bus engines
WLTC_Class1	Worldwide Harmonized Light-duty Test Cycle of class 1
WLTC_Class2	Worldwide Harmonized Light-duty Test Cycle of class 2
WLTC_Class3	Worldwide Harmonized Light-duty Test Cycle of class 3

Inports

The following table shows the inports:

Name	Unit	Description
n_Engine_Min	[rpm]	Minimum engine speed
n_Engine_Max	[rpm]	Maximum engine speed
Trq_Engine_Max	[Nm]	Maximum engine torque
t_Preview_Driver	[s]	Driver preview time of the reference vehicle speed
t_Maneuver	[s]	Maneuver time
t_Maneuver_Offs	[s]	Maneuver time with offset

Outports

The following table shows the outports:

Name	Unit	Description
Gear	[]	Gear value
n_Engine_Set	[rpm]	Engine speed setpoints
Pos_ClutchPedal	[%]	Clutch pedal setpoints
State_Key	[-1_2]	Key state: ▪ -1: Lock ▪ 0: Acc ▪ 1: Ignition ▪ 2: Starter
Sw_Gear	[0|1]	Gear value activation switch: ▪ 0: Off ▪ 1: On
Sw_StartButton	[0|1]	Engine start button actuation switch: ▪ 0: Button released ▪ 1: Button pressed
Sw_Testbench	[0|1]	Test bench activation switch: ▪ 0: Off ▪ 1: On
Sw_TorqueController	[0|1]	Torque controller activation switch: ▪ 0: Off ▪ 1: On

Name	Unit	Description
Trq_Engine_Set	[Nm]	Engine torque setpoints
v_Vehicle_Preview_Set	[km/h]	Preview vehicle velocity setpoints
v_Vehicle_Set	[km/h]	Vehicle velocity setpoints

Parameters

The following table shows the parameters:

Name	Unit	Description
Map_Gear_Set	[]	Gear value
Map_KeyState	[-1_2]	Key state: ▪ -1: Lock ▪ 0: Acc ▪ 1: Ignition ▪ 2: Starter
Map_Pos_ClutchPedal	[%]	Clutch pedal setpoints
Map_Sw_Engine	[0|1]	Engine activation switch: ▪ 0: Turn the engine off ▪ 1: Turn the engine on
Map_Sw_Testbench	[0|1]	Test bench activation switch: ▪ 0: Off ▪ 1: On
Map_Sw_TorqueController	[0|1]	Torque controller activation switch: ▪ 0: Off ▪ 1: On
Map_Trq_Engine_Set	[]	Engine torque setpoints
Map_n_Engine_Testbench	[]	Engine speed setpoints
Map_v_Vehicle_Ref	[km/h]	Vehicle velocity setpoints
Sw_Gear_Set	[0|1]	Gear value activation switch: ▪ 0: Off ▪ 1: On
Sw_Unit_Trq_Engine	[1|2]	Unit of engine torque setpoints ▪ %: Percentage of the maximum value ▪ Nm: Absolute in Nm
Sw_Unit_n_Engine	[1|2]	Unit of engine speed setpoints ▪ %: Percentage of the maximum value ▪ Nm: Absolute in rpm

Related topics

References

History of the TEST_CYCLE Block..300
Test Cycle (ModelDesk Parameterizing 📖)

Measurement

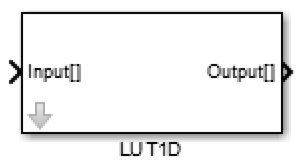
Where to go from here

Information in this section

Look-Up Table 1-D

Description

The LUT1D block evaluates the mask parameter with a 1-D look-up table by `output=f(input)`.



Inports

The following table shows the inports:

Name	Unit	Description
Input	[]	Input for evaluating the look-up table

Outports

The following table shows the outports:

Name	Unit	Description
Output	[]	Output = f(Input)

Parameters

The following table shows the parameters:

Name	Unit	Description
Map_LUT1D	[]	1-D Look-up table values

Related topics

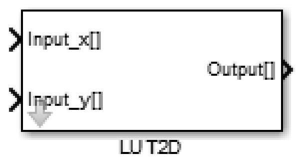
References

History of the LUT1D Block....293
LUT1D (ModelDesk Parameterizing 📖)

Look-Up Table 2-D

Description

The LUT2D block evaluates the mask parameter with a 2-D look-up table by `output=f(Input_x, Input_y)`.



Inports

The following table shows the inports:

Name	Unit	Description
Input_x	[]	Input for x-axis
Input_y	[]	Input for y-axis

Outports

The following table shows the outports:

Name	Unit	Description
Output	[]	Output signal

Parameters

The following table shows the parameters:

Name	Unit	Description
Map_LUT2D	[]	2-D look-up table values

Related topics

References

History of the LUT2D Block....293
LUT2D (ModelDesk Parameterizing 📖)

Others

Where to go from here

Information in this section

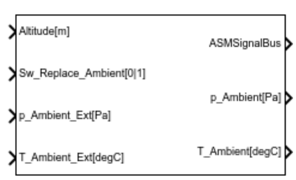
Ambient

Description

The AMBIENT block calculates ambient conditions such as the temperature and pressure.

There are different modes to determine the ambient conditions:

- Altitude: The ambient conditions are determined depending on the vehicle altitude.
- Constant: The temperature and pressure of the ambient are constant.
- External: The source for calculation is outside the block.



Inports

The following table shows the inports:

Name	Unit	Description
Altitude	[m]	Altitude of the vehicle
p_Ambient_Ext	[Pa]	External ambient pressure

Name	Unit	Description
Sw_Replace_Ambient	[0|1]	Switch to enable an external source for ambient conditions: ▪ 0: Disabled ▪ 1: Enabled
T_Ambient_Ext	[degC]	External ambient temperature

Outports

The following table shows the inports:

Name	Unit	Description
ASMSignalBus	[]	Signal bus that contains signals of ASM components. Refer to ASMSignalBus (ASM User Guide 📖).
p_Ambient	[Pa]	Ambient pressure
T_Ambient	[°C]	Ambient temperature

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_p_Ambient	[Pa]	Ambient pressure (constant)
Const_T_Ambient	[°C]	Ambient temperature (constant)
Map_p_Ambient	[Pa]	Ambient pressure, [Pa] = f(altitude)
Map_T_Ambient	[°C]	Ambient temperature, [°C] = f(altitude)
Sw_Ambient	[1|2|3]	Switch for source of ambient conditions: ▪ 1: Altitude ▪ 2: Constant ▪ 3: External

Related topics

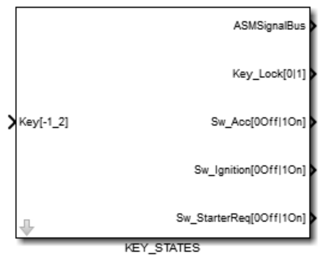
References

History of the AMBIENT Block..277

Key States

Description

The KEY_STATES block calculates the ignition and starter request according to the key position.



Inports

The following table shows the inports:

Name	Unit	Description
Key	[-1_2]	Key position: ▪ -1: Off ▪ 0: Park ▪ 1: Ignition on ▪ 2: Starter request

Outports

The following table shows the outports:

Name	Unit	Description
Key_Lock	[0|1]	Key locked signal: ▪ 0: Key is not locked ▪ 1: Key is locked
Sw_Acc	[0|1]	State of accessories: ▪ 0: Accessories are off ▪ 1: Accessories are on
Sw_Ignition	[0|1]	Ignition request ▪ 0: Ignition is off ▪ 1: Ignition is on
Sw_StarterReq	[0|1]	Starter request ▪ 0: Starter is off ▪ 1: Starter is on

Parameter

The block contains no parameters.

Related topics

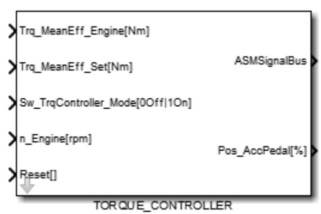
References

History of the KEY_STATES Block 289

Torque Controller

Description

The torque controller model allows you to set a fixed engine torque controlled. This is comparable to an engine test bench and can be used to examine the engine at a fixed engine torque.



The torque controller model is implemented as a PI controller.

A feed forward controller is implemented in parallel to the PI controller for better control of the engine torque.

Note

When activating the torque controller, make sure the driver is completely inactive. Otherwise driver intervention may lead to inconsistent results.

Inports

The following table shows the inports:

Name	Unit	Description
n_Engine	[rpm]	Engine speed
Reset	[]	Reset all integrators to their initial conditions
Sw_TrqController_Mode	[0|1]	Switch for enable or disable torque controller model ▪ 0: Off ▪ 1: On
Trq_MeanEff_Engine	[Nm]	Mean effective engine torque
Trq_MeanEff_Set	[Nm]	Mean effective engine torque setpoint

Outports

The following table shows the outports:

Name	Unit	Description
Pos_AccPedal	[%]	Accelerator pedal position

Parameters

The following table shows the block parameters:

Name	Unit	Description
Const_I_Gain	[]	Torque controller I-gain
Const_P_Gain	[]	Torque controller P-gain
Map_Trq_Engine_Inv	[]	Inverse engine map, Pos_AccPed[%] = f(n_Engine, Trq_Engine)

Related topics

References

History of the TORQUE_CONTROLLER Block.. 300
Torque Controller (ModelDesk Parameterizing 🕮)
Torque Controller V3 (ModelDesk Parameterizing 🕮)

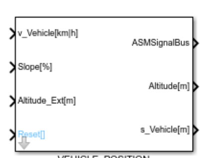
Vehicle Position

Description

The VEHICLE_POSITION block calculates the altitude of the vehicle and the driven distance. You can switch the source of the altitude data.

The following modes for the source of the altitude data are available:

- Calculation: The altitude is based on the vehicle speed and the slope of the road.
- Constant: The altitude is always constant.
- External: The source of the altitude is outside of the block.



The altitude is calculated as follows:

$$Altitude[m] = \int \sin(\alpha_{Slope}) \cdot V_{Vehicle} \cdot dt$$

Inports

The following table shows the inports:

Name	Unit	Description
Altitude_Ext	[m]	External altitude of the vehicle
Reset	[]	Reset integrators to their initial conditions
Slope	[%]	Slope of the road
v_Vehicle	[km/h]	Vehicle velocity

Outports

The following table shows the outports:

Name	Unit	Description
Altitude	[m]	Altitude of the vehicle
s_Vehicle	[m]	Driven distance of the vehicle

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_Altitude_Init	[m]	Constant initial altitude
Const_s_Vehicle_Init	[m]	Initial position of the vehicle
StepSize	[s]	Simulation step size
Sw_Altitude	[1|2|3]	Switch for source of altitude: ▪ 1: Calculation ▪ 2: Constant ▪ 3: External

Related topics

References

Vehicle Position (ModelDesk Parameterizing 📖)

Soft ECU

Where to go from here

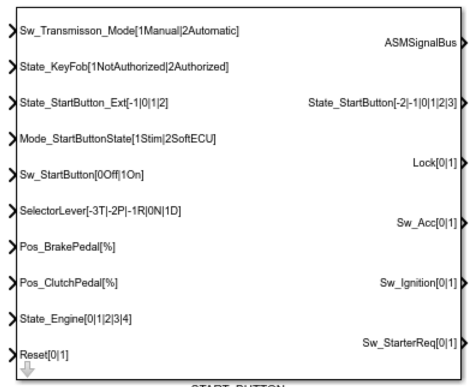
Information in this section

Body

Engine Start Button

Description

The START_BUTTON block simulates the engine start button ECU that starts and shuts down the engine. It uses a state machine to simulate the different states. An external switch is used to simplify the key authorization process.



START_BUTTON

You can use the block with vehicles equipped with manual or automatic transmissions. According to the transmission type, the engine starts when the start button is pressed and held while the start operator (driver) conditions are fulfilled. These conditions are shown in the following table:

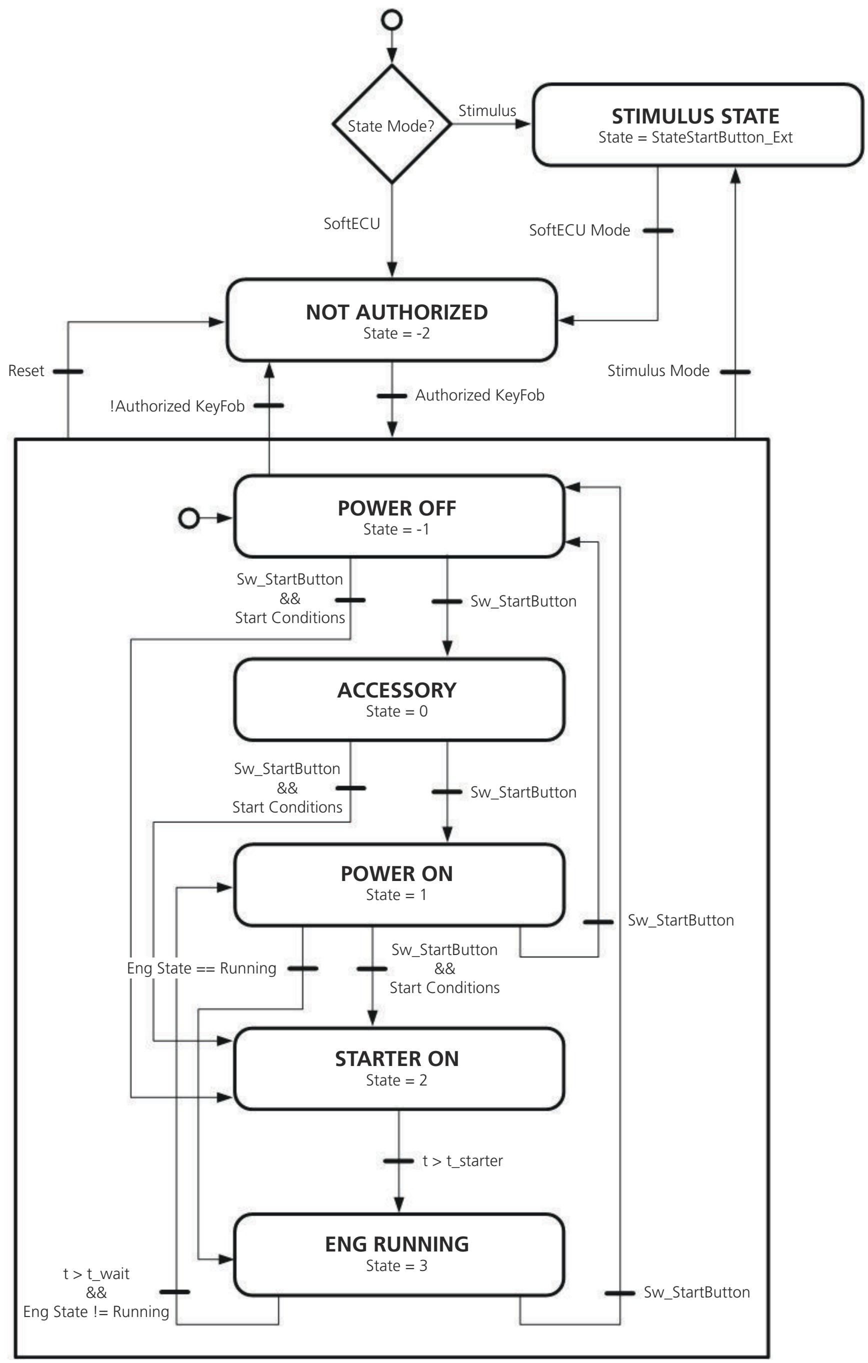
Transmission Type	Conditions
Manual	▪ Authorized key fob ▪ Clutch pedal pressed
Automatic	▪ Authorized key fob ▪ Selector lever in N or P Position ▪ Brake pedal pressed

In addition to the conditions stated above, the system responds only if you press the button and hold it for a time longer than a specified value (`Const_t_Min_Active` parameter). This means short button actuations are ignored.

If the engine is running and you press the button and hold it for a while, the engine switches off.

If the operator conditions above are not fulfilled and you press the button and hold it for a while, this leads to other states in which the engine is not started but other control signals are enabled, such as the accessory signal. You can also stimulate the different states and completely bypass the state machine.

The following state machine shows the working principle of the ECU:



In each state, the ECU calculates different control signals. The following table describes the states and their meanings:

State	Description
Not Authorized	Unauthorized key fob. The engine cannot start.

State	Description
Stimulus	Stimulus state. In this state, the ECU calculates the control signals according to the input: `State_StartButton_Ext[-1|0|1|2]`
Power Off	The default state with an authorized key fob.
Accessory	Accessory is on, for example, you can switch the radio on.
Power On	Power is on, for example, you can control car windows.
Starter On	The ECU sends a starter request to the engine ECU, which can then activate the engine starter.
Engine Running	The ECU detects the engine running state.

Inports

The following table shows the inports:

Name	Unit	Description
Mode_StartButtonState	[1|2]	Start button state mode: ▪ 1: Stimulus ▪ 2: Soft ECU
Pos_BrakePedal	[%]	Brake pedal position
Pos_ClutchPedal	[%]	Clutch pedal position
Reset	[0|1]	Reset of states
SelectorLever	[-3|-2|-1|0|1]	Selector lever position: ▪ -3: TipShift ▪ -2: Park ▪ -1: Reverse ▪ 0: Neutral ▪ 1: Drive
State_Engine	[0|1|2|3|4]	Engine state: ▪ 0: Engine off ▪ 1: Ignition on ▪ 2: Ignition on and starter activated ▪ 3: Engine is running ▪ 4: Ignition is switched off, shutdown active
State_KeyFob	[1|2]	An input that simplifies the key fob authentication process: ▪ 1: Not authorized ▪ 2: Authorized
State_StartButton_Ext	[-1|0|1|2]	Stimulated start button state if the `Mode_StartButtonState` input is set to `Stimulus`: ▪ -1: Power off ▪ 0: Accessory on ▪ 1: Power on ▪ 2: Starter on
Sw_StartButton	[0|1]	Start button actuation input
Sw_Transmission_Mode	[1|2]	Transmission type switch: ▪ 1: Manual

Name	Unit	Description
		▪ 2: Automatic

Outports

The following table shows the outports:

Name	Unit	Description
ASMSignalBus	[]	Signal bus that contains signals of ASM components. Refer to ASMSignalBus (ASM User Guide 📖).
Lock	[0|1]	Button lock signal (in case of unauthorized key fob or power off): ▪ 0: Start button is not locked ▪ 1: Start button is locked
State_StartButton	[-2|-1|0|1|2|2]	Start button state: ▪ -2: Unauthorized key fob ▪ -1: Power off ▪ 0: Accessory on ▪ 1: Power on ▪ 2: Starter on ▪ 3: Engine running
Sw_Acc	[0|1]	State of accessories: ▪ 0: Accessories are off ▪ 1: Accessories are on
Sw_Ignition	[0|1]	Ignition signal (terminal 15): ▪ 0: Off ▪ 1: On
Sw_StarterReq	[0|1]	Starter request signal (usually sent to the engine ECU): ▪ 0: Off ▪ 1: On

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_Pos_BrakePedal_LowLim	[%]	Minimum value for pressed brake pedal
Const_Pos_ClutchPedal_LowLim	[%]	Minimum value for pressed clutch pedal
Const_t_Min_Active	[s]	Minimum pushing time for active button
Const_t_Min_Starter	[s]	Minimum starter request activation time
StepSize	[s]	Simulation step size

Related topics

References

History of the START_BUTTON Block........298
Start Button (ModelDesk Parameterizing 📖)

Engine

Where to go from here

Information in this section

Engine Operation Basic

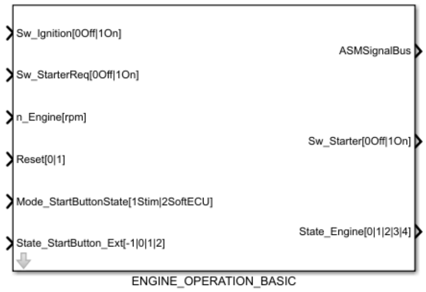
Description

The ENGINE_OPERATION_BASIC block detects the engine operation state from the engine speed and the ignition as well as the starter request switch. It activates the starter and gives information about the engine state.

The following engine states are possible:

- 0: Engine off/Error
- 1: Ignition on
- 2: Starter on
- 3: Engine running
- 4: Engine shutdown

The following illustration shows the Simulink implementation of the block:



Inports

The following table shows the inports:

Name	Unit	Description
Mode_StartButtonState	[1|2]	Mode of start button state: ▪ 1: Stimulus ▪ 2: Soft ECU
n_Engine	[rpm]	Engine speed
Reset	[0|1]	Reset of states
State_StartButton_Ext	[-1|0|1|2]	External start button state in case of stimulus: ▪ -1: Power off ▪ 0: Power on ▪ 1: Accessory ▪ 2: Starter on
Sw_Ignition	[0|1]	Switch for ignition signal (terminal 15): ▪ 0: Off ▪ 1: On
Sw_StarterReq	[0|1]	Switch for starter request signal (usually sent to engine ECU): ▪ 0: Off ▪ 1: On

Outports

The following table shows the outports:

Name	Unit	Description
ASMSignalBus	[]	Signal bus that contains signals of ASM components. Refer to ASMSignalBus (ASM User Guide 📖).
State_Engine	[0|1|2|3|4]	Engine state ▪ 0: Engine off ▪ 1: Ignition on ▪ 2: Ignition on and starter activated ▪ 3: Engine is running ▪ 4: Ignition is switched off, shutdown active
Sw_Starter	[0|1]	Starter activate switch (output of ECU) ▪ 0: Off

Name	Unit	Description
		▪ 1: On

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_n_Engine_LowLim_Shutdown	[rpm]	Lower engine speed limit for shutdown state
Const_n_Engine_Min_EngineOn	[rpm]	Minimum engine speed when engine is on
Const_t_Max_Starter	[s]	Maximum duration for switching the starter on
Const_t_Shutdown	[s]	Engine shutdown duration

ESP Fast Torque Set

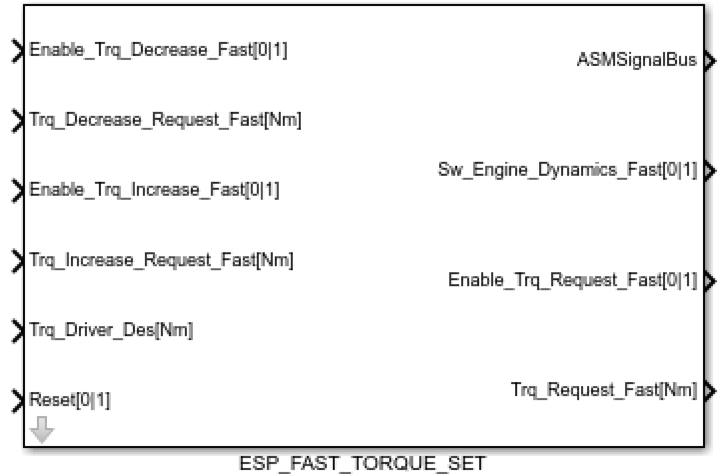
Description

This subsystem is used to realize a fast torque intervention. Because the engine basic model (see Engine on page 69) does not simulate the functionality of a fast torque intervention, for example, via ignition or injection control, a switch flag (**Sw_Engine_Dynamics_Fast**) is used. This flag signal is routed to the engine basic and is used there to increase the engine dynamic.

If the enable flag signals are set, the corresponding requested torque is applied as output torque. The transition between the requested torques is carried out via a first-order delay.

The driver desired torque has also an influence to the torque requests. At a torque increase situation the maximum value of the torque request and the driver desired torque is used. At a torque decrease situation the minimum value of the torque request and the driver desired torque is used.

The following illustration shows the ESP_FAST_TORQUE_SET block.



Inports

The following table shows the inports.

Name	Unit	Description
Enable_Trq_Decrease_Fast	[0|1]	Signal from ESP ECU to enable or disable the fast torque decreasing request
Enable_Trq_Increase_Fast	[0|1]	Signal from ESP ECU to enable or disable the fast torque increasing request
Reset	[]	Reset all integrators in the block to their initial condition
Trq_Decrease_Request_Fast	[Nm]	The torque request from ESP ECU, fast decreasing
Trq_Driver_Des	[Nm]	Driver desired torque
Trq_Increase_Request_Fast	[Nm]	The torque request from ESP ECU, fast increasing

Outports

The following table shows the outports.

Name	Unit	Description
ASMSignalBus	[]	Signal bus that contains signals of ASM components. Refer to ASMSignalBus (ASM User Guide 📖).
Enable_Trq_Intervention_Fast	[0|1]	Signal to enable or disable a fast torque request
Sw_Engine_Dynamics_Fast	[0|1]	Flag, routed to engine basic, to increase the engine dynamic ▪ 0: Standard ▪ 1: Fast
Trq_Request_Fast	[Nm]	The torque request fast

Parameters

The following table shows the parameters.

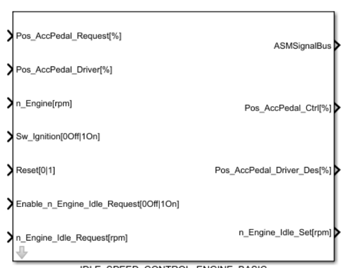
Name	Unit	Description
StepSize	[s]	Simulation step size

Idle Speed Control Engine Basic

Description

The IDLE_SPEED_CONTROL_ENGINE_BASIC block builds the idle speed controller used to keep the engine speed at a certain value while the engine is idling. The controller is implemented as a PI controller. In addition, the model accepts an external idle speed request, i.e., external idle speed request from the transmission control unit (TCU). This functionality can be activated with the Sw_n_Engine_Idle_Request and n_Engine_Idle_Request inports.

The following illustration shows the Simulink representation of the block:



Inports

The following table shows the inports.

Name	Unit	Description
Enable_Ignition	[0|1]	Ignition signal (terminal 15) ▪ 0: Off ▪ 1: On
n_Engine	[rpm]	Engine speed
n_Engine_Idle_Request	[rpm]	Engine idle speed request
Pos_AccPedal_Driver	[%]	Driver accelerator pedal position
Pos_AccPedal_Request	[%]	Accelerator pedal position influenced by torque requests
Reset	[]	Reset of states
Sw_n_Engine_Idle_Request	[0|1]	Switch to activate engine idle speed request ▪ 0: Off ▪ 1: On

Outports

The following table shows the outports.

Name	Unit	Description
ASMSignalBus	[]	Signal bus that contains signals of ASM components. Refer to ASMSignalBus (ASM User Guide).
n_Engine_Idle_Set	[rpm]	Set point for idle speed of combustion engine
Pos_AccPedal_Driver_Des	[%]	Driver desired accelerator pedal position without controller intervention
Pos_AccPedal_Ctrl	[%]	Accelerator pedal position influenced by the controller

Parameters

The following table shows the parameters.

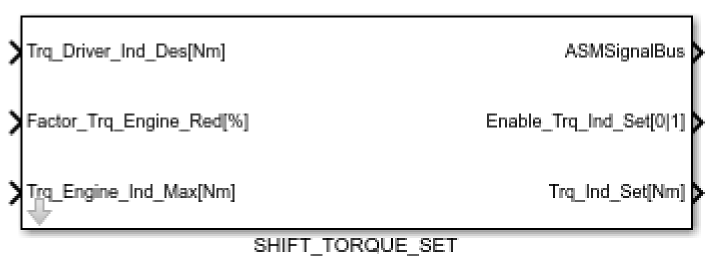
Name	Unit	Description
Const_I_Idle	[1/s]	I gain of the idle speed controller
Const_P_Idle	[]	P gain of the idle speed controller
Const_n_EngineIdle_Set	[rpm]	Engine idle speed setpoint
StepSize	[s]	Simulation step size

Shift Torque Set

Description

The SHIFT_TORQUE_SET block calculates the desired indicated engine torque depending on the driver's wish and the transmission control unit intervention. The block offers a coupling with the Soft ECU Transmission and allows a torque reduction during the gearshift process.

The following illustration shows the Simulink representation of the engine model.



Inports

The following table shows the inports:

Name	Unit	Description
Factor_Trq_Engine_Red[%]	[%]	Engine torque reduction factor
Trq_Driver_Ind_Des	[Nm]	Induced engine torque setpoint of driver
Trq_Engine_Ind_Max	[Nm]	Maximum induced engine torque

Outports

The following table shows the outports:

Name	Unit	Description
Enable_Trq_Ind_Set	[0|1]	Activation flag of engine torque intervention
Trq_Ind_Set	[Nm]	Induced engine torque setpoint

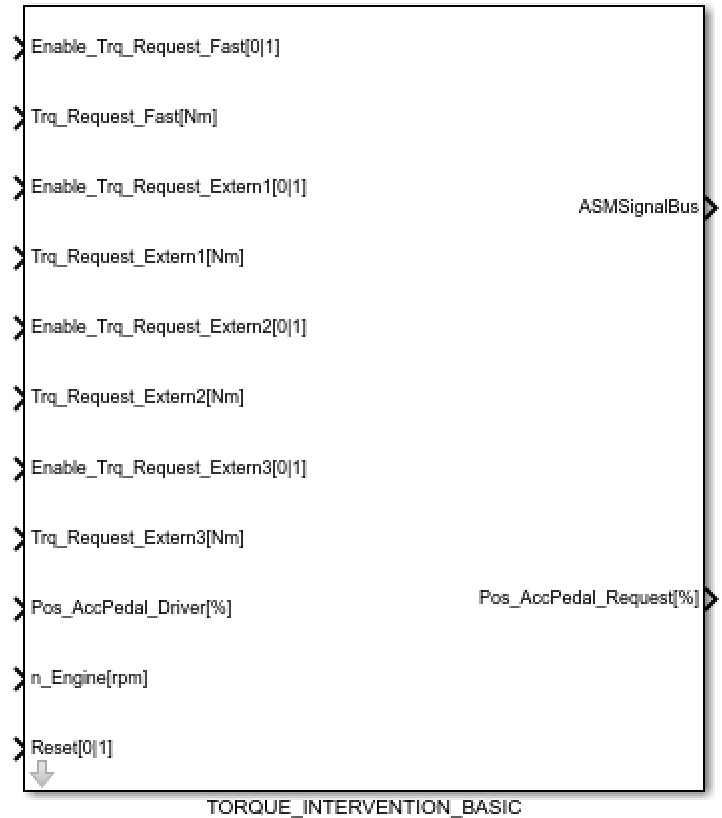
Torque Intervention Basic

Description

The TORQUE_INTERVENTION_BASIC block is used to implement a torque intervention, i.e., an external torque request from the transmission control unit (TCU). For this, an accelerator pedal control is implemented in this model. To get a certain torque from the engine, the accelerator pedal position must be calculated at the current engine speed. This is achieved by using an inversed engine torque map.

Depending on different enable flags and priorities, the corresponding accelerator pedal position is output. In this case, the external torque request has the highest priority and is followed by the driver torque request.

The following illustration shows the Simulink implementation of the block:



Inports

The following table shows the inports:

Name	Unit	Description
Enable_Trq_Request_Extern1	[0|1]	Signal to enable or disable the 1st external torque request
Enable_Trq_Request_Extern2	[0|1]	Signal to enable or disable the 2nd external torque request
Enable_Trq_Request_Extern3	[0|1]	Signal to enable or disable the 3rd external torque request
Enable_Trq_Request_Fast	[0|1]	Signal to enable or disable the fast torque request
n_Engine	[rpm]	Engine speed
Pos_AccPedal_Driver	[%]	Driver accelerator pedal position
Reset	[0|1]	Reset of states
Trq_Request_Extern1	[Nm]	1st external torque request
Trq_Request_Extern2	[Nm]	2nd external torque request
Trq_Request_Extern3	[Nm]	3rd external torque request
Trq_Request_Fast	[Nm]	Fast torque request

Outports

The following table shows the outports:

Name	Unit	Description
ASMSignalBus	[]	Signal bus that contains signals of ASM components. Refer to ASMSignalBus (ASM User Guide 🕮).
Pos_AccPedal_Request	[%]	Requested accelerator pedal position

Parameter

The following table shows the parameters:

Name	Unit	Description
Map_Trq_Engine_Inv	[%]	Inverse engine map Pos_AccPedal = f(n_Engine[rpm], Trq_Engine[Nm])

Related topics

References

Torque Intervention Basic (ModelDesk Parameterizing 🕮)

Hybrid

Soft ECU BSG

Description

The SOFTECU_BSG (belt-driven starter generator) block controls the hybrid engine mode and the electric machine torque.

The hybrid engine modes are switched based on acceleration and brake pedal positions.

The block also includes an additional brake control for recuperation.

Hybrid engine modes

There are different hybrid engine modes. The lower the number of the hybrid engine mode, the higher its priority.

The conditions are as follows:

Input	Mode
Mode 0: Stop ICE	
State_Engine	= 0 (Engine Off) or = 4 (Shutdown)

Input	Mode
Mode 1: Start ICE	
State_Engine	= 2 (Ignition On, Starter On)
Mode 2: Generator	
State_Engine	= 3 (Engine Running)
SOC_Bat	= 0 (Low)
Pos_Brake_Pedal	< Const_Pos_BrakePedal_LowLim
Mode 3: Recuperation	
State_Engine	= 3 (Engine Running)
SOC_Bat	≠ 2 (High)
Pos_BrakePedal	≥ Const_Pos_BrakePedal_LowLim
Pos_ClutchPedal	< Const_Pos_ClutchPedal_LowLim
Gear_Drivetrain	≠ 0
n_Engine	≥ Const_n_Recup
Mode 4: Boost	
State_Engine	= 3 (Engine Running)
SOC_Bat	≠ 0 (Low)
Pos_BrakePedal	< Const_Pos_BrakePedal_LowLim
Pos_AccPedal	≥ Const_Pos_AccPedal_LowLim
Pos_AccPedal Gear_Drivetrain	≥ Const_Pos_AccPedal_LowLim_Boost or ≠ Gear_Drivetrain (previous time step)
Mode 5: Idle	
	No other mode is active

Inports

The following table shows the inports:

Name	Unit	Description
Const_Trq_Max_Brake	[Nm]	Maximum brake torque
Gear_Drivetrain	[]	Manual and automatic gear
n_EM	[rad|s]	Electric machine rotational speed
n_Engine	[rpm]	Engine speed
Omega_In_Diff	[rad|s]	Differential input speed
Pos_AccPedal	[%]	Accelerator pedal position
Pos_BrakePedal	[%]	Brake pedal position
Pos_ClutchPedal	[%]	Clutch pedal position
Reset_States	[0|1]	Reset memory blocks to their initial condition
SOC_Bat_HV	[%]	Battery state of charge

Name	Unit	Description
State_Engine	[0|1|2|3|4]	Engine state: ▪ 0: Engine off ▪ 1: Ignition on ▪ 2: Ignition on and starter activated ▪ 3:Engine is running ▪ 4: Ignition is switched off, shutdown active
Sw_Ignition	[0|1]	Ignition signal (terminal 15): ▪ 0: Off ▪ 1: On
Sw_Starter	[0Off|1On]	Switch to activate starter: ▪ 0: Off ▪ 1: On
Sw_StarterReq	[0|1]	Starter request signal (usually sent to engine ECU): ▪ 0: Off ▪ 1: On
T_Coolant_ICE	[°C]	Engine coolant temperature
Trq_EM	[Nm]	Electric machine torque

Outports

The following table shows the outports:

Name	Unit	Description
Ignition_ICE	[0Off|1On]	Ignition ICE: ▪ 0: Off ▪ 1: On
Mode_BSG	[-1|0|1|2|3|4|5]	Belt-driven starter generator mode: ▪ -1: ▪ 0: ▪ 1: ▪ 2: ▪ 3: ▪ 4: ▪ 5:
Pos_BrakePedal_Desired	[%]	Desired position of brake pedal
StarterReq_ICE	[0Off|1On]	Starter request ICE: ▪ 0: Off ▪ 1: On
Starter_Drivetrain	[0Off|1On]	Switch for drivetrain starter: ▪ 0: Off ▪ 1: On
State_HybridEngine	[0|1|2|3|4]	Hybrid engine state: ▪ 0: Stop ICE ▪ 1: Start ICE

Name	Unit	Description
		▪ 2: Generator ▪ 3: Recuperation ▪ 4: Boost
Trq_Request_EM	[Nm]	Electric machine torque request

Parameters

The follwing table shows the parameters:

Name	Unit	Description
Const_Trq_Max_EM	[Nm]	Maximum electric machine torque
Const_n_Starter_Max	[rpm]	Maximum electric machine speed to start the engine
Const_Hyst_AccPedal_Boost	[%]	Acceleration pedal hysteresis for boosting
Const_Hyst_n_Recup	[rpm]	Engine speed hysteresis for recuperation
Const_n_Recup	[rpm]	Minimum engine speed for recuperation
Const_Pos_AccPedal_LowLim	[%]	Minimum pressed acceleration pedal position
Const_Pos_AccPedal_LowLim_Boost	[%]	Minimum acceleration pedal position for boosting
Const_Pos_BrakePedal_LowLim	[%]	Minimum pressed brake pedal position
Const_Pos_ClutchPedal_LowLim	[%]	Minimum pressed clutch pedal position
Const_SOC_Hyst_Battery	[%]	Hysteresis for battery state of charge
Const_SOC_Max_Battery	[%]	High battery state of charge
Const_SOC_Min_Battery	[%]	Low battery state of charge
Const_T_Min_Coolant_ICE	[°C]	Minimum engine coolant temperature
Map_Trq_EM_Boost	[Nm]	Electric machine torque map for boosting
Map_Trq_EM_Generator	[Nm]	Electric machine torque map for generation
Map_Trq_EM_Recuperation	[Nm]	Electric machine torque map for recuperation
Sw_State_BSG	[0|1]	BSG hybrid activation switch: ▪ 0: Off ▪ 1: On

Transmission

Where to go from here

Information in this section

Clutch Control

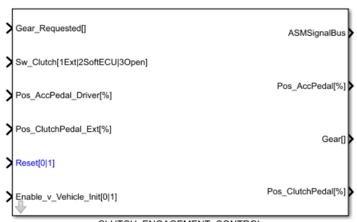
Where to go from here

Information in this section

Clutch Engagement Control

Description

The **CLUTCH_ENGAGEMENT_CONTROL** block controls the clutch actuation according to the requested gear. It can be used for different types of transmission, e.g., with an automated manual transmission (AMT). Such a clutch control is also needed in parallel hybrid topologies where the clutch is located between the electric machine and the transmission.



The block does not provide feedback control. Instead, only user-defined clutch disengagement and engagement is used. Moreover, you can use external stimulus signals to specify the clutch pedal position.

During clutch actuation, the accelerator pedal can be scaled with a predefined factor. The gear request is passed to the output once the clutch is completely open.

Inports

The following table shows the inports:

Name	**Unit**	**Description**
Enable_v_Vehicle_Init	[0|1]	Drivetrain initialization flag for scenarios with non-zero vehicle initial velocity
Gear_Requested	[]	Requested gear
Pos_AccPedal_Driver	[%]	Accelerator pedal position from driver
Pos_ClutchPedal_Ext	[%]	External stimulus clutch pedal position
Reset	[0|1]	Reset of states
Sw_Clutch	[1|2|3]	Clutch pedal position mode: ▪ 1: External ▪ 2: Soft ECU ▪ 3: Open

Outports

The following table shows the outports:

Name	Unit	Description
ASMSignalBus	[]	Signal bus that contains signals of ASM components. Refer to ASMSignalBus (ASM User Guide 📖).
Gear	[]	Requested gear after clutch is completely disengaged
Pos_AccPedal	[%]	Scaled accelerator pedal position as a function of the requested gear time
Pos_ClutchPedal	[%]	Controlled clutch pedal position as a function of the requested gear time

Parameters

The following table shows the parameters:

Name	Unit	Description
Map_Factor_Pos_AccPedal	[%]	Percentage of accelerator pedal intervention as a function of the requested gear time
Map_Pos_ClutchPedal_Disengage	[%]	Clutch pedal disengagement position as a function of the requested gear time
Map_Pos_ClutchPedal_Engage	[%]	Clutch pedal engagement position after clutch disengagement finished
StepSize	[s]	Simulation step size

Related topics

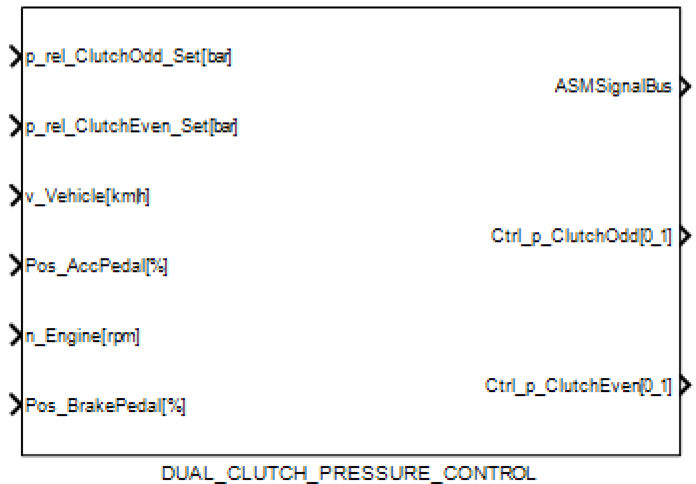
References

Clutch Engagement Control (ModelDesk Parameterizing 📖)
History of the CLUTCH_ENGAGEMENT_CONTROL Block...279

Dual Clutch Pressure Control

Description

The DUAL_CLUTCH_PRESSURE_CONTROL block translates the desired clutch pressures to control values for a hydraulic actuation system.



