ASM Gasoline Engine

Reference

For ASM Gasoline Engine Blockset 4.2.1 and ASM Gasoline Engine Operator Blockset 4.2.1

Release 2021-A – May 2021

dSPACE

How to Contact dSPACE

Mail:	dSPACE GmbH Rathenaustraße 26 33102 Paderborn Germany
Tel.:	+49 5251 1638-0
Fax:	+49 5251 16198-0
E-mail:	info@dspace.de
Web:	http://www.dspace.com

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33102 Paderborn
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About This Reference

Content

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

Required knowledge

Knowledge in working with MATLAB/Simulink is assumed. This reference is primarily targeted at engineers who want to test an ECU in hardware-in-the-loop simulation.

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>
```

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

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Overview of the Gasoline Engine Library

Gasoline Engine Library

Introduction

This topic gives you an overview of the ASM Gasoline Engine Library.

Opening the model

You can open the library in MATLAB/Simulink. Refer to How to Open an ASM Library (ASM Gasoline Engine Model Description 🕮).

Contents

The following illustration shows the first level of the library.

The library has three main subsystems.

Soft ECU The Soft ECU subsystem contains all the subsystems that allow you to use the engine model offline or if a real ECU is not available. Refer to Soft ECU on page 121.

SI Engine The SI Engine subsystem contains allthe Simulink blocks necessary to model a gasoline engine. Refer to SI Engine on page 13.

Demos The Demos subsystem contains ready-to-use demo models that you can use to start modelling. Refer to Demos on page 165.

SI Engine

Where to go from here

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The VENT_SHUT_VALVE block calculates the mass flow between the canister and the ambient atmosphere on the basis of pressure differences and the valve position.

Air Filter

Description

The AIRFILTER block calculates the pressure drop in the air filter depending on the engine mass flow. The air filter output pressure is be used as input for the turbocharger compressor.

Inports

The following table shows the inports:

Name	Unit	Description
mdot_AirFilter	[kg/h]	Air mass flow through air filter
p_Ambient	[Pa]	Ambient pressure

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_Out_AirFilter	[Pa]	Air filter output pressure

Parameters

The following table shows the parameters:

Name	Unit	Description
Map_p_Diff_Static	[Pa]	Air filter pressure difference based on air mass flow = f([kg|s])

Related topics

References

Airfilter (ModelDesk Parameterizing 🕮)
History of the AIRFILTER Block..... 238

EGR Cooler

Description

The exhaust gas flow has to be cooled to lower the temperature in the intake manifold, even at high EGR rates. Higher temperatures are observed to lead to higher emission of particulates [Jun03] on page 281.

The EGRCOOLER block calculates the output temperature of the cooler as a function of the temperature difference between input and coolant. The cooler efficiency is taken into account. It depends on the mass flow and the temperature difference between input and coolant. Pressure changes are not considered.

Inports

The following table shows the inports:

Name	Unit	Description
mdot_EGRCooler	[kg/s]	Total mass flow through the EGR cooler
return_EGRCooler	[1|0]	Flag indicating whether there is a back flow through the EGR cooler ▪ 0: No backflow T_ExhMan is used as input temperature. ▪ 1: Backflow T_InMan is used as input temperature.
T_Coolant	[°C]	Coolant temperature of the EGR cooler (usually this is the water temperature)
T_ExhMan	[°C]	Temperature of the exhaust manifold (accumulator connected to the input side)
T_InMan	[°C]	Temperature of the intake manifold (accumulator connected to the 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 🕮).
T_In_EGRCooler	[°C]	Temperature at the inlet of the EGR cooler
T_Out_EGRCooler	[°C]	Temperature at the output of the EGR cooler

Parameters

The following table shows the parameters:

Name	Unit	Description
Map_eta_Cooler	[]	Efficiency of the EGR cooler: f(mdot_Cooler, T_delta(cooler-inlet to coolant))
Sw_State_Cooler	[0|1]	Switch for activating the EGR cooler: ▪ 0: Off ▪ 1: On

Processing information

The cooler efficiency is calculated from an engine test bench measurement of the variables cooler input temperature (= exhaust manifold temperature), cooler output temperature (= intake manifold temperature), and coolant temperature.

$$\eta_{Cooler} = \frac{T_{Cooler,In} - T_{Cooler,Out}}{T_{Cooler,In} - T_{Coolant}}$$