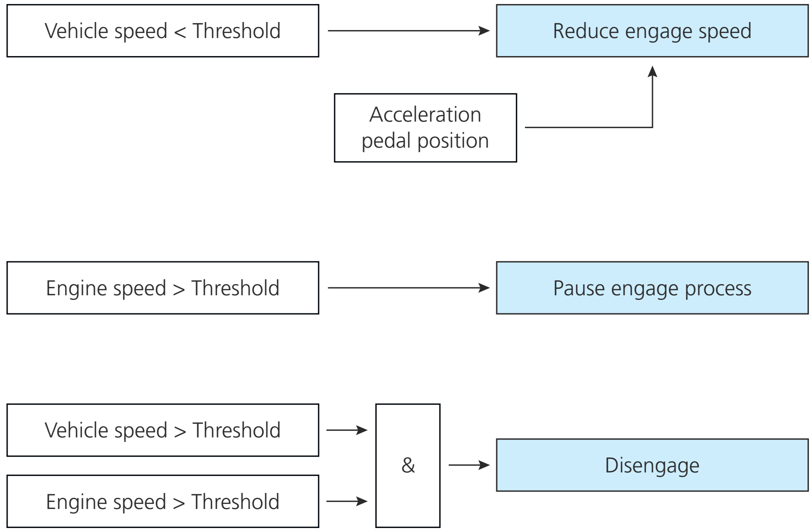
It considers the driver pedal positions as well as engine and vehicle speed to dynamically control the clutch engagement process. It uses a default engagement and disengagement rates to reach the requested pressures.

The default engagement rate is influenced by interventions:

- Below a certain vehicle velocity, the engagement rate is reduced by a factor according to the acceleration pedal position
- If the engine speed drops below a certain threshold, the engagement rate will be set to zero to hold the clutch and pause the progress

Additionally, at low engine speeds below a certain threshold the controller overrides the requested pressures to disengage the clutches, if the brake pedal is pressed. In that case, the disengagement rate will be infinite.

The following illustration summarizes the influences on the engage process:



Inports

The following table shows the inports:

Name	Unit	Description
n_Engine	[rpm]	Engine speed
p_rel_ClutchEven_Set	[bar]	Relative set pressure for even clutch
p_rel_ClutchOdd_Set	[bar]	Relative set pressure for odd clutch
Pos_AccPedal	[%]	Accelerator pedal position
Pos_BrakePedal	[%]	Brake pedal position
v_Vehicle	[km/h]	Vehicle velocity

Outports

The following table shows the outports:

Name	Unit	Description
ASMSignalBus	[]	Signal bus that contains signals of ASM components. Refer to ASMSignalBus (ASM User Guide 🕮).
Ctrl_p_ClutchEven	[0_1]	Control signal for even clutch pressure
Ctrl_p_ClutchOdd	[0_1]	Control signal for odd clutch pressure

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_Pos_BrakePedal_Braking_LowLim	[%]	Lower threshold for high brake pedal to interrupt clutch actuation during braking
Const_Rate_Max_Diseng	[bar/s]	Maximum disengaging rate (negative) of clutch pressure

Name	Unit	Description
Const_Rate_Max_Engage	[bar/s]	Maximum engaging rate of clutch pressure
Const_n_Engine_Braking_UpLim	[rpm]	Upper threshold for low engine speed threshold to interrupt clutch actuation during braking
Const_n_Engine_Engage_UpLim	[rpm]	Upper threshold for low engine speed threshold to intervene the clutch engagement actuation
Const_v_Vehicle_Engage_UpLim	[km/h]	Upper threshold for low vehicle speed threshold to intervene the clutch engagement actuation
Map_Ctrl_p_ClutchEven	[0_1]	Inverse map of desired even clutch pressure = f(p_EvenClutch_Set[bar])
Map_Ctrl_p_ClutchOdd	[0_1]	Inverse map of desired odd clutch pressure = f(p_OddClutch_Set[bar])
Map_Factor_Rate_Engage	[0_1]	Clutch pressure factor map to limit the clutch engagement actuation at low vehicle speeds = f(Pos_AccPedal[%])

Related topics

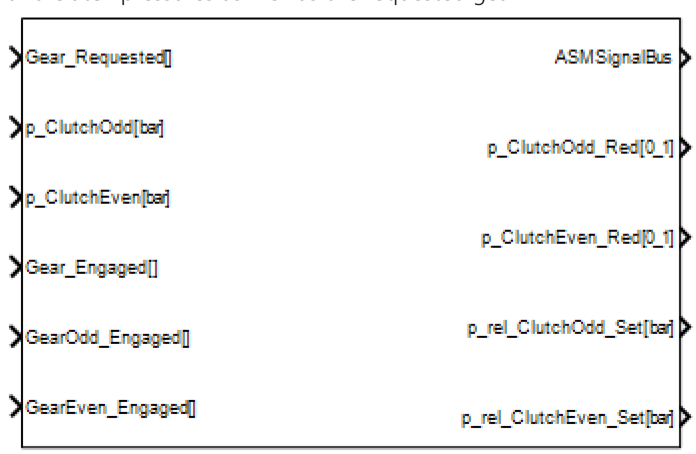
References

Dual Clutch Pressure Control (ModelDesk Parameterizing 📖)

Dual Clutch Pressure Set

Description

The DUAL_CLUTCH_PRESSURE_SET block evaluates the current engaged gears and clutch pressures as well as the requested gear.



DUAL_CLUTCH_PRESSURE_SET

Then, it sets desired clutch pressures for both clutches. Moreover, it delivers the normalized clutch pressure to inform about the engagement progress.

A clutch will be engaged under the following main conditions:
- The corresponding available gear is equal to the requested gear.
- A gear other than zero is requested.
- The other clutch is not engaged.

Additionally, with the Sw_Actuate_Clutch parameter the block can be configured as follows:
- 0 – Instant: Immediately disengage the clutch if the current gear is not equal to the requested gear.
- 1 – Held: Keep the clutch closed until the requested gear is available for the other clutch. In this case, the clutch will still be opened if the requested and current gear differ by 2 or more.

Inports

The following table shows the inports:

Name	Unit	Description
Gear_Engaged	[]	Currently engaged gear of the transmission
Gear_Requested	[]	Requested gear of the transmission
GearEven_Engaged	[]	Currently engaged even gear
GearOdd_Engaged	[]	Currently engaged odd gear
p_ClutchEven	[bar]	Even clutch cylinder pressure
p_ClutchOdd	[bar]	Odd clutch cylinder pressure

Outports

The following table shows the outports:

Name	Unit	Description
ASMSignalBus	[]	Signal bus that contains signals of ASM components. Refer to ASMSignalBus (ASM User Guide 📖).
p_ClutchEven_Red	[0_1]	Normalized even clutch cylinder pressure
p_ClutchOdd_Red	[0_1]	Normalized odd clutch cylinder pressure
p_rel_ClutchEven_Set	[bar]	Relative set pressure for even clutch
p_rel_ClutchOdd_Set	[bar]	Relative set pressure for odd clutch

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_p_Closed_ClutchEven	[bar]	Desired closed pressure of even clutch
Const_p_Closed_ClutchOdd	[bar]	Desired closed pressure of odd clutch
Sw_Actuate_Clutch	[0|1]	Clutch actuation mode depending on available gears ▪ 0: Instant ▪ 1: Held

Related topics

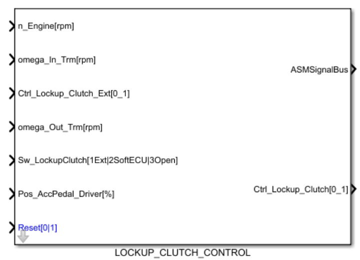
References

Dual Clutch Pressure Set (ModelDesk Parameterizing)

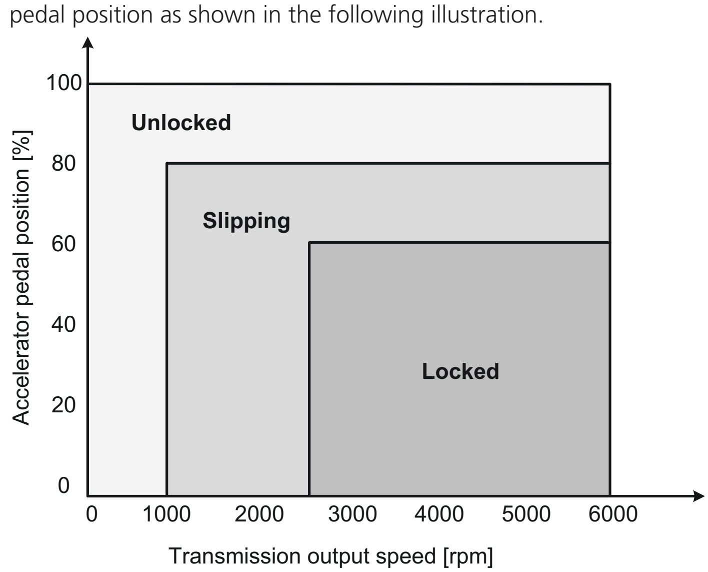
Lockup Clutch Control

Description

The LOCKUP_CLUTCH_CONTROL block controls the lockup clutch in automatic transmissions. The main function of the lockup clutch is to mechanically connect and disconnect the engine from the rest of the transmission units to increase the efficiency and avoid oscillations in the drivetrain.



The control strategy depends on the lockup state (unlock, slip, or lock), which is determined according to the transmission output speed and the accelerator pedal position as shown in the following illustration.



The lockup clutch is unlocked at the lowest transmission output speed and the highest accelerator pedal position to enable vehicle startup and isolate the engine oscillations, respectively.

The lockup clutch is locked at relatively high transmission speeds to increase the efficiency of the drivetrain by avoiding losses in the torque converter.

Between the lock and unlock states, slipping is allowed. Lockup clutch slipping is controlled by using a PI controller with the speed ratio as a feedback signal. The actual speed ratio is calculated as the ratio of the transmission input speed to the engine speed and can be used as an indicator of slipping in the torque converter.

Moreover, it is possible to use external stimulus signals for the lockup clutch control.

Inports

The following table shows the inports:

Name	Unit	Description
Ctrl_Lockup_Clutch_Ext	[0_1]	External stimulus lockup clutch control
n_Engine	[rpm]	Engine speed
omega_In_Trm	[rpm]	Transmission input speed
omega_Out_Trm	[rpm]	Transmission output speed
Pos_AccPedal_Driver	[%]	Accelerator pedal position from the driver
Reset	[0|1]	Reset of states
Sw_LockupClutch	[1|2|3]	Lockup clutch control mode: ▪ 1: External ▪ 2: Soft ECU ▪ 3: Open

Outports

The following table shows the outports:

Name	Unit	Description
ASMSignalBus	[]	Signal bus that contains signals of ASM components. Refer to ASMSignalBus (ASM User Guide 🕮).
Ctrl_Lockup_Clutch	[0_1]	Lockup clutch control signal

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_P_LockupClutch	[]	P gain of lockup clutch controller
Const_I_LockupClutch	[1/s]	I gain of lockup clutch controller
Map_State_LockupClutch	[0_1]	Lockup clutch state = f(Pos_AccPedal,omega_Out_Trm)
StepSize	[s]	Simulation step size

Related topics

References

Lockup Clutch Control (ModelDesk Parameterizing 🕮)

Common Parameters

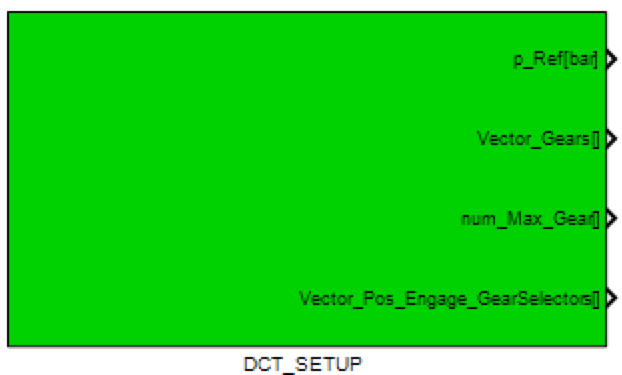
Where to go from here

Information in this section

DCT Setup

Description

The DCT_Setup block holds the transmission setup parameters for the Soft ECU that are shared from the transmission model.



It configures the gear distribution to the gear selectors and the gear selector positions for engaged gears.

Outports

The following table shows the outports:

Name	Unit	Description
num_Max_Gear	[]	Maximum available gear number
p_Ref	[bar]	Reference pressure
Vector_Gears	[]	Vector containing the gear numbers ordered by their position in the DCT topology [Odd1 Right; Odd1 Left; Odd2...]
Vector_Pos_Engage_GearSelectors	[]	Vector containing the engage positions of all gears in the DCT topology [Odd1 Right; Odd1 Left; Odd2...]

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_Gear_Left_GearSelectorEven1	[-]	Gear on the left side of even gear selector #1
Const_Gear_Left_GearSelectorEven2	[-]	Gear on the left side of even gear selector #2
Const_Gear_Left_GearSelectorEven3	[-]	Gear on the left side of even gear selector #3
Const_Gear_Left_GearSelectorEven4	[-]	Gear on the left side of even gear selector #4
Const_Gear_Left_GearSelectorEven5	[-]	Gear on the left side of even gear selector #5
Const_Gear_Left_GearSelectorOdd1	[-]	Gear on the left side of odd gear selector #1
Const_Gear_Left_GearSelectorOdd2	[-]	Gear on the left side of odd gear selector #2
Const_Gear_Left_GearSelectorOdd3	[-]	Gear on the left side of odd gear selector #3
Const_Gear_Left_GearSelectorOdd4	[-]	Gear on the left side of odd gear selector #4
Const_Gear_Left_GearSelectorOdd5	[-]	Gear on the left side of odd gear selector #5
Const_Gear_Right_GearSelectorEven1	[-]	Gear on the right side of even gear selector #1
Const_Gear_Right_GearSelectorEven2	[-]	Gear on the right side of even gear selector #2
Const_Gear_Right_GearSelectorEven3	[-]	Gear on the right side of even gear selector #3
Const_Gear_Right_GearSelectorEven4	[-]	Gear on the right side of even gear selector #4
Const_Gear_Right_GearSelectorEven5	[-]	Gear on the right side of even gear selector #5
Const_Gear_Right_GearSelectorOdd1	[-]	Gear on the right side of odd gear selector #1
Const_Gear_Right_GearSelectorOdd2	[-]	Gear on the right side of odd gear selector #2
Const_Gear_Right_GearSelectorOdd3	[-]	Gear on the right side of odd gear selector #3
Const_Gear_Right_GearSelectorOdd4	[-]	Gear on the right side of odd gear selector #4
Const_Gear_Right_GearSelectorOdd5	[-]	Gear on the right side of odd gear selector #5
Const_Pos_Eng_Left_GearSelectorEven1	[mm]	Engagement position on the left side of the even gear selector #1
Const_Pos_Eng_Left_GearSelectorEven2	[mm]	Engagement position on the left side of the even gear selector #2
Const_Pos_Eng_Left_GearSelectorEven3	[mm]	Engagement position on the left side of the even gear selector #3
Const_Pos_Eng_Left_GearSelectorEven4	[mm]	Engagement position on the left side of the even gear selector #4
Const_Pos_Eng_Left_GearSelectorEven5	[mm]	Engagement position on the left side of the even gear selector #5
Const_Pos_Eng_Left_GearSelectorOdd1	[mm]	Engagement position on the left side of the odd gear selector #1
Const_Pos_Eng_Left_GearSelectorOdd2	[mm]	Engagement position on the left side of the odd gear selector #2
Const_Pos_Eng_Left_GearSelectorOdd3	[mm]	Engagement position on the left side of the odd gear selector #3
Const_Pos_Eng_Left_GearSelectorOdd4	[mm]	Engagement position on the left side of the odd gear selector #4
Const_Pos_Eng_Left_GearSelectorOdd5	[mm]	Engagement position on the left side of the odd gear selector #5
Const_Pos_Eng_Right_GearSelectorEven1	[mm]	Engagement position on the right side of the even gear selector #1
Const_Pos_Eng_Right_GearSelectorEven2	[mm]	Engagement position on the right side of the even gear selector #2
Const_Pos_Eng_Right_GearSelectorEven3	[mm]	Engagement position on the right side of the even gear selector #3

Name	Unit	Description
Const_Pos_Eng_Right_GearSelectorEven4	[mm]	Engagement position on the right side of the even gear selector #4
Const_Pos_Eng_Right_GearSelectorEven5	[mm]	Engagement position on the right side of the even gear selector #5
Const_Pos_Eng_Right_GearSelectorOdd1	[mm]	Engagement position on the right side of the odd gear selector #1
Const_Pos_Eng_Right_GearSelectorOdd2	[mm]	Engagement position on the right side of the odd gear selector #2
Const_Pos_Eng_Right_GearSelectorOdd3	[mm]	Engagement position on the right side of the odd gear selector #3
Const_Pos_Eng_Right_GearSelectorOdd4	[mm]	Engagement position on the right side of the odd gear selector #4
Const_Pos_Eng_Right_GearSelectorOdd5	[mm]	Engagement position on the right side of the odd gear selector #5
Const_p_Ref	[bar]	Reference pressure

Related topics

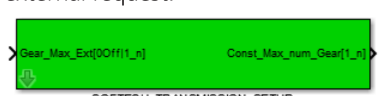
References

DCT Setup (ModelDesk Parameterizing 📖)

Soft ECU Transmission Setup

Description

The SOFTECU_TRANSMISSION_SETUP block provides dimension and general setup parameters for the Soft ECU Transmission model. For example, it provides the highest possible requested gear. The behavior can also be influenced by an external request.



SOFTECU_TRANSMISSION_SETUP

Inports

The following table shows the inports:

Name	Unit	Description
Gear_Max_Ext	[1_n]	External highest gear

Outports

The following table shows the outports:

Name	Unit	Description
Const_Max_num_Gear	[1_n]	Highest requested gear

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_Max_num_Gear	[]	Highest requested gear

Related topics

References

SoftECU Transmission Setup (ModelDesk Parameterizing 📖)

Engine Intervention

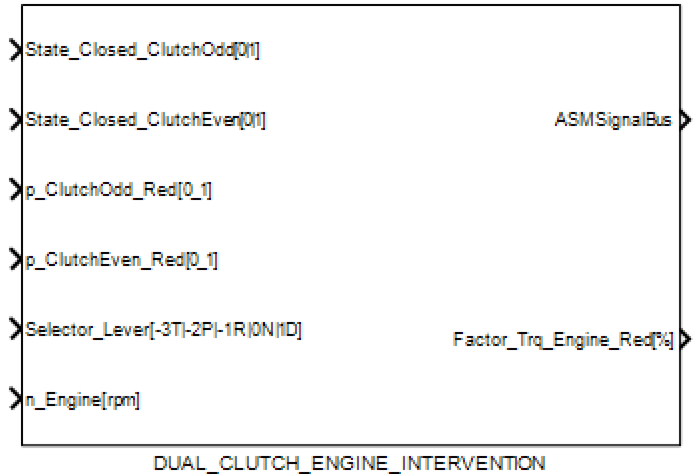
Where to go from here

Information in this section

Dual Clutch Engine Intervention

Description

The DUAL_CLUTCH_ENGINE_INTERVENTION block generates torque reduction factor for the engine ECU during shifting and clutch engagement to keep engine speed smooth.



It considers the current progress of clutch engagement. As long as the clutch pressures are low, the intervention request is high. The further the clutches engage, the less intervention is needed. The intervention request is translated to the torque reduction factor by a map.

The engine intervention is only active above a certain engine speed threshold.

Inports

The following table shows the inports:

Name	Unit	Description
n_Engine	[rpm]	Engine speed
p_ClutchEven_Red	[0_1]	Normalized even clutch cylinder pressure
p_ClutchOdd_Red	[0_1]	Normalized odd clutch cylinder pressure
Selector_Lever	[-3T|-2P|-1R|0N|1D]	Selector lever position: ▪ -3: TipShift ▪ -2: Park ▪ -1: Reverse ▪ 0: Neutral ▪ 1: Drive
State_Closed_ClutchEven	[0|1]	State of even clutch: ▪ 0: Open ▪ 1: Closed
State_Closed_ClutchOdd	[0|1]	State of odd clutch: ▪ 0: Open ▪ 1: Closed

Outports

The following table shows the outports:

Name	Unit	Description
ASMSignalBus	[]	Signal bus that contains signals of ASM components. Refer to ASMSignalBus (ASM User Guide 📖).
Factor_Trq_Engine_Red	[%]	Factor to reduce engine torque: ▪ 1: Full torque ▪ 0: No torque

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_n_Engine_LowLim	[rpm]	Lower engine speed threshold to intervene the engine torque while shifting
Map_Factor_Trq_Engine_Red	[%]	Percentage of engine torque intervention as a function of the intervention request = f(Request_Intervention[0_1])

Related topics

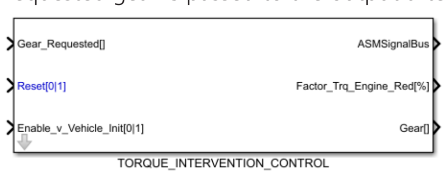
References

Dual Clutch Engine Intervention (ModelDesk Parameterizing 📖)

Torque Intervention Control

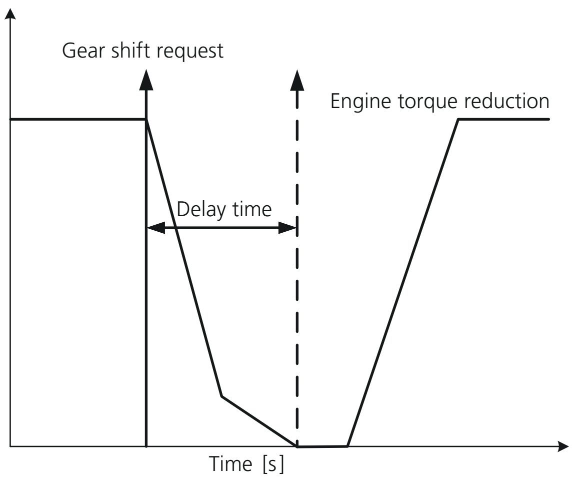
Description

The TORQUE_INTERVENTION_CONTROL block specifies the torque intervention while shifting gears as a scaling of the engine torque in percent. The requested gear is passed to the output after a predefined delay time.



This block connects the transmission ECU and the engine ECU, because an engine torque reduction is usually requested while shifting gears. The request from the transmission is converted to a set value for the engine ECU.

The following illustration shows an example of the torque intervention request. The torque is reduced once a gear is requested. This gear request is then delayed by a user-defined time:



The torque is reduced once a gear is requested. This gear request is then delayed by a user-defined time.

Inports

The following table shows the inports:

Name	Unit	Description
Enable_v_Vehicle_Init	[0|1]	Drivetrain initialization flag for scenarios with non-zero vehicle initial velocity
Gear_Requested	[]	Requested gear
Reset	[0|1]	Reset of states

Outports

The following table shows the outports:

Name	Unit	Description
ASMSignalBus	[]	Signal bus that contains signals of ASM components. Refer to ASMSignalBus (ASM User Guide 📖).
Factor_Trq_Engine_Red	[%]	Percentage factor of engine torque
Gear	[]	Requested gear after engine torque intervention

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_t_Gear_Offs	[s]	Requested gear delay time
Map_Factor_Trq_Engine_Red	[%]	Percentage of engine torque intervention as a function of the requested gear time
StepSize	[s]	Simulation step size

Related topics

References

Torque Intervention Control (ModelDesk Parameterizing 📖)

Gear Selector Control

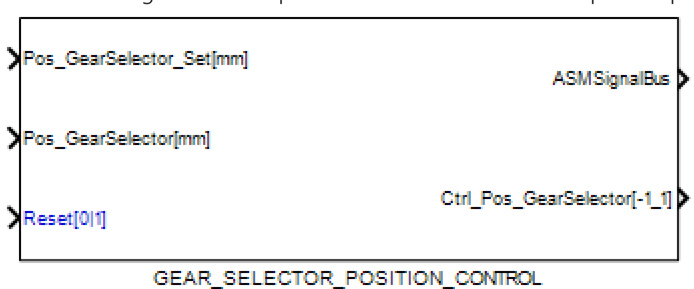
Where to go from here

Information in this section

Gear Selector Position Control

Description

The GEAR_SELECTOR_POSITION_CONTROL block contains a PID controller. This controller generates a continuous signal between +1 and -1 to increase or decrease the gear selector position until it reaches the requested position.



There is a map to adapt the PID controller output to the characteristics of the actuation system. The output signal can also use the range of +1 to -1 and might require some further adaptations, e.g., saturation blocks, to work with the corresponding actuators properly.

Inports

The following table shows the inports:

Name	Unit	Description
Pos_GearSelector	[mm]	Current position of the gear selector
Pos_GearSelector_Set	[mm]	Desired position of the gear selector
Reset	[0|1]	Reset of states

Outports

The following table shows the outports:

Name	Unit	Description
ASMSignalBus	[]	Signal bus that contains signals of ASM components. Refer to ASMSignalBus (ASM User Guide 📖).
Ctrl_Pos_GearSelector	[-1_1]	Control signal to actuate the gear selector position

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_D_Ctrl	[-]	D-Gain of the PID controller
Const_I_Ctrl	[-]	I-Gain of the PID controller
Const_P_Ctrl	[-]	P-Gain of the PID controller
Const_Pos_Dead_Ctrl	[mm]	Controller dead zone
Map_Ctrl_Pos_GearSelector	[0_1]	Position control signal map = f(Ctrl[0_1])
StepSize	[s]	Simulation step size

Related topics

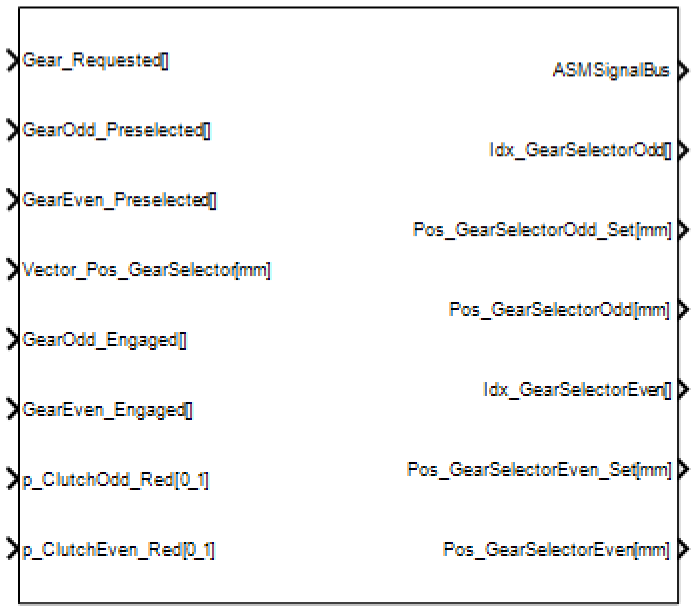
References

Gear Selector Position Control (ModelDesk Parameterizing 📖)

Gear Selector Position Set

Description

The GEAR_SELECTOR_POSITION_SET block organizes the actuation of up to 10 gear selectors.



It compares the requested odd and even gears to the gear distribution of the transmission to determine a desired position for every gear selector. A shift logic considers the current positions to order observe disengage and engage processes.

The block outputs the index of the gear selector which should be actuated. The index is 1-5 for the gear selectors Odd1-Odd5 and 6-10 for the gear selectors Even1-Even5. It also provides the current and requested positions for this particular gear selector.

With the Sw_Parallel_Actuation parameter, the block can be configured to allow parallel actuation of the odd and even transmission parts. If parallel actuation is disabled, either odd or even transmission are actuated while the other output signals are zero.

Inports

The following table shows the inports:

Name	Unit	Description
Gear_Requested	[]	Requested gear of the transmission
GearEven_Engaged	[]	Currently engaged even gear
GearEven_Preselected	[]	Requested even gear for pre-selection
GearOdd_Engaged	[]	Currently engaged odd gear

Name	Unit	Description
GearOdd_Preselected	[]	Requested odd gear for pre-selection
p_ClutchEven_Red	[0_1]	Normalized even clutch cylinder pressure
p_ClutchOdd_Red	[0_1]	Normalized odd clutch cylinder pressure
Vector_Pos_GearSelector	[mm]	Vector containing the current gear selector positions ordered by the DCT topology [Odd 1-5; Even 1-5]

Outports

The following table shows the outports:

Name	Unit	Description
ASMSignalBus	[]	Signal bus that contains signals of ASM components. Refer to ASMSignalBus (ASM User Guide 📖).
Idx_GearSelectorEven	[]	Index of the actuated gear selector (for parallel actuation: even gear selector only). ▪ 1-5: Odd 1-5 ▪ 6-10: Even 1-5
Idx_GearSelectorOdd	[]	Index of the actuated gear selector (for parallel actuation: odd gear selector only). ▪ 1-5: Odd 1-5 ▪ 6-10: Even 1-5
Pos_GearSelectorEven	[mm]	Position of the actuated gear selector (for parallel actuation: even gear selector only).
Pos_GearSelectorEven_Set	[mm]	Desired position of the actuated gear selector (for parallel actuation: even gear selector only).
Pos_GearSelectorOdd	[mm]	Position of the actuated gear selector (for parallel actuation: odd gear selector only).
Pos_GearSelectorOdd_Set	[mm]	Desired position of the actuated gear selector (for parallel actuation: odd gear selector only).

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_Pos_Diseng_LowLim	[mm]	Smallest gear selector position threshold to consider gear as disengaged
Sw_Parallel_Actuation	[0|1]	Enable parallel actuation of odd and even gearbox

Related topics

References

Gear Selector Position Set (ModelDesk Parameterizing 📖)

Gear Shift Strategy

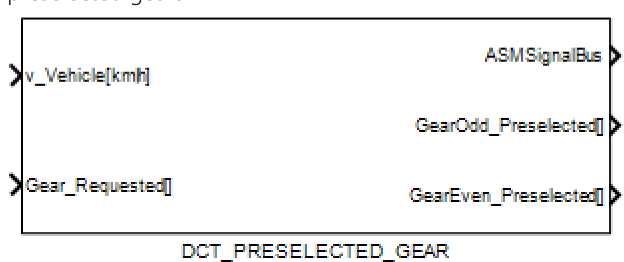
Where to go from here

Information in this section

DCT Preselected Gear

Description

The DCT_PRESELECTED_GEAR block extends the transmission gear request to preselected gears.



It considers the dual clutch transmission gear configuration and the requested overall transmission gear to determine requested gears for the odd and the even part transmission. The pre-selection observes the vehicle speed to prepare a higher or lower gear for the gearshift expected to follow.

Inports

The following table shows the inports:

Name	Unit	Description
Gear_Requested	[]	Requested gear of the transmission
v_Vehicle	[km/h]	Vehicle velocity

Outports

The following table shows the outports:

Name	Unit	Description
ASMSignalBus	[]	Signal bus that contains signals of ASM components. Refer to ASMSignalBus (ASM User Guide 📖).
GearEven_Preselected	[]	Requested even gear for pre-selection
GearOdd_Preselected	[]	Requested odd gear for pre-selection

Parameters

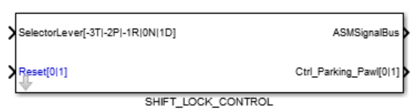
The following table shows the parameters:

Name	Unit	Description
StepSize	[s]	Simulation step size

Shift Lock Control

Description

The SHIFT_LOCK_CONTROL block activates the parking lock when the selector lever is in the P position.



Inports

The following table shows the inports:

Name	Unit	Description
Reset	[0|1]	Reset of states
SelectorLever	[-3|-2|-1|0|1]	Selector lever position for automatic transmission: ▪ -3 : TipShift ▪ -2 : Park ▪ -1 : Reverse ▪ 0 : Neutral ▪ 1 : Drive

Outports

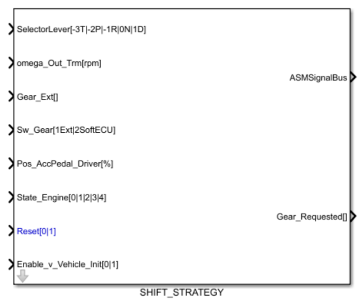
The following table shows the outports:

Name	Unit	Description
ASMSignalBus	[]	Signal bus that contains signals of ASM components. Refer to ASMSignalBus (ASM User Guide 📖).
Ctrl_Parking_Pawl	[0|1]	Parking pawl control

Shift Strategy

Description

The SHIFT_STRATEGY block controls the gearshift request when the selector lever is in the D or R position.

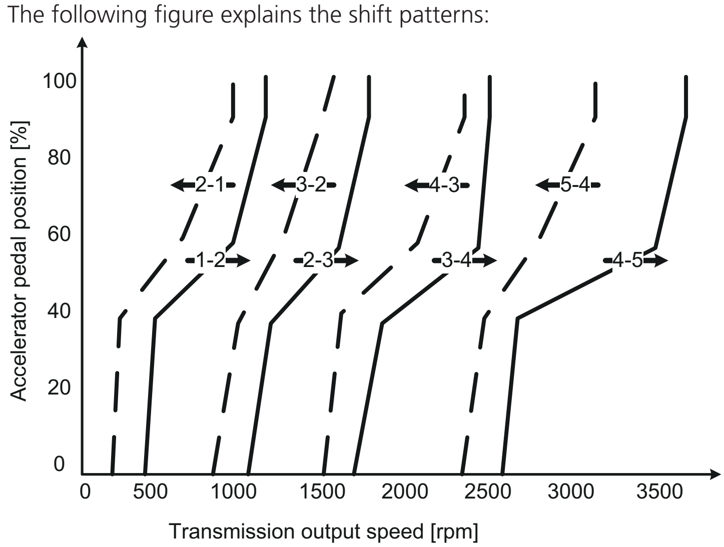


The shift request is controlled according to predefined shift patterns, which depend on the transmission output speed and the accelerator pedal position.

Two shift patterns for the up shift and down shift are parameterized in the block. Each shift pattern calculates the shift thresholds of the transmission output speed for several possible gears. These thresholds are then compared with the actual transmission output speed to request an up shift or down shift.

Shift patterns

The following figure explains the shift patterns:



To illustrate the shift strategy, up shift 1-2 and down shift 2-1 are clarified in the following:

As the driver shifts the selector lever to the D position, the first gear is requested and engaged at the same time. Meanwhile, the transmission output speed is increased to some point between curves 2-1 and 1-2. If the driver demands more acceleration by pressing the accelerator pedal, the transmission output speed increases accordingly and curve 1-2 is crossed. After curve1-2 is crossed, the second gear is requested.

Down shift 2-1 can be understood in a similar way. As the vehicle decelerates, the transmission output speed is decreased to a point where curve 2-1 is crossed and the first gear is requested.

To prevent the phenomenon of gear hunting, i.e., frequent up shifting and down shifting, a minimum time between two successive shifts is observed (**Const_t_Min_Shift[s]** parameter). In this way, and after successfully shifting gears, no additional shift request occurs within the specified time. If the user sets a sufficient time, gears can be skipped. However, this strongly depends on the shift patterns and the driving situation.

The gear request can be reset at any time by using the reset of states. Moreover, the gear request is reset automatically if the engine was stalled.

You can also use external stimulus gear requests instead of the automatic control.

Inports

The following table shows the inports:

Name	Unit	Description
Enable_v_Vehicle_Init	[0|1]	Drivetrain initialization flag for scenarios with non-zero vehicle initial velocity
Gear_Ext	[]	External stimulus gear
omega_Out_Trm	[rpm]	Transmission output speed
Pos_AccPedal_Driver	[%]	Accelerator pedal position from driver
Reset	[0|1]	Reset of states
SelectorLever	[-3|-2|-1|0|1]	Selector lever position for automatic transmission: ▪ -3 : TipShift ▪ -2 : Park ▪ -1 : Reverse ▪ 0 : Neutral ▪ 1 : Drive
State_Engine	[0|1|2|3|4]	Switch for state of engine: ▪ 0: Engine off / Error ▪ 1: Ignition on ▪ 2: Starter on ▪ 3: Engine running ▪ 4: Engine shutdown
Sw_Gear	[1|2]	Gear mode: ▪ 1: External ▪ 2: Soft ECU

Outports

The following table shows the outports:

Name	Unit	Description
ASMSignalBus	[]	Signal bus that contains signals of ASM components. Refer to ASMSignalBus (ASM User Guide 📖).
Gear_Requested	[]	Requested gear

Parameters

The following table shows the parameters:

Name	Unit	Description
Map_omega_Down shift	[rpm]	Transmission output speed for gear down shift schedule = f(Pos_AccPedal,Gear_Current)
Map_omega_Up shift	[rpm]	Transmission output speed for gear up shift schedule = f(Pos_AccPedal,Gear_Current)
StepSize	[s]	Simulation step size

Related topics

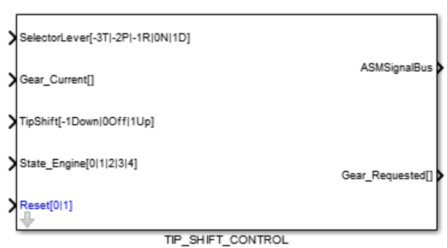
References

Shift Strategy (ModelDesk Parameterizing 📖)

TipShift Control

Description

The TIP_SHIFT_CONTROL block allows external shift requests when the selector lever is in the T position. The shift requests are triggered via the TipShift lever.



If the driver shifts the selector lever to the T position, the TipShift signal is used for gearshifting.

This signal has three values:

- -1: down shift
- 0: off
- 1: up shift

Each time the driver tips the TipShift up or down, a gear up shift or down shift is requested, respectively.

However, two conditions have to be fulfilled:
- The lowest possible gear is -1.
- A gearshift request can only be considered if the previous requested gear was successfully engaged.

Inports

The following table shows the inports:

Name	Unit	Description
Gear_Current	[]	Current gear
Reset	[0|1]	Reset of states
SelectorLever	[-3|-2|-1|0|1]	Selector lever position for automatic transmission: ▪ -3 : TipShift ▪ -2 : Park ▪ -1 : Reverse ▪ 0 : Neutral ▪ 1 : Drive
TipShift	[-1|0|1]	TipShift request signal for TipTronic function: ▪ -1 : Down shift ▪ 0 : Off ▪ 1 : Up shift
State_Engine	[0|1|2|3|4]	Engine state: ▪ 0: Engine off/Error ▪ 1: Ignition on ▪ 2: Starter on ▪ 3: Engine running ▪ 4: Engine shutdown

Outports

The following table shows the outports:

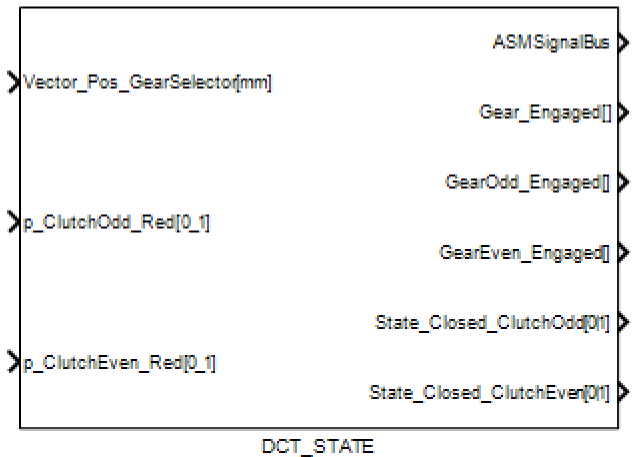
Name	Unit	Description
ASMSignalBus	[]	Signal bus that contains signals of ASM components. Refer to ASMSignalBus (ASM User Guide 📖).
Gear_Requested	[]	Requested gear

Transmission State

DCT State

Description

The DCT_STATE block determines the current engaged gears of a dual clutch transmission according to the gear selector positions.



It also outputs the overall engaged transmission gear according to the normalized pressures of the clutches. Additionally, it converts the clutch pressures to state which switches from *open* to *closed* at a certain threshold.

Inports

The following table shows the inports:

Name	Unit	Description
p_ClutchEven_Red	[0_1]	Normalized even clutch cylinder pressure
p_ClutchOdd_Red	[0_1]	Normalized odd clutch cylinder pressure
Vector_Pos_GearSelector	[mm]	Vector containing the current gear selector positions ordered by the DCT topology [Odd 1-5; Even 1-5]

Outports

The following table shows the outports:

Name	Unit	Description
ASMSignalBus	[]	Signal bus that contains signals of ASM components. Refer to ASMSignalBus (ASM User Guide 📖).
Gear_Engaged	[]	Currently engaged gear of the transmission
GearEven_Engaged	[]	Currently engaged even gear

Name	Unit	Description
GearOdd_Engaged	[]	Currently engaged odd gear
State_Closed_ClutchEven	[0|1]	State of even clutch: ▪ 0: Open ▪ 1: Closed
State_Closed_ClutchOdd	[0|1]	State of odd clutch: ▪ 0: Open ▪ 1: Closed

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_p_Clutch_Red_LowLim	[0_1]	Lower clutch nominal pressure threshold to detect clutch as closed

Related topics

References

DCT State (ModelDesk Parameterizing 📖)

Valve Control

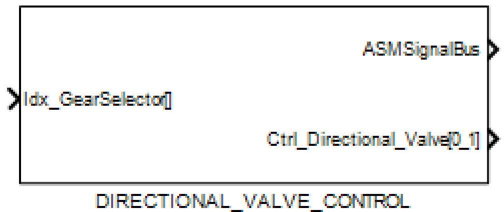
Where to go from here

Information in this section

Directional Valve Control

Description

The DIRECTIONAL_VALVE_CONTROL block is used to generate control signals for On/Off directional valves, which are used to switch a hydraulic path from one gear selector to another.



The index number of the target gear selector from the actuation logic is translated into an On/Off signal by a map.

The map must be match the required directional valve signals to reach the desired gear selector. Multiple instances of the controller can be used for multiple serial or parallel directional valves.

Inports

The following table shows the inports:

Name	Unit	Description
Idx_GearSelector	[]	Index of the actuated gear selector: ▪ 1-5: Odd 1-5 ▪ 6-10: Even 1-5

Outports

The following table shows the outports:

Name	Unit	Description
ASMSignalBus	[]	Signal bus that contains signals of ASM components. Refer to ASMSignalBus (ASM User Guide 📖).
Ctrl_Directional_Valve	[0_1]	Control signal to switch directional valves according to the actuated gear selector

Parameters

The following table shows the parameters:

Name	Unit	Description
Map_Ctrl_Routing	[0_1]	Routing control signal map = f(Idx_GearSelector[-])

Related topics

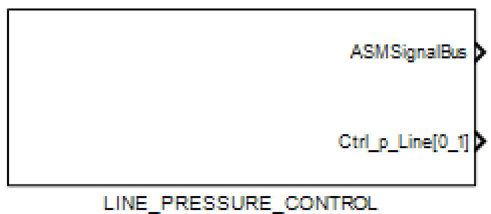
References

Directional Valve Control (ModelDesk Parameterizing 📖)

Line Pressure Control

Description

The LINE_PRESSURE_CONTROL block is used to generate control signals for On/Off directional valves, which are used to switch a hydraulic path from one gear selector to another.



It sets the control signal for a pressure control valve according to a characteristics map.

Outports

The following table shows the outports:

Name	Unit	Description
ASMSignalBus	[]	Signal bus that contains signals of ASM components. Refer to ASMSignalBus (ASM User Guide 📖).
Ctrl_p_Line	[0_1]	Control signal for line pressure control valve

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_p_Line_Set	[bar]	Desired line pressure
Map_Ctrl_p_Line	[0_1]	Inverse map of desired line pressure = f(p_Des[bar])

Related topics

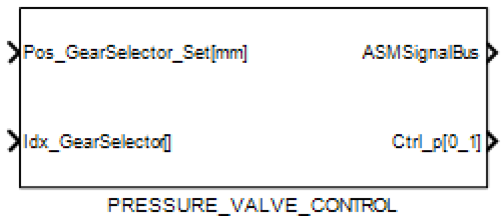
References

Line Pressure Control (ModelDesk Parameterizing 📖)

Pressure Valve Control

Description

The PRESSURE_VALVE_CONTROL block sets the desired pressure for shifting actuation according to the desired gear selector position and the index number of the gear selector.



It differentiates between three cases:

- Index = 0 – No actuation required, no shift pressure, control signal is zero
- Index ≠ 0, desired position = 0 – Disengage demand, disengage shift pressure, control signal according to characteristics map
- Index ≠ 0, desired position ≠ 0 – Engage demand, engage shift pressure, control signal according to characteristics map

Inports

The following table shows the inports:

Name	Unit	Description
Idx_GearSelector	[]	Index of the actuated gear selector: ▪ 1-5: Odd 1-5 ▪ 6-10: Even 1-5
Pos_GearSelector_Set	[mm]	Desired position of the gear selector

Outports

The following table shows the outports:

Name	Unit	Description
ASMSignalBus	[]	Signal bus that contains signals of ASM components. Refer to ASMSignalBus (ASM User Guide 📖).
Ctrl_p	[0_1]	Control signal for shift pressure control valve

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_p_Diseng_Set	[bar]	Desired disengagement pressure
Const_p_Engage_Set	[bar]	Desired engagement pressure
Map_Ctrl_p	[0_1]	Inverse map of desired pressure = f(p_Set[bar])

Related topics

References

Pressure Valve Control (ModelDesk Parameterizing 📖)

Vehicle

Driving Resistances

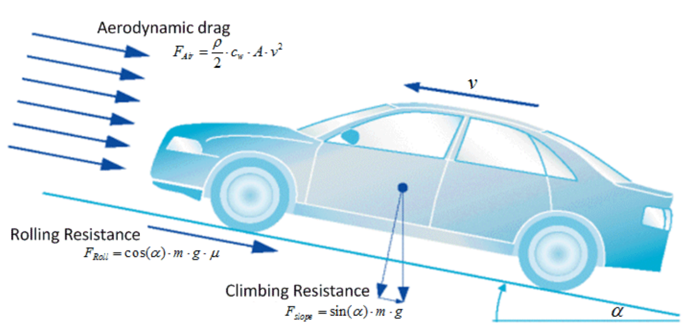
Description

The driving resistances and the vehicle speed are calculated in this model.

The driving resistances of the vehicle include the following forces:

- Rolling resistance
- Aerodynamic drag
- Climbing resistance

also illustrated in the figure below.



To calculate the traction force, which is the total force to accelerate the vehicle, the following equation is used:

$$F_{traction} = F_{Driving} - \left(F_{Roll} + F_{Air} + F_{Slope}\right) - F_{Brake}$$

where:

$F_{Driving}$ is the driving force applied to the driving shafts

F_{Brake} is the braking force

Since neither tire nor slip are considered, the traction force is limited by the maximum friction between the vehicle and the road. This friction depends on the tire-road characteristics and determines the maximum acceleration as well as the minimum braking distance.

The maximum friction force is calculated using this equation:

$$F_{Fric\_max} = \cos(\alpha) \cdot m \cdot g \cdot \mu_{Fric}$$

where:

α is the slope angle

m is the vehicle mass

g is the gravitational constant

μ_{Fric} is the friction coefficient based on tire-road characteristics

The vehicle velocity is then calculated by the integration of the traction force divided by the reduced vehicle mass.

Inports

The following table shows the inports:

Name	Unit	Description
Ctrl_Parking_Pawl	[0|1]	Parking pawl control signal
Inertia_Out_Diff	[kg m^2]	Inertia reduced to the differential output shaft
m_AddLoad	[kg]	Additional load mass
Pos_BrakePedal	[%]	Brake pedal position
Reset	[]	Reset of states
Slope	[%]	Current road slope
Trq_Out_Diff	[Nm]	Differential output torque

Outports

The following table shows the outports:

Name	Unit	Description
omega_Wheel	[rad/s]	Wheel speed
v_Vehicle	[km/h]	Vehicle velocity

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_A_Vehicle	[m^2]	Vehicle cross section
Const_cw	[]	Drag coefficient
Const_F_Brake_Max	[N]	Maximum braking force
Const_Fric_Coeff	[]	Friction coefficient based on tire-road characteristics
Const_g	[m/s^2]	Gravitational constant
Const_m_Vehicle	[kg]	Vehicle mass
Const_mue_Tire	[]	Rolling resistance coefficient
Const_r_Tire	[m]	Dynamic tire radius
Const_rho_Air	[kg/m^3]	Air density
StepSize	[s]	Simulation step size

Related topics

References

History of the DRIVING_RESISTANCES Block.. 282

Demos

Where to go from here

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Drivetrain Basic Model

Where to go from here

Information in this section

Basics on the Drivetrain Basic Demo Model

Basics

The Drivetrain Basic model is a longitudinal model of a vehicle drivetrain which transfers the torque from the engine to the wheel.

Overview of the Drivetrain Basic Model

Introduction

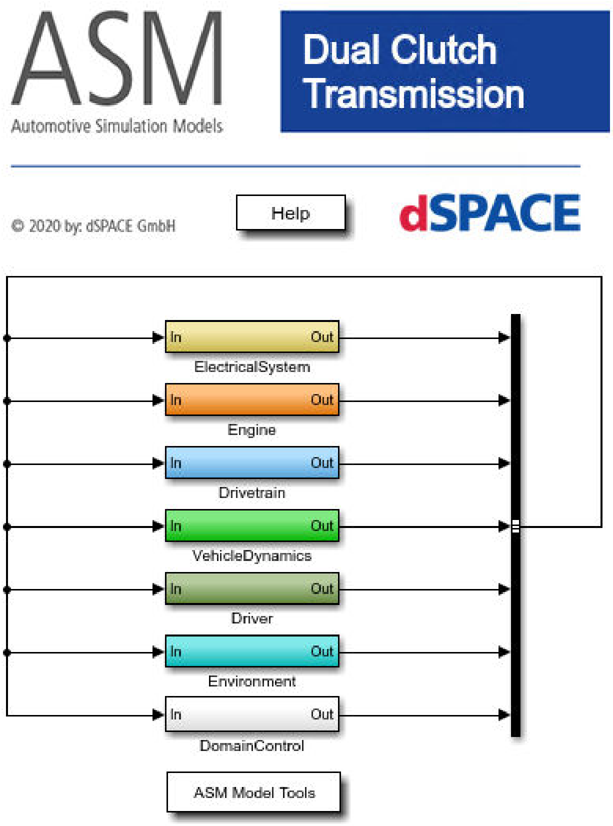
This topic gives you an overview of the Drivetrain Basic Model showing the ASM modules that are implemented in the model.

Opening the Model

Refer to How to Start with an ASM Demo Model via MATLAB (ASM Drivetrain Basic Model Description 🕮).

Top layer

The following illustration shows the top layer of the model in Simulink.



ASM modules

The model consists of the following ASM modules:

- Electrical System Basic Module on page 172
- Engine Basic Module on page 173
- Drivetrain (DCT) Module on page 169
- Vehicle Dynamics Basic Module on page 182
- Driver Basic Module on page 167
- Environment Basic Module on page 176
- Start System Module on page 179
- Torque Manager Basic Module on page 180
- Driver Assistance Simple Module on page 166

ASM Modules

Where to go from here

Information in this section

Driver Assistance Simple Module

Description

This module provides default values for adaptive cruise control (ACC) signals.

The following tables show the external inports and outports of the ASM module.

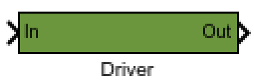
Outports Control

The following table shows the ports of the Interface_External_Out:

Name	Unit	Description
AEB	[0|1]	Autonomous emergency brake flag from soft ecu ACC
Enable_Trq_Decrease_ACC	[0|1]	Enable torque decrease ACC
Enable_Trq_Increase_ACC	[0|1]	Enable torque increase ACC
FCW	[0|1]	Forward collision warning flag from soft ecu ACC
Trq_DecreaseRequest_ACC	[Nm]	Torque decrease request ACC
Trq_IncreaseRequest_ACC	[Nm]	Torque increase request ACC

Driver Basic Module

Description



The Driver module is essential for controlled longitudinal maneuvers, such as following a velocity profile (driving cycle). It controls the pedals and gear in such a way that the vehicle follows given references.

The following tables show the external inports and outports of the ASM module.

Subsystems

- Driver Subsystem on page 184

Inports Plant

The following table shows the ports of the Interface_External_In:

Name	Unit	Description
Enable_v_Vehicle_Init	[0|1]	Drivetrain initialization flag for scenarios with non-zero vehicle initial velocity
F_Driving_Res	[N]	Sum of driving resistances acting on the vehicle
Gear_Maneuver	[]	Gear stimulus from the maneuver
Gear_Max	[0|1_n]	Gear setpoint defined by the maneuver input ▪ 0: Off ▪ 1_n: Gear setpoint
m_Total_Vehicle	[kg]	Total vehicle mass

Name	Unit	Description
Mode_AcceleratorBrake	[1|2]	Controls whether the accelerator and brake pedal positions are stimulus signals or controlled by the driver: ▪ 1: Stimulus ▪ 2: Driver
Mode_GearClutch	[1|2|3|4]	Switch for the mode signal of the gear and clutch pedal source: ▪ 1: Stimulus ▪ 2: Driver ▪ 3: Open clutch ▪ 4: Reference gear
Mode_SelectorLever	[1|2]	Switch for the mode signal of the selector lever source ▪ 1: Stimulus ▪ 2: Driver
Mode_Transmission	[1|2]	Transmission mode switch ▪ 1: Manual ▪ 2: Automatic
n_Engine	[rpm]	Speed of the combustion engine
n_Engine_Idle_Set	[rpm]	Set point for the idle speed of combustion engine
omega_In_Diff	[rad/s]	Differential input speed
Pos_AccPedal_Maneuver	[%]	Accelerator pedal position stimulus from the maneuver scheduler
Pos_BrakePedal_Maneuver	[%]	Brake pedal position stimulus from the maneuver scheduler
Pos_ClutchPedal_Maneuver	[%]	Clutch pedal position stimulus from the maneuver scheduler
Reset_States	[0|1]	Reset states
SelectorLever_Maneuver	[-3|-2|-1|0|1]	Selector lever position from the maneuver: ▪ -3: TipShift ▪ -2: Park ▪ -1: Reverse ▪ 0: Neutral ▪ 1: Drive
State_Engine	[0|1|2|3|4]	Engine state ▪ 0: Engine off ▪ 1: Ignition on ▪ 2: Ignition on and starter activated ▪ 3: Engine is running ▪ 4: Ignition is switched off, shutdown active

Name	Unit	Description
State_StartStop	[1|2|3|4]	Start-stop state: ▪ 1: Off ▪ 2: Not ready ▪ 3: Ready to stop the engine ▪ 4: Engine actively stopped by the system
Sw_Testbench	[0|1]	Switch to activate the test bench: ▪ 0: Off ▪ 1: On
Sw_TorqueController	[0|1]	Switch to activate the torque controller: ▪ 0: Off ▪ 1: On
v_Vehicle	[m/s]	Vehicle velocity
v_Vehicle_Preview_Ref	[km/h]	Preview reference vehicle velocity
v_Vehicle_Ref	[km/h]	Reference vehicle velocity

Outports Plant

The following table shows the ports of the Interface_External_Out:

Name	Unit	Description
Gear	[]	Gear
Pos_AccPedal	[%]	Position of the accelerator pedal
Pos_BrakePedal	[%]	Brake pedal position
Pos_ClutchPedal	[%]	Clutch pedal position
SelectorLever	[-3|-2|-1|0|1]	Selector lever position ▪ -3: TipShift ▪ -2: Park ▪ -1: Reverse ▪ 0: Neutral ▪ 1: Drive
t_Preview_vRef_Driver	[s]	Preview time for the driver model

Drivetrain (DCT) Module

Description

This is a longitudinal model of the vehicle drivetrain which transfers the torque from engine to the wheel. It consists of a flexible Dual-Clutch-Transmission (DCT) model with detailed hydraulic actuation. The model also includes a control strategy for clutch pressure and gear shift.

The following tables show the external inports and outports of the ASM module.

Subsystems

The module contains the following subsystems:

- Soft ECU Transmission Subsystem on page 187

Inports Control

The following table shows the ports of the Interface_External_In:

Name	Unit	Description
Enable_Trq_Shift_Request	[0|1]	Flag to enable ICE torque intervention during gear shift
Gear_Maneuver	[]	Gear stimulus from the maneuver
Mode_GearClutch	[1|2|3|4]	Switch for mode signal of gear and clutch pedal source: ▪ 1: Stimulus ▪ 2: Driver ▪ 3: Open clutch ▪ 4: Reference gear
Pos_AccPedal	[%]	Position of the accelerator pedal
Pos_BrakePedal	[%]	Brake pedal position
Reset_States	[0|1]	Reset states
SelectorLever	[-3|-2|-1|0|1]	Selector lever position: ▪ -3: TipShift ▪ -2: Park ▪ -1: Reverse ▪ 0: Neutral ▪ 1: Drive
State_Engine	[0|1|2|3|4]	Engine state: ▪ 0: Engine off ▪ 1: Ignition on ▪ 2: Ignition on and starter activated ▪ 3: Engine is running ▪ 4: Ignition is switched off, shutdown active
Sw_TipShift	[-1|0|1]	TipShift request signal: ▪ -1: Down shift ▪ 0: Off ▪ 1: Up shift
Trq_Shift_Request	[Nm]	Torque intervention during gear shift
v_Vehicle	[km/h]	Vehicle velocity

The following table shows the interface to connect an external ECU (real ECU):

Name	Unit	Description
Ctrl_Even_Directional_Valve	[0_1]	Nominated control signal of the directional valve of even gears
Ctrl_Odd_Directional_Valve	[0_1]	Nominated control signal of the directional valve of odd gears
Ctrl_Parking_Pawl	[0|1]	Parking pawl control signal
Ctrl_p_EvenClutch_Valve	[0_1]	Nominated control signal of even the clutch control valve
Ctrl_p_Line_Valve	[0_1]	Control signal for the line pressure control valve
Ctrl_p_OddClutch_Valve	[0_1]	Nominated control signal of the odd clutch control valve
Ctrl_p_Shift_Even_Left_Valve	[0_1]	Nominated control signal of the shift valve of the even-left gears
Ctrl_p_Shift_Even_Right_Valve	[0_1]	Nominated control signal of the shift valve of the even-right gears
Ctrl_p_Shift_Odd_Left_Valve	[0_1]	Nominated control signal of the shift valve of the odd-left gears
Ctrl_p_Shift_Odd_Right_Valve	[0_1]	Nominated control signal of the shift valve of the odd-right gears
Ctrl_Pump	[0_1]	Control signal of the pump ([-1_0]: Backward flow, [0_1]: Forward flow) in Selective Catalytic Reduction (SCR) supply system
Factor_Trq_Engine_Red	[0_1]	Engine torque reduction factor

Outports Control

The following table shows the ports of the Interface_External_Out:

Name	Unit	Description
Ctrl_Praking_Pawl	[0|1]	Parking pawl control signal
Factor_Trq_Engine_Red	[%]	Engine torque reduction factor

Inports Plant

The following table shows the ports of the Interface_External_In:

Name	Unit	Description
CrankAngle_Cyl	[aTDC]	Crank angle per cylinder, positive value is after TDC
n_Engine_Set	[rpm]	Setpoint for speed of combustion engine
omega_Wheel	[rad/s]	Wheel speed
Reset_States	[0|1]	Reset states

Name	Unit	Description
Starter_Drivetrain	[0|1]	Engine starter switch: ▪ 0: Off ▪ 1: On
Sw_Testbench	[0|1]	Switch to activate the test bench: ▪ 0: Off ▪ 1: On
Trq_MeanEff_Engine	[Nm]	Mean effective engine torque

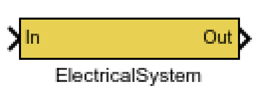
Outports Plant

The following table shows the ports of the Interface_External_Out:

Name	Unit	Description
Gear	[]	Gear
Inertia_Out_Diff	[kg m^2]	Inertia reduced to the differential output shaft
Mode_Transmission	[1|2]	Transmission mode switch: ▪ 1: Manual ▪ 2: Automatic
n_Engine	[rpm]	Speed of combustion engine
omega_In_Diff	[rad/s]	Differential input speed
Sw_CrankShaft_Reset	[0|1]	Crankshaft reset switch: ▪ 0: Disabled ▪ 1: Enabled
Trq_BSG	[Nm]	Torque of the belt-driven starter generator (BSG)
Trq_Out_Diff	[Nm]	Differential output torque

Electrical System Basic Module

Description



The ASM Module Electrical System Basic provide constant values of the voltage, state of charge and temperature of a low and a high voltage battery. The DC link voltage represents the voltage of the high voltage battery. It can be exchanged with a more complex ASM module.

The following tables show the external in- and outports of the ASM module.

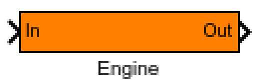
Outports Plant

The following table shows the ports of the Interface_External_Out:

Name	Unit	Description
SOC_Bat_HV	[%]	State of charge high voltage battery
SOC_Bat_LV	[%]	State of charge low voltage battery
T_Bat_HV	[°C]	Temperature high voltage battery
T_Bat_LV	[°C]	Temperature low voltage battery
V_Bat_HV	[V]	Voltage of high voltage battery
V_Bat_LV	[V]	Voltage of low voltage battery
V_DCLink	[V]	DC Link voltage

Engine Basic Module

Description



The engine is modelled as a simple look-up table, where the engine torque is calculated as a function of engine speed and the driver accelerator pedal position.

The following tables show the external inports and outports of the ASM module.

Subsystems

The module contains the following subsystems:

- Engine Basic Subsystem on page 193
- Soft ECU Engine Subsystem on page 193

Inports Control

The following table shows the ports of the Interface_External_In:

Name	Unit	Description
Enable_n_Engine_Idle_Request	[0|1]	Flag to activate the engine idle speed request: ▪ 0: Off ▪ 1: On
Enable_Trq_Decrease_Fast_ESP	[0|1]	Flag to enable or disable the request for ESP fast torque decreasing
Enable_Trq_Increase_Fast_ESP	[0|1]	Flag to enable or disable the request for ESP fast torque increasing

Name	Unit	Description
Enable_Trq_Request_Extern1	[0|1]	Flag to enable or disable the first external torque request
Enable_Trq_Request_Extern2	[0|1]	Flag to enable or disable the second external torque request
Factor_Trq_Engine_Red	[%]	Engine torque reduction factor
Mode_StartButtonState	[1|2]	Controls whether the signal for the activation of the start button is calculated by the soft ecu or provided by a stimulus signal. ▪ 1: Stimulus ▪ 2: Soft ECU
n_Engine	[rpm]	Speed of the combustion engine
n_Engine_Idle_Request	[rpm]	Engine idle speed request
Pos_AccPedal_Driver	[%]	Position of the accelerator pedal from the longitudinal controller
Reset_States	[0|1]	Reset states
State_StartButton	[-1|0|1|2]	State of the start button: ▪ -1: Power off ▪ 0: Acceleration ▪ 1: Power on ▪ 2: Starter on
Sw_CrankShaft_Reset	[0|1]	Crankshaft reset switch: ▪ 0: Disabled ▪ 1: Enabled
Sw_Ignition	[0|1]	Ignition signal - terminal 15: ▪ 0: Off ▪ 1: On
Sw_StarterReq	[0|1]	Starter request signal (usually sent to engine ECU): ▪ 0: Off ▪ 1: On
Trq_Decrease_Request_Fast_ESP	[Nm]	ESP fast torque decreasing request
Trq_Increase_Request_Fast_ESP	[Nm]	ESP fast torque increasing request
Trq_Request_Extern1	[Nm]	First external torque request
Trq_Request_Extern2	[Nm]	Second external torque request
Trq_Request_ICE	[Nm]	Torque request ICE
Vehicle_Topology	[-2|-1|0|2]	Vehicle topology: ▪ -2: EM only ▪ -1: ICE only ▪ 0: P0 hybrid ▪ 2: P2 hybrid

Outports Control

The following table shows the ports of the Interface_External_Out:

Name	Unit	Description
CrankAngle_Cyl	[aTDC]	Crank angle per cylinder, positive value is after TDC
Enable_Trq_Shift_Request	[0|1]	Flag to enable the ICE torque intervention during gear shift
EngOP_Num	[]	Engine operation point
n_Engine_Idle_Set	[rpm]	Setpoint for the idle speed of combustion engine
n_Engine_Meas	[rpm]	Measured speed of the combustion engine
p_Ambient	[Pa]	Ambient pressure
Pos_AccPedal_Meas	[%]	Measured accelerator pedal position
State_ICEngine	[0|1|2|3|4]	ICE state: ▪ 0: Off or error ▪ 1: Ignition on ▪ 2: Starter on ▪ 3: Running ▪ 4: Shutdown
State_StartStop	[1|2|3|4]	Start-stop state: ▪ 1: Off, ▪ 2: Not ready ▪ 3: Ready to stop the engine ▪ 4: Engine actively stopped by the system
Sw_Replace_Env	[0|1]	Switch for replacing the ambient conditions ▪ 0: Off - source is parameters ▪ 1: On - source is measurements
Sw_Starter	[0|1]	Starter activate switch: ▪ 0: Off ▪ 1: On
T_Ambient	[°C]	Ambient temperature
Trq_MeanEff_Engine_Meas	[Nm]	Measured mean effective engine torque
Trq_Shift_Request	[Nm]	Torque intervention during gear shift

Inports Plant

The following table shows the ports of the Interface_External_In:

Name	Unit	Description
n_Engine	[rpm]	Speed of combustion engine
Reset_States	[0|1]	Reset states

Name	Unit	Description
v_x_Vehicle	[km/h]	Vehicle velocity in forward direction

Outports Plant

The following table shows the ports of the Interface_External_Out:

Name	Unit	Description
T_Coolant_ICE	[°C]	Temperature of the engine coolant
Trq_Fric_Engine	[Nm]	Friction torque of the engine
Trq_MeanEff_Engine	[Nm]	Mean effective engine torque

Environment Basic Module

Description

The environment provides the reference values to the driver and other model parts, for example to follow a reference velocity profile or an engine speed set. It is possible to perform different maneuvers, like stimulus or driving cycles.

The following tables show the external inports and outports of the ASM module.

Inports Plant

The following table shows the ports of the Interface_External_In:

Name	Unit	Description
EngOP_Num	[]	Engine operation point
n_Engine	[rpm]	Speed of the combustion engine
n_Engine_Meas	[rpm]	Measured speed of the combustion engine
p_Ambient	[Pa]	Ambient pressure
Pos_AccPedal_Meas	[%]	Measured accelerator pedal position
State_Engine	[0|1|2|3|4]	Engine state: ▪ 0: Engine off ▪ 1: Ignition on ▪ 2: Ignition on and starter activated ▪ 3: Engine is running ▪ 4: Ignition is switched off, shutdown active
Sw_Replace_Env	[0|1]	Switch for replacing the ambient conditions: ▪ 0: Off - source is parameters

Name	Unit	Description
		▪ 1: On - source is measurements
T_Ambient	[°C]	Ambient temperature
t_Preview_vRef_Driver	[s]	Preview time for the driver model
Trq_MeanEff_Engine	[Nm]	Mean effective engine torque
Trq_MeanEff_Engine_Meas	[Nm]	Measured mean effective engine torque
v_Vehicle	[km/h]	Vehicle velocity

Outports Plant

The following table shows the ports of the Interface_External_Out:

Name	Unit	Description
Enable_v_Init	[0|1]	Drivetrain initialization flag for scenarios with non-zero vehicle initial velocity
EngOPNum	[]	Engine operating point number
Gear_Maneuver	[]	Gear stimulus from the maneuver
Gear_Max	[0|1_n]	Gear setpoint defined by the maneuver input ▪ 0: Off ▪ 1_n: Gear setpoint
Mode_AcceleratorBrake	[1|2]	Controls whether accelerator and brake pedal positions are stimulus signals or controlled by driver ▪ 1: Stimulus ▪ 2: Driver
Mode_GearClutch	[1|2|3|4]	Switch for the mode signal of gear and clutch pedal source: ▪ 1: Stimulus ▪ 2: Driver ▪ 3: Open clutch ▪ Reference gear
Mode_SelectorLever	[1|2]	Switch for mode signal of the selector lever source: ▪ 1: Stimulus ▪ 2: Driver
Mode_StartButtonState	[1|2]	Controls whether the signal for the activation of the start button is calculated by the soft ECU or provided by a stimulus signal: ▪ 1: Stimulus ▪ 2: Soft ECU
n_Engine_Set	[rpm]	Setpoint for the speed of the combustion engine

Name	Unit	Description
p_Ambient	[Pa]	Ambient pressure
Pos_AccPedal_Maneuver	[%]	Accelerator pedal position stimulus from the maneuver scheduler
Pos_BrakePedal_Maneuver	[%]	Brake pedal position stimulus from the maneuver scheduler
Pos_ClutchPedal_Maneuver	[%]	Clutch pedal position stimulus from the maneuver scheduler
Reset_States	[0|1]	Reset states
s_Total_Vehicle_Road	[m]	Driven distance of the vehicle
SelectorLever_Maneuver	[-3|-2|-1|0|1]	Selector lever position from maneuver: ▪ -3: TipShift ▪ -2: Park ▪ -1: Reverse ▪ 0: Neutral ▪ 1: Drive
Slope	[%]	Slope of the road
State_StartButton	[-1|0|1|2]	State of the start button: ▪ -1: Power off ▪ 0: Acceleration ▪ 1: Power on ▪ 2: Starter on
Sw_StartButton	[0|1]	Start button actuation input: ▪ 0: Off ▪ 1: On
Sw_Testbench	[0|1]	Switch to activate the test bench: ▪ 0: Off ▪ 1: On
Sw_TipShift_Maneuver	[-1|0|1]	TipShift request stimulus signal from the maneuver: ▪ -1 : Down shift ▪ 0: Off ▪ 1: Up shift
Sw_TorqueController	[0|1]	Switch to activate the torque controller: ▪ 0: Off ▪ 1: On
T_Ambient	[°C]	Ambient temperature
v_Vehicle_Ref	[km/h]	Reference vehicle velocity
v_Vehicle_Preview_Ref	[km/h]	Preview reference vehicle velocity

Start System Module

Description

StartSystem

The StartSystem module contains models responsible for switching the engine on and off. It is mainly an ECU which responds to the user actuation request and sends the corresponding instructions to the engine ECU to start or turn off the engine.

The following tables show the external inports and outports of the ASM module.

Inports Control

The following table shows the ports of the Interface_External_In:

Name	Unit	Description
Mode_StartButtonState	[1|2]	Controls whether the signal for the activation of the start button is calculated by the soft ECU or provided by a stimulus signal ▪ 1: By Stimulus signal ▪ 1: By Soft ECU
Mode_Transmission	[1|2]	Transmission mode switch ▪ 1: Manual ▪ 2: Automatic
Pos_BrakePedal	[%]	Brake pedal position
Pos_ClutchPedal	[%]	Clutch pedal position
Reset_States	[0|1]	Reset states
SelectorLever	[-3|-2|-1|0|1]	Selector lever position ▪ -3: TipShift ▪ -2: Park ▪ -1: Reverse ▪ 0: Neutral ▪ 1: Drive
State_Engine	[0|1|2|3|4]	Engine state ▪ 0: Engine off ▪ 1: Ignition on ▪ 2: Ignition on and starter activated ▪ 3: Engine is running ▪ 4: Ignition is switched off, shutdown active
State_StartButton	[-1|0|1|2]	State of the start button ▪ -1: Power off ▪ 0: Accessory on ▪ 1: Power on ▪ 2: Starter on

Name	Unit	Description
Sw_CrankShaft_Reset	[0|1]	Crankshaft reset switch ▪ 0: Disabled ▪ 1: Enabled
Sw_StartButton	[0|1]	Start button actuation input ▪ 0: Off ▪ 1: On

The following table shows the interface to connect an external ECU (real ECU):

Name	Unit	Description
Sw_Ignition	[0|1]	Ignition signal - terminal 15
Sw_StarterReq	[0|1]	Starter request signal (usually sent to engine ECU): ▪ 0: Off ▪ 1: On

Outports Control

The following table shows the ports of the Interface_External_Out:

Name	Unit	Description
Sw_Ignition	[0|1]	Ignition signal - terminal 15 ▪ 0: Off ▪ 1: On
Sw_StarterReq	[0|1]	Starter request signal (usually sent to engine ECU) ▪ 0: Off ▪ 1: On

Torque Manager Basic Module

Description

The hybrid manager basic model serves as a mock-up for a hybrid manager. It is used if the vehicle only has only a conventional internal combustion engine. The signals are remapped so that the engine is set to internal combustion engine only.

It can be exchanged with a more advanced ASM module.

The following tables show the external inports and outports of the ASM module.

Inports Control

The following table shows the ports of the Interface_External_In:

Name	Unit	Description
Pos_BrakePedal	[%]	Brake pedal position
State_Engine	[0|1|2|3|4]	Engine state ▪ 0: Engine off ▪ 1: Ignition on ▪ 2: Ignition on and starter activated ▪ 3: Engine is running ▪ 4: Ignition is switched off, shutdown active
Sw_Ignition	[0|1]	Ignition signal - terminal 15: ▪ 0: Off ▪ 1: On
Sw_Starter	[0|1]	Starter activate switch: ▪ 0: Off ▪ 1: On
Sw_StarterReq	[0|1]	Starter request signal (usually sent to the engine ECU): ▪ 0: Off ▪ 1: On

Outports Control

The following table shows the ports of the Interface_External_Out:

Name	Unit	Description
HybridMode_ICE	[0|1|2|3]	Hybrid mode of the combustion engine: ▪ 0: ICE off ▪ 1: ICE on, idle ▪ 2: ICE on, power ▪ 3: Error
Ignition_ICE	[0|1]	Ignition ICE: ▪ 0: Off ▪ 1: On
Mode_BSG	[-1|0|1|2|3|4|5]	Mode of the belt-driven starter generator (BSG): ▪ -1: Not available ▪ 0: Stop combustion engine ▪ 1: Start combustion engine ▪ 2: Generator ▪ 3: Recuperation ▪ 4: Boost ▪ 5: Idle
Pos_BrakePedal_Desired	[%]	Desired brake pedal position
StarterReq_ICE	[0|1]	Starter request ICE: ▪ 0: Off ▪ 1: On

Name	Unit	Description
Starter_Drivetrain	[0|1]	Engine starter switch: ▪ 0: Off ▪ 1: On
State_DCLink	[0|1]	State DC link: ▪ 0: Off ▪ 1: On
State_Engine	[0|1|2|3|4]	Engine state: ▪ 0: Engine off ▪ 1: Ignition on ▪ 2: Ignition on and starter activated ▪ 3: Engine is running ▪ 4: Ignition is switched off, shutdown active
Sw_DriveMode	[0|1|2]	Drive mode: ▪ 0: Hybrid ▪ 1: ICE only ▪ 2: EM only
Torque_Request_Brake	[Nm]	Torque request brake
Trq_Request_EM	[Nm]	Torque request EM
Trq_Request_ICE	[Nm]	Torque request ICE
Vehicle_Topology	[-2|-1|0|2]	Vehicle topology: ▪ -2: EM only ▪ -1: ICE only ▪ 0: P0 hybrid ▪ 2: P2 hybrid

Vehicle Dynamics Basic Module

Description

Vehicle dynamics calculates the vehicle speed based on the traction and load torque from the external driving resistances (aerodynamics, slope, friction).

The following tables show the external inports and outports of the ASM module.

Outports Control

The following table shows the ports of the Interface_External_Out:

Name	Unit	Description
Enable_p_Brake_Desired	[0|1]	Enable desired brake pressure
Enable_TrqDecrease_Fast_ESP	[0|1]	Enable torque decrease fast ESP

Name	Unit	Description
Enable_TrqDecrease_Slow_ESP	[0|1]	Enable slow torque decrease request for ESP
Enable_TrqIncrease_ESP	[0|1]	Enable ESP torque increase
p_Brake_Desired	[bar]	Desired brake pressure
Trq_DecreaseRequest_Fast_ESP	[Nm]	Torque decrease request fast ESP
Trq_DecreaseRequest_Slow_ESP	[Nm]	ESP slow torque decrease request
Trq_IncreaseRequest_ESP	[Nm]	ESP torque increase request

Inports Plant

The following table shows the ports of the Interface_External_In:

Name	Unit	Description
Ctrl_Parking_Pawl	[0|1]	Parking pawl control signal
Inertia_Out_Diff	[kg m^2]	Inertia reduced to the differential output shaft
Pos_BrakePedal_Desired	[%]	Desired brake pedal position
Reset_States	[0|1]	Reset states
s_Vehicle	[m]	Driven distance of the vehicle
Slope	[%]	Slope of the road
Trq_Out_Diff	[Nm]	Differential output torque

Outports Plant

The following table shows the ports of the Interface_External_Out:

Name	Unit	Description
F_Driving_Res	[N]	Sum of driving resistances acting on the vehicle
m_Total_Vehicle	[kg]	Total vehicle mass
omega_Wheel	[rad/s]	Wheel speed
Trq_Max_Brake	[Nm]	Maximum brake torque
v_Vehicle	[km/h]	Vehicle velocity in km/h
v_Vehicle	[m/s]	Vehicle velocity in m/s

Subsystems

Introduction

The following subsystems are contained inside the ASM modules.

Where to go from here

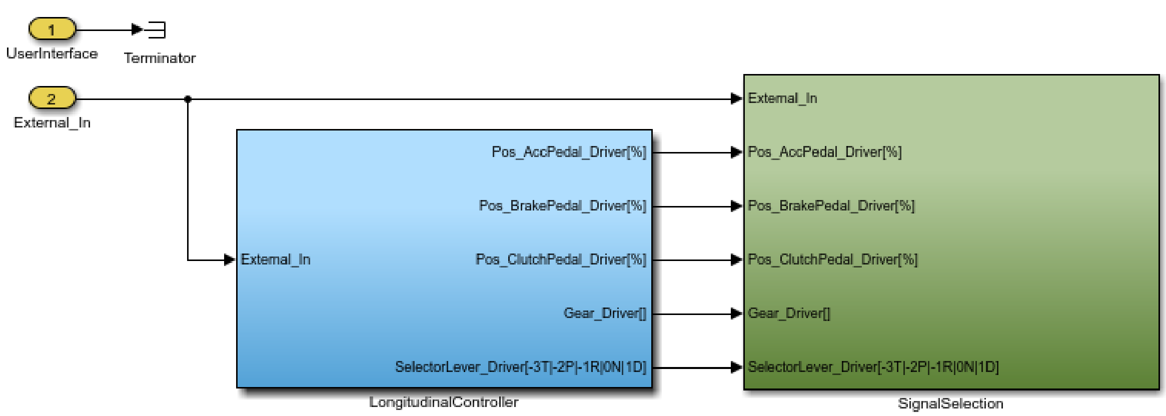
Information in this section

Subsystems of the Driver Basic Module

Driver Subsystem

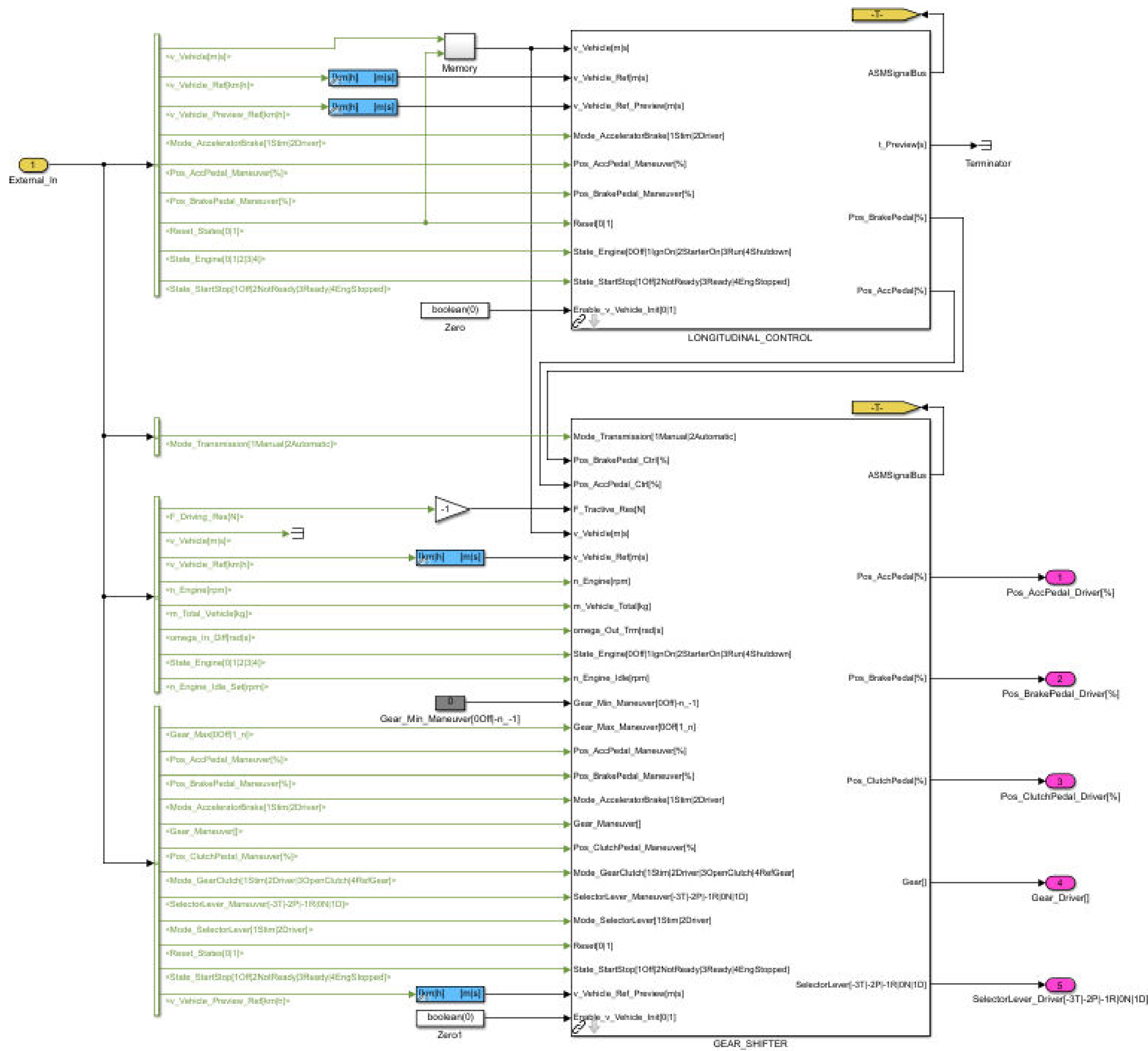
Overview

The **Driver** model consists of two main subsystems, which are shown in the following illustration:



The **SignalSelection** subsystem offers a central access point to all relevant signals of the **Driver** and other environment blocks.

The **LongitudinalController** subsystem includes the main longitudinal driver models, which are used to control the accelerator pedal, brake pedal, selector lever, clutch pedal, and gearshift. The following illustration shows the LongitudinalController subsystem:



The LONGITUDINAL_CONTROL block controls the accelerator pedal and brake pedal. Both pedals are controlled in such a way that the vehicle follows a given reference velocity. The longitudinal controller comprises feedback and feed forward. Only one of the two pedals can be activated at a time.