The default map of the Map_eta_EGRCooler parameter is shown in the following illustration.

Related topics

References

EGR Cooler Gasoline (ModelDesk Parameterizing 🕮)
History of the EGR_COOLER Block..... 246

EGR Valve (Mechanical)

Description

The EGR_VALVE_MECHANICAL block calculates the position of the EGR valve according to the control signal. By switching off the supply of the valve, a constant position (rest position) is specified.

Inports

The following table shows the inports:

Name	Unit	Description
Ctrl_EGR	[0_1]	Control signal (PWM) for the actuation of the EGR valve
Reset	[0|1]	Reset integrators to their initial states ▪ 0: Off ▪ 1: Reset
Sw_Supply	[0|1]	Switching the supply of the EGR valve ▪ 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 🕮).
Pos_EGR	[%]	Position of the EGR valve

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_Pos_Rest	[%]	Rest position of the valve (supply switched off)
Const_t_PT1_Pos	[s]	PT1 constant for dynamic behavior
Map_Ctrl2Pos	[%]	Conversion of the control signal (PWM) to position, f(Ctrl_EGR)
NumberofIterations	[]	Number of air path iterations in each simulation step
StepSize	[s]	Simulation step size
Sw_State_ValveMechanical	[0|1]	Switch for activating the EGR valve: ▪ 0: Off ▪ 1: On

Related topics

References

EGR Valve Mechanical (ModelDesk Parameterizing 🕮)
History of the EGR_VALVE_MECHANICAL Block..... 248

EGR Valve

Description

The EGR valve can be used to reduce NO_x emissions. A defined exhaust mass flow is added to the fresh air flow using an exhaust gas recirculation (EGR) valve.

The EGR_VALVE block calculates the mass flow of air and the exhaust gas flow through the EGR valve as a function of pressure difference and position of the valve.

The EGR valve is modeled as an isentropic flow through an orifice with a variable cross-section.

The mass flow through the EGR valve can be written with the following equation:

$$\dot{m}_{EGR} = A(Pos_{EGR}) \cdot P_{In} \cdot \sqrt{\frac{2}{R \cdot T_{In}}} \cdot \psi\left(\frac{P_{out}}{P_{in}}\right)$$

The flow function Ψ is defined as follows:

$$\Psi\left(\frac{P_{out}}{P_{in}}\right) = \begin{cases} \sqrt{\frac{K}{K-1}\left[\left(\frac{P_{out}}{P_{in}}\right)^{\frac{2}{K}} - \left(\frac{P_{out}}{P_{in}}\right)^{\frac{K+1}{K}}\right]} & \frac{P_{out}}{P_{in}} \geq \left(\frac{2}{K-1}\right)^{\frac{K}{K-1}} \\ \left(\frac{2}{K+1}\right)^{\frac{1}{K-1}} \cdot \sqrt{\frac{K}{K+1}} & \frac{P_{out}}{P_{in}} < \left(\frac{2}{K-1}\right)^{\frac{K}{K-1}} \end{cases}$$

Where the flow function Ψ is limited to a specific value if the EGR mass flow reaches sonic speed. Ψ is not implemented analytically but as a look-up table.

The cross-section is adjusted to the measured engine data during the parameterization process. It can be a cosine function like

$$A(Pos_{EGR}) = \frac{1}{2} A_{max}(1 - cos(2 \cdot Pos_{EGR}))$$

The complete mass flow through the EGR valve can be divided into fresh air and exhaust gas. These are calculated on the basis of mass fractions that enter the EGR valve.

The model does not take the temperature change of the mass flow into account.

Inports

The following table shows the inports:

Name	Unit	Description
p_In_EGR	[Pa]	EGR input pressure (= pressure before turbine)
p_Out_EGR	[Pa]	EGR output pressure (= intake manifold pressure)
Pos_EGR	[%]	Position of the EGR valve
T_In_EGR	[°C]	Input temperature of the EGR
T_Out_EGR	[°C]	Output temperature of the EGR valve (backward flow)
Xsi_Air_In_EGR	[0_1]	Input mass fraction of air
Xsi_Exh_In_EGR	[0_1]	Input mass fraction of exhaust gas
Xsi_Air_Out_EGR	[0_1]	Output mass fraction of air (backward flow)
Xsi_Exh_Out_EGR	[0_1]	Output mass fraction of exhaust gas (backward flow)
R_In_EGR	[J|(kgK)]	Input gas constant of mass flow of EGR
R_Out_EGR	[J|(kgK)]	Output gas constant of mass flow of EGR (backward flow)

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 🕮).
mdot_Out_EGR_Air	[kg/h]	Fresh air mass flow through EGR
mdot_Out_EGR_Exh	[kg/h]	Exhaust mass flow through EGR
return_EGR	[0|1]	Signal to indicate the backward flow through EGR valve

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_A_max	[m^2]	Maximum flow area for the EGR
Map_A_Red	[]	Area reduce factor according to the EGR position (Map_A_red = f(Pos_EGR))
Map_Psi	[]	Flow function PSI for EGR = f(pout/pin)
Sw_State_Valve	[0|1]	Switch for activating the EGR valve: ▪ 0: Off ▪ 1: On

Processing information

The flow function ψ and the cross section of the EGR valve are generated during parameterization. The next illustration shows the curve of the flow function Ψ.

The illustration below shows an example of the area reduce factor depending on position of the EGR valve.