The longitudinal driver models can handle several drivetrain and brake system variants. The blocks provide interfaces for easy adaptation to new vehicle variants.

The GEAR_SHIFTER block controls the gears and clutch for manual transmission and the selector lever for automatic transmission. The accelerator pedal and brake pedal positions are modified in particular driving situations. Vehicle startup is also done by the GEAR_SHIFTER block.

Simulation scenarios

The longitudinal driver models are configurable and can be set to perform several simulation scenarios, which are summarized in the following table:

Scenario	Source		Driver Task	
	Reference	Stimulus	Manual Transmission	Automatic Transmission
1	Velocity	–	Driver controls AccPedal, BrakePedal, Gear, and ClutchPedal	Driver controls AccPedal, BrakePedal, and SelectorLever
2	Velocity Gear	–	Driver controls AccPedal, BrakePedal, and ClutchPedal	Driver controls AccPedal, BrakePedal, and SelectorLever
3	Velocity	ClutchPedal Gear	Driver controls AccPedal and BrakePedal	Driver controls AccPedal, BrakePedal, and SelectorLever
4	–	AccPedal BrakePedal	Driver controls ClutchPedal and Gear	Driver controls SelectorLever

The simulation scenarios are illustrated in more detail in the following:

Scenario 1 The driver follows the reference velocity by controlling the accelerator, brake and clutch pedals. Additionally, the gearshift or the selector lever is controlled, depending on the transmission type.

Scenario 2 The driver follows the reference velocity and gear by controlling the accelerator, brake and clutch pedals. In this case, the reference gear is used to trigger the clutch pedal control or the selector lever, depending on the transmission type.

Scenario 3 The driver follows the reference velocity, while the positions of the gearshift and the clutch pedal are predefined. In this case, the driver controls the accelerator and brake pedals. If automatic transmission is active, the predefined gear is used to trigger the selector lever control.

Scenario 4 The driver controls the clutch pedal and the gearshift as well as the selector lever according to the accelerator and brake pedals. These are controlled by a stimulus.

The longitudinal driver models offer a wide variety of features, which can be configured by using the model parameters. The following table shows the most important features:

Feature	Description
Engine stall detection	All controls are disabled when the engine has been stalled.
Gear skipping and hold during downshift	During emergency or hard braking, the driver holds the current gear or skips gears during fast downshift.
Gear skipping during upshift	The driver skips gears during acceleration.
Startup gear	The driver selects the most suitable gear during startup.
Gear passing through neutral during gearshift	The driver passes the gear through neutral during gearshift.
Clutch hold during gearshift	The driver holds the clutch completely open during gearshift.
Following low velocities	The driver controls a slipping clutch to follow low velocities.

Feature	Description
Considering the tractive resistance	The driver takes the tractive resistance into consideration during startup and gearshift.
Backwards driving	The driver can drive backwards with manual and automatic transmission.

Subsystems

The following list contains all the model's subsystems:

- Longitudinal Control on page 89
- Gear Shifter on page 74

Subsystems of the Drivetrain DCT Module

Soft ECU Transmission Subsystem

Description

The Soft ECU Transmission model is used to simulate the behavior of a transmission control unit (TCU).

Its main task is to control the gearshift process, which is initiated by using either the selector lever or the TipShift lever. In addition to the gearshift task, there are control strategies for normal clutches and torque converters equipped with a lockup clutch.

The driver can request gear engagement by controlling the selector lever, which has the following positions:

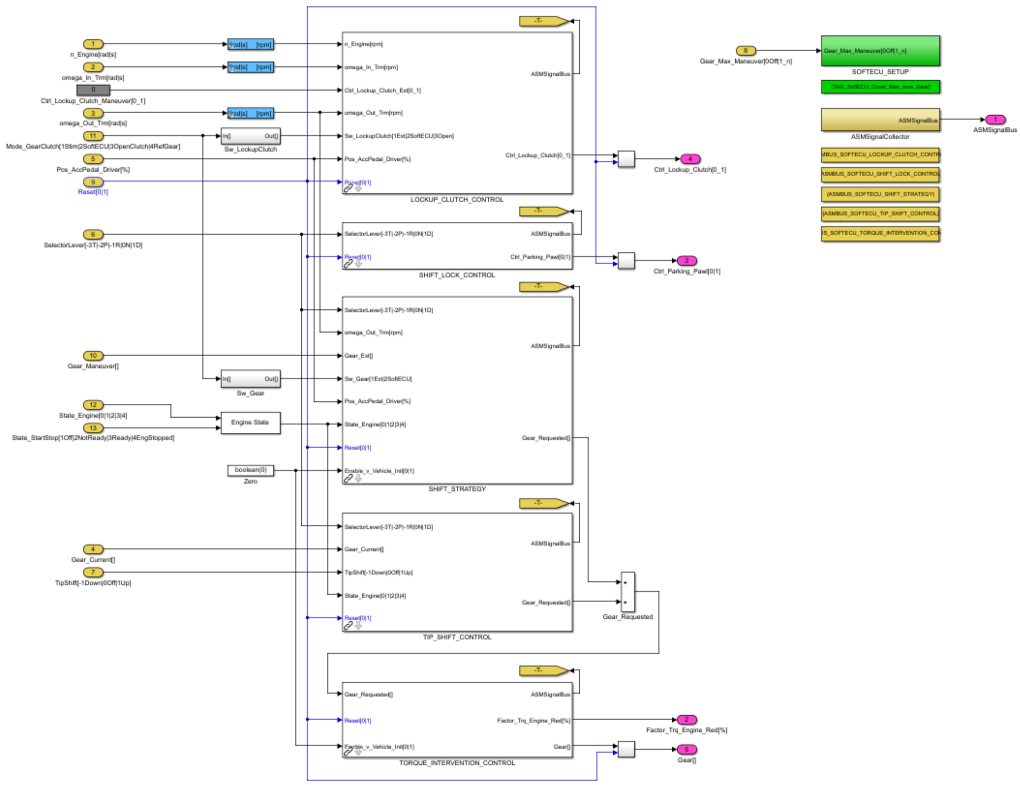
Position	Description
P	Park: Activates the parking pawl
R	Reverse: Engages the reverse gear
N	Neutral: Engages the neutral gear
D	Drive: Engages the first gear and afterwards shifts up or down automatically according to the driving situation
T	TipShift: Activates the TipShift (TipTronic) function. The gears can then be shifted according to the driver's demand

The implementation of the Soft ECU Transmission is divided into several modular blocks according to specific functions:

- CLUTCH_ENGAGEMENT_CONTROL: clutch control strategy
- LOCKUP_CLUTCH_CONTROL: lockup clutch control strategy
- SHIFT_LOCK_CONTROL: shift lock
- SHIFT_STRATEGY: gearshift strategy

- SOFTECU_TRANSMISSION_SETUP: common soft ECU parameters
- TORQUE_INTERVENTION_CONTROL: engine torque intervention during gearshift
- TIP_SHIFT_CONTROL: TipShift control
- DCT_PRESELECTED_GEAR (refer to DCT Preselected Gear on page 147): preselected gear for DCT
- DUAL_CLUTCH_PRESSURE_SET (refer to Dual Clutch Pressure Set on page 132): dual clutch pressure setpoint
- DUAL_CLUTCH_PRESSURE_CONTROL (refer to Dual Clutch Pressure Control on page 130): dual clutch pressure control
- DCT_STATE (refer to DCT State on page 153): state of DCT
- DCT_SETUP (refer to DCT Setup on page 136): common Soft ECU parameters for DCT
- DUAL_CLUTCH_ENGINE_INTERVENTION (refer to Dual Clutch Engine Intervention on page 139): engine torque intervention during gearshift for DCT
- LINE_PRESSURE_CONTROL (refer to Line Pressure Control on page 156): line pressure control
- GEAR_SELECTOR_POSITION_SET (refer to Gear Selector Position Set on page 145): gear selector position setpoint
- GEAR_SELECTOR_POSITION_CONTROL (refer to Gear Selector Position Control on page 143): gear selector position control
- DIRECTIONAL_VALVE_CONTROL (refer to Directional Valve Control on page 155): directional valve control
- PRESSURE_VALVE_CONTROL (refer to Pressure Valve Control on page 157): pressure valve control

The following illustration shows an example of the Soft ECU for an Automatic Transmission:



Inports

The following table shows the inports:

Name	Unit	Description
Gear_Current	[]	Current gear
Gear_Maneuver	[]	External stimulus gear
Gear_Max_Maneuver	[0Off|1_n]	Highest allowed gear for the maneuver
Mode_GearClutch	[1|2|3|4]	Gear and clutch mode: ▪ 1: Stimulus mode ▪ 2: Soft ECU mode ▪ 3: Open clutch mode ▪ 4: Reference gear mode
n_Engine	[rad/s]	Engine speed
omega_In_Trm	[rad/s]	Transmission input speed
omega_Out_Trm	[rad/s]	Transmission output speed
Pos_AccPedal_Driver	[%]	Accelerator pedal position from driver
Reset	[0|1]	Reset of states
SelectorLever	[-3|-2|-1|0|1]	Selector lever position for automatic transmission ▪ -3 : TipShift

Name	Unit	Description
		▪ -2 : Park ▪ -1 : Reverse ▪ 0 : Neutral ▪ 1 : Drive
State_Engine	[0|1|2|3|4]	Engine state switch: ▪ 0: Engine off/Error ▪ 1: Ignition on ▪ 2: Starter on ▪ 3: Engine running ▪ 4: Engine shutdown
TipShift	[-1|0|1]	TipShift request signal for TipTronic function: ▪ -1 : Downshift ▪ 0 : Off ▪ 1 : Upshift

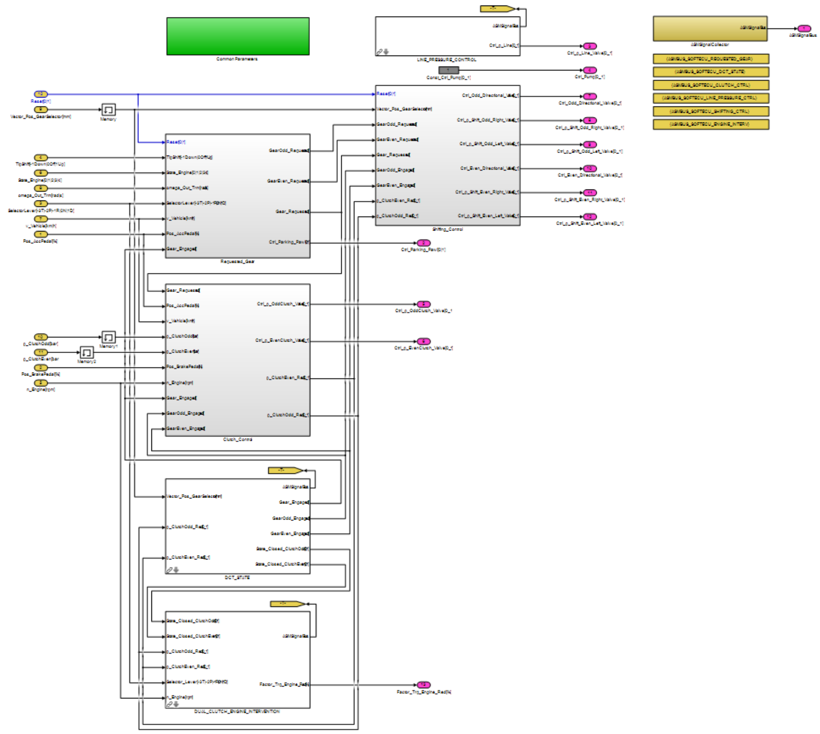
Outports

The following table shows the outports:

Name	Unit	Description
ASMSignalBus	[]	Signal bus that contains signals of ASM components. Refer to ASMSignalBus (ASM User Guide).
Ctrl_Lockup_Clutch	[%]	Lockup clutch control signal
Ctrl_Parking_Pawl	[0|1]	Parking pawl control signal
Factor_Trq_Engine_Red	[%]	Engine torque reduction factor
Gear	[]	Requested gear

Example

The following illustration shows an example of the Soft ECU for an Dual-Clutch-Transmission:



Inports

The following table shows the inports:

Name	Unit	Description
n_Engine	[rad/s]	Engine speed
omega_Out_Trm	[rad/s]	Transmission output speed
Pos_AccPedal	[%]	Accelerator pedal position from driver
Pos_BrakePedal	[%]	Brake pedal position from driver
p_ClutchEven	[bar]	Cylinder pressure of the even clutch
p_ClutchOdd	[bar]	Cylinder pressure of the odd clutch
Reset	[0|1]	Reset of states
SelectorLever	[-3|-2|-1|0|1]	Selector lever position for automatic transmission ▪ -3: Tip shift ▪ -2: Park ▪ -1: Reverse ▪ 0: Neutral ▪ 1: Drive
State_Engine	[0|1|2|3|4]	▪ 0: Engine off / Error ▪ 1: Ignition on ▪ 2: Starter on ▪ 3: Engine running

Name	Unit	Description
		▪ 4: Engine shutdown
TipShift	[-1|0|1]	Tip shift request signal for tiptronic function: ▪ -1: Downshift ▪ 0: Off ▪ 1: Upshift
Vector_Pos_GearSelector	[mm]	Vector of gear selectors positions
v_Vehicle	[km/h]	Vehicle velocity

Outports

The following table shows the outports:

Name	Unit	Description
ASMSignalBus	[]	Signal bus that contains signals of ASM components. Refer to ASMSignalBus (ASM User Guide 📖).
Ctrl_Parking_Pawl	[0|1]	Parking pawl control signal
Ctrl_p_Line_Valve	[0_1]	Control signal of the line pressure control valve
Ctrl_Pump	[0_1]	Control signal of the hydraulic pump
Ctrl_p_OddClutch_Valve	[0_1]	Control signal of the odd clutch pressure control valve
Ctrl_p_EvenClutch_Valve	[0_1]	Control signal of the even clutch pressure control valve
Ctrl_Odd_Directional_Valve	[0_1]	Control signal of the odd gears directional valve
Ctrl_p_Shift_Odd_Right_Valve	[0_1]	Control signal of the shift pressure control valve of the odd/right gears
Ctrl_p_Shift_Odd_Left_Valve	[0_1]	Control signal of the shift pressure control valve of the odd/left gears
Ctrl_Even_Directional_Valve	[0_1]	Control signal of the even gears directional valve
Ctrl_p_Shift_Even_Right_Valve	[0_1]	Control signal of the shift pressure control valve of the even/right gears
Ctrl_p_Shift_Even_Left_Valve	[0_1]	Control signal of the shift pressure control valve of the even/left gears
Factor_Trq_Engine_Red	[%]	Engine torque reduction factor

Subsystems of the Engine Basic Module

Where to go from here

Information in this section

Engine Basic Subsystem

Overview

The engine is the power source in the drivetrain, and the driver controls the engine by the accelerator pedal. The output of the engine is the torque resulting from both the combustion and the resulting engine speed. The engine model does not model the combustion process. In the engine block, the engine torque is calculated as a function of engine speed and accelerator pedal position

Subsystems

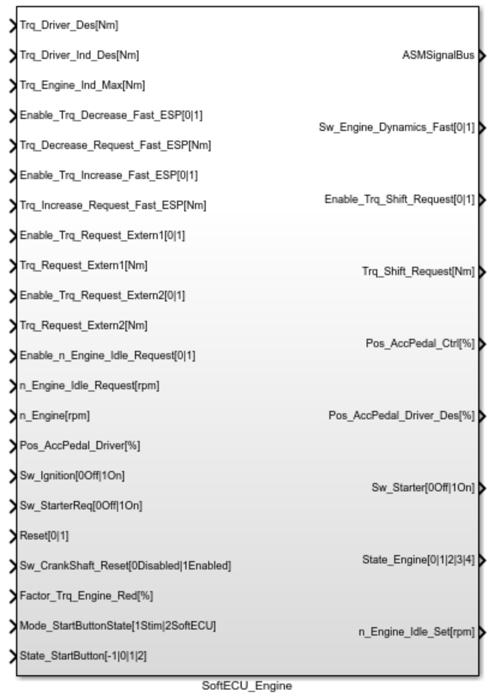
- Engine on page 69
- Fuel Consumption on page 71

Soft ECU Engine Subsystem

Description

The soft ECU engine gets torque requests from different ECUs and systems, for example, an ESP ECU, a CC ECU or a hybrid management system. These requests depend on the dynamic states of the vehicle, which require the engine torque to be decreased or increased. The engine ECU can control engine torque in a slow way (for example, by setting the accelerator pedal position) or in a fast way (for example, by controlling the injection and ignition).

Also an idle speed control is included in the soft ECU.



Inports

The following table shows the inports.

Name	Unit	Description
Enable_n_Engine_Idle_Request	[0|1]	Switch to activate the engine idle speed request: ▪ 0: Off ▪ 1: On
Enable_Trq_Decrease_Fast_ESP	[0|1]	Signal from ESP ECU to enable or disable the fast torque decreasing request
Enable_Trq_Increase_Fast_ESP	[0|1]	Signal from ESP ECU to enable or disable the fast torque increasing request
Enable_Trq_Request_Extern	[0|1]	Signal to enable or disable the external torque request
Factor_Trq_Engine_Red	[%]	Requested engine torque reduction factor from the transmission control unit
Mode_StartButtonState	[1|2]	Mode of start button state: ▪ 1: Stimulus ▪ 2: Soft ECU
n_Engine	[rpm]	Engine speed
n_Engine_Idle_Request	[rpm]	Engine idle speed request
Pos_AccPedal_Driver	[%]	Driver accelerator pedal position
Reset	[]	Reset of states
State_StartButton	[-1|0|1|2]	Start button state in case of stimulus: ▪ -1: Power off

Name	Unit	Description
		▪ 0: Power on ▪ 1:Accessory on ▪ 2: Starter on
Sw_Crankshaft_Reset	[0|1]	Switch to enable/disable crankshaft reset: ▪ 0: Disable ▪ 1: Enable
Sw_Ignition	[0|1]	Ignition signal (terminal 15) ▪ 0: Off ▪ 1: On
Sw_StarterReg	[0|1]	Starter request signal (usually sent to engine ECU) ▪ 0: Off ▪ 1: On
Trq_Decrease_Request_Fast_ESP	[Nm]	The torque request from ESP ECU, fast decreasing
Trq_Driver_Des	[Nm]	Driver desired torque
Trq_Driver_Ind_Des	[Nm]	Desired indicated torque reqeusted by the driver
Trq_Engine_Ind_Max	[Nm]	Maximum available indicated engine torque
Trq_Increase_Request_Fast_ESP	[Nm]	The torque request from ESP ECU, fast increasing
Trq_Request_Extern	[Nm]	The external torque request

Outports

The following table shows the outports.

Name	Unit	Description
ASMSignalBus	[]	Signal bus that contains signals of ASM components. Refer to ASMSignalBus (ASM User Guide 📖).
Pos_AccPedal_Driver_Des	[%]	Driver desired accelerator pedal position
Pos_AccPedal_Ctrl	[%]	Accelerator pedal position influenced by the idle speed controller and the torque intervention
State_Engine	[0|1|2|3|4]	Engine state ▪ 0: Engine off ▪ 1: Ignition on ▪ 2: Ignition on and starter activated ▪ 3: Engine running ▪ 4: Ignition switched off, shutdown
Sw_Engine_Dynmaics_Fast	[0|1]	Flag, routed to engine basic, to increase the engine dynamic ▪ 0: Standard ▪ 1: Fast
Sw_Starter	[0|1]	Switch for starter activation (output from ECU) ▪ 0: Off ▪ 1: On

Blocks

- Idle Speed Control Engine Basic
- ESP Fast Torque Set
- Torque Intervention Basic
- Shift Torque Set
- Engine Operation Basic

Blocks from Former Versions

Introduction

The following topics provide information on blocks that were used in former library versions.

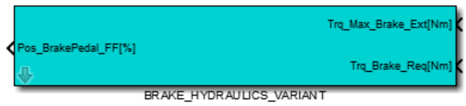
Where to go from here

Information in this section

Brake Hydraulics Variant

Description

The brake hydraulics variant contains the variant-dependent inverse model of the brake system. It provides the feed forward control for the brake pedal according to a required braking torque.



The brake hydraulics variant subsystem contains a simplified inverse model of the brake system. It calculates the required brake pedal position according to a required braking torque.

Inports

The following table shows the inports.

Name	Unit	Description
Trq_Brake_Req	[Nm]	Braking torque requested from feed forward controller
Trq_Max_Brake_Ext	[Nm]	Maximum braking torque at 100% brake pedal position

Outports

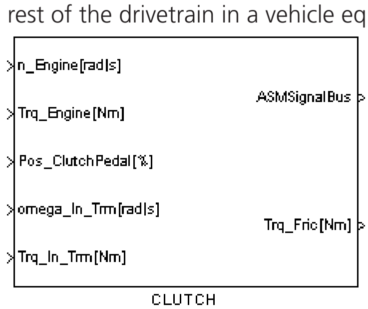
The following table shows the outports.

Name	Unit	Description
Pos_BrakePedal_FF	[%]	Brake pedal position corresponding to the requested braking torque

Clutch (Version 2.0 or Earlier)

Description

The function of the clutch is to connect and disconnect the engine to/from the rest of the drivetrain in a vehicle equipped with a manual gearbox.



The clutch friction torque is composed of two components. The clutch static torque T_{cst} balances the motor and the gearbox input to run at almost the same speed. To allow the transition from a certain slip speed to the locked state, a dynamic term is added as a function of the relative velocity. The maximum friction torque $T_{cfr,max}$ is a function of the clutch geometry parameters. The following equation shows the calculation of the clutch friction torque:

$$T_{cfr} = \left[T_{cst} + D\left(\omega_{Engine} - \omega_{Trm,In}\right)\right] \le T_{cfr,max}$$

The static torque can be calculated from the steady state condition, at $(\omega_{Engine} - \omega_{Trm,In})$, which leads to the static torque calculation

$$T_{cst} = \frac{T_{Engine} + T_{Trm,In}}{2}$$

Note

The maximum transferable clutch friction torque is scaled with the clutch pedal position from zero to the fully depressed position.

Inports

The following table shows the inports:

Name	Unit	Description
n_Engine	[rad/s]	Engine speed
omega_In_Trm	[rad/s]	Transmission input shaft speed
Pos_Clutch_Pedal	[%]	Position of the clutch pedal for manual transmission
Trq_Engine	[Nm]	Mean effective engine torque
Trq_In_Trm	[Nm]	Input torque from transmission input shaft

Outports

The following table shows the outports:

Name	Unit	Description
Trq_Fric	[Nm]	Clutch friction torque to crankshaft

Parameters

The following table shows the block parameters:

Name	Unit	Description
Const_Damping	[Nm/rad/s]	Clutch torsion spring damping
Const_Torque_Max	[Nm]	Maximum transferable clutch friction torque

Related topics

References

Clutch.......... 33
Clutch (Version 2.0 or Earlier) (ModelDesk Parameterizing 🕮)

Common Drivetrain Parameters (Version 4.0 or Earlier)

Description

Common parameters is a subsystem containing all parameters used several times in the model. It provides a central access point to the parameters for online access. If a parameter is changed, the change affects all the parts of the model that use the parameter online and offline.

Outports

The following table shows the outports:

Name	Unit	Description
Const_Diff_Ratio	[]	Final drive ratio
Const_m_Vehicle	[kg]	Vehicle mass
Const_r_Tire	[m]	Dynamics tire radius

Related topics

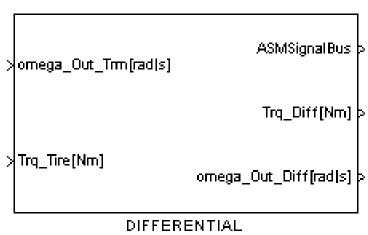
References

Common Drivetrain Parameters (Version 4.0) (ModelDesk Parameterizing 🕮)
Differential Basic V2 (ModelDesk Parameterizing 🕮)

Differential (Version 2.0 or Earlier)

Description

The differential transmits the torque from the gearbox with a fixed ratio to the tires.



The differential model contains a simple ratio between the input and output torque. No efficiency and no speed differences between the two output shafts are considered.

Inports

The following table shows the inports:

Name	Unit	Description
omega_Out_Trm	[rad/s]	Transmission output speed
Try_Tire	[Nm]	Tire torque

Outports

The following table shows the outports:

Name	Unit	Description
Trq_Diff	[Nm]	Differential torque
omega_Out_Diff	[rad/s]	Differential output speed

Related topics

References

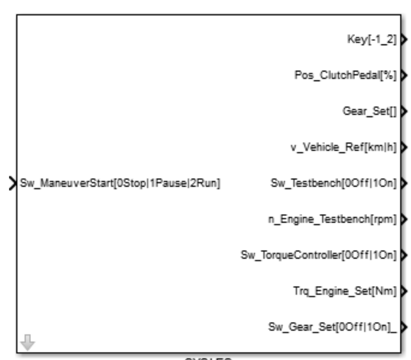
CYCLES Block (Version 7.0 or Earlier)

Description

The driver maneuver contains the engine and chassis dynamometer test cycles, which can be defined by a certain MATLAB function in your installation.

CYCLES

The CYCLES block provides the necessary data to simulate engine as well as chassis dynamometer test cycles. Several standard emission test procedures are included and can be used in combination with the ASM demos.



CYCLES

The longitudinal driver model follows the reference velocity, which is defined by the chassis dynamometer test cycles. The test bench and torque controller models are used to control the reference engine speed and torque, which are defined by the engine test cycles.

The following test cycles are included in the installation:

Test Cycle	Description
AC	Aachen city cycle
ESC	European Stationary Cycle

Test Cycle	Description
ETC	New transient cycle for truck and bus engines
EUDC	Extra-urban driving cycle for low-powered vehicles without additional gear information
EUDC with gear	Extra-urban driving cycle for low-powered vehicles including additional gear information for five gears
EUDC with 6 gears	Extra-urban driving cycle for low-powered vehicles including additional gear information for six gears
FFE_City	City cycle
FTP75	Federal test procedure
FTP75_short	Federal test procedure without pause
FTP75_transient	Engine dynamometer schedule for heavy-duty diesel engines
US06	Supplemental FTP driving schedule
SC03	Supplemental FTP driving schedule
JP_JC08	Japanese chassis dynamometer test cycle for light vehicles (< 3500 kg GVW)
JP_JE05	The JE05 cycle (also known as the ED12) is a transient test based on Tokyo driving conditions.
JP_JE05 with gear	The JE05 cycle (also known as the ED12) is a transient test based on Tokyo driving conditions. This data also includes gear information for a five-gear transmission.
HIGHWAY	Highway fuel economic test driving cycle
Jap_10-15	Japanese 10-15 exhaust emission & fuel economy driving schedule
WHTC	Engine dynamometer schedule for truck and bus engines
WLTC_Class1	Worldwide Harmonized Light Vehicle Test Procedure of class 1
WLTC_Class2	Worldwide Harmonized Light Vehicle Test Procedure of class 2
WLTC_Class3	Worldwide Harmonized Light Vehicle Test Procedure of class 3

Note

The test cycle has to be initialized by the `asm_eng_drivingcycles.m` function. For a detailed explanation, refer to asm_eng_drivingcycles (ASM User Guide 📖).

Inports

The following table shows the inports:

Name	Unit	Description
Sw_ManeuverStart	[0|1|2]	Switch used to control the time of the Driver maneuver: ▪ 0: Stop maneuver ▪ 1: Pause maneuver ▪ 2: Run maneuver

Outports

The following table shows the outports:

Name	Unit	Description
Gear_Set	[]	Gear position setpoint for manual transmission
Key	[-1|0|1|2]	Key position: ▪ -1: Off ▪ 0: Park ▪ 1: Ignition on ▪ 2: Starter request
n_Engine_Testbench	[rpm]	Engine speed setpoint for the test bench
Pos_ClutchPedal	[%]	Clutch pedal position for the gear position setpoint
Sw_Gear_Set	[0|1]	Switch to activate external gear setting: ▪ 0: Off ▪ 1: On
Sw_Testbench	[0|1]	Switch to activate the engine test bench: ▪ 0: Off ▪ 1: On
Sw_Torque_Controller	[0|1]	Switch to activate the torque controller: ▪ 0: Off ▪ 1: On
Trq_Engine_Set	[Nm]	Engine torque setpoint for torque controller
v_Vehicle_Ref	[km/h]	Reference vehicle velocity

Parameters

The following table shows the block parameters:

Name	Unit	Description
Const_Key_Time_Offset	[s]	Key offset time
Const_Start_Time	[s]	Test cycle initial time
Const_n_Engine_Max	[rpm]	Maximum engine speed
Const_n_Engine_Min	[rpm]	Minimum engine speed
Map_Gear_Set	[]	Gear setpoints during chassis dynamometer cycle
Map_KeyState	[-1_2]	Key state
Map_Pos_ClutchPedal	[%]	Clutch pedal setpoints during chassis dynamometer cycle
Map_Sw_Testbench	[0|1]	Test bench activation switch during engine dynamometer cycle: ▪ 0: Off ▪ 1: On
Map_Sw_TorqueController	[0|1]	Torque controller activation switch during engine dynamometer cycle: ▪ 0: Off ▪ 1: On
Map_Trq_Engine_Max	[Nm]	Maximum engine torque map as a function of the engine speed
Map_Trq_Engine_Set	[]	Engine torque setpoints during engine dynamometer cycle
Map_n_Engine_Testbench	[]	Engine speed setpoints during engine dynamometer cycle

Name	Unit	Description
Map_v_Vehicle_Ref	[km/h]	Reference vehicle velocity during chassis dynamometer cycle
StepSize	[s]	Simulation step size
Sw_Gear_Set	[0|1]	Gear setpoints activation switch during chassis dynamometer cycle: ▪ 0: Off ▪ 1: On
Sw_Unit_Trq_Engine	[1|2]	Unit of engine torque setpoints: ▪ %: Percentage of the maximum value ▪ Nm: Absolute value in Nm
Sw_Unit_n_Engine	[1|2]	Unit of engine speed setpoints: ▪ %: Percentage of the maximum value ▪ rpm: Absolute value in rpm

Related topics

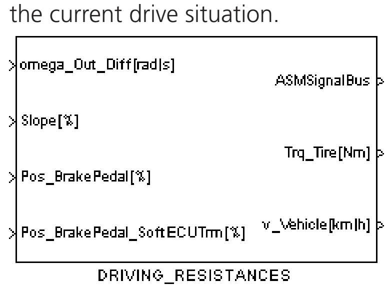
References

Cycles V7 (ModelDesk Parameterizing 📖)
Engine Data V7 (ModelDesk Parameterizing 📖)

Driving Resistances (Version 4.0 or Earlier)

Description

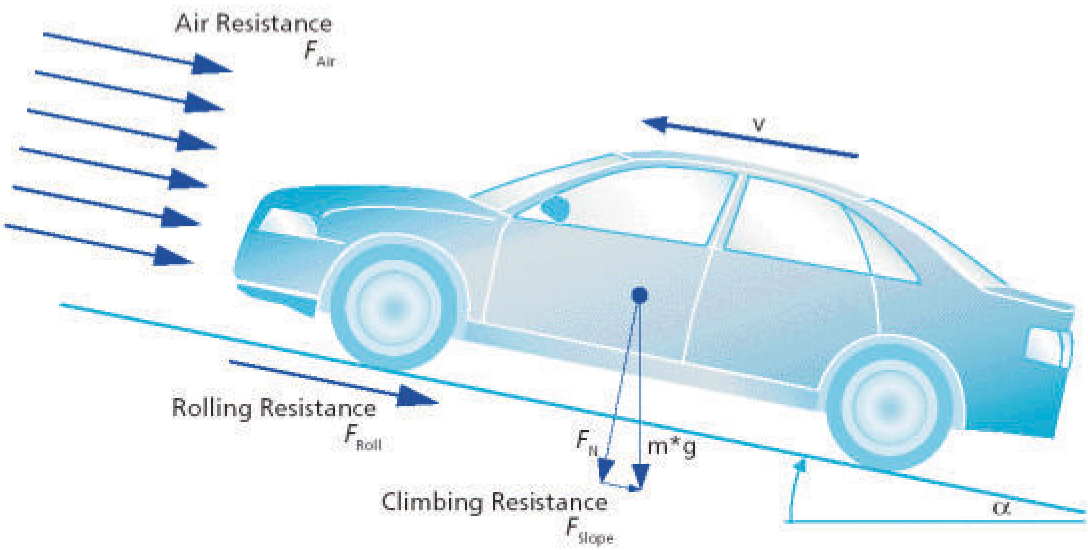
This model calculates the driving resistances and the vehicle speed according to the current drive situation.



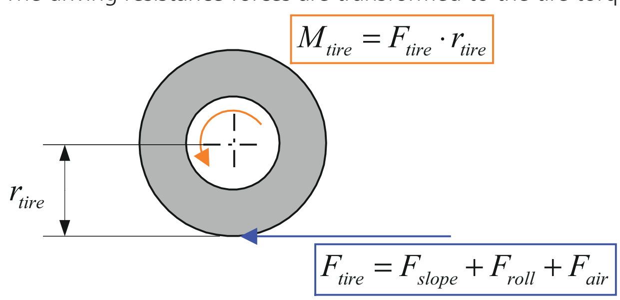
The driving resistances of the vehicle can be calculated with the following forces:

- Air resistance
- Slope resistance
- Brake resistance
- rolling resistance

The illustration below illustrates the forces.



The driving resistance forces are transformed to the tire torque via the tire radius.



The vehicle speed is calculated with the following equation:

$$v_{Vehicle} = n_{OutDiff} \cdot 2 \cdot \pi \cdot r_{Tyre}$$

Inports

The following table shows the inports:

Name	Unit	Description
omega_Out_Diff	[rad/s]	Differential output speed
Pos_BrakePedal	[%]	Position of the brake pedal
Pos_BrakePedal_SoftECUTrm	[%]	Position of the brake pedal for parking position of automatic transmission
Slope	[%]	Road slope

Outports

The following table shows the outports:

Name	Unit	Description
Trq_Tire	[Nm]	Tire torque
v_Vehicle	[km/h]	Vehicle speed

Parameters

The following table shows the block parameters:

Name	Unit	Description
Const_A_Vehicle	[m²]	Vehicle cross section
Const_Cw_Vehicle	[]	cw value
Const_F_Brake_max	[N]	Maximum braking force
Const_m_Vehicle	[kg]	Vehicle mass
Const_mue_Tire	[]	Friction coefficient tire
Const_r_Tire	[m]	Tire radius
Const_Rho_Air	[kg/m³]	Air density
g	[m/s²]	Gravity acceleration

Related topics

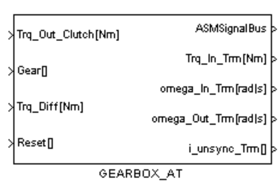
References

Driving Resistances...159
Vehicle Dynamics Basic V4 (ModelDesk Parameterizing)

Gearbox_AT (Version 8.0 or Earlier)

Description

From the point of view of the model, the automatic transmission is identical to the manual transmission.



The automatic transmission model calculates the gearbox output speed from the clutch and the load torque. The model takes into account that a gearshift changes the inertias of the gearbox. This is taken into account via extended Newton's law.

$$\dot{\omega} = \frac{-i_{Gear} \cdot Trq_{clutch} - 2 \cdot \dot{i}_{Gear} \cdot i_{Gear} \cdot J_{Transmission,\,in} \cdot \omega - Trq_{Diff} - Trq_{Brake}}{{i_{Gear}}^2 \cdot J_{Transmission,\,in} + J_{Transmission,\,out}}$$

Synchronization during a shift process is represented by a first-order delay element.

$$t_{Gear} \cdot \dot{i}_{Gear} + i_{Gear} = i_{Gear,\,set}$$

This also provides the time derivative of the gear ratio which is used for extended Newton's law.

Inports

The following table shows the inports:

Name	Unit	Description
Gear	[]	Selected gear for automatic transmission
Reset	[]	Reset all integrators to their initial conditions
Trq_Diff	[Nm]	Differential torque
Trq_Out_Clutch	[Nm]	Clutch torque to transmission

Outports

The following table shows the outports:

Name	Unit	Description
i_unsync_Trm	[]	Unsynchronized transmission ratio
omega_In_Trm	[rad/s]	Transmission input shaft speed
omega_Out_Trm	[rad/s]	Transmission output shaft speed
Trq_In_Trm	[Nm]	Transmission input torque

Parameters

The following table shows the block parameters:

Name	Unit	Description
Const_Gear_Ratio	[]	Table of gear ratio
Const_Inertia_Clutch	[kg m²]	Inertia of clutch
Const_Inertia_Drivetrain	[kg m²]	Inertia of drive shaft
Const_Inertia_Geartrain_In	[kg m²]	Inertia of transmission input shaft
Const_Inertia_Geartrain_Out	[kg m²]	Inertia of transmission output shaft
Const_T_PT1	[s]	Time constant of first-order delay for synchronization
StepSize	[s]	Simulation step size

Related topics

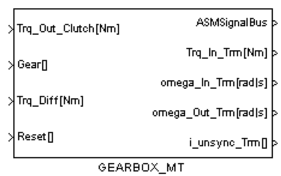
References

Automatic Transmission Basic V8 (ModelDesk Parameterizing 📖)
Gearbox Automatic Transmission.. 63

Gearbox_MT (Version 8.0 or Earlier)

Description

The manual transmission model calculates the gearbox output speed from the clutch and the load torque.



The model takes into account that a gearshift changes the inertias of the gearbox with extended Newton's law.

$$\dot{\omega} = \frac{-i_{Gear} \cdot T_{Clutch} - 2 \cdot \dot{i}_{Gear} \cdot i_{Gear} \cdot J_{Trm,\,In} \cdot \omega - T_{Load}}{i_{Gear} \cdot J_{Trm,\,in} + J_{Trm,\,Out}}$$

Synchronization during a shift process is represented by a first-order delay element.

$$t_{Gear} \cdot \dot{i}_{Gear} + i_{Gear} = i_{Gear,\,set}$$

This also provides the time derivative of the gear ratio which is used for extended Newton's law.

Inports

The following table shows the inports:

Name	Unit	Description
Gear	[]	Selected gear for automatic transmission
Reset	[]	Reset all integrators to their initial conditions
Trq_Diff	[Nm]	Differential torque
Trq_Out_Clutch	[Nm]	Clutch torque to transmission

Outports

The following table shows the outports:

Name	Unit	Description
i_unsync_Trm	[]	Unsynchronized transmission ratio
omega_In_Trm	[rad/s]	Transmission input shaft speed
omega_Out_Trm	[rad/s]	Transmission output shaft speed
Trq_In_Trm	[Nm]	Clutch torque

Parameters

The following table shows the block parameters:

Name	Unit	Description
Const_Gear_Ratio	[]	Table of gear ratio
Const_Inertia_Clutch	[kgm²]	Inertia of clutch
Const_Inertia_Drivetrain	[kgm²]	Inertia of drive shaft
Const_Inertia_Geartrain_In	[kgm²]	Inertia of transmission input shaft
Const_Inertia_Geartrain_Out	[kgm²]	Inertia of transmission output shaft
Const_T_PT1	[s]	Time constant of first-order delay for synchronization
StepSize	[s]	Simulation step size

Related topics

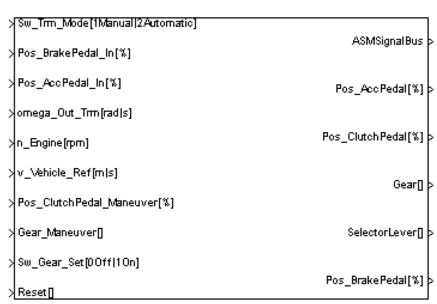
References

Gearbox Manual Transmission.. 61
Manual Transmission Basic V8 (ModelDesk Parameterizing 📖)

Gearshifter (Version 6.0 or Earlier)

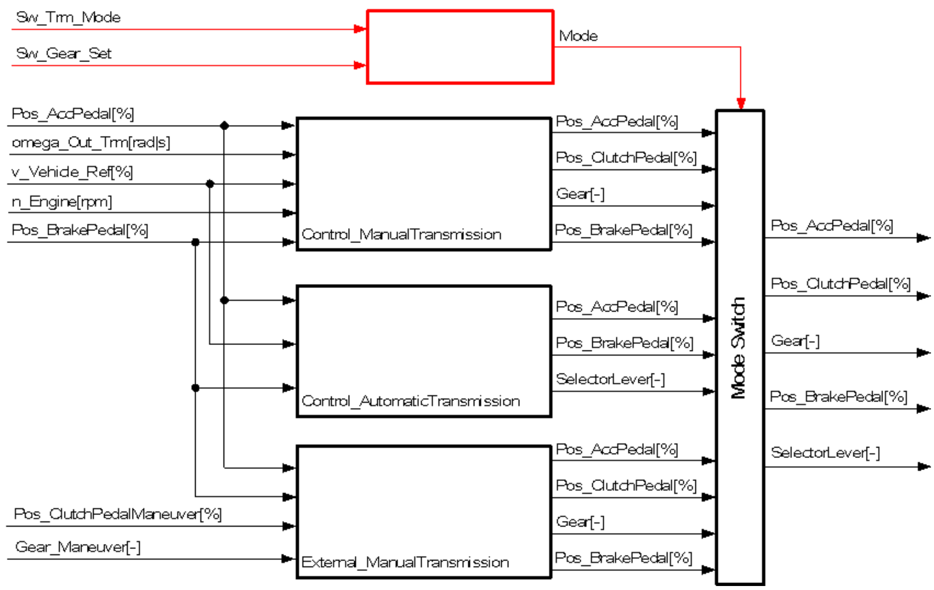
Description

The **GEAR_SHIFTER** block shifts the gears according to the current driving situation for an automatic or manual transmission.



GEAR_SHIFTER

The following illustration presents an overview of the modes of the GEAR_SHIFTER block.



The GEAR_SHIFTER block can handle three different shift modes:

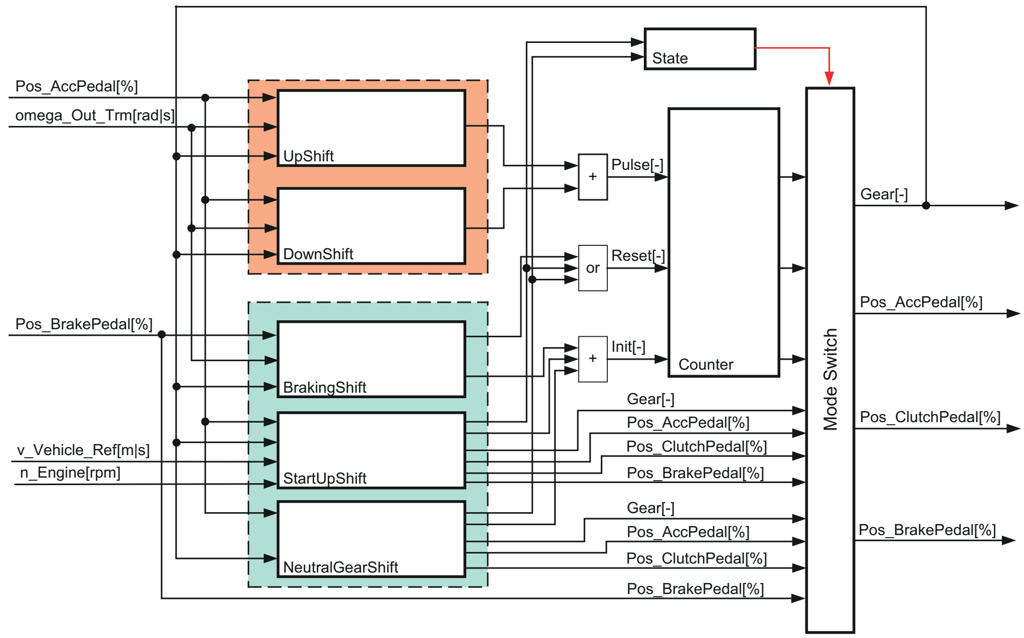
- Shifting a manual transmission
- Shifting an automatic transmission
- External shift input

Shifting the manual transmission is done by the Control_ManualTransmission function, which engages the correct gear for the current driving situation.

Shifting automatic transmission is done by engaging the driving position if the reference velocity goes above zero. Neutral position is engaged if the reference velocity is set to zero. Shifting itself is done by the Soft ECU transmission. This situation is handled by the `Control_AutomaticTransmission` function.

An external shift input is defined by a special kind of driving cycle which also includes the gear position. The `External_ManualTransmission` function has been implemented for this.

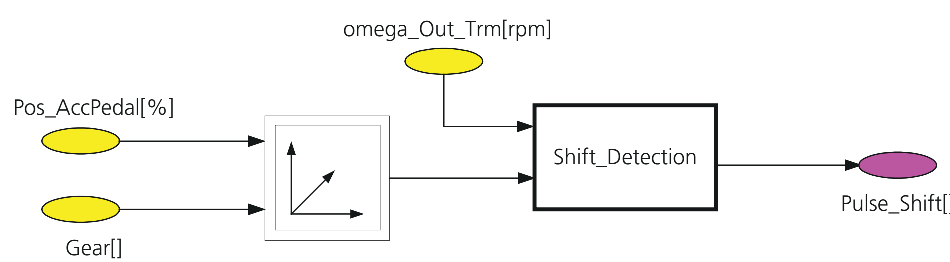
The following illustration shows an overview of the `Control_ManualTransmission` function.



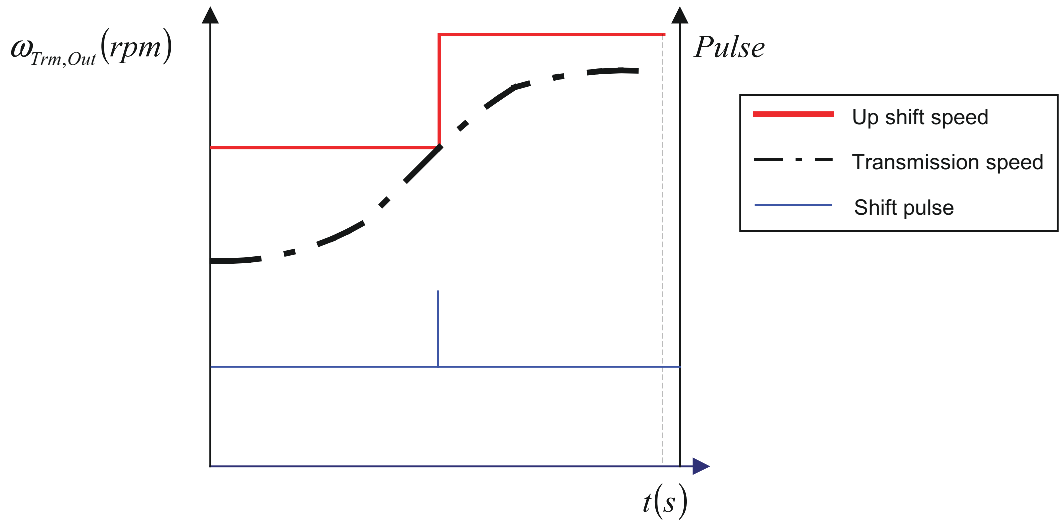
The model is divided into three sections. The light red section contains all the function which shift a gear up or down. The cyan subsystem contains functions for particular driving situations. Finally, the counter section is the gear shifter itself, which generates the gear for the transmission and the pedal positions. The mode switch section enables the correct signals for the current driving situation. The following three paragraphs describe the different parts of the Gearshifter block.

Shifting section (light red)

Generally speaking, the shifting functionality compares the current transmission output speed with an upshift or downshift speed. If the transmission output speed crosses the upshift or downshift speed for the current driving situation, a pulse is generated. Inside the gear shifter, this pulse is used to engaged the clutch, to decrease the accelerator pedal, and to increase or decrease the current gear position.



The next illustration shows a typical upshift functionality:



If the transmission output speed crosses the upshift signal, a shift pulse is generated. This forces the transmission to shift up a gear.

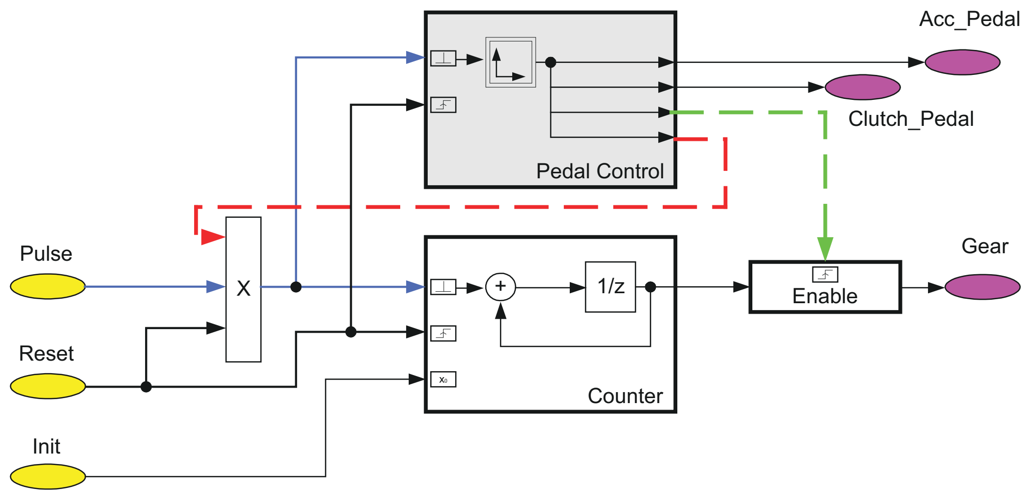
Particular driving situations (cyan)

The models for particular driving situation are used to shift to a certain gear position. These models does not shift via pulse but via gear positions which are generated according to the current driving situation. Currently three functions are implemented:

- The neutral gear function resets the gear position to the neutral position if the vehicle reaches zero velocity. This avoids an engine cut off.
- The brake shift function checks whether the shifting functions have set the current gear correctly for a specific brake pedal position. In certain driving situations, the driver may brake the vehicle very fast, which leads to rapidly decreasing vehicle speed. Because a gearshift takes some time it may happen that the shifting section does not set the correct gear for the current vehicle speed. This can happen because although a second gearshift is necessary, it cannot be executed because the first gearshift has not finished. The brake shift function therefore compares the current gear with the recommended gear position during a braking maneuver. If a difference occurs, the recommended gear position is engaged.
- Shift start is a special function which engages the first gear and controls the clutch for acceleration start.

Gear shifter

The gear shifter itself evaluates each shift request and transforms it into a corresponding gear and pedal position. The next illustration is a schematic of the gear shifter:



The gear shifter consists of three functions. The counter is responsible for the gear position. The pedal control controls the pedal and decides if a pulse or reset is possible. It also controls the enable block, which allows the current gear position in the counter to be sent to the transmission model.

Inports

The following table shows the inports:

Name	Unit	Description
Gear_Maneuver	[]	Gear setpoint defined by maneuver input
n_Engine	[rpm]	Engine speed
omega_Out_Trm	[rad/s]	Transmission output speed
Pos_AccPedal_In	[%]	Accelerator pedal position
Pos_BrakePedal_In	[%]	Brake pedal position
Pos_ClutchPedal_Maneuver	[%]	Clutch pedal setpoint defined by maneuver input
Reset	[]	Reset all integrators to their initial conditions
Sw_Gear_Set	[0|1]	Switch to activate external gear and clutch setting ▪ 0: Off ▪ 1: On
SW_Trm_Mode	[1|2]	Switch for enabling manual or automatic transmission ▪ 1: Manual ▪ 2: Automatic
v_Vehicle_Ref	[m/s]	Vehicle reference speed

Outports

The following table shows the outports:

Name	Unit	Description
Gear	[]	Gear for manual transmission
Pos_AccPedal	[%]	Accelerator pedal position

Name	Unit	Description
Pos_BrakePedal	[%]	Brake pedal position
Pos_ClutchPedal	[%]	Clutch pedal position
Selector_Lever_Out	[]	Selector lever for automatic transmission

Parameters

The following table shows the block parameters:

Name	Unit	Description
Map_omega_DownShift	[rpm]	Table for the transmission output shaft speed for a gear downshift = f(Gear, Pos_AccPedal)
Map_omega_UpShift	[rpm]	Table for the transmission output shaft speed for a gear upshift = f(Gear, Pos_AccPedal)
Map_Pos_Clutch_Pedal_StartUp	[%]	Clutch pedal position during start
Const_I_Gain_StartUp	[]	I Gain for startup PI controller
Const_n_Engine_StartUp_Set	[rpm]	Engine speed setpoint while starting from standstill
Const_P_Gain_StartUp	[]	P Gain for startup PI controller
Const_t_DownShift	[s]	Time constant for an gear downshift
Const_t_Shift	[s]	Shift time
Const_t_UpShift	[s]	Time constant for an gear upshift
StepSize	[s]	Simulation step size

Related topics

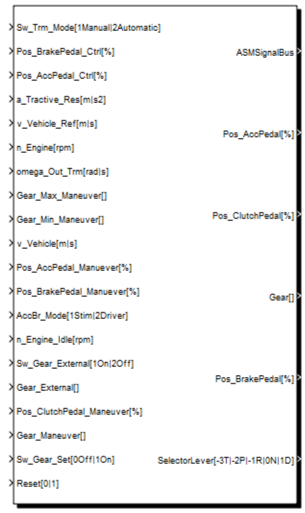
References

Gear Shifter.. 74
Gear Shifter Basic V6 (ModelDesk Parameterizing 📖)

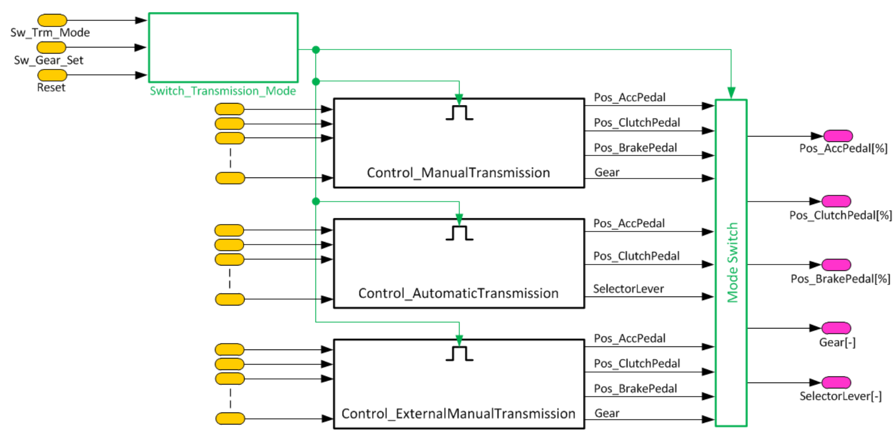
Gear Shifter (Version 7.0)

Description

The **GEAR_SHIFTER** block shifts the gears and controls the clutch pedal for an automatic or manual transmission according to the driving situation. There is also a user-defined mode for you to define the gear and the clutch pedal position yourself.



The following illustration shows the structure of the GEAR_SHIFTER block and gives an overview of the different modes.



The GEAR_SHIFTER block can handle three different modes:

- Manual transmission shifting (refer to Gear Shifter - Manual Transmission Shifting on page 218): This mode is active if the Sw_Trm_Mode[1Manual|2Automatic] inport = 1.
- Automatic transmission shifting (refer to Gear Shifter - Automatic Transmission Shifting on page 217): This mode is active if the Sw_Trm_Mode[1Manual|2Automatic] inport = 2.
- External manual transmission shifting (refer to Gear Shifter - External Manual Transmission Shifting on page 227): This mode is active if the Sw_Trm_Mode[1Manual|2Automatic] inport = 1 AND the Sw_Gear_Set[0Off|1On] inport = 1.

Related topics

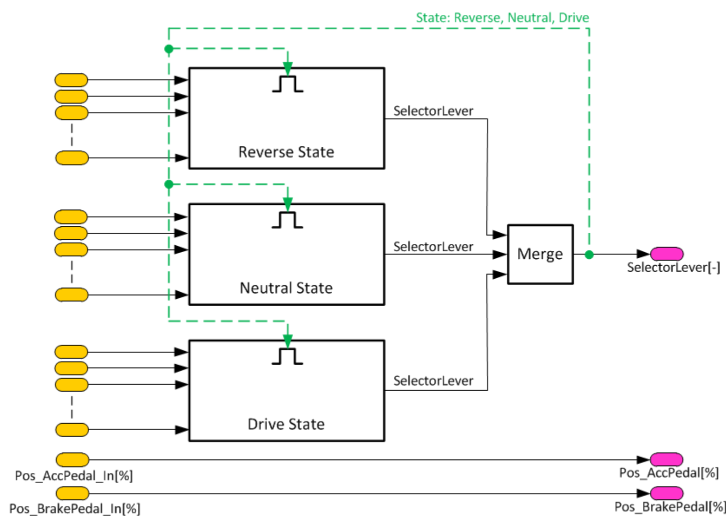
References

Gear Shifter - Automatic Transmission Shifting

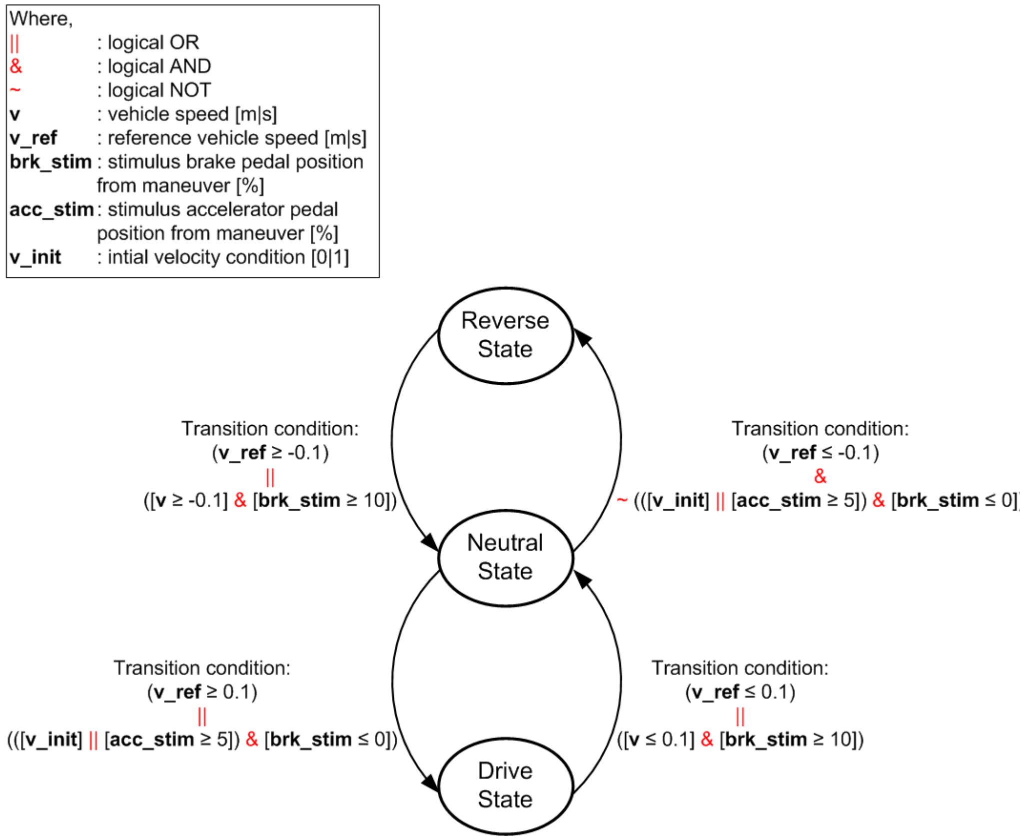
Description

In this mode, the selector lever is simulated for an automatic transmission. The following illustration shows the structure of the block.

The automatic transmission shifting belongs to the **Gear_Shifter 7.0** block. Refer to Gear Shifter (Version 7.0) on page 215.



A state machine has been implemented to check the driving situation continuously and set the correct selector lever, where only one state can be active at a time. The transition from one state to another is conditionally driven and only occurs in a rational manner. The following figure illustrates the simulated states as well as the transitions between them.



While the selector lever is set in this block, the shifting itself is done by the SOFT_ECU_TRANSMISSION block.

Related topics

References

Gear Shifter - Manual Transmission Shifting

Description

In this mode,the driver shifts the gear and controls the pedals according to the driving situation.

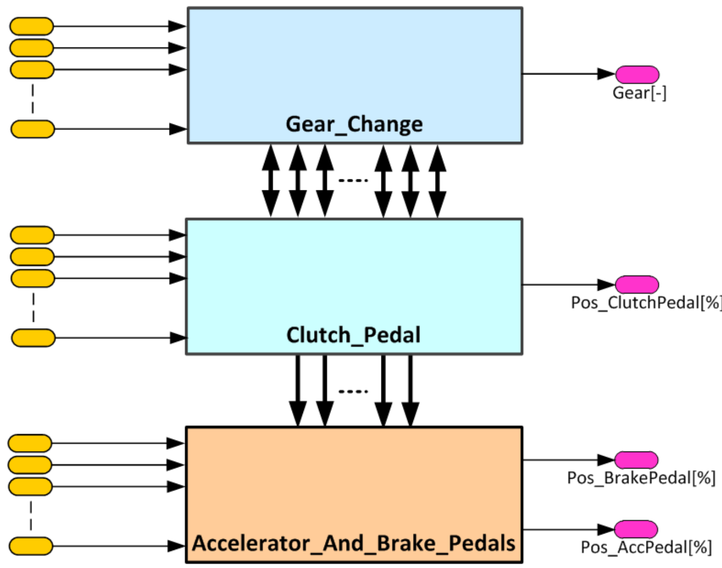
The manual transmission shifting belongs to the Gear_Shifter 7.0 block. Refer to Gear Shifter (Version 7.0) on page 215.

A gearshift process begins with analyzing the driving situation and calculating the recommended gear. This gear is then sent as a request for clutch disengagement. When the clutch is completely disengaged, the requested gear is set and the clutch is engaged again. Other driving situations might require holding the gear, gear skipping, fast up shift or down shift, etc.

These functionalities are implemented in three subsystems:

- Gear_Change: Simulates gearshifts.
- Clutch_Pedal: Controls the clutch pedal.
- Accelerator_And_Brake_Pedal: Controls the accelerator pedal during startup.

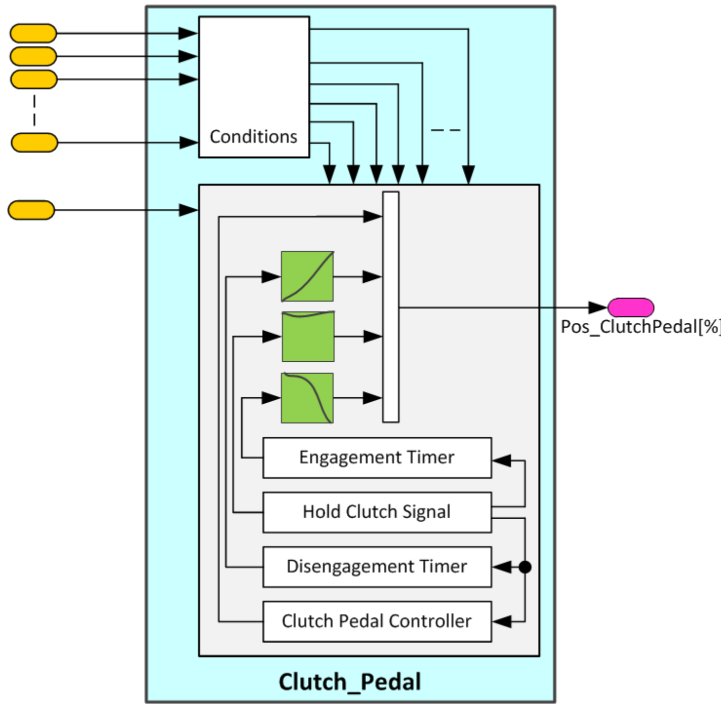
The following illustration shows how these subsystems are interconnected:



The calculations made inside each subsystem are described below.

Clutch_Pedal subsystem

In this subsystem the disengagement and engagement of the clutch pedal are triggered according to the requested gear and other conditions. You can define the clutch pedal positions during actuation via look-up-tables. The clutch pedal position is also controlled in special situations. The following illustration shows this subsystem:



Besides the gearshifting request, there are several other implemented conditions which control the actuation of the clutch pedal. Most of these conditions are related to user-defined parameters. See the following table.

Condition	Description
Low_Engine_Speed	Indicates whether a low engine speed has been reached.
	Parameter: None Calculation unit: [rpm] True: {engine speed} ≤ {1.8*current engine idle speed} False: {engine speed} ≥ {1.9*current engine idle speed}
Engine_On	Indicates whether the engine is on.
	Parameter: None Calculation unit: [rpm] Relay is implemented with input = engine speed, switch on point = 200 (true), switch off point = 25 (false)
Hard_Braking	Indicates whether the driver has to brake hard.
	Parameter: Const_a_x_Vehicle_LowLim Calculation unit: [m/s^2]

Condition	Description
	True: {reference vehicle acceleration} < {parameter} False: Otherwise
Small_Velocity	Indicates whether there is a small reference vehicle velocity.
	Parameter: Const_v_x_Vehicle_LowLim Calculation unit: [m/s] True: {reference vehicle velocity} ≤ {parameter} False: {reference vehicle velocity} ≥ {parameter + 0.4167}
Startup	Indicates whether there is a startup.
	Parameter: None Calculation unit: [m/s] True: ({vehicle reference velocity} > {0.05}) & (gear = neutral) False: Otherwise
Standstill	Indicates whether the vehicle is at a standstill.
	Parameter: None Calculation unit: [m/s] True: {vehicle reference velocity} ≤ {0.05} False: Otherwise
Initial_Velocity	Indicates whether the maneuver is defined with initial vehicle velocity.
	Parameter: None Calculation unit: [m/s] True: {vehicle velocity change in one simulation step size} ≥ {3} False: Otherwise
Big_Acceleration	Indicates whether a big acceleration is required during startup to follow the reference vehicle velocity.
	Parameter: Const_a_x_Vehicle_UpLim Calculation unit: [m/s^2] True: {reference vehicle acceleration} > {parameter} False: Otherwise
Big_Tractive_Resistance_Acceleration	Indicates whether a big driving resistance has to be overcome during startup.
	Parameter: Const_a_Tractive_Res_UpLim Calculation unit: [m/s^2]

Condition	Description
	True: {tractive resistance acceleration} > {parameter} False: Otherwise

The actuation of the clutch pedal can be divided into three phases:

- Disengagement
- Hold
- Engagement

These phases are normally carried out in succession. However, disengagement always has the highest priority. It means the clutch pedal can always be disengaged at any time regardless of its actual position. Each of these phases is activated if certain conditions are fulfilled.

The clutch pedal is disengaged in the following cases:

- A gear change is requested.
- Reference vehicle velocity becomes small (Small_Velocity condition is true).
- The driver is braking hard (Hard_Braking condition is true) and a low engine speed is reached (Low_Engine_Speed condition is true).

The clutch pedal is held completely opened if clutch disengagement has ended and if at least one of the following conditions is fulfilled:

- Tracking small reference vehicle velocity (Small_Velocity condition is true). In this case, the driver follows the reference velocity with controlled clutch pedal position.
- The driver continues to brake hard (Hard_Braking condition is true) and there is low engine speed (Low_Engine_Speed is true).
- Startup with slipping clutch where no big acceleration is required (Big_Tractive_Resistance_Acceleration condition and Big_Acceleration condition are false)

If clutch disengagement ends and none of the conditions above is true, the clutch pedal is held completely open while the gear is being changed for a user-defined time, i.e., parameter Const_t_Hold_ClutchPedal.

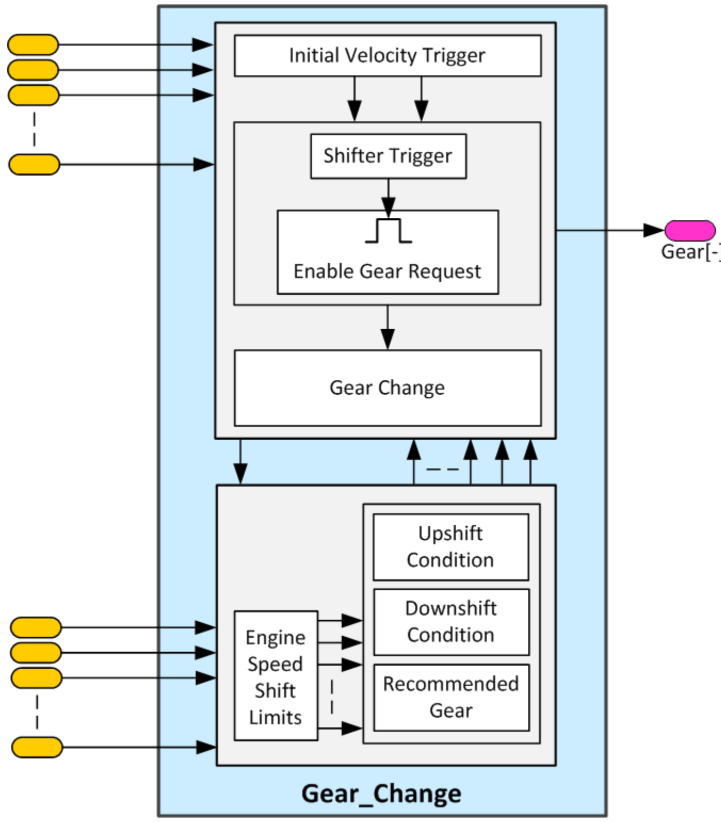
When clutch hold ends, clutch engagement is performed unconditionally.

The clutch pedal position is also controlled in special situations using a PI controller. The controller is active during the hold and engagement phases of the clutch pedal, if the disengagement phase has been ended and at least one of the following conditions is fulfilled:

- Tracking small reference vehicle velocity (Small_Velocity condition is true)
- Startup with slipping clutch where no big acceleration is required (Big_Tractive_Resistance_Acceleration condition and Big_Acceleration condition are false)

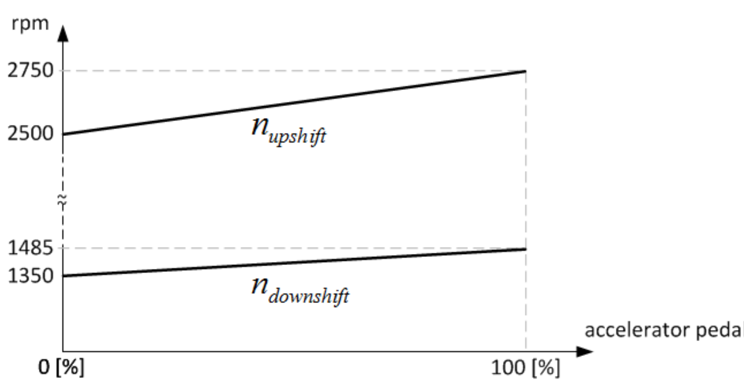
Gear_Change subsystem

The Gear_Change subsystem calculates the recommended gear according to the driving situation and simulates the gearshifts. The following illustration shows the subsystem.



First, the engine speed limits for the shift process and the ideal engine speed for the current and possible gears are calculated. You can parameterize engine speed limits as functions of the accelerator pedal position (parameters Map_n_Engine_Upshift_Lim and Map_n_Engine_Downshift_Lim) via look-up-tables.

The following illustration shows example values of the diesel engine speed limits for the up shift and down shift as functions of the accelerator pedal position.



For the calculation of the ideal engine speed, the gearbox ratios and the transmission output speed are needed:

where:

$$n_{current,\,ideal} = i_{current}\omega_{Gear,\,Out}$$

$$\overline{n}_{possible,\,ideal} = \overline{i}_{possible}\omega_{Gear,\,Out}$$

where:

$n_{current,\,ideal}$	is the ideal engine speed of the current gear
$i_{current}$	is the gearbox ratio of the current gear
$\omega_{Gear,\,Out}$	is the transmission output speed
$\overline{n}_{possible,\,ideal}$	is a vector of ideal engine speeds of all possible gears
$\overline{i}_{possible}$	is a vector of gearbox ratios of all possible gears

If the user-defined engine speed limits are used for the shift process, the ideal engine speeds of the possible gears are filtered, so that only certain gears are considered for further calculations. The ideal engine speeds of these gears should fulfill the following condition:

$$n_{upshift} \geq \overline{n}_{allowed,\,ideal} \geq \left(n_{downshift} + n_{shift,\,bias}\right)$$

where:

$n_{upshift}$	is the up shift engine speed limit
$n_{downshift}$	is the down shift engine speed limit
$\overline{n}_{allowed,\,ideal}$	is a vector of the ideal engine speeds of the allowed gears
$n_{shift,\,bias}$	is the engine speed shift bias

The engine speed shift bias is a function of the tractive resistance acceleration and defined in a look-up-table. This value is used to avoid oscillations in the calculated allowed gears, because the transmission output speed drops as the driver disengages the clutch pedal, causing a drop in the calculated ideal engine speeds stated in the equations above.

The look-up-table also includes the engine speed drop after lowering the gear, i.e., it provides a nonzero value for zero tractive resistance acceleration, and thus gear hunting can be avoided.

Afterwards, the recommended gear for the current driving situation is calculated from the allowed gears. That is, a check is made whether the current driver behavior indicates accelerating or braking demand. If there is acceleration, the maximum allowed gear is selected, whereas if there is braking, the minimum allowed gear is selected. In other words, this simulates an eco-friendly driving manner.

The up shift request is triggered as the ideal engine speed of the current gear becomes greater than or equals the up shift limit, as shown below:

$$request_{upshift} = \begin{cases} 1, & n_{current,\,ideal} \geq n_{upshift} \\ 0, & otherwise \end{cases}$$

The down shift request is triggered as the ideal engine speed of the current gear becomes smaller than or equals the down shift limit, as shown below:

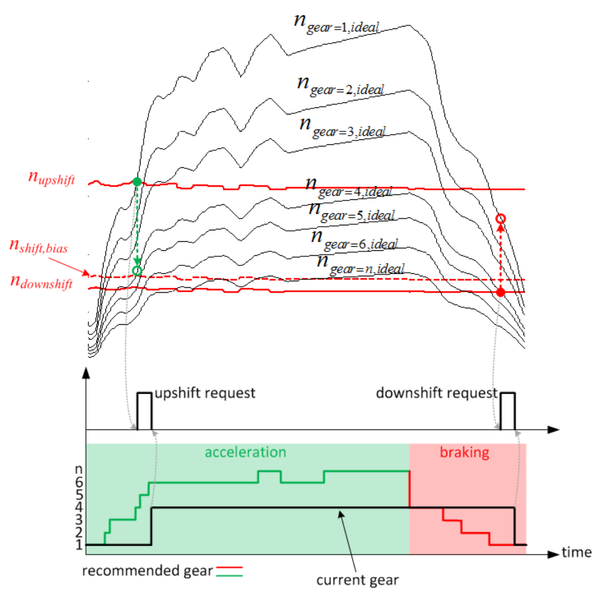
$$request_{downshift} = \begin{cases} 1, & n_{current,\,ideal} \leq n_{downshift} \\ 0, & otherwise \end{cases}$$

The up shift or down shift request triggers a gear change request for clutch disengagement. Depending on the driving situation, these requests might be disabled. For example, this happens if the driver recognizes that hard braking is required (Hard_Braking condition is true). In this case, the up shift and down shift requests are deactivated and the gear is held. Meanwhile, once the driver recognizes a low engine speed (Low_Engine_Speed condition is true), the clutch is disengaged to avoid an engine stall just like the real driver would do.

The gear change request causes the clutch to be disengaged. Once the clutch is completely disengaged, a gearshift occurs.

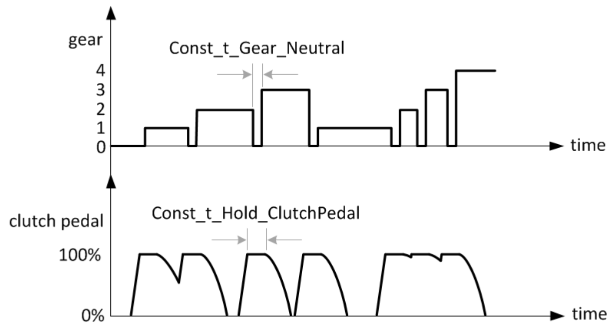
In braking maneuvers which are not recognized as hard braking (Hard_Braking condition is false), the driver can skip gears during the down shift process whenever this is necessary.

The illustration below shows the calculation of the gearshift in accelerating and braking maneuvers:



During the gearshift, you can activate the feature for passing the gear through neutral using the parameter Const_t_Gear_Neutral. This parameter defines the time that the gear passes through neutral during the gearshift process and provides a realistic gearshifting behavior. If the parameter is zero, this feature is inactive.

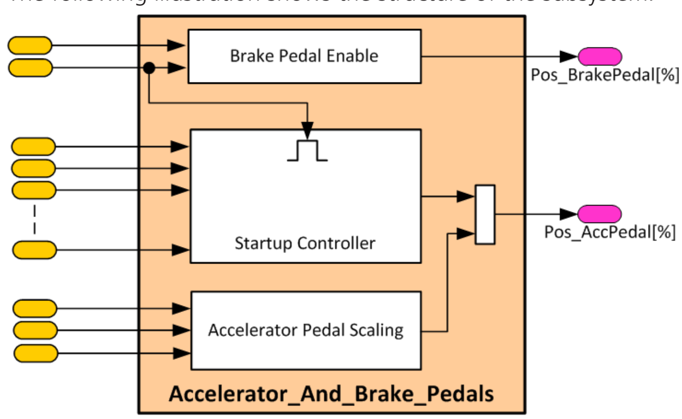
Since the gear passes through neutral only when the clutch is completely opened, the parameter Const_t_Gear_Neutral should always be less than or equal to the time the clutch pedal remains completely open, i.e., parameter Const_t_Hold_ClutchPedal. If this condition is not fulfilled, the minimum time from both parameters is used. The illustration below shows the gear passing through neutral during the gearshift process using both parameters.



You can also force the driver to select a certain gear value at any time during the simulation. This feature is available by using the inports Sw_Gear_External[1On|2Off] and Gear_External[]. If Sw_Gear_External is set to 1, the Gear_External value is used as the current gear. If Sw_Gear_External is set back to 0, the calculated gear is used as mentioned in the calculations above. To use this feature, the inport Sw_Trm_Mode[1Manual|2Automatic] should be 1.

Accelerator_And_Brake_Pedal subsystem

The following illustration shows the structure of the subsystem:



This subsystem implements the startup functionality. A PI controller is used to modify the accelerator pedal position to reach a user-defined engine speed (parameter Const_n_Engine_StartUp_Set) during vehicle startup.

The startup controller is activated during startup only if at least one of the following conditions is fulfilled:

- There is big tractive resistance (Big_Tractive_Resistance_Acceleration condition is true)
- The maneuver or the vehicle velocity are initialized with a nonzero value (Initial_Velocity condition is true or reference vehicle velocity starts with a nonzero value).
- Big acceleration is needed to follow the reference vehicle velocity (Big_Acceleration condition is true)

The brake pedal position is disabled if the startup controller is active.

Since this block ensures a correct startup, you should consider changing the defined engine speed during startup, for example, if the vehicle has to start on a steep hill.

Another block is used to scale the accelerator pedal position during a gear change. For the scaling, a user-defined look-up-table is used as a function of the inverse of the normalized clutch pedal position (parameter Map_Pos_AccPedal).

Related topics

References

Gear Shifter - External Manual Transmission Shifting

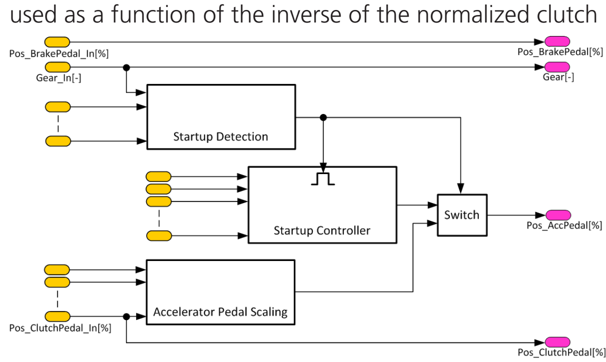
Description

The external manual transmission shifting belongs to the **Gear_Shifter 7.0** block. Refer to Gear Shifter (Version 7.0) on page 215.

This user-defined mode handles maneuvers with a predefined gear change set and the corresponding clutch pedal position. The values of the accelerator and brake pedals are controlled in the longitudinal controller.

The user-predefined gear and clutch pedal position are forwarded to the outports. Additionally, when a startup is detected, a PI controller controls the accelerator pedal position to reach a user-defined engine speed (parameter Const_n_Engine_StartUp_Set).

In all other cases the accelerator pedal position is forwarded to the outport and scaled only if a gear change occurs. For the scaling, a simplified look-up-table is used as a function of the inverse of the normalized clutch pedal position.



Inports

The following table shows the inports:

Name	Unit	Description
a_Tractive_Res	[m/s^2]	Tractive resistance acceleration
AccBr_Mode	[1|2]	Mode signal for accelerator and brake pedal ▪ 1: Stimulus ▪ 2: Driver
Gear_External	[]	User-defined external gear
Gear_Maneuver	[]	Stimulus gear from maneuver
Gear_Max_Maneuver	[]	Maximum gear from maneuver
Gear_Min_Maneuver	[]	Minimum gear from maneuver
n_Engine	[rpm]	Engine speed
n_Engine_Idle	[rpm]	Engine idle speed
omega_Out_Trm	[rad/s]	Transmission output speed
Pos_AccPedal_Ctrl	[%]	Calculated accelerator pedal position from the longitudinal controller
Pos_AccPedal_Maneuver	[%]	Stimulus accelerator pedal position from maneuver
Pos_AccBrake_Maneuver	[%]	Stimulus brake pedal position from maneuver
Pos_BrakePedal_Ctrl	[%]	Calculated brake pedal position from the longitudinal controller
Pos_ClutchPedal_Maneuver	[%]	Stimulus clutch pedal position from maneuver
Reset_States	[0|1]	Reset
Sw_Gear_External	[1|2]	Switch for user-defined external gear ▪ 1: On ▪ 2: Off
Sw_Gear_Set	[0|1]	Switch for stimulus gear from maneuver ▪ 0: Off ▪ 1: On
Sw_Trm_Mode	[1|2]	Switch for enabling manual or automatic transmission ▪ 1: Manual ▪ 2: Automatic
v_Vehicle	[m/s]	Vehicle velocity
v_Vehicle_Ref	[m/s]	Reference vehicle velocity

Outports

The following table shows the outports:

Name	Unit	Description
ASMSignalBus	[]	Signal bus that contains signals of ASM components. Refer to ASMSignalBus (ASM User Guide 📖).
Gear	[]	Gear
Pos_AccPedal	[%]	Accelerator pedal position
Pos_BrakePedal	[%]	Brake pedal position
Pos_ClutchPedal	[%]	Clutch pedal position

Name	Unit	Description
SelectorLever	[-3|-2|-1|0|1]	Selector lever position ▪ -3: Tip shift ▪ -2: Park ▪ -1: Reverse ▪ 0: Neutral ▪ 1: Drive

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_a_Tractive_Res_UpLim	[m/s^2]	Tractive resistance acceleration threshold for startup
Const_a_x_Vehicle_LowLim	[m/s^2]	Hard braking threshold for gear hold
Const_a_x_Vehicle_UpLim	[m/s^2]	Acceleration threshold for startup
Const_I_Gain_ClutchPedal	[1/s]	I gain of clutch pedal controller
Const_I_Gain_StartUp	[1/s]	I gain of accelerator pedal startup controller
Const_n_Engine_StartUp_Set	[rpm]	Engine speed setpoint during startup
Const_P_Gain_ClutchPedal	[]	P gain of clutch pedal controller
Const_P_Gain_StartUp	[]	P gain of accelerator pedal startup controller
Const_Pos_AccPedal_Startup_FF	[%]	Accelerator pedal position for startup
Const_t_Gear_Neutral	[s]	Time of gear passing through neutral during gear change
Const_t_Hold_ClutchPedal	[s]	Disengaged clutch hold time
Const_v_x_Vehicle_LowLim	[m/s]	Small velocity threshold for driving with slipping clutch
Map_i_Ratio	[]	Gear ratio = f(gear)
Map_n_Engine_Downshift_Lim	[rpm]	Down shift engine speed limit = f(Pos_AccPedal)
Map_n_Engine_Upshift_Lim	[rpm]	Up shift engine speed limit = f(Pos_AccPedal)
Map_omega_Out_Trm_Shift_Bias	[rpm]	Transmission output speed shift bias = f(tractive resistance acceleration)
Map_Pos_AccPedal	[0_1]	Accelerator pedal factor during gear change = f(Pos_ClutchPedal)
Map_Pos_ClutchPedal_Disengagement	[%]	Clutch pedal disengagement position not during startup = f(t)
Map_Pos_ClutchPedal_Disengagement_StartUp	[%]	Clutch pedal disengagement position during startup = f(t)
Map_Pos_ClutchPedal_Engagement	[%]	Clutch pedal engagement position not during startup = f(t)
Map_Pos_ClutchPedal_Engagement_StartUp	[%]	Clutch pedal engagement position during startup = f(t)
StepSize	[s]	Simulation step size
Sw_Upshift_Gear_Skipping	[1|2]	Gear skipping switch during up shift ▪ 1: On ▪ 2: Off

Handling of unused inports

Depending on the demo model and the library, some of the inport signals might not be used. In this case, these inports cannot be connected to dummy values. They should be connected to constant values instead.

These are defined in the following table:

Inport Name	Not Used If
AccBr_Mode	Its value = 0
Pos_AccPedal_Maneuver	Its value = 0
Pos_BrakePedal_Maneuver	Its value = 0
Gear_External	Sw_Gear_External = 2 OR Sw_Trm_Mode ≠ 1
Gear_Max_Maneuver	Its value = 0
Sw_Gear_Set	Its value = 0
Sw_Gear_Set	Its value = 0

Related topics

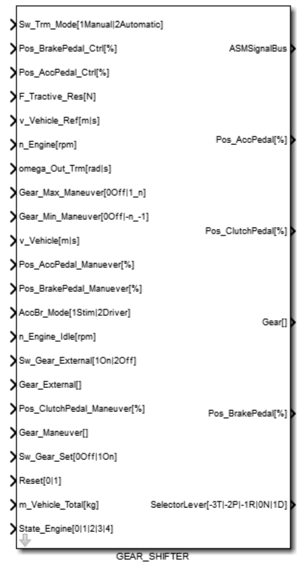
References

Gear Shifter - Automatic Transmission Shifting.......217
Gear Shifter - Manual Transmission Shifting.......218
Gear Shifter (Version 7.0).......215

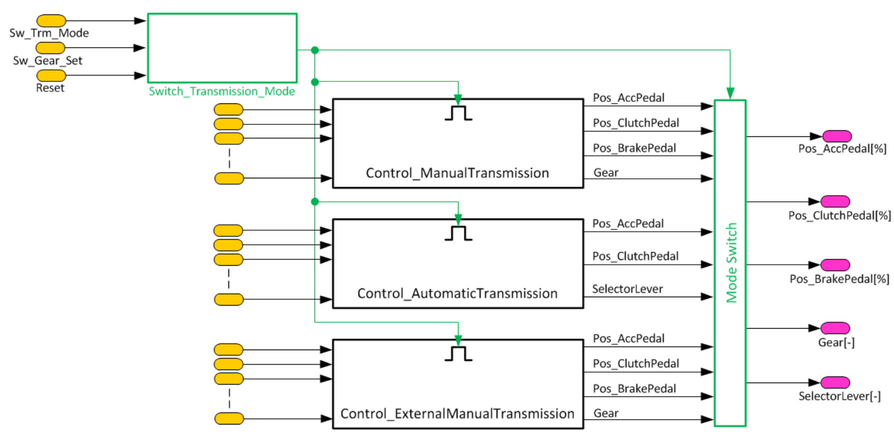
Gear Shifter (Version 8.0 - 10.0)

Description

The **GEAR_SHIFTER** block shifts the gears and controls the clutch pedal for an automatic or manual transmission according to the driving situation. There is also a user-defined mode for you to define the gear and the clutch pedal position yourself.



The following illustration shows the structure of the GEAR_SHIFTER block and gives an overview of the different modes.



The GEAR_SHIFTER block can handle three different modes:

- Manual transmission shifting (refer to Gear Shifter - Manual Transmission Shifting on page 233): This mode is active if the Sw_Trm_Mode[1Manual|2Automatic] inport = 1.
- Automatic transmission shifting (refer to Gear Shifter - Automatic Transmission Shifting on page 232): This mode is active if the Sw_Trm_Mode[1Manual|2Automatic] inport = 2.
- External manual transmission shifting (refer to Gear Shifter - External Manual Transmission Shifting on page 242): This mode is active if the Sw_Trm_Mode[1Manual|2Automatic] inport = 1 AND the Sw_Gear_Set[0Off|1On] inport = 1.

Related topics

References

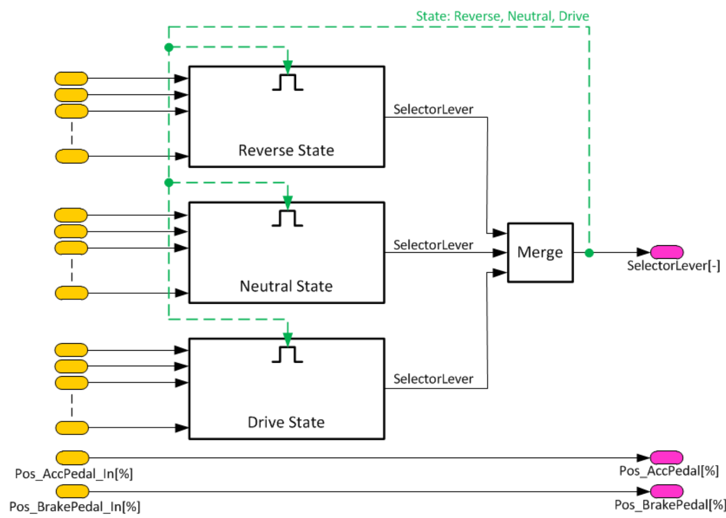
Gear Shifter - Automatic Transmission Shifting

Description

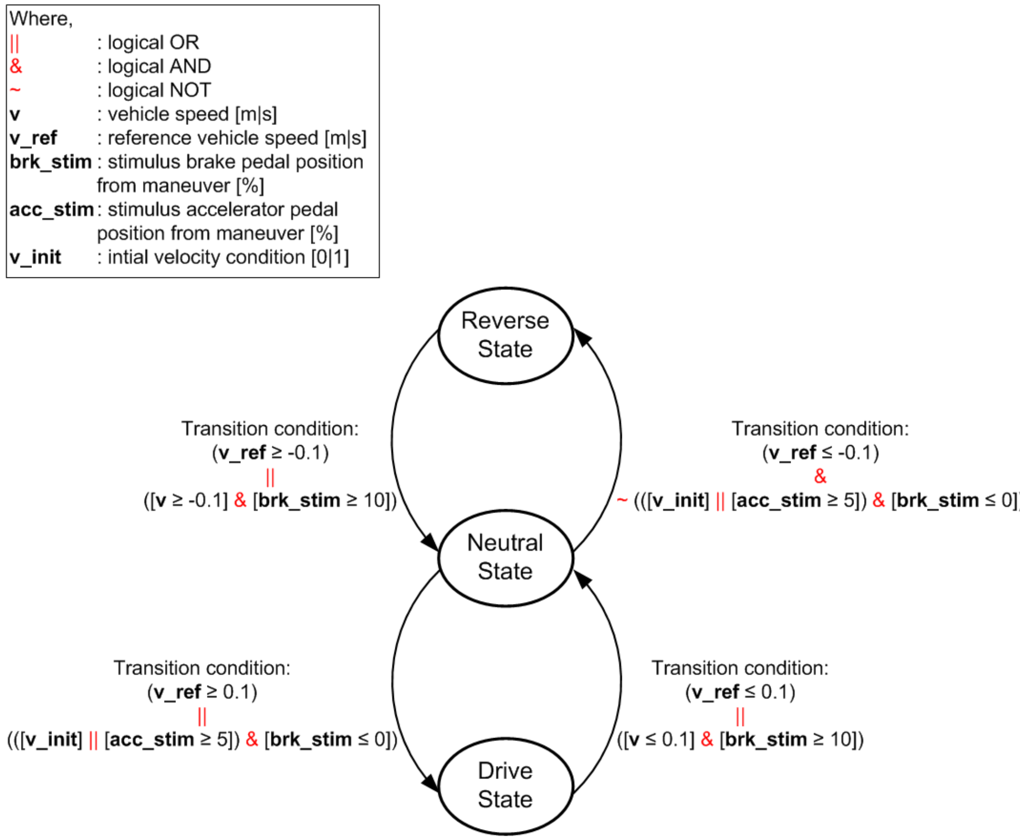
In this mode, the selector lever is simulated for an automatic transmission.

The automatic transmission shifting belongs to the **Gear_Shifter 8.0** block. Refer to Gear Shifter (Version 8.0 - 10.0) on page 230.

The following illustration shows the structure of the block.



A state machine has been implemented to check the driving situation continuously and set the correct selector lever, where only one state can be active at a time. The transition from one state to another is conditionally driven and only occurs in a rational manner. The following figure illustrates the simulated states as well as the transitions between them.



While the selector lever is set in this block, the shifting itself is done by the SOFT_ECU_TRANSMISSION block.

Related topics

References

Gear Shifter - Manual Transmission Shifting

Description

In this mode,the driver shifts the gear and controls the pedals according to the driving situation.

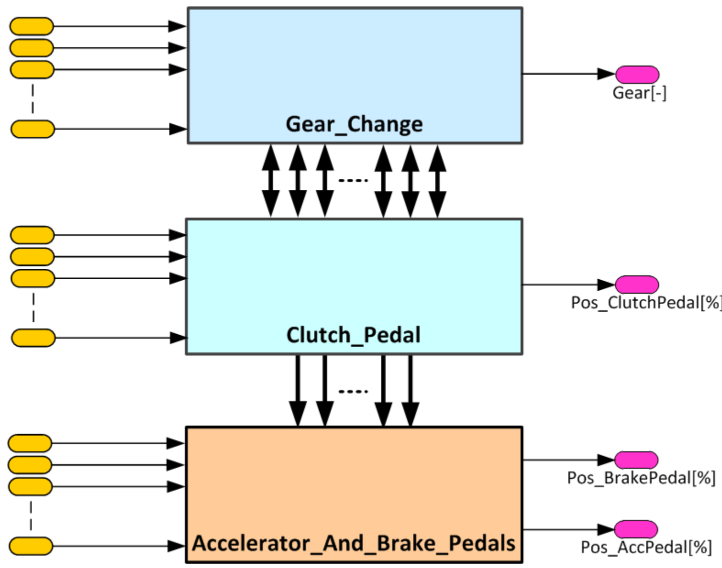
The manual transmission shifting belongs to the **Gear_Shifter 8.0** block. Refer to Gear Shifter (Version 8.0 - 10.0) on page 230.

A gearshift process begins with analyzing the driving situation and calculating the recommended gear. This gear is then sent as a request for clutch disengagement. When the clutch is completely disengaged, the requested gear is set and the clutch is engaged again.

These functionalities are implemented in three subsystems:

- Gear_Change: Simulates gearshifts.
- Clutch_Pedal: Controls the clutch pedal.
- Accelerator_And_Brake_Pedal: Controls the accelerator pedal during startup.

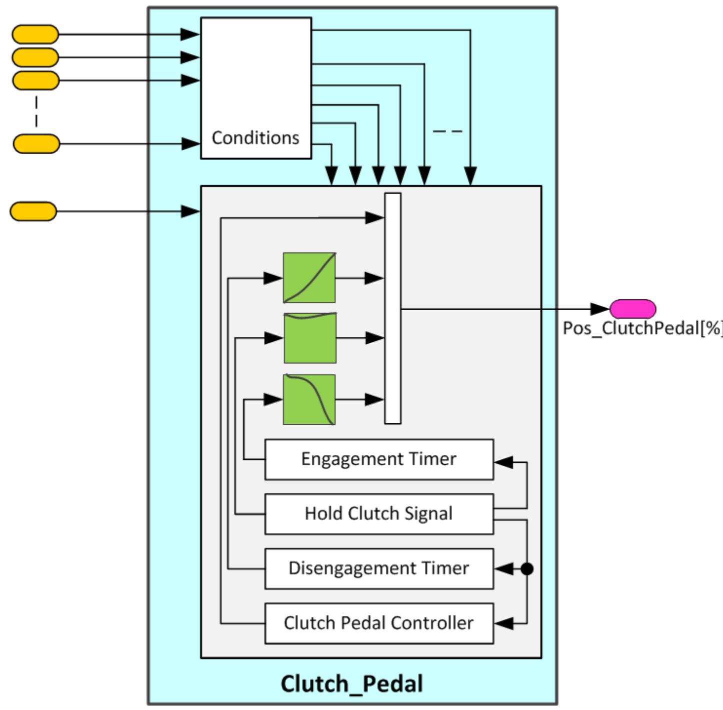
The following illustration shows how these subsystems are interconnected:



The calculations made inside each subsystem are described below.

Clutch_Pedal subsystem

In this subsystem the disengagement and engagement of the clutch pedal are triggered according to the requested gear and other conditions. You can define the clutch pedal positions during actuation via look-up-tables. The clutch pedal position is also controlled in special situations. The following illustration shows this subsystem:



Besides the gearshifting request, there are several other implemented conditions which control the actuation of the clutch pedal. Most of these conditions are related to user-defined parameters. See the following table.

Condition	Description
Low_Engine_Speed	Indicates whether a low engine speed has been reached.
	Parameter: None Calculation unit: [rpm] True: {engine speed} ≤ {current engine idle speed + 100} False: {engine speed} ≥ {current engine idle speed + 500}
Engine_On	Indicates whether the engine is on.
	Parameter: None Calculation unit: [] The signal is calculated from the State_Engine[0|1|2|3|4] input signal and is active if the engine state equals 3, otherwise it is inactive.
Hard_Braking	Indicates whether the driver has to brake hard.
	Parameter: Const_a_x_Vehicle_LowLim Calculation unit: [m/s^2] True: {reference vehicle acceleration} < {parameter} False: Otherwise
Small_Velocity	Indicates whether there is a small reference vehicle velocity.
	Parameter: Const_v_x_Vehicle_LowLim Calculation unit: [m/s]

Condition	Description
	True: {reference vehicle velocity} ≤ {parameter} False: {reference vehicle velocity} ≥ {parameter + 0.4167}
Startup	Indicates whether there is a startup.
	Parameter: None Calculation unit: [m/s] True: ({vehicle reference velocity} > {0.05}) & (gear = neutral) False: Otherwise
Standstill	Indicates whether the vehicle is at a standstill.
	Parameter: None Calculation unit: [m/s] True: {vehicle reference velocity} ≤ {0.05} False: Otherwise
Initial_Velocity	Indicates whether the maneuver is defined with initial vehicle velocity.
	Parameter: None Calculation unit: [m/s] True: {vehicle velocity change in one simulation step size} ≥ {3} False: Otherwise
Big_Acceleration	Indicates whether a big acceleration is required during startup to follow the reference vehicle velocity.
	Parameter: Const_a_x_Vehicle_UpLim Calculation unit: [m/s^2] True: {reference vehicle acceleration} > {parameter} False: Otherwise
Big_Tractive_Resistance_Acceleration	Indicates whether a big driving resistance has to be overcome during startup.
	Parameter: Const_a_Tractive_Res_UpLim Calculation unit: [m/s^2] True: {tractive resistance acceleration} > {parameter} False: Otherwise

The actuation of the clutch pedal can be divided into three phases:

- Disengagement
- Hold
- Engagement

These phases are normally carried out in succession. However, disengagement always has the highest priority. It means the clutch pedal can always be disengaged at any time regardless of its actual position. Each of these phases is activated if certain conditions are fulfilled.

The clutch pedal is disengaged in the following cases:

- A gear change is requested.
- Reference vehicle velocity becomes small (Small_Velocity condition is true).
- The driver is braking hard (Hard_Braking condition is true) and a low engine speed is reached (Low_Engine_Speed condition is true).

The clutch pedal is held completely opened if clutch disengagement has ended and if at least one of the following conditions is fulfilled:

- Tracking small reference vehicle velocity (Small_Velocity condition is true).
- The driver continues to brake hard (Hard_Braking condition is true) and there is low engine speed (Low_Engine_Speed is true).
- Startup with slipping clutch where no big acceleration is required (Big_Tractive_Resistance_Acceleration condition and Big_Acceleration condition are false)

If clutch disengagement ends and none of the conditions above is true, the clutch pedal is held completely open while the gear is being changed for a user-defined time, i.e., parameter Const_t_Hold_ClutchPedal.

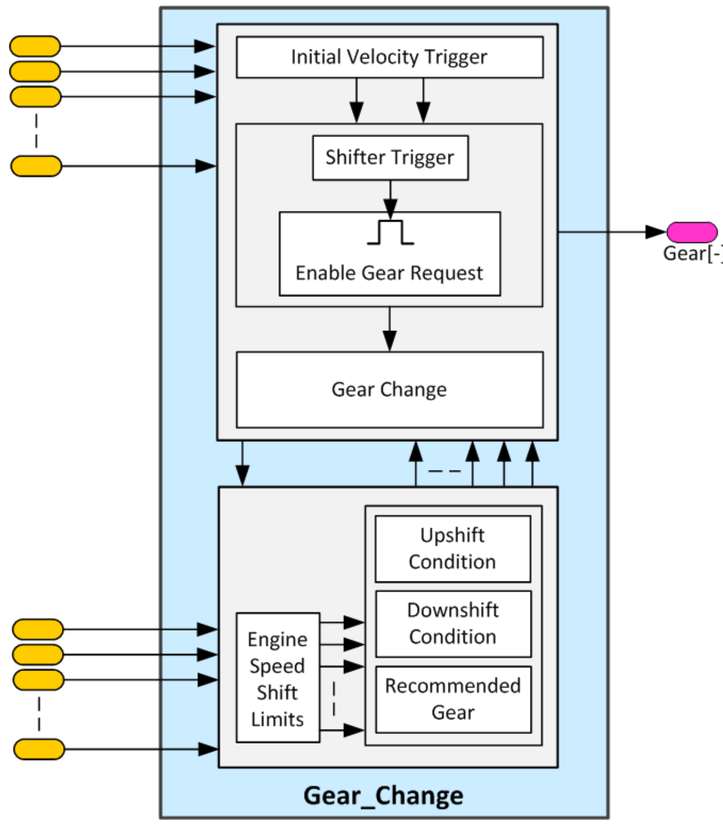
When clutch hold ends, clutch engagement is performed unconditionally.

The clutch pedal position is also controlled in special situations using a PI controller. The controller is active during the hold and engagement phases of the clutch pedal, if the disengagement phase has been ended and at least one of the following conditions is fulfilled:

- Tracking small reference vehicle velocity (Small_Velocity condition is true)
- Startup with slipping clutch where no big acceleration is required (Big_Tractive_Resistance_Acceleration condition and Big_Acceleration condition are false)

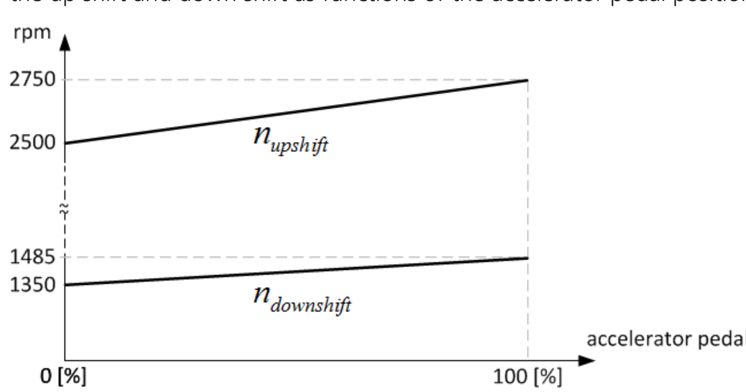
Gear_Change subsystem

The Gear_Change subsystem calculates the recommended gear according to the driving situation and simulates the gearshifts. The following illustration shows the subsystem.



First, the engine speed limits for the shift process and the ideal engine speed for the current and possible gears are calculated. You can parameterize engine speed limits as functions of the accelerator pedal position (parameters Map_n_Engine_Upshift_Lim and Map_n_Engine_Downshift_Lim) via look-up-tables.

The following illustration shows exemplary values of the engine speed limits for the up shift and down shift as functions of the accelerator pedal position.



For the calculation of the ideal engine speed, the gearbox ratios and the transmission output speed are needed:

where:

$$n_{current,\,ideal} = i_{current}\omega_{Gear,\,Out}$$

$$\overline{n}_{possible,\,ideal} = \overline{i}_{possible}\omega_{Gear,\,Out}$$

where:

$n_{current,\,ideal}$	is the ideal engine speed of the current gear
$i_{current}$	is the gearbox ratio of the current gear
$\omega_{Gear,\,Out}$	is the transmission output speed
$\overline{n}_{possible,\,ideal}$	is a vector of ideal engine speeds of all possible gears
$\overline{i}_{possible}$	is a vector of gearbox ratios of all possible gears

If the user-defined engine speed limits are used for the shift process, the ideal engine speeds of the possible gears are filtered, so that only certain gears are considered for further calculations. The ideal engine speeds of these gears should fulfill the following condition:

$$n_{upshift} \geq \overline{n}_{allowed,\,ideal} \geq \left(n_{downshift} + n_{shift,\,bias}\right)$$

where:

$n_{upshift}$	is the up shift engine speed limit
$n_{downshift}$	is the down shift engine speed limit
$\overline{n}_{allowed,\,ideal}$	is a vector of the ideal engine speeds of the allowed gears
$n_{shift,\,bias}$	is the engine speed shift bias

The engine speed shift bias is a function of the tractive resistance acceleration and defined in a look-up-table. This value is used to avoid oscillations in the calculated allowed gears, because the transmission output speed drops as the driver disengages the clutch pedal, causing a drop in the calculated ideal engine speeds stated in the equations above.

Afterwards, the recommended gear for the current driving situation is calculated from the allowed gears. That is, a check is made whether the current driver behavior indicates accelerating or braking demand. If there is acceleration, the maximum allowed gear is selected, whereas if there is braking, the minimum allowed gear is selected. In other words, this simulates an eco-friendly driving manner.

The up shift request is triggered as the ideal engine speed of the current gear becomes greater than or equals the up shift limit, as shown below:

$$request_{upshift} = \begin{cases} 1, & n_{current,\,ideal} \geq n_{upshift} \\ 0, & otherwise \end{cases}$$

The down shift request is triggered as the ideal engine speed of the current gear becomes smaller than or equals the down shift limit, as shown below:

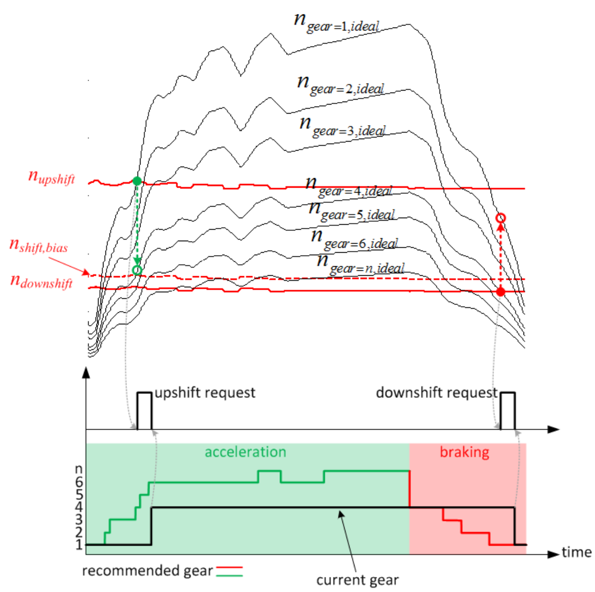
$$request_{downshift} = \begin{cases} 1, & n_{current,\,ideal} \leq n_{downshift} \\ 0, & otherwise \end{cases}$$

The up shift or down shift request triggers a gear change request. Depending on the driving situation, these requests might be disabled. For example, this happens if the driver recognizes that hard braking is required (Hard_Braking condition is true). In this case, the up shift and down shift requests are deactivated and the gear is held. Meanwhile, once the driver recognizes a low engine speed (Low_Engine_Speed condition is true), the clutch is disengaged to avoid an engine stall just like the real driver would do.

The gear change request causes the clutch to be disengaged. Once the clutch is completely disengaged, a gearshift occurs.

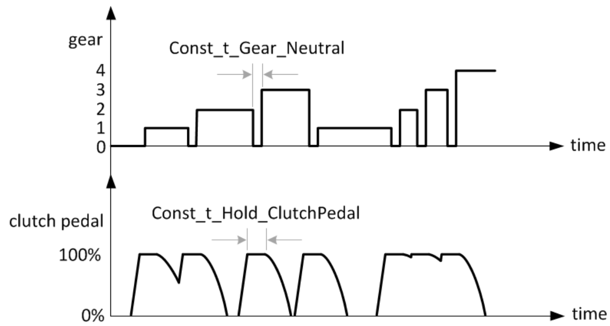
In braking maneuvers which are not recognized as hard braking (Hard_Braking condition is false), the driver can skip gears during the down shift process whenever this is necessary. However, during the gear up shift you can activate or deactivate this feature using the Sw_Upshift_Gear_Skipping parameter. This also includes the selection of the startup gear, which is selected depending on the load conditions.

The illustration below shows the calculation of the gearshift in accelerating and braking maneuvers:



During the gearshift, you can activate the feature for passing the gear through neutral using the parameter Const_t_Gear_Neutral. This parameter defines the time that the gear passes through neutral during the gearshift process and provides a realistic gearshifting behavior. If the parameter is zero, this feature is inactive.

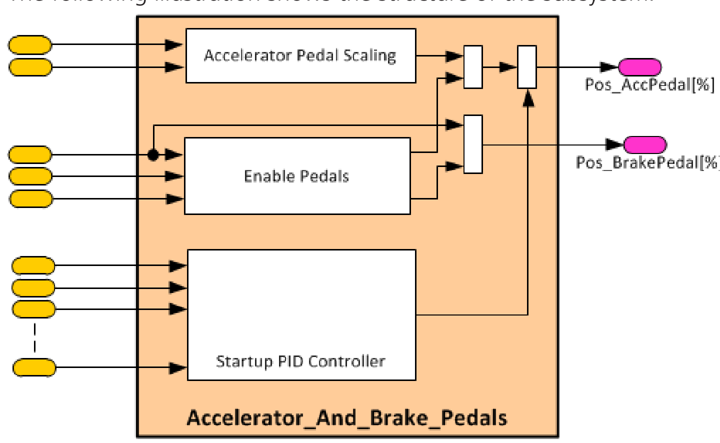
Since the gear passes through neutral only when the clutch is completely opened, the parameter Const_t_Gear_Neutral should always be less than or equal to the time the clutch pedal remains completely open, i.e., parameter Const_t_Hold_ClutchPedal. If this condition is not fulfilled, the minimum time from both parameters is used. The illustration below shows the gear passing through neutral during the gearshift process using both parameters.



You can also force the driver to select a certain gear value at any time during the simulation. This feature is available by using the inports Sw_Gear_External[1On|2Off] and Gear_External[]. If Sw_Gear_External is set to 1, the Gear_External value is used as the current gear. If Sw_Gear_External is set back to 0, the calculated gear is used as mentioned in the calculations above. To use this feature, the inport Sw_Trm_Mode[1Manual|2Automatic] should be 1.

Accelerator_And_Brake_Pedal subsystem

The following illustration shows the structure of the subsystem:



This subsystem implements the startup functionality. A PID controller is used to modify the accelerator pedal position to reach a user-defined engine speed (parameter Const_n_Engine_StartUp_Set) during vehicle startup.

The startup controller is activated during startup only if at least one of the following conditions is fulfilled:

- There is big tractive resistance (Big_Tractive_Resistance_Acceleration condition is true)
- The maneuver or the vehicle velocity are initialized with a nonzero value (Initial_Velocity condition is true or reference vehicle velocity starts with a nonzero value).
- Big acceleration is needed to follow the reference vehicle velocity (Big_Acceleration condition is true)

The brake pedal position is disabled if the startup controller is active.

Since this block ensures a correct startup, you should consider changing the defined engine speed during startup, for example, if the vehicle has to start on a steep hill.

Another block is used to scale the accelerator pedal position during a gear change. For the scaling, a user-defined look-up-table is used as a function of the inverse of the normalized clutch pedal position (parameter Map_Pos_AccPedal).

Related topics

References

Gear Shifter - External Manual Transmission Shifting

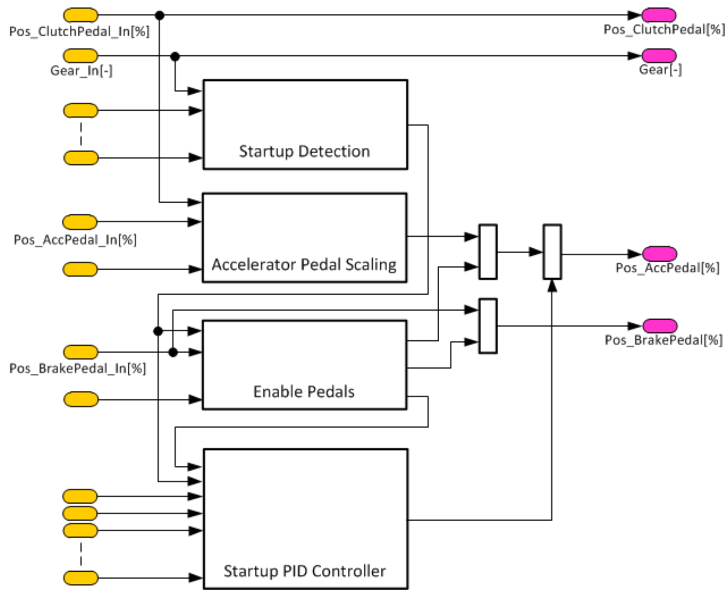
Description

The external manual transmission shifting belongs to the **Gear_Shifter 8.0** block. Refer to Gear Shifter (Version 8.0 - 10.0) on page 230.

This user-defined mode handles maneuvers with a predefined gear change set and the corresponding clutch pedal position. The values of the accelerator and brake pedals are controlled in the longitudinal controller.

The user-predefined gear and clutch pedal position are forwarded to the outports. Additionally, when a startup is detected, a PID controller controls the accelerator pedal position to reach a user-defined engine speed (Const_n_Engine_StartUp_Set parameter).

In all other cases the accelerator pedal position is forwarded to the outport and scaled only if a gear change occurs. For the scaling, a simplified look-up-table is used as a function of the inverse of the normalized clutch pedal position.



Inports

The following table shows the inports:

Name	Unit	Description
AccBr_Mode	[1|2]	Mode signal for accelerator and brake pedal ▪ 1: Stimulus ▪ 2: Driver
F_Tractive_Res	[N]	Tractive resistance force
Gear_External	[]	User-defined external gear
Gear_Maneuver	[]	Stimulus gear from maneuver
Gear_Max_Maneuver	[0Off|1_n]	Maximum gear from maneuver
Gear_Min_Maneuver	[0Off|-n_-1]	Minimum gear from maneuver
m_Vehicle_Total	[kg]	Vehicle mass
n_Engine	[rpm]	Engine speed
n_Engine_Idle	[rpm]	Engine idle speed
omega_Out_Trm	[rad/s]	Transmission output speed
Pos_AccPedal_Ctrl	[%]	Calculated accelerator pedal position from the longitudinal controller
Pos_AccPedal_Stim	[%]	Stimulus accelerator pedal position from maneuver
Pos_BrakePedal_Ctrl	[%]	Calculated brake pedal position from the longitudinal controller
Pos_BrakePedal_Stim	[%]	Stimulus brake pedal position from maneuver
Pos_ClutchPedal_Maneuver	[%]	Stimulus clutch pedal position from maneuver
Reset_States	[0|1]	Reset
State_Engine	[0|1|2|3|4]	Engine state: ▪ 0: Engine off/ Error ▪ 1: Ignition on ▪ 2: Starter on

Name	Unit	Description
		▪ 3: Engine running ▪ 4: Engine shutdown
Sw_Gear_External	[1|2]	Switch for user-defined external gear ▪ 1: On ▪ 2: Off
Sw_Gear_Set	[0|1]	Switch for stimulus gear from maneuver ▪ 0: Off ▪ 1: On
Sw_Trm_Mode	[1|2]	Switch for enabling manual or automatic transmission ▪ 1: Manual ▪ 2: Automatic
v_Vehicle	[m/s]	Vehicle velocity
v_Vehicle_Ref	[m/s]	Reference vehicle velocity

Outports

The following table shows the outports:

Name	Unit	Description
ASMSignalBus	[]	Signal bus that contains signals of ASM components. Refer to ASMSignalBus (ASM User Guide 📖).
Gear	[]	Gear
Pos_AccPedal	[%]	Accelerator pedal position
Pos_BrakePedal	[%]	Brake pedal position
Pos_ClutchPedal	[%]	Clutch pedal position
SelectorLever	[-3|-2|-1|0|1]	Selector lever position ▪ -3: Tip shift ▪ -2: Park ▪ -1: Reverse ▪ 0: Neutral ▪ 1: Drive

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_a_Tractive_Res_UpLim	[m/s^2]	Tractive resistance acceleration threshold for startup
Const_a_x_Vehicle_LowLim	[m/s^2]	Hard braking threshold for gear hold
Const_a_x_Vehicle_UpLim	[m/s^2]	Acceleration threshold for startup
Const_D_Gain_Startup	[s]	D gain of accelerator pedal startup controller
Const_I_Gain_ClutchPedal	[1/s]	I gain of clutch pedal controller
Const_I_Gain_StartUp	[1/s]	I gain of accelerator pedal startup controller
Const_n_Engine_StartUp_Set	[rpm]	Engine speed setpoint during startup

Name	Unit	Description
Const_P_Gain_ClutchPedal	[]	P gain of clutch pedal controller
Const_P_Gain_StartUp	[]	P gain of accelerator pedal startup controller
Const_t_Gear_Neutral	[s]	Time of gear passing through neutral during gear change
Const_t_Hold_ClutchPedal	[s]	Disengaged clutch hold time
Const_v_x_Vehicle_LowLim	[m/s]	Small velocity threshold for driving with slipping clutch
Map_Gear_Startup	[]	Startup gear
Map_i_Ratio	[]	Gear ratio = f(gear)
Map_n_Engine_Downshift_Lim	[rpm]	Down shift engine speed limit = f(Pos_AccPedal)
Map_n_Engine_Upshift_Lim	[rpm]	Up shift engine speed limit = f(Pos_AccPedal)
Map_omega_Out_Trm_Shift_Bias	[rpm]	Transmission output speed shift bias = f(tractive resistance acceleration)
Map_Pos_AccPedal	[0_1]	Accelerator pedal factor during gear change = f(Pos_ClutchPedal)
Map_Pos_ClutchPedal_Disengagement	[%]	Clutch pedal disengagement position not during startup = f(t)
Map_Pos_ClutchPedal_Disengagement_StartUp	[%]	Clutch pedal disengagement position during startup = f(t)
Map_Pos_ClutchPedal_Engagement	[%]	Clutch pedal engagement position not during startup = f(t)
Map_Pos_ClutchPedal_Engagement_StartUp	[%]	Clutch pedal engagement position during startup = f(t)
StepSize	[s]	Simulation step size
Sw_Upshift_Gear_Skipping	[1|2]	Gear skipping switch during up shift ▪ 1: On ▪ 2: Off

Handling of unused inports

Depending on the demo model and the library, some of the inport signals might not be used. In this case, these inports cannot be connected to dummy values. They should be connected to constant values instead.

These are defined in the following table:

Inport Name	Not Used If
AccBr_Mode	Its value = 0
Pos_AccPedal_Stim	Its value = 0
Pos_BrakePedal_Stim	Its value = 0
Gear_External	Sw_Gear_External = 2 OR Sw_Trm_Mode ≠ 1
Gear_Max_Maneuver	Its value = 0
Gear_Min_Maneuver	Its value = 0
Sw_Gear_Set	Its value = 0

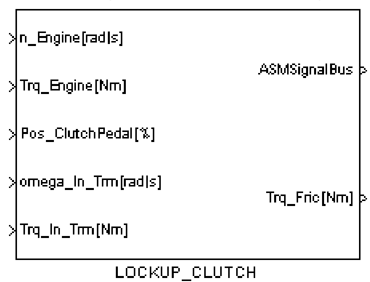
Related topics

References

Lockup Clutch (Version 2.0 or Earlier)

Description

The lockup clutch is mounted parallel to the torque converter.



The lockup clutch friction torque is composed of two components. The lockup clutch static torque T_{cst} balances the motor and the gearbox input to run at almost the same speed. To allow the transition from a certain slip speed to the locked state, a dynamic term is added as a function of the relative velocity. The maximum friction torque $T_{cfr,max}$ is a function of the lockup clutch geometry parameters. The following equation shows the calculation of the clutch friction torque:

$$T_{cfr} = \left|T_{cst} + D\left(\omega_{Engine} - \omega_{Trm,In}\right)\right| \leq T_{cfr,max}$$

The static torque can be calculated from the steady state condition, at $(\omega_{Engine} - \omega_{Trm,In})$, which leads to the static torque calculation

$$T_{cst} = \frac{T_{Engine} + T_{Trm,In}}{2}$$

Note

The maximum transferable lockup clutch friction torque is scaled with the lockup clutch pedal position from zero to the fully depressed position.

Inports

The following table shows the inports:

Name	Unit	Description
n_Engine	[rad/s]	Engine speed
omega_In_Trm	[rad/s]	Transmission input shaft speed
Pos_Clutch_Pedal	[%]	Position of the clutch pedal for manual transmission
Trq_Engine	[Nm]	Mean effective engine torque
Trq_In_Trm	[Nm]	Input torque from transmission input shaft

Outports

The following table shows the outports:

Name	Unit	Description
Trq_Fric	[Nm]	Clutch friction torque to crankshaft

Parameters

The following table shows the block parameters:

Name	Unit	Description
Const_Damping	[Nm/rad/s]	Clutch torsion spring damping
Const_Torque_Max	[Nm]	Maximum transferable clutch friction torque

Related topics

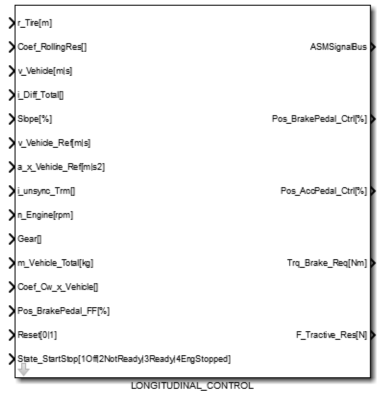
References

Lock-Up Clutch.. 35
Torque Converter (Version 4.0 or Earlier) (ModelDesk Parameterizing 📖)

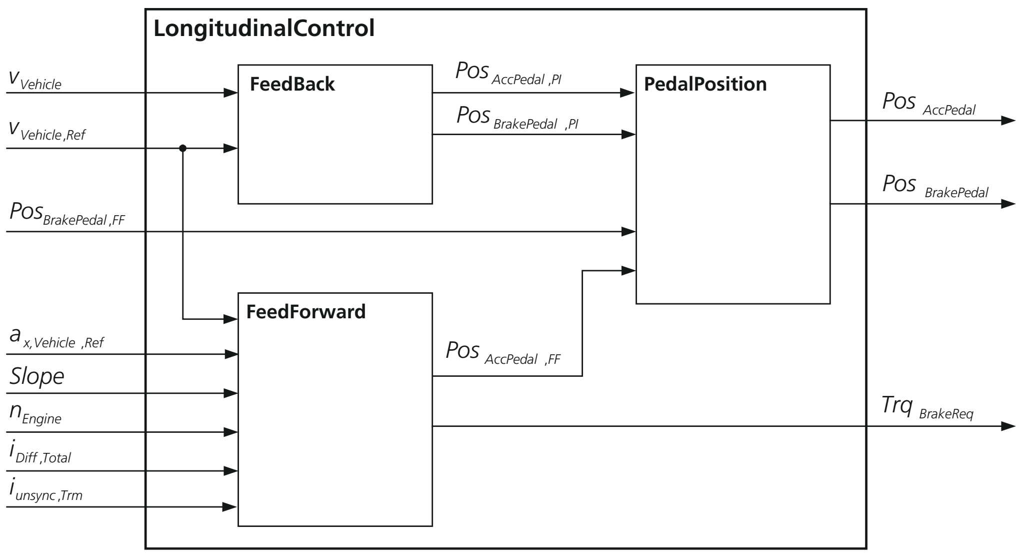
Longitudinal Control (Version 8.0 or earlier)

Description

The **LONGITUDINAL_CONTROL** block controls the accelerator pedal and brake pedal. Both pedals are controlled in such a way that the vehicle follows a given reference velocity. The longitudinal controller comprises feedback and feed forward. Only one of the two pedals can be activated at a time.



The following illustration shows the main signal flow in the LONGITUDINAL_CONTROL block.

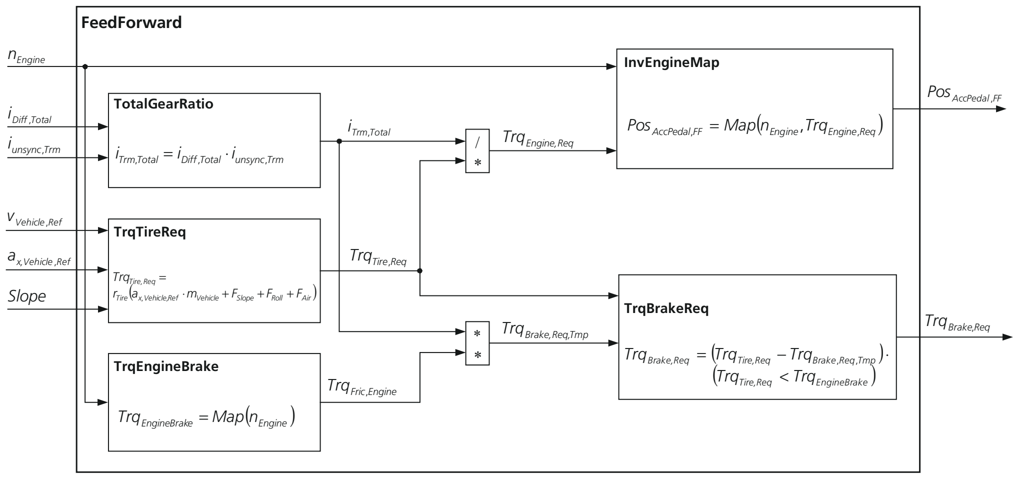


The longitudinal controller can handle several vehicle variants. The following paragraphs describe the feed forward, feedback and lockpedals sections in detail. The vehicle variant handling is also described.

FeedForward

The feed forward controller calculates the requested accelerator pedal position and the requested braking torque according to reference velocity and reference acceleration. Simplified inverse dynamics models of drivetrain and engine are implemented.

The feed forward controller comprises the calculation of the requested tire torque, the calculation of the total gear ratio, the calculation of the available engine braking torque, and an inverse engine map. The following illustration shows the main signal flow in the feed forward controller.



Only one pedal is actuated at a time.

Feedback

The feedback controller controls the accelerator pedal and brake pedal to keep the difference between vehicle velocity and reference velocity at zero. The feedback controller comprises 2 PI controllers. The accelerator pedal and brake pedal each have one PI controller. An anti-windup functionality in the integrators is implemented using saturated integrators.

To ensure anti-windup, the integrator for accelerator pedal control is reset if one of the following conditions applies.

- The vehicle velocity is very small. This functionality is necessary for vehicle startup.
- The difference between vehicle velocity and reference velocity is large.
- A gearshift was performed.
- The brake pedal is activated.

To ensure anti-windup, the integrator for brake pedal control is reset if one of the following conditions applies.

- The difference between vehicle velocity and reference velocity is large.
- The accelerator pedal is activated.

LockPedals

The feed forward and feedback controllers provide the accelerator pedal and brake pedal positions. The resulting accelerator and brake pedal positions are calculated as the sum of the two controller signals.

In some cases it may occur that the preceding controllers actuate both pedals simultaneously. An internal logic ensures that only one pedal is actuated at a time. The logic has the following features.

- If feed forward is present, the pedal which contains feed forward is actuated.
- If no feed forward is present, the brake pedal has priority for reference acceleration below a certain threshold. The accelerator pedal has priority if the reference acceleration exceeds a certain value.

Inports

The following table shows the inports:

Name	Unit	Description
a_x_Vehicle_Ref	[m/s²]	Vehicle reference acceleration
Coef_RollingRes	[]	Tire friction coefficient
Gear	[]	Current gear
i_Diff_Total	[]	Differential transmission ratio
i_unsync_Trm	[]	Unsynchronized transmission ratio
m_Vehicle_Total	[kg]	Vehicle mass
n_Engine	[rpm]	Engine speed
Reset	[0|1]	Reset of states
r_Tire	[m]	Dynamic tire radius
Slope	[%]	Road slope
State_StartStop	[1|2|3|4]	State of start-stop system: ▪ 1. Switched off ▪ 2. Not ready (conditions are not fulfilled) ▪ 3. Ready (waiting for driver action) ▪ 4. Engine actively stopped by the system
v_Vehicle	[m/s]	Vehicle speed
v_Vehicle_Ref	[m/s]	Vehicle reference speed

Outports

The following table shows the outports:

Name	Unit	Description
F_Tractive_Res	[N]	Tractive resistance force
Pos_AccPedal_Ctrl	[%]	Controlled accelerator pedal position
Pos_BrakePedal_Ctrl	[%]	Controlled brake pedal position
Trq_Brake_Req	[Nm]	Requested brake torque

Parameters

The following table shows the block parameters:

Name	Unit	Description
Const_A_x_Vehicle	[m²]	Vehicle cross section
Const_Dens_Air	[kg/m³]	Air density
Const_g	[m/s²]	Gravity constant
Const_PICtrl_Acc	[kp,ki]	PI controller gains for accelerator pedal control
Const_PICtrl_Brake	[kp,ki]	PI controller gains for brake pedal control
Map_Trq_Engine_Inv	[]	Inverse engine map
Map_Trq_Fric_Engine	[Nm]	Engine friction torque[Nm] = f(n_Engine)

Name	Unit	Description
StepSize	[s]	Simulation step size
Sw_FeedForward_Mode	[1|2]	Feed forward calculation mode: ▪ Torque-based ▪ Power-based

Related topics

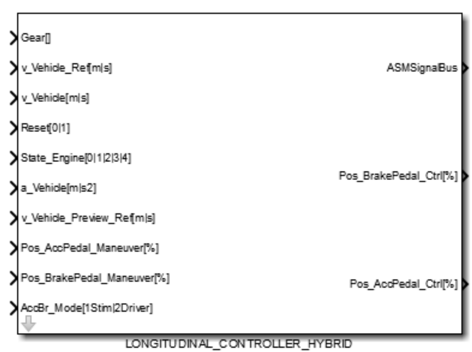
References

Longitudinal Control... 89
Longitudinal Control V8 (ModelDesk Parameterizing 📖)

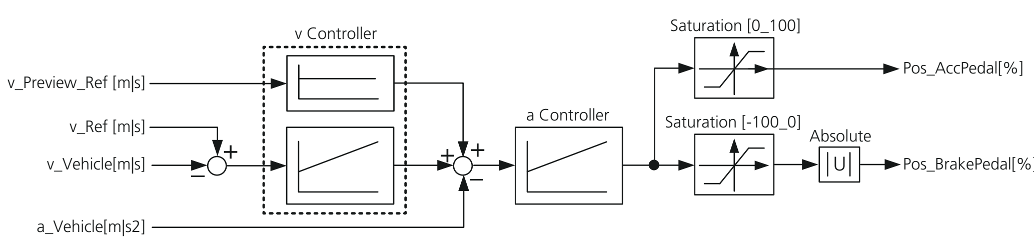
Longitudinal Controller Hybrid (Version 5.0 or Earlier)

Description

The LONGITUDINAL_CONTROLLER_HYBRID block controls the accelerator and brake pedals to follow a given reference velocity.



The block is modeled as a cascade controller with two PI controllers. The following figure shows the schematic of the block.



The velocity controller generates an acceleration set signal, which is used to generate an error signal for the acceleration controller. The control signal of the acceleration controller is then interpreted as an acceleration or brake demand depending on its sign.

The pedals are controlled in such a way that one pedal is pressed at a time. The minimum time needed to switch between different pedals can be parameterized. To simulate a more realistic pedal actuation, you can limit the maximum allowed rate of pedal actuation. Moreover, the driver can tolerate a specific velocity difference. This tolerated value is set as a function of the reference speed. If the actual relative velocity lies within the parameterized limits, the driver does not contribute actively to the pedals actuation.

Inports

The following table shows the inports:

Name	Unit	Description
a_Vehicle	[m/s^2]	Vehicle acceleration
AccBr_Mode	[1|2]	Mode signal for accelerator and brake pedal: ▪ 1. Stimulus ▪ 2. Driver
Gear	[]	Current gear
Pos_AccPedal_Maneuver	[%]	Accelerator pedal position from maneuver
Pos_BrakePedal_Maneuver	[%]	Brake pedal position from maneuver
Reset	[0|1]	Reset of states
State_Engine	[0|1|2|3|4]	Engine state: ▪ 0: Engine off/Error ▪ 1: Ignition on ▪ 2: Starter on ▪ 3: Engine running ▪ 4: Engine shutdown
v_Vehicle	[m/s]	Vehicle velocity
v_Vehicle_Preview_Ref	[m/s]	Preview vehicle reference velocity
v_Vehicle_Ref	[m/s]	Vehicle reference velocity

Outports

The following table shows the outports:

Name	Unit	Description
ASMSignalBus	[]	Signal bus that contains signals of ASM components. Refer to ASMSignalBus (ASM User Guide 🕮).
Pos_AccPedal_Ctrl	[%]	Controlled accelerator pedal position
Pos_BrakePedal_Ctrl	[%]	Controlled brake pedal position

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_I_aCtrl_Pedals	[1/s]	I gain of acceleration controller
Const_I_vCtrl_Pedals	[1/s]	I gain of velocity controller

Name	Unit	Description
Const_P_aCtrl_Pedals	[]	P gain of acceleration controller
Const_Pos_BrakePedal_Standstill	[%]	Brake pedal actuation in standstill
Const_Preview_vCtrl_Pedals	[]	Preview gain of velocity controller
Const_P_vCtrl_Pedals	[]	P gain of velocity controller
Const_Rate_Max_AccPedal	[%/s]	Maximum allowed rate of accelerator pedal
Const_Rate_Max_BrakePedal	[%/s]	Maximum allowed rate of brake pedal
Const_t_Min_Pedals	[s]	Minimum time needed to switch between different pedals
Map_v_Dead_Driver	[km/h]	Tolerated relative velocity = f(v_Vehicle_Ref)
StepSize	[s]	Simulation step size
Sw_v_Dead_Driver	[0|1]	Switch to activate the tolerated relative velocity: ▪ 0: Off ▪ 1: On

Related topics

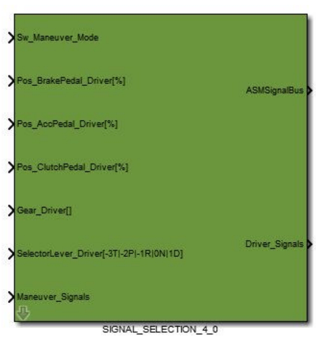
References

Long Controller Hybrid V5 (ModelDesk Parameterizing 📖)

Signal Selection (Version 4.0 or Earlier)

Description

The SIGNAL_SELECTION_4_0 subsystem is the interface between the maneuver, driver, and vehicle models. Depending on the maneuver definition, the pedals, gear, and selector lever wheel are actuated by stimulus or controlled by the driver.



Other signals in the Maneuver_Signals bus, such as ignition, starter request and test bench related signals are just routed through this block.

Inports

The following table shows the inports:

Name	Unit	Description
Gear_Driver	[]	Gear from longitudinal controller
Maneuver_Signals	[]	Signal bus containing maneuver signals
Pos_AccPedal_Driver	[%]	Accelerator pedal position from longitudinal controller
Pos_ClutchPedal_Driver	[%]	Clutch pedal position from longitudinal controller
SelectorLever_Driver	[-3|-2|-1|0|1]	Selector lever position from driver: ▪ -3: T ▪ -2: P ▪ -1: R ▪ 0: N ▪ 1: D
Sw_Maneuver_Mode	[1|2|3|4]	Switch to select signal source: ▪ 1: Offline manual ▪ 2: Online manual ▪ 3: Stimulus maneuver ▪ 4: Driver maneuver

Outports

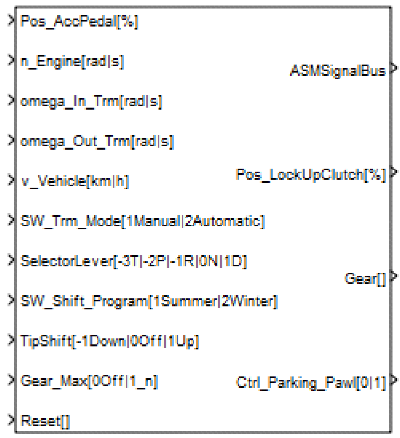
The following table shows the outports:

Name	Unit	Description
ASMSignalBus	[]	Signal bus that contains signals of ASM components. Refer to ASMSignalBus (ASM User Guide 📖).
Driver_Signals	[]	Signal bus containing driver signals

Soft ECU Transmission Basic (Version 7.0 or Earlier)

Description

The Soft ECU Transmission Basic controls the automatic gearbox. It engages the gears and controls the lockup clutch according to lever position.

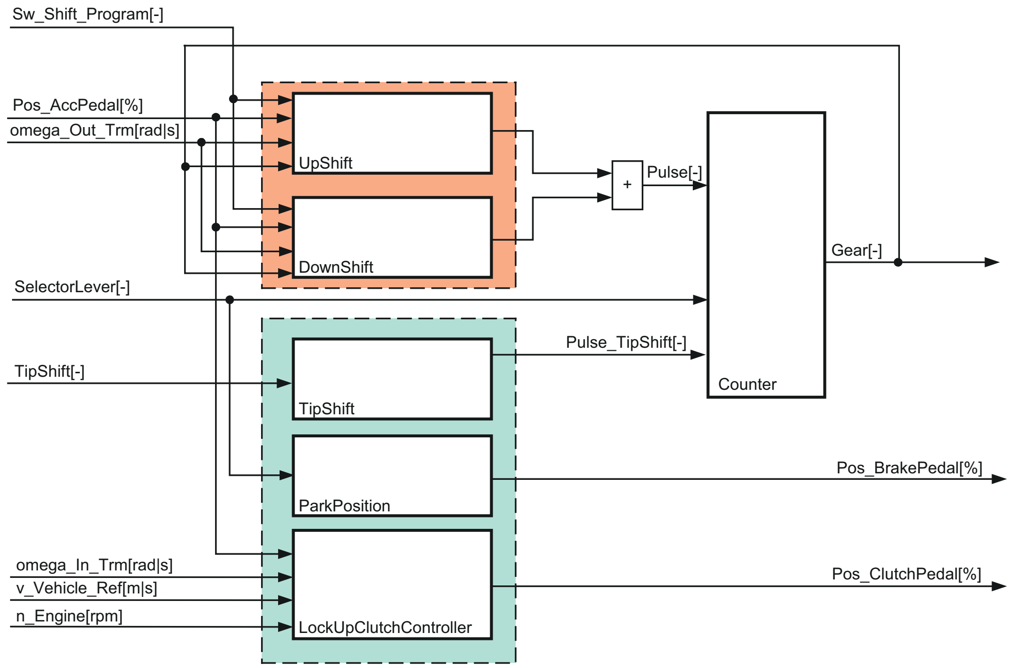


The automatic gearbox lever has five positions:

Position	Description
P – Park	Disengages the clutch and brakes the vehicle for parking position
R – Reverse	Engages the reverse gear
N – Neutral	Engages the neutral gear
D – Drive	Engages the first gear and shifts up or down depending on the transmission output speed and on the accelerator pedal position
T – TipShift	Manual shifting with an automatic transmission

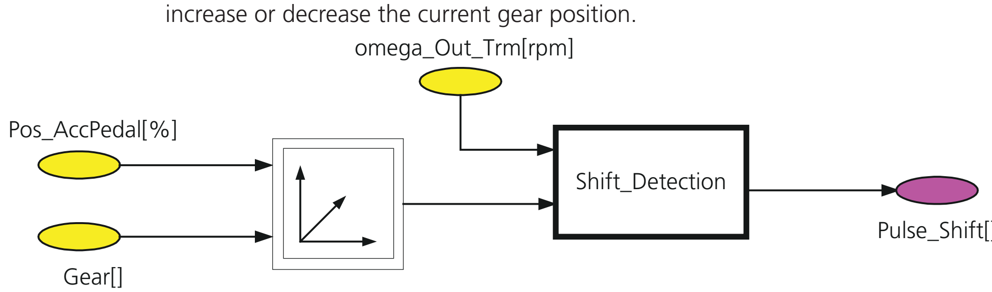
In the drive position, the Soft TCU engages the first gear and shifts automatically according to the transmission output speed and the accelerator pedal position. The lockup clutch is also controlled according to vehicle speed and to the accelerator pedal position. This makes it possible to drive the vehicle without any user gear shifting.

The following illustration gives a basic overview of the Soft ECU Transmission Basic.

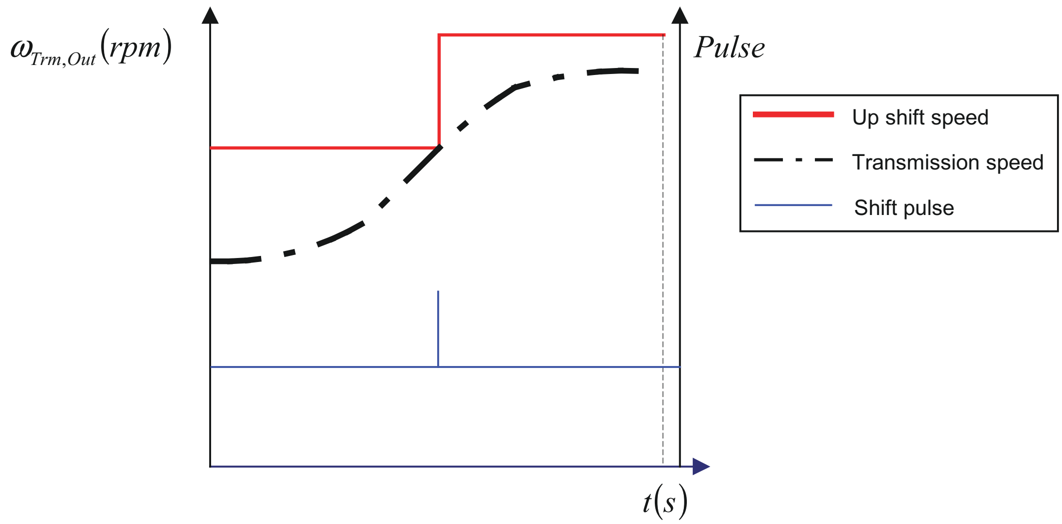


The model is divided into three sections. The light red section contains all the function which shift a gear up or down. The cyan subsystem contains functions for particular driving situations. Finally, the counter section is the gear shifter itself, which generates the gear for the transmission and the pedal positions. The mode switch section enables the correct signals for the current driving situation. The following three paragraphs describe the different parts of the Soft ECU Transmission Basic.

Shifting Section (light red) Generally speaking, the shifting functionality compares the current transmission output speed with an upshift or downshift speed. If the transmission output speed crosses the upshift or downshift speed for the current driving situation, a pulse is generated. Inside the gear shifter, this pulse is used to engaged the clutch, to decrease the accelerator pedal, and to increase or decrease the current gear position.



The following illustration shows a typical upshift functionality:



If the transmission output speed crosses the upshift signal, a shift pulse is generated. This forces the transmission to shift up a gear.

Particular Driving Situations (cyan) The models for particular driving situation are used to handle additional functionalities inside the Soft ECU transmission.

- The TipShift function is used to handle manual gear shifting with the automatic transmission.
- The ParkPosition function is used to engage the brakes if the selector lever stands in parking position.
- The LockUpClutch Controller function is used to control the lockup clutch of the torque converter according to the current driving situation.

Counter The counter engages the gear according to the current selector lever position or to the manually selected gear if the TipShift function is used.

Inports

The following table shows the inports:

Name	Unit	Description
Gear_max	[off|1_n]	Maximum gear number to be engaged by the driver or the Soft ECU transmission
n_Engine	[rad/s]	Engine speed
omega_In_Trm	[rad/s]	Transmission input speed
omega_Out_Trm	[rad/s]	Transmission output speed
Pos_AccPedal	[%]	Accelerator pedal position
Reset	[]	Reset all integrators to their initial conditions
SelectorLever	[]	Position of the gear lever for automatic transmission
SW_Shift_Program	[1|2]	Switch for different shift programs of the Soft ECU transmission ▪ 1: Summer ▪ 2: Winter

Name	Unit	Description
SW_Trm_Mode	[]	Transmission mode for engaging Soft ECU transmission
TipShift	[-1|0|1]	Input for TipShift function of Soft ECU transmission
v_Vehicle	[km/h]	Vehicle speed

Outports

The following table shows the outports:

Name	Unit	Description
Ctrl_Parking_Pawl	[0|1]	Parking pawl control signal
Gear	[]	Selected gear for the automatic transmission
Pos_LockUpClutch	[%]	Position of the lockup clutch

Parameters

The following table shows the block parameters:

Name	Unit	Description
Const_I_LockupClutch	[]	I Gain for lockup clutch controller
Const_LockupClutch_Set	[]	Table for setpoint of lockup clutch slip = f(Vehicle Speed, Pos_AccPedal)
Const_P_LockupClutch	[]	P Gain for lockup clutch controller
Const_t_DownShift	[s]	Time constant for a gear downshift
Const_t_UpShift	[s]	Time constant for a gear upshift
Map_ClutchActive	[]	Table for lockup clutch state = f(Vehicle Speed)
Map_omega_DownShift	[rpm]	Table with transmission speed for gear downshift = f(Pos_AccPed, Gear)
Map_omega_UpShift	[rpm]	Table with transmission speed for gear upshift = f(Pos_AccPed, Gear)
StepSize	[s]	Simulation step size

Related topics

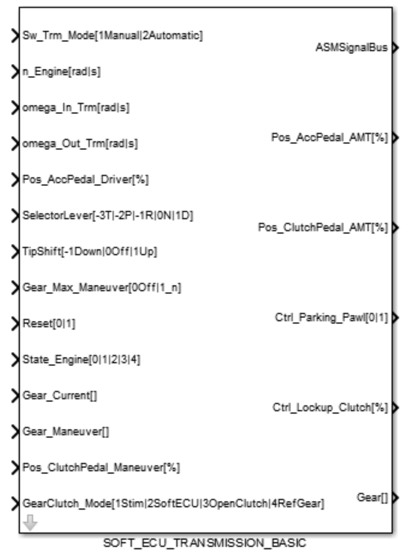
References

Soft ECU AT Basic V7 (ModelDesk Parameterizing 📖)

Soft ECU Transmission Basic (Version 8.0 and 9.0)

Description

The block controls the gearshift process of an automatic transmission. The shift process can be initiated by using the selector lever or the tipshift. It also offers a control strategy for the lockup clutch of the torque converter. For an automated manual transmission (AMT), the clutch is also controlled while the gear is being shifted.



The driver can request gear engagement by controlling the selector lever, which has the following positions:

Position	Description
P	Park: Activates the parking pawl
R	Reverse: Engages the reverse gear
N	Neutral: Engages the neutral gear
D	Drive: Engages the first gear and afterwards shifts up or down automatically according to the driving situation
T	Tip shift: Activates the tip shift (tiptronic) function. The gears can then be shifted according to the driver's demand

The gearshift process and the clutch control, both lockup and AMT clutch, can also be influenced by stimuli and external requests. The gear can be influenced by the Gear_Maneuver inport. The clutch is influenced by the Pos_ClutchPedal_Maneuver inport.

Therefore, the block performs different simulation scenarios according to the GearClutch_Mode inport.

The following table illustrates the possible simulation scenarios performed by the block:

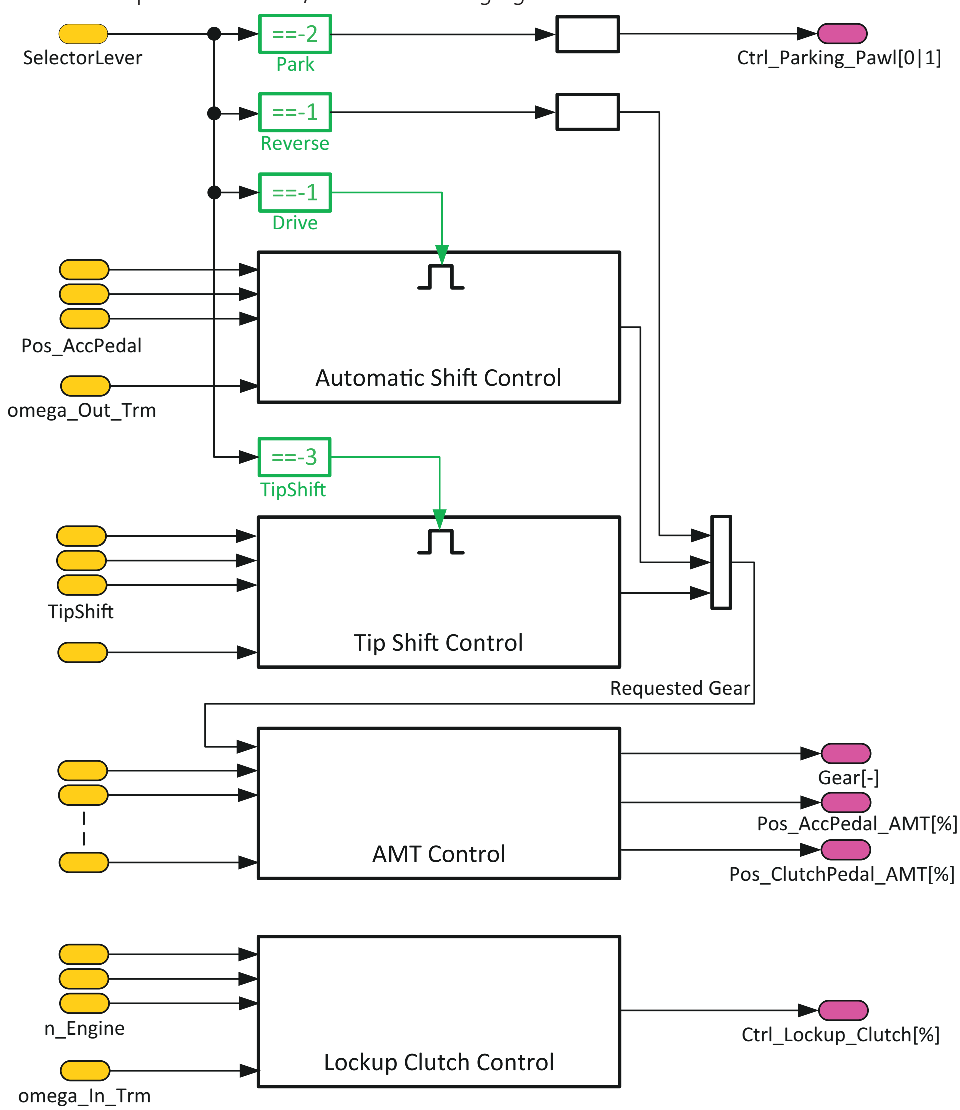
GearClutch_Mode	Gear	Lockup Clutch (Sw_AMT = 0) or AMT Clutch (Sw_AMT = 1)
1 Stim: Stimulus mode	Gear_Maneuver	Pos_ClutchPedal_Maneuver
2 SoftECU: Automatic control mode	Controlled by the soft ECU	Controlled by the soft ECU
3 OpenClutch: Open clutch mode	Controlled by the soft ECU	Pos_ClutchPedal_Maneuver (if simulated with Maneuver Scheduler, the clutch is opened gradually)

GearClutch_Mode	Gear	Lockup Clutch (Sw_AMT = 0) or AMT Clutch (Sw_AMT = 1)
4 RefGear: Reference gear mode	Controlled according to Gear_Maneuver, which is used as a set value	Controlled by the soft ECU

Note

Both stimulus and external request features are deactivated in the standard demos. By default, the demos are configured to mode 2.

The Soft ECU Transmission model is divided into several subsystems according to specific functions, see the following figure:



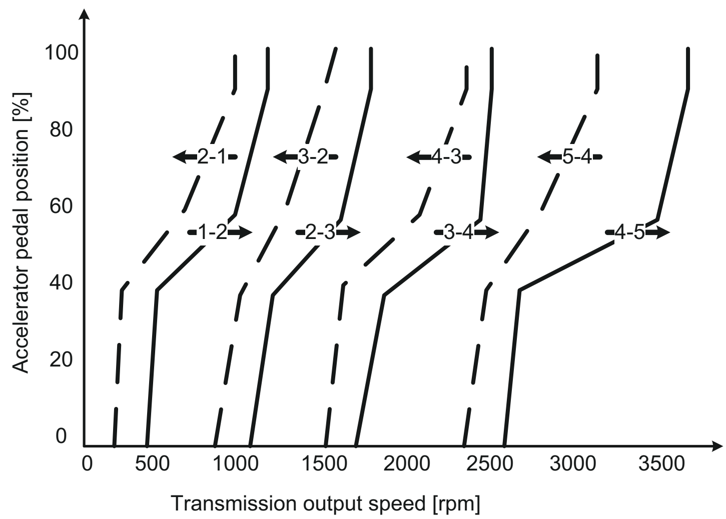
The following sections describe the control strategies of the Soft ECU Transmission.

Automatic shift control

The subsystem is active if the driver shifts the selector lever to the D position. The gear is then shifted up and down automatically according to the accelerator pedal position and the transmission output speed.

Two shift patterns for up shift and down shift are parameterized inside the block. Each shift pattern calculates the shift thresholds of the transmission output speed for several possible gears. These thresholds are then compared with the actual transmission output speed to request an up shift or down shift.

The following illustration displays these shift patterns:



To illustrate the shift strategy, up shift 1-2 and down shift 2-1 are clarified in the following:

As the driver shifts the selector lever to the D position, the first gear is requested and engaged at the same time. Meanwhile, the transmission output speed is being increased to some point between curves 2-1 and 1-2. If the driver demands more acceleration by pressing the accelerator pedal, the transmission output speed will be increased accordingly and curve 1-2 will be crossed. After curve1-2 is crossed, the second gear is requested.

Down shift 2-1 can be understood in a similar way. As the driver decelerates, the transmission output speed is decreased to some point, where curve 2-1 is crossed and the first gear is requested.

To prevent the phenomenon of gear hunting, i.e., frequent up shifting and down shifting, a minimum time between two successive shifts is considered (**Const_t_Min_Shift[s]** parameter). In this way and after a successful gearshift, another shift request within the mentioned time is disabled. If the user sets a sufficient time, gear skipping can be reached. However, this strongly depends on the shift patterns and the driving situation.

The gear request can be reset at any time by using the reset of states. Moreover, this is automatically done if the engine was stalled.

Tip shift control

The subsystem is active if the driver shifts the selector lever to the T position. Afterwards, the driver can take the control to shift the gear up and down.

If the driver shifts the selector lever to the T position, the tip shift signal will be observed.

This signal has three values:
- -1: Down shift
- 0: Off
- 1: Up shift

Each time the driver tips the tip shift up or down, a gear up shift or down shift is requested, respectively.

However, two conditions have to be fulfilled:
- The lowest possible gear is -1.
- A gearshift request can be considered only if the previously requested gear was successfully engaged.

Automated manual transmission control

The functionality of an automated manual transmission (AMT) control is implemented in this subsystem. It can be activated using the Sw_AMT[0|1] parameter.

The block controls the clutch pedal position while shifting gear. This is essential, for example, in parallel hybrid topologies, where the clutch between the electric machine and the transmission needs to be controlled. It is ensured that the gear is requested only if the clutch pedal is completely disengaged.

Additionally, the accelerator pedal position is scaled while shifting gear by a user-defined function.

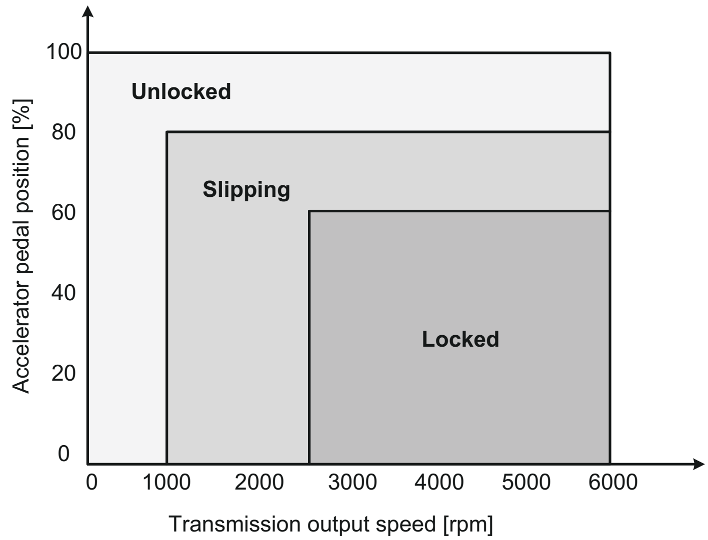
Note

At the moment, the model does not have a startup controller to ensure a soft vehicle launch. Therefore, it might be not suitable to use it for vehicles equipped with AMT and without a startup element. as for example a torque converter.

Lockup clutch control

The block controls the lockup clutch in automatic transmissions. The main function of the lockup clutch is to mechanically connect or disconnect the engine from the rest of the transmission units to increase efficiency and avoid oscillations in the drivetrain.

The lockup states are simplified as a function of the accelerator pedal position and the transmission output speed. See the following illustration:



The lockup clutch is unlocked at the lowest transmission output speed and the highest accelerator pedal position to enable vehicle startup and isolate the engine oscillations, respectively.

The lockup clutch is locked at relatively high transmission speeds to increase the efficiency of the drivetrain by avoiding losses in the torque converter.

Between the lock and unlock states, slipping is allowed. Lockup clutch slipping is controlled by using a PI controller with the speed ratio as a feedback signal. The actual speed ratio is calculated as the ratio of the transmission input speed to the engine speed and can be used as an indicator of slipping in the torque converter.

Inports

The following table shows the inports:

Name	Unit	Description
Gear_Current	[]	Current gear
Gear_Maneuver	[]	Stimulus gear from maneuver
Gear_Max_Maneuver	[0Off|1_n]	Highest allowed gear for the maneuver
GearClutch_Mode	[1|2|3|4]	Gear and clutch mode: ▪ 1: Stimulus mode ▪ 2: SoftECU mode ▪ 3: Open clutch mode ▪ 4: Reference gear mode
n_Engine	[rad/s]	Engine speed
omega_In_Trm	[rad/s]	Transmission input speed
omega_Out_Trm	[rad/s]	Transmission output speed
Pos_AccPedal_Driver	[%]	Accelerator pedal position from driver
Pos_ClutchPedal_Maneuver	[%]	Stimulus clutch pedal position

Name	Unit	Description
Reset	[0|1]	Reset of states
SelectorLever	[-3|-2|-1|0|1]	Selector lever position for automatic transmission ▪ -3: TipShift ▪ -2: Park ▪ -1: Reverse ▪ 0: Neutral ▪ 1: Drive
State_Engine	[0|1|2|3|4]	Engine state switch: ▪ 0: Engine off/Error ▪ 1: Ignition on ▪ 2: Starter on ▪ 3: Engine running ▪ 4: Engine shutdown
Sw_Trm_Mode	[1|2]	Transmission mode switch: ▪ 1: Manual transmission ▪ 2: Automatic transmission
TipShift	[-1|0|1]	TipShift request signal for TipTronic function: ▪ -1: Down shift ▪ 0: Off ▪ 1: Up shift

Outports The following table shows the outports:

Name	Unit	Description
ASMSignalBus	[]	Signal bus that contains signals of ASM components. Refer to ASMSignalBus (ASM User Guide 📖).
Ctrl_Lockup_Clutch	[%]	Lockup clutch control signal
Ctrl_Parking_Pawl	[0|1]	Parking pawl control signal
Gear	[]	Requested gear
Pos_AccPedal_AMT	[%]	Scaled accelerator pedal position for automated manual transmission
Pos_ClutchPedal_AMT	[%]	Controlled clutch pedal position for automated manual transmission

Parameters The following table shows the parameters:

Name	Unit	Description
Const_I_LockupClutch	[1/s]	I gain of lockup clutch controller
Const_Max_Gear_Gearbox	[]	Maximum gearbox gear
Const_P_LockupClutch	[]	P gain of lockup clutch controller
Const_t_Min_Shift	[s]	Minimum time required between two successive shifts
Map_Factor_AccPedal	[0_1]	Accelerator pedal scaling factor during clutch actuation in AMT
Map_omega_Down shift	[rpm]	Transmission output speed for gear down shift schedule

Name	Unit	Description
Map_omega_Up shift	[rpm]	Transmission output speed for gear up shift schedule
Map_Pos_Diseng_ClutchPedal	[%]	Clutch pedal disengagement position while shifting gear in AMT
Map_Pos_Eng_ClutchPedal	[%]	Clutch pedal engagement position while shifting gear in AMT
Map_State_LockupClutch	[0_1]	Lockup clutch state
StepSize	[s]	Simulation step size
Sw_AMT	[0|1]	Switch to activate AMT control

Related topics

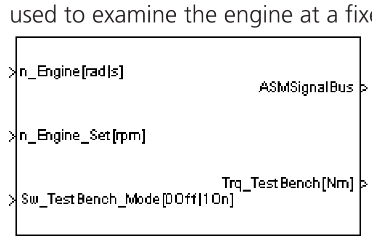
Basics

Soft ECU Transmission Basic V9 (ModelDesk Parameterizing 📖)

Test Bench (Version 2.0 or Earlier)

Description

The test bench model allows you to set a fixed engine speed controlled by the test bench controller. This is comparable to an engine test bench and can be used to examine the engine at a fixed engine speed.



TEST_BENCH

The test bench model is implemented as a PI controller.

Inports

The following table shows the inports:

Name	Unit	Description
n_Engine	[rad/s]	Engine speed
n_Engine_Set	[rpm]	Engine speed setpoint
Sw_TestBench_Mode	[0|1]	Switch for enable or disable test bench model ▪ 0: Off ▪ 1: On

Outports

The following table shows the outports:

Name	Unit	Description
Trq_TestBench	[Nm]	Test bench torque

Parameters

The following table shows the block parameters:

Name	Unit	Description
Const_P_Gain	[]	Test bench controller P-Gain
Const_I_Gain	[]	Test bench controller I-Gain
Const_Trq_max	[Nm]	Maximum dynamometer torque

Related topics

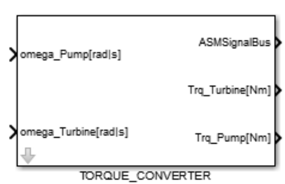
References

Test Bench..48
Test Bench V2 (ModelDesk Parameterizing 📖)

Torque Converter (Version 4.0 or Earlier)

Description

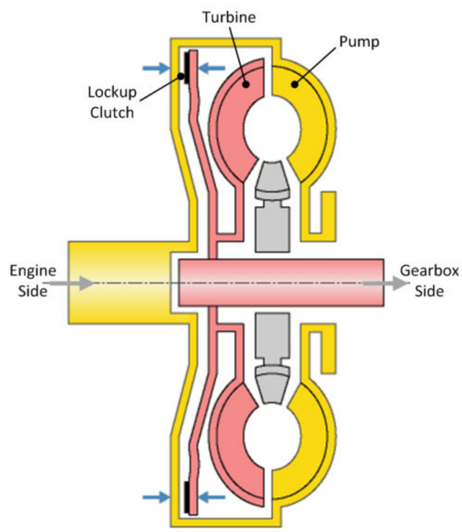
The torque converter is used in the automatic transmission drivetrain to transfer the engine torque to the transmission system.



The torque converter consists of the following elements

- Pump
- Turbine
- Stator

The next illustration shows a schematic of a torque converter:



The pump is mounted on the engine crankshaft and accelerates the oil flowing to the turbing inside the converter. From the turbine, the oil flows through the stator back to the pump. If the pump speed is greater than turbine speed, the torque converter increases the turbine torque. If the pump speed is nearly equal to the turbine speed, the converter works as a hydraulic clutch and transmits the pump torque to the turbine shaft.

The pump torque is modeled with the following equation, where the function f is a look-up table (Map_Eta_Slip):

$$T_p = f\left(\frac{\omega Turbine}{\omega Pump}\right) \cdot \omega_P{}^2$$

The turbine torque is calculated with the next equation, where the function g is a look-up table (Map_Rel_Trq_PumpTurb):

$$T_T = T_P \cdot g\left(\frac{\omega Turbine}{\omega Pump}\right)$$

Inports

The following table shows the inports:

Name	Unit	Description
omega_Pump	[rad/s]	Pump shaft speed
omega_Turbine	[rad/s]	Turbine shaft speed

Outports

The following table shows the outports:

Name	Unit	Description
Trq_Pump	[Nm]	Pump torque
Trq_Turbine	[Nm]	Turbine torque

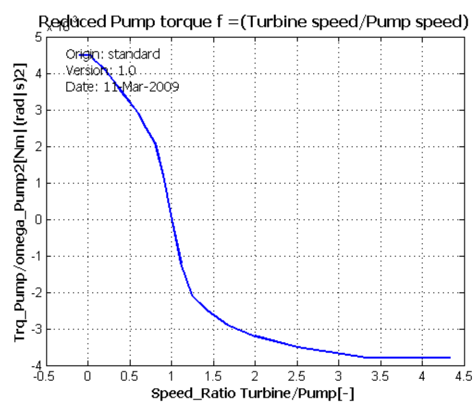
Parameters

The following table shows the block parameters:

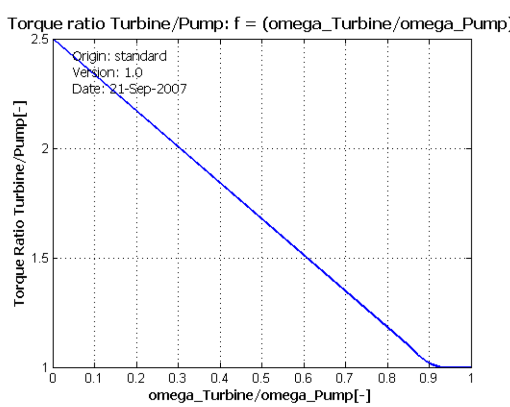
Name	Unit	Description
Map_Eta_Slip	[Nm/(rad/s)^2]	Reduced pump torque: f = (Turbine speed/Pump speed)
Map_Rel_Trq_PumpTurb	[]	Torque ratio Turbine/Pump: f = (Pump speed/Turbine speed)

Processing information

The next illustration shows an example of pump torque calculation.



The next illustration shows an example of turbine torque calculation.



Related topics

References

Torque Converter..41
Torque Converter (Version 4.0 or Earlier) (ModelDesk Parameterizing 📖)

New Features/Migration History of the ASM Drivetrain Basic Blockset

Introduction

The following topics provide an overview of the changes to the ASM products in the previous Releases.

For an overview of the new features and migration of the current Release, refer to Automotive Simulation Models (ASM) (New Features and Migration 📖).

Where to go from here

Information in this section

General Changes to the ASM Drivetrain Basic Blockset

Release 2020-B

The Road subsystem has been upgraded with new blocks to calculate the vehicle position and ambient conditions.

Release 2018-A

Environment subsystem The library blocks of the Environment subsystem were rearranged with respect to their functionality.

Relocated library blocks Blocks that were moved in the library are automatically migrated. During the migration, the links to these blocks are changed according to the new positions in the library.

Release 2017-B

Rearranged library The library blocks are rearranged because of the newly introduced dual-clutch transmission demo. The blocks in the library are grouped according to their functionality. Moreover, several new blocks are introduced to cover a comprehensive simulation of the dual-clutch transmission.

Blocks that were moved in the library are automatically migrated. During the migration, the links to these blocks are changed according to the new positions in the library.

Release 2017-A

ASM Driver The driver is now able to automatically drive backwards with manual transmission. In case of a negative reference velocity course, it controls the clutch and the gear to follow it. Moreover, the driver can now be used for the simulation with a start-stop system.

Release 2016-B

Look-up table migration The discontinued Simulink blocks Lookup and Lookup2D in the ASM library blocks were updated to the new standard Simulink Look-up table (n-D) block. Refer to Changes to all ASM Products (ASM User Guide 📖).

The look-up tables were updated in the following blocks within this library:

- CRANKSHAFT
- CYCLES_7_0
- GEARBOX_AT, GEARBOX_AT_1_0, GEARBOX_AT_8_0
- GEARBOX_MT, GEARBOX_MT_1_0, GEARBOX_MT_8_0
- GEAR_SHIFTER_2_0, GEAR_SHIFTER_6_0
- LONGITUDINAL_CONTROL
- SOFT_ECU_TRANSMISSION_1_0
- SOFT_ECU_TRANSMISSION_BASIC_7_0
- TORQUE_CONTROLLER_3_0
- TORQUE_CONVERTER, TORQUE_CONVERTER_4_0

License check of ASM Utils blocks The ASM_UTILS license was discontinued. The ASM Utils blocks now check the license of the ASM blockset in which they are used.

The Utils blocks in the following blocks within this library were updated:

- GEAR_SHIFTER_6_0
- SOFT_ECU_TRANSMISSION_BASIC_7_0

Release 2016-A

Engine simulation New blocks have been introduced to simulate a simplified engine. It is now possible to build a simplified virtual vehicle by using only the ASM Drivetrain Basic Blockset.

The new blocks are:

- ENGINE: Simulates simplified engine dynamics
- FUEL_CONSUMPTION: Used with the ENGINE block to calculate the fuel consumption and the carbon dioxide emissions

- ENGINE_OPERATION_BASIC: Part of the soft ECU model of the engine. It detects the engine state and activates the starter.
- IDLE_SPEED_CONTROL_ENGINE_BASIC: Part of the soft ECU model of the engine. It simulates the idle speed controller.
- TORQUE_INTERVENTION_ENGINE_BASIC: Part of the soft ECU model of the engine. It implements an external engine torque request.

Rearranged library blocks A new subsystem named Engine has been added at the top level. It contains the ENGINE and FUEL_CONSUMPTION blocks.

Inside the Soft ECU subsystem, two new subsystems have been added:

- Transmission: Contains the soft ECU blocks of the transmission.
- Engine: Contains the new soft ECU blocks of the engine.

Release 2013-A

The ASM DrivetrainBasic_lib has been significantly changed. The new blocks now have similar interfaces to the drivetrain in the ASM VehicleDynamics_lib. This makes it easier to exchange the third party models. In addition, the implementation of the library blocks is now easier to understand.

Restructuring the library meant that many blocks were changed. This might include changes in the implementation, block interfaces and parameters to make the blocks compatible with the restructured library.

Release 7.3

An integrator reset has been inserted to support a global reset in the ASM mean value engine models.

The library blocks now support reverse engine rotations, for example, for start-stop applications.

Release 7.0

The driving cycle JC08 is now included as a demo cycle.

Release 6.6

The ASM Drivetrain Basic Operator Blockset is new. It is the operator version of the ASM Drivetrain Basic Blockset.

The operator version has been designed for Simulink simulation only.

The operator model offers the same functionality, simulation quality and parameterization options as the standard simulation package. The operator version is compatible with the standard model (developer version) and can be parameterized by using ASMParameterization and ModelDesk.

The fundamental difference is the implementation of the library components: The components are encapsulated in S-functions. The blocks are accessible in the model so that the input and output behavior can be studied and parameters can be changed.

History of the AMBIENT Block

Release 2019-B

The AMBIENT block was split in two blocks: VEHICLE_POSITION and AMBIENT.

The VEHICLE_POSITION block calculates the altitude of the vehicle and the driven distance.

The AMBIENT block calculates the temperature and pressure of the ambient area.

In previous Releases, both functionalities were implemented in one AMBIENT block.

Note

The altitude calculation, now in the VEHICLE_POSITION block and based on the road slope and the vehicle speed, was incorrect in previous Releases. If you use the ambient pressure and temperature based on this calculation, the simulation behavior of your model changes after migration. The migration process automatically corrects this error.

Release 2018-A

The following inports were added:

- Sw_Replace_Ambient
- p_Ambient_Stim
- T_Ambient_Stim

The following parameters were added:

- Const_p_Ambient
- Const_T_Ambient

Also, a new outport was added to output the current altitude of the vehicle: Altitude_Vehicle[m]. Before, this signal was a part of the ASMSignalBus but not as an outport. The unit of the signal was changed from [m] to [km].

Now, when you set the Sw_Replace_Ambient variable to 1, the ambient conditions are specified as stimulus signals (e.g., measurement) that provide the block input via p_Ambient_Stim and T_Ambient_Stim.

Release 2017-B

The new AMBIENT block calculates the ambient temperature and pressure depending on the altitude. The block is part of the Environment/Road system.

Related topics

References

Ambient.. 102

History of the BRAKE_HYDRAULICS_VARIANT Block

Release 2018-A

This block became obsolete. During migration, the links to the BRAKE_HYDRAULICS_VARIANT block are changed to the former version.

Related topics

References

Brake Hydraulics Variant.. 199

History of the CLUTCH Block

Release 2015-A

To simulate the kiss point, a new parameter (Map_Trq_Clutch_Red) has been introduced. The parameter describes the clutch nominal torque capacity as a function of the clutch actuation signal: i.e., clutch pedal position or lockup clutch control.

A new parameter has been added: Map_Trq_Clutch_Red. The parameter is initialized with a linear relationship, so the previous behavior of the block remains unchanged.

Release 2013-A

The implementation of the block was completely changed to improve the simulation stability and provide better isolation of the engine oscillations. The block has now different inports, outports and parameters. The old implementation is still available in the blocks of the previous version.

The block cannot be migrated automatically, due to the restructuring of the library.

Therefore, the link to the CLUTCH block is changed to the former implementation, which is located in FormerVersions/CLUTCH_2_0, during the migration of older ASM releases.

The simulation behavior does not change. If the new block features are to be used, you can drag the CLUTCH block from the ASM_DrivetrainBasic_lib to the model. You must adapt the inports, outports and parameters manually.

Release 6.2

The friction model has been enhanced with additional saturation of the static torque.

Related topics	References

History of the CLUTCH_ENGAGEMENT_CONTROL Block

Release 2020-B	The block has a new inport: Enable_v_Vehicle_Init. To keep the model behavior unchanged, it is connected to a constant block during migration.
Release 2018-A	The issue of the block not passing reverse gears was solved.
Related topics	References

History of the COMMON_DRIVETRAIN_PARAMETERS Block

Release 2013-A

The block was deleted, but its parameters have been assigned to other blocks.

These parameters can now be changed from a unique location in the model, i.e., in the DRIVING_RESISTANCES and DIFFERENTIAL block. This avoids the multiple use of the same parameter in different blocks.

The old implementation is still available in the blocks of the previous version.

Because the block no longer exists in the library, its link is changed to the former implementation during migration from older ASM releases. The former implementation is located in FormerVersions/COMMON_DRIVETRAIN_PARAMETERS_4_0.

Release 7.3

The internal Goto blocks have been converted to output ports. Goto blocks with the original tags are added to the new output ports during migration. Now multi-instances of the block can be used within one model.

Release 6.2

The Mux for creating a bus have been replaced by BusCreator blocks.

History of the CRANKSHAFT Block

Release 2016-B

The continuous integrator inside the block has been replaced with a discrete one.

Release 2013-A

The maximum and minimum engine speed can now be parameterized in the CRANKSHAFT block.

Two new parameters have been added:
- Const_n_Engine_Max
- Const_n_Engine_Min

The sign of the Trq_Clutch[Nm] inport has been changed to compensate for the restructuring of the connected blocks.

Release 7.3

The engine speed integrator lower limit has been changed from zero to minus infinity to allow negative engine speeds, for example, for start-stop applications. An absolute block in MassTorqueModulation has been added to also process negative engine speeds. The block has been adapted to support engine reset functionality.

Release 6.5

The `"^"` sign has been removed from the block name.

Related topics

References

Crankshaft.. 44

History of the CYCLES Block

Release 2016-B

The block has been moved to the FormerVersions and discontinued. During the migration, the link is changed to `FormerVerions/CYCLES_7_0`.

Release 2016-A

The integrator inside the block is changed from continuous to discrete. A bug related to the key signal definition when the start time is not zero has been fixed.

Release 2015-B

The CYCLES block now accepts the definitions of test cycles with an engine switch-off phase. The engine can now be switched off and restarted during the test to test a warm restart. In the test cycle definition file a new variable

(**Sw_Engine**) can be added. This variable has a value of 0 to switch the engine off and 1 to switch it on.

For an example, refer to the **Ftp_75** test cycle in the new **Engine** demo models. A lower engine speed is also implemented as a new parameter to prevent the test bench from switching the engine off during the execution of a dynamometer test cycle.

During migration, the new **Const_n_Engine_Min** parameter for the lower engine speed is added. This parameter will have a default value of 0 to keep the old behavior unchanged.

Release 2014-B

The integrator inside the **CYCLES** block is changed from continuous to discrete to ensure a unified step size for the provided signals.

Release 6.5

Now, the **CYCLES** block can also handle engine cycles and is supported by ModelDesk.

If the model already supports ModelDesk, it will be possible to parameterize this block via ModelDesk. Default driving cycles can be copied from the ModelDesk pool of the related current demo model to the ModelDesk pool of the migrated project. To provide support for engine cycles, several new parameters and outports have been added. See the block documentation for details. The new parameters which are related to the cycles are initialized by the modified asm_eng_drivingcycle function. Some engine cycles are scaled with engine data. The related new parameters are set to default values and have to be adapted if such engine cycles are used. During migration, the new outports are automatically connected to the appropriate signal. If the parent system of the block has been changed, this might fail. In this case compare the connections to the current demo model and modify them manually.

History of the DIFFERENTIAL Block

Release 2013-A

The block now has the final driving ratio as a parameter. The implementation and the inports and outports have changed. The old implementation is still available in the blocks of the previous version.

The block cannot be migrated automatically, due to the restructuring of the library.

Therefore, the link to the **DIFFERENTIAL** block is changed to the former implementation, which is located in FormerVersions/ DIFFERENTIAL_2_0, during the migration of older ASM releases. The simulation behavior does not change.

If the new block features are to be used, you can drag the **DIFFERENTIAL** block from the ASM_DrivetrainBasic_lib to the model. You must adapt the inports, outports and parameters manually.

Release 7.1	The differential ratio has been added to the ASMSignalBus.
Related topics	References

History of the DRIVING_RESISTANCES Block

Release 2016-B

The friction between the tire and road can be now described with the Const_Fric_Coeff parameter. You can use the parameter to limit the driving and braking forces.

Release 2015-A

The block parameters are separated in a new subsystem inside the block. The driving resistances are added to the ASMSignalBus block.

Release 2013-A

The block was completely restructured. The inports and outports have been changed. The parameters remain unchanged. The old implementation is still available in the blocks of the previous version.

The block cannot be migrated automatically due to the restructuring of the library.

Therefore, the link to the DRIVING_RESISTANCES block is changed to the former implementation, which is located in FormerVersions/DRIVING_RESISTANCES_4_0, during the migration of older ASM releases. The simulation behavior does not change.

If the new block features are to be used, you can drag the DRIVING_RESISTANCES block from the ASM_DrivetrainBasic_lib to the model. You must adapt the inports, outports and parameters manually.

Release 7.1

The "^" sign has been removed in the units of the mask descriptions and block name.

The following signals have been added to the ASMSignalBus:

- r_Tire[m]
- F_Brake_Max[N]
- rho_Air[kg|m3]
- Vehicle_CrossSection[m2]
- Cw_Vehicle[]

- Coef_RollingRes[]
- m_Vehicle[kg]

Release 6.5	The "^" sign has been removed from the block name.
Related topics	References

History of the ENGINE Block

Release 2020-B	There is a new outport for engine-indicated torque: Trq_Ind_Engine. The outport is terminated during migration.
Release 2016-B	The size of the engine torque parameter has been expanded from [30x30] to [31x30]. The old parameter is extrapolated and initialized in `asmmigratepost`.
Related topics	References

History of the ENGINE_DATA Block

Release 2020-A	The size of the Map_Trq_Engine_Max parameter was changed from [14,2] to [21,2] values.
Related topics	References

History of the ENGINE_TORQUE_SET_INTERVENTION Block

Release 2020-B	The block was renamed to SHIFT_TORQUE_SET. You can use it to implement torque intervention during a gearshift.

History of the GEAR_SHIFTER Block

Release 2020-B	The data type of the State_Engine[0|1|2|3|4] inport was changed from *uint8* to *double*. The block has a new inport: Enable_v_Vehicle_Init. To keep the model behavior unchanged, it is connected to a constant block during migration.
Release 2018-A	The new v_Vehicle_Ref_Preview[m|s] inport was added. During migration, this inport is connected to a Constant block so that the previous block behavior remains unchanged.
Release 2017-A	A new inport for the start-stop system status has been added to the block: State_StartStop[1Off|2NotReady|3Ready|4EngStopped]. During migration, this inport is connected to a Constant block.
Release 2016-B	The block has a new parameter (Sw_ClutchPedal_EngineOff) to actuate the clutch pedal while the engine is not running. The behavior in hard braking scenarios where the clutch should not be disengaged if the current gear is neutral has been improved.
Release 2016-A	The block has been restructured to offer new features and make it more compatible with other ASM blocks. For example, it is now possible to use the stimulus accelerator and brake pedal signals while the GEAR_SHIFTER block controls the selector lever or the gear as well as the clutch position. Due to the considerable changes in this block, it cannot be migrated automatically. Therefore, during the migration, the link to the GEAR_SHIFTER block is changed to the former implementation version: `FormerVersions/GEAR_SHIFTER_13_0`. The former version of the block still contains some new features. To use the new GEAR_SHIFTER block, add it to your model from the ASM Environment Library. In this case, you must manually adapt the inports and outports.

Release 2015-A

A startup gear other than 1 is now possible. This builds up a more realistic behavior for the simulation of truck driving.

In addition, the startup behavior has been improved by introducing a new PID controller instead of the previous feed forward plus PI controller. The accelerator pedal actuation during the startup phase is now smoother and the reference engine speed can be reached more efficiently.

The block cannot be automatically migrated, due to the big changes in the inports and the block parameters. Therefore, during migration, the link to GEAR_SHIFTER is changed to the former implementation in FormerVersions/GEAR_SHIFTER_7_0.

To use the new implementation, drag the GEAR_SHIFTER block from the ASM Drivetrain Basic Library to the model. However, a hand adaptation of the inports, outports and parameters is necessary.

Release 2014-A

The block has been revised and new approaches have been developed. The revised block ensures better handling of different driving situations, realistically simulates several behaviors, and offers more possibilities for future extension. It also gives you more control to change the behavior via user-defined parameters.

The new GEAR_SHIFTER offers the following features:

- Fully parameterizable implementation
- Flexible clutch actuation according to the driving situation
- Gear skipping during downshift, e.g., emergency brake
- Gear skipping during upshift, e.g., truck application
- Manual modification of the current gear via external gear triggering
- The driver can now also shift the selector lever to reverse in automatic transmission
- Tracking of small velocities with slipping clutch
- Consideration of the effort needed to overcome driving resistances during the startup
- Detection of engine stall
- Realistic simulation of behavior when the gear passes through neutral during gear shifting

The block cannot be migrated automatically due to major changes in the inports as well as in the block parameters. Therefore, during migration, the link to GEAR_SHIFTER is changed to the former implementation, which is located in FormerVersions- GEAR_SHIFTER_6_0.

To use the new implementation, you can drag the GEAR_SHIFTER block from the ASM_DrivetrainBasic_lib library to the model. The inports, outports and parameters must be adapted manually.

Release 7.3	The block has been adapted to support engine reset functionality. To get the reset functionality, you must connect the new port manually. See the demo model for an example.
Release 6.5	The Sw_Gear_Set[0Off|1On] inport has been introduced for activating external control of manual transmission. The inport is connected to the related output of the CYCLES block.
Release 6.1	The new ASM_SHIFTABLE_LOOKUP block from the ASM Utilities library has been included (see above). Changes in the downshift table are now automatically considered in the calculation of the maximum gear and the calculation of the recommended gear.
Related topics	References Gear Shifter.......... 74

History of the GEARBOX_AT Block

Release 2019-A

The issue of gear synchronization failure during shifting through neutral was solved.

Release 2015-A

The damping coefficient of the gearbox input shaft has been added as a mask parameter: Const_Damping_Gear_In.

Release 2013-A

A new implementation is used and the calculations are now easier to understand. Due to this change the block has new inports, outports and parameters. The old implementation is still available in the blocks of the previous version.

The block cannot be migrated automatically due to the restructuring of the library.

Therefore, the link to the GEARBOX_AT block is changed to the former implementation, which is located in FormerVersions/ GEARBOX_AT_8_0, during the migration of older ASM releases. The simulation behavior does not change.

If the new block features are to be used, you can drag the GEARBOX_AT block from the ASM_DrivetrainBasic_lib to the model. You must adapt the inports, outports and parameters manually.

Release 7.4	To simplify the model, the PT1 element with time constant 0.001 was deleted from the Trq_Trm_In[Nm] outport because it had negligible effect. A unit delay is added during migration.
Release 7.3	The block has been adapted to support engine reset functionality. To get the reset functionality, you must connect the new port manually. See the demo model for an example.
Release 6.5	The "^" sign has been removed from the block name.
Release 6.4	The real-time path to the Const_Inert_Gear_In and Const_Inert_Clutch parameters has been changed.
Release 6.3	The parameterization of the Simulation Step Size parameter has been moved from the workspace to the mask. Now all the parameters of a library block are parameterized via the mask.
Release 6.2	The friction model has been enhanced with additional saturation of the static torque.

Related topics

References

Gearbox Automatic Transmission........ 63

History of the GEARBOX_MT Block

Release 2019-A	The issue of gear synchronization failure during shifting through neutral was solved. The shifting through neutral feature can be activated in the GEAR_SHIFTER block.
Release 2015-A	The damping coefficient of the gearbox input shaft has been added as a mask parameter: Const_Damping_Gear_In.

Release 2013-A	A new implementation is used and the calculations are now easier to understand. Due to this change the block has new inports, outports and parameters. The old implementation is still available in the blocks of the previous version. The block cannot be migrated automatically due to the restructuring of the library. Therefore, the link to the **GEARBOX_MT** block is changed to the former implementation, which is located in FormerVersions/ GEARBOX_MT_8_0, during the migration of older ASM releases. The simulation behavior does not change. If the new block features are to be used, you can drag the **GEARBOX_MT** block from the ASM_DrivetrainBasic_lib to the model. You must adapt the inports, outports and parameters manually.
Release 7.4	To simplify the model, the PT1 element with time constant 0.001 was deleted from the **Trq_Trm_In[Nm]** outport because it had negligible effect. A unit delay is added during migration.
Release 7.3	The block has been adapted to support engine reset functionality. To get the reset functionality, you must connect the new port manually. See the demo model for an example.
Release 6.5	The "^" sign has been removed from the block name.
Release 6.4	The real-time path to the **Const_Inert_Gear_In** and **Const_Inert_Clutch** in **GEARBOX_MT** parameters has been changed.
Release 6.3	The parameterization of the **Simulation Step Size** parameter has been moved from the workspace to the mask. Now all the parameters of a library block are parameterized via the mask.
Release 6.2	The friction model has been enhanced with additional saturation of the static torque.
Related topics	References Gearbox Manual Transmission 61

History of the IDLE_SPEED_CONTROL Block

Release 2020-B

The block has a new outport for set point of idle speed: n_Engine_Idle_Set. The outport is terminated during migration.

History of the KEY_STATES Block

Release 6.5

This block is new. It calculates the ignition and starter request according to the key position.

Related topics

References

History of the LOCKUP_CLUTCH Block

Release 2015-A

To simulate the kiss point, a new parameter (Map_Trq_Clutch_Red) has been introduced. The parameter describes the clutch nominal torque capacity as a function of the clutch actuation signal: i.e., clutch pedal position or lockup clutch control.

A new parameter has been added: Map_Trq_Clutch_Red. The parameter is initialized with a linear relationship, so the previous behavior of the block remains unchanged.

Release 2013-A

The implementation of the block was completely changed to improve the simulation stability and provide better isolation of the engine oscillations. The block now has different inports, outports and parameters. The old implementation is still available in the blocks of the previous version.

The block cannot be migrated automatically, due to the restructuring of the library.

Therefore, the link to the LOCKUP_CLUTCH block is changed to the former implementation, which is located in FormerVersions/LOCKUP_CLUTCH_2_0, during the migration of older ASM releases. The simulation behavior does not change.

If the new block features are to be used, you can drag the LOCKUP_CLUTCH block from the ASM_DrivetrainBasic_lib to the model. You must adapt the inports, outports and parameters manually.

Release 6.2

The friction model has been enhanced with additional saturation of the static torque.

Related topics

References

Lock-Up Clutch.. 35

History of the LOCKUP_CLUTCH_CONTROL Block

Release 2020-B

The unit of the control signal was changed from [0_1] to [%] and a first-order-dynamics filter was added to the control signal to restore the previous behavior.

Related topics

References

Lockup Clutch Control.. 134

History of the LONGITUDINAL_CONTROL Block

Release 2020-B

The data type of the State_Engine[0|1|2|3|4] inport was changed from *uint8* to *double*.

The block has a new inport: Enable_v_Vehicle_Init. To keep the model behavior unchanged, it is connected to a constant block during migration.

Release 2019-A

The issue of increased turnaround time with active preview time was solved by using a customized variable time delay block.

Release 2018-B

There were bug fixes related to inaccurate tracking of low velocities and to not responding to the preview reference speed during vehicle start.

Release 2018-A	During the migration, the links to the block are changed to the former version implementation. Longitudinal Control (Version 8.0 or earlier) on page 247
Release 2017-A	A new inport for the start-stop system status has been added to the block: State_StartStop[1Off|2NotReady|3Ready|4EngStopped]. During migration, this inport is connected to a Constant block.
Release 2016-B	The size of the inverse engine torque parameter has been expanded from [40x40] to [41x40]. The old parameter is extrapolated and initialized in `asmmigratepost`. The continuous integrators inside the block have been replaced with discrete ones.
Release 2015-A	In the new LONGITUDINAL_CONTROL block, the tractive resistance force is calculated instead of the tractive resistance acceleration. During migration, this calculation is compensated to keep the old behavior unchanged.
Release 2014-A	Calculation of the tractive resistance acceleration has been added and routed as an outport. It is used by the GEAR_SHIFTER block as an indication of the effort needed to overcome the driving resistances.
Release 7.3	An optional power-based feed forward control has been added. This can be activated by a switch parameter. Additional power-base feed forward control has been added. To keep the original behavior, the torque-based feed forward control is activated after migration.
Release 7.1	This block has been synchronized with the environment. The following mask parameters have been removed: ▪ Tire radius ▪ Rolling resistance ▪ Air resistance ▪ Vehicle mass ▪ Differential ratio These signals became input ports instead.

The mask parameters for the following parameters are now shared with the DRIVING_RESISTANCE block.

- Gravity constant
- Vehicle cross section
- Air density

The new block now has independent parameters.

The calculation of the feed forward signal for the brake pedal has been moved to a separate BRAKE_HYDRAULICS_VARIANT block.

Migration is automatic.

Related topics

References

Longitudinal Control..89

History of the LONGITUDIANL_CONTROLLER_HYBRID Block

Release 2019-A

The block is discontinued and shifted to former version implementations. During migration, the library link to the LONGITUDINAL_CONTROLLER_HYBRID block is changed to the former version LONGITUDINAL_CONTROLLER_HYBRID_5_0.

Release 2017-A

The block has new inports:

- Pos_AccPedal_Maneuver[%]
- Pos_BrakePedal_Maneuver[%]
- AccBr_Mode[1Stim|2Driver]

These inports are used to keep the driver inactive during stimulus maneuvers. Moreover, they enable a gentle pedal transition when switching between stimulus and driver maneuvers.

During migration, these inports are connected to Constant blocks.

Release 2016-B

The block has several new features:

- It is now possible to limit the actuation rate of both pedals.
- The minimum time needed to switch between different pedals can be set to a nonzero value.
- The driver can tolerate certain speed differences.
- A new controller parameter for the preview reference speed has been added as a preparation for improved controller strategy.

For this, the following new parameters are added during migration:

- Const_Rate_Max_AccPedal and Const_Rate_Max_BrakePedal: Pedals maximum rate of change
- Cont_t_min_Pedals: Minimum time needed to switch between different pedals
- Map_v_Dead_Driver and Sw_v_Dead_Driver: Tolerated relative velocity
- Const_Preview_vCtrl_Pedals: Controller parameter for the preview reference speed

Release 2016-A

The actual vehicle acceleration is used instead of the approximated value. The vehicle acceleration is fed to the block via a new inport that is connected with the corresponding signal during migration.

Release 2015-A

This new block simulates the driver behavior to follow a reference velocity by controlling the accelerator and brake pedals. The new block does not use the vehicle parameters and can be used as a modular block.

History of the LUT1D Block

Release 2014-B

The LUT1D block is new. It can be used to include measurement data in a model. For the block, a new subsystem has been created in ASM_DrivetrainBasic_lib/Driver/Measurement.

Related topics

References

Look-Up Table 1-D.. 100

History of the LUT2D Block

Release 2015-A

This block is new. It can be used to include measurement data in the model. For the block, a new subsystem is created in ASM_DrivetrainBasic_lib/Driver/Measurement.

Related topics

References

Look-Up Table 2-D.. 101

History of the MANEUVER_CONTROL Block

Release 2018-B

The ASMSignalBus outport was added.

Release 2016-B

The new block **MANEUVER_CONTROL** is introduced which describes a central maneuver control for the engine demos. This block controls the start, pause and stop of maneuver time, as well as the maneuver status.

Until now, the maneuver control functionality was divided between the **CYCLES** and other non-library blocks. Using linked library blocks, offers a unified implementation for all engine demos. This implementation can be extended and benefit from new features in the future.

Moreover, with the new block, it is now possible to start, stop and reset the maneuver during the simulation on dSPACE platforms using only ModelDesk.

Related topics

References

Maneuver Control.. 94

History of the SHAFT_RIGID Block

Release 2016-B

A new parameter has been added to describe the rotation damping.

A new inport has been added for an external initialization of the speed integrator.

Release 2015-A

This new block represents a general shaft. The block calculates the shaft speed from the shaft inertia and the applied torques.

Related topics

References

Rigid Shaft.. 53

History of the SHIFT_STRATEGY Block

Release 2020-B	The block has a new inport: Enable_v_Vehicle_Init. To keep the model behavior unchanged, it is connected to a constant block during migration.

History of the SIGNAL_SELECTION Block

Release 2014-B	The SIGNAL_SELECTION block has been removed from the library and is kept in the demos as a regular Simulink subsystem. The former version of the block is also kept in the Former Versions sublibrary: ASM_DrivetrainBasic_lib/Driver/FormerVersions/SIGNAL_SELECTION_4_0 During the migration, the link to the block is changed to the Former Versions sublibrary.
Release 7.3	The Reset_States signal has been included in the Maneuver bus.
Release 6.2	The Mux for creating a bus have been replaced by BusCreator blocks.

History of the SIMPLE_GEAR Block

Release 2020-B	The Omega_In[rpm] outport was added to the ASMSignalBus.
Related topics	References Simple Gear........ 51

History of the SOFT_ECU_BSG Block

Release 2020-B	This is a new block for simulating a belt-integrated starter generator. Different hybrid modes are selected based on pedal positions. The electric torque request depends on mode-specific maps.

Related topics

References

History of the SOFT_ECU_TRANSMISSION_BASIC Block

Release 2016-B

The SOFT_ECU_TRANMISSION_BASIC block has been modularized. The old functionalities and controller strategies have been subdivided into several modular blocks.

You can now modify and extend the controller structure according to your needs. The new implementation offers also the possibility to integrate a third-party controller strategy.

The following blocks were added to the library:

- CLUTCH_ENGAGEMENT_CONTROL
- LOCKUP_CLUTCH_CONTROL
- SHIFT_LOCK_CONTROL
- SHIFT_STRATEGY
- SOFTECU_TRANSMISSION_SETUP
- TORQUE_INTERVENTION_CONTROL
- TIP_SHIFT_CONTROL

Because of its completely new structure, the previous SOFT_ECU_TRANSMISISON_BASIC block is not migrated to the new implementation. Instead, the previous block is been saved in FormerVersions, and the link is changed to this block during migration.

Release 2016-A

It is now possible to stimulate the SOFT_ECU_TRANSMISSION_BASIC block with stimulus or reference gear and clutch pedal position signals.

The stimulus gear and clutch pedal are forwarded to the output without further actions. Depending on whether the AMT switch is active or not, the clutch pedal signal is used for the AMT clutch or the lockup clutch, respectively.

The reference gear is used as a set value that affects the other outputs.

These features are deactivated per default and can be activated using a switch in the demo model.

During migration, the new inports are connected to dummy values. However, you can still connect the inports with the related signals from the model to use the block functionality.

Release 2015-A

The block has been completely revised and a new approach has been implemented. The new block offers a better overview, a more robust implementation and several new functionalities.

The new SOFT_ECU_TRANSMISSION_BASIC block offers the following features:

- Robust automatic shift strategy with gear skipping functionality
- Revised implementation of tiptronic control
- New lockup clutch control strategy
- Clutch and accelerator pedal control for automated manual transmissions

The new SOFT_ECU_TRANSMISSION_BASIC block cannot be automatically migrated, due to the new added block parameter. Therefore, during migration, the link to the SOFT_ECU_TRANSMISSION_BASIC block is changed to the former implementation, in FormerVersions/SOFT_ECU_TRANSMISSION_BASIC_7_0.

To use the new implementation, the SOFT_ECU_TRANSMISSION_BASIC block, drag it from the ASM Drivetrain Basic Library to the model. However, a hand adaptation of the inports, outports and parameters is necessary.

Release 2013-B

The FurtherShiftTables ground blocks have been replaced by constant zero blocks to avoid dimension problems in Simulink.

Release 2013-A

The old output Pos_BrakePedal_SoftECU[%] signal in the SOFT_ECU_TRANSMISSION_BASIC block was adapted to simulate the parking pawl control. This signal can be set, if the corresponding selector lever is selected.

The Pos_BrakePedal_SoftECUTrm[%] outport has been scaled and its label is changed during the migration from older ASM releases.

Release 7.3

The block has been adapted to support engine reset functionality. To get the reset functionality, you must connect the new port manually. See the demo model for an example.

Release 7.0

The parameterization MDL structure has been changed from MDL.SoftECU.SoftECUTransmission to MDL.SoftECU.SoftECUTransmissionBasic. This makes the parameter independent of the parameter of the SOFT_ECU_TRANSMISSION in the vehicle dynamics model. The renaming is automatically generated in the postmigrate variant.

Release 6.4

The SOFT_ECU_TRANSMISSION block has been renamed SOFT_ECU_TRANSMISSION_BASIC. There is no functional change.

Release 6.1	The new ASM_SHIFTTABLE_LOOKUP block from the ASM Utilities library has been included. Changes in the downshift table are now automatically considered in the calculation of the maximum gear.

History of the SOFT_ECU_TRANSMISSION_9_0 Block

Release 2016-B	The block cannot be automatically migrated. Therefore, during the migration the link to the block is changed to former implementation, which is located in `FormerVersions/SOFT_ECU_TRANSMISSION_9_0`. To benefit from the new implementation, the delivered demos can serve as templates for the use of the new blocks.

History of the START_BUTTON Block

Release 2020-B	The data type of the State_Engine[0|1|2|3|4] inport was changed from *uint8* to *double*.
Release 2018-B	A new START_BUTTON block was added to the SoftECU subsystem to simulate an engine start button.
Related topics	References Engine Start Button........ 110

History of the STARTER Block

Release 6.5	The `"^"` sign has been removed from the block name.
Release 6.2	The Mux for creating a bus have been replaced by BusCreator blocks. The MDL.DrivetrainBasic.Starter.Const_n_Starter_Max mask parameters is now only used once in the model. The n_Engine[rad/s] input value is converted to unit [rpm] internally.

Related topics

References

History of the SWITCHES_CRANKSHAFT Block

Release 2013-A

A mask description was added to this block.

History of the SWITCHES_DRIVETRAINBASIC Block

Release 2020-B

The global Goto block was replaced by an outport.

Release 2013-A

A mask description was added to this block.

History of the TEST_BENCH Block

Release 2015-A

The dynamometer inertia is now considered as a parameter.

The block cannot be automatically migrated, due to the new added block parameter. Therefore, during migration, the link to the TEST_BENCH block is changed to the former implementation in FormerVersions/TEST_BENCH_2_0.

To use the new implementation, drag the TEST_BENCH block from the ASM Drivetrain Basic Library to the model. However a hand adaptation of the parameters is necessary.

Release 6.5

The anti-windup of the controller has been improved. The Const_Trq_Max parameter is now unique below the mask, so the real-time path to this variable has been changed.

Related topics	References

History of the TEST_CYCLE Block

Release 2018-B	The new Map_Sw_Engine parameter has been added to simulate the engine start button for test cycles.
Release 2018-A	The calculation of v_Vehicle_Set_Preview[m|s] was activated.
Related topics	References

History of the TORQUE_CONTROLLER Block

Release 2016-B	The size of the inverse engine torque parameter has been expanded from [40x40] to [41x40]. The old parameter is extrapolated and initialized in `asmmigratepost`.
Release 2014-B	The TORQUE_CONTROLLER block can now also be activated if a negative torque set is provided. During the migration, a set of blocks is added to the Sw_TrqController_Mode[0Off|1On] inport, so that the block is inactive if there is a negative torque set. This ensures the old functionality of the block.
Release 7.3	The block has been adapted to support engine reset functionality. To get the reset functionality, you must connect the new port manually. See the demo model for an example.

Release 7.1

The torque controller now has its own inverted engine map instead of using the one from the driver, and the implementation has been redesigned. These changes are automatically migrated. The link is changed to the former version during migration. You can also copy the new block manually, in which case you must also adapt the parameterization project and the controller parameter.

Related topics

References

Torque Controller.......... 105

History of the TORQUE_CONVERTER Block

Release 2013-A

The sign of the outports is changed to compensate for the changes due to the restructuring of the ASM DrivetrainBasic_lib. No other changes have been made in the calculations or the parameters. The old implementation is still available in the blocks of the previous version.

During the migration from older ASM releases, the link to the **TORQUE_CONVERTER** block is changed to the former implementation, which is located in FormerVersions/TORQUE_CONVERTER_4_0. The simulation behavior does not change.

Release 7.1

The torque controller now has its own inverted engine map instead of using the one from the driver, and the implementation has been redesigned. These changes are automatically migrated. The link is changed to the former version during migration. You can also copy the new block manually, in which case you must also adapt the parameterization project and the controller parameter.

Release 6.4

The **TORQUE_CONVERTER** block has been improved so that it can also handle negative pump speeds. The default parameterization for dragging the engine has also been optimized.

In the new **TORQUE_CONVERTER** block, there are only changes inside the library block which are transferred automatically. If you want to use the new default parameterization, you have to transfer it manually to the old projects from the demo project.

Related topics

References

Torque Converter.......... 41

History of the TORQUE_INTERVENTION_CONTROL Block

Release 2020-B

The block has a new inport: Enable_v_Vehicle_Init. To keep the model behavior unchanged, it is connected to a constant block during migration.

History of the TORQUE_INTERVENTION_ENGINE_BASIC Block

Release 2020-B

The block was shifted to the *former versions*.

The successor is the TORQUE_INTERVENTION_BASIC block in: `ASM_DrivetrainBasic_lib/SoftECU/SoftECU_Engine/` that covers the same functionality.

During migration the link to the TORQUE_INTERVENTION_BASIC block is changed to the former version in `ASM_DrivetrainBasic_lib/SoftECU/SoftECU_Engine/FormerVersions/TORQUE_INTERVENTION_BASIC_1_0`.

Related topics

References

History of the Drivetrain Basic Demo Model

Release 2020-B

Maneuver types The *Offline Manual* and *Online Manual* maneuver types (MATLAB parameter CPT.MDL_SW.Sw_Maneuver) were merged.

The following table shows you the new maneuver types and the corresponding values of the CPT.MDL_SW.Sw_Maneuver parameter:

New Maneuver Types	Former Maneuver Types
1 Manual	1 Offline Manual 2 Online Manual
3 Stimulus	3 Stimulus Maneuver
4 Test Cycle[1]	4 Driver Maneuver

[1] This maneuver type has been renamed, but its functionality has not changed.

When you work in Simulink, you can now control maneuver signals, such as the accelerator or brake pedal, via new dashboard instruments in: /Environment/Plant/UserInterface/PAR_Plant/Manual_Controller.

Migrated ASM models are not affected by these changes.

New demo components The folllowing blocks are new:

- VEHICLE_POSITION
- AMBIENT
- ESP_FAST_TORQUE_SET
- ENGINE_OPERATION_BASIC
- ESP_FAST_TORQUE_SET

Release 2019-A

New test cycles Two new engine dynamometer test cycles were added to the demo model:

- Non-Road Steady Cycle (NRSC)
- Non-Road Transient (NRTC)

Changes in EUDC test cycles The first standstill time of the EUDC test cycles was changed from 50 seconds to 11 seconds, according to the official resources. This change is not migrated for older test cycle versions.

Release 2018-A

ASM Driver A new longitudinal driver model based on a different control strategy is introduced. The new model simulates a more realistic pedal actuation. Refer to Driver (ASM Environment Reference 📖).

Appendix

Bibliography

List of literature

The following literature provides more details:

[Bre02] Brendecke T.: Virtuelle Echtzeitumgebung für Getriebesteuergeräte mit Hardware-in-the-Loop. Shaker Verlag, 2002.

[Lec94] Lechner G., Naunheimer H.: Fahrzeuggetriebe. Berlin: Springer, 1994.

[Mit95] Mitschke M.: Dynamik der Kraftfahrzeuge. Berlin: Springer, 1995.

[Wal99] Wallentwoitz H.: Längsdynamik von Kraftfahrzeugen. Lecture note, RWTH Aachen, 1999.