The maximum cross-section (Const_A_max) is calculated on the basis of the operating point of the engine with a maximum flow mass of the EGR.

Related topics

References

EGR Valve Gasoline (ModelDesk Parameterizing 🕮)
History of the EGR_VALVE Block..... 247

Exhaust Manifold

Description

The EXHAUST_MANIFOLD block calculates manifold temperature and pressure as a function of air mass flows (in/out) and their corresponding temperatures.

The exhaust manifold contains two modeling approaches depending on the type of turbocharger used. For a description of air path modeling, refer to Air Path Subsystem on page 193.

In the look-up table modeling approach (basic turbocharger), the temperature and pressure are simulated statically by look-up tables, according to the engine operating point. The dynamic is simulated by a first-order delay element.

In the physical modeling approach (advanced turbocharger), the exhaust manifold model calculates the manifold temperature, the manifold pressure, and the mass inside the manifold. It is modeled as an open thermodynamic system, where the mass of gas can increase or decrease with time (filling and emptying model).

The two governing equations for such systems are the Conservation of Mass and the Conservation of Energy. Respecting heat losses through the manifold walls and assuming an ideal gas with constant specific heats, the differential equations for the manifold can be derived.

Firstly, the manifold mass is calculated using the *Conservation of Mass* equation.

$$\frac{dm_{ExMan}}{dt} = \dot{m}_{Out,Engine} - \dot{m}_{In,EGR} - \dot{m}_{In,Turb}$$

Secondly, the exhaust manifold temperature follows from the equation for Conservation of Energy.

$$\dot{T}_{ExMan} = \frac{c_p}{c_v m_{ExMan}}\left(\dot{m}_{Out,Engine}\,T_{Out,Engine} - \dot{m}_{In,EGR}\,T_{In,EGR} - \dot{m}_{In,Turb}\,T_{ExMan}\right) - \frac{1}{m_{ExMan}}\left(T_{ExMan}\left(\dot{m}_{Out,Engine} - \dot{m}_{In,EGR} - \dot{m}_{In,Turb}\right)\right) - \frac{1}{c_v m_{ExhMan}}\left(T_{ExhMan} - T_{Ambient}\right)k_{ExhMan}\,A_{ExhMan}$$

The ideal gas law returns the manifold pressure.

$$P_{ExMan} = \frac{R}{V_{ExMan}} m_{ExMan}\,T_{ExMan}$$

Tip

A general derivation of these equations can be found in [Hey88] on page 281.

Inports

The following table shows the inports:

Name	Unit	Description
EngOP	[rpm][mm^3/cyc]	Engine operating point: n_Engine[rpm], q_Inj_1cyl[mm^3/cyc]
mdot_Air_EGR	[kg/h]	Mass flow of the air through the EGR
mdot_Air_Turb	[kg/h]	Mass flow of the air through the turbine
mdot_Air_WG	[kg/h]	Mass flow of the air through the wastegate
mdot_Exh_EGR	[kg/h]	Mass flow of the exhaust gas through the EGR
mdot_Exh_Turb	[kg/h]	Mass flow of the exhaust gas through the turbine
mdot_Exh_WG	[kg/h]	Mass flow of the exhaust gas through the wastegate

Name	Unit	Description
mdot_Out_Engine	[kg/h]	Mass flow out of the piston engine (exhaust gas)
p_Ambient	[Pa]	Ambient pressure
Reset	[]	Reset of all integrators to their initial conditions
Sw_ExhMan	[1|2]	Switch for activating one of the following modeling approaches: ▪ 1: Physical modeling approach ▪ 2: Look-up table modeling approach
T_Ambient	[°C]	Ambient temperature
T_Out_Engine	[°C]	Engine output temperature
Xsi_Air_Engine	[0_1]	Mass fraction of the air out of the piston engine
Xsi_Exh_Engine	[0_1]	Mass fraction of the exhaust gas out of the piston engine

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_ExhMan	[Pa]	Exhaust manifold pressure
R_ExhMan	[J|(kgK)]	Gas constant in the exhaust manifold
T_ExhMan	[°C]	Exhaust manifold temperature
Xsi_Air_ExhMan	[0_1]	Mass fraction of air in the exhaust manifold
Xsi_Exh_ExhMan	[0_1]	Mass fraction of exhaust gas in the exhaust manifold

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_A_ExhMan	[m^2]	Surface area of the exhaust manifold
Const_k_ExhMan	[W/[K m^2]]	Coefficient of the heat transfer
Const_PT1_p	[s]	PT1 constant for the dynamic behavior of the exhaust pressure
Const_PT1_T	[s]	PT1 constant for the dynamic behavior of the exhaust temperature
Const_V_ExhMan	[m^3]	Volume of the exhaust manifold[1)]
Map_p_ExhMan_Rel	[Pa]	Static pressure of the exhaust manifold: f(n_Engine, q_Mean_Inj)
Map_T_ExhMan	[°C]	Static temperature of the exhaust manifold: f(n_Engine, q_Mean_Inj)
NumberofIterations	[1_n]	Iteration number of the air path (for numerical oversampling)
StepSize	[s]	Step size

1) Small manifold volumes can lead to numerically instable systems. Therefore a minimum exhaust manifold volume of 2 liters is recommended.

Related topics

References

Exhaust Manifold Gasoline (ModelDesk Parameterizing 🕮)
History of the EXHAUST_MANIFOLD Block..... 251

Intercooler

Description

To cool down the compressed air from the compressor, a cooler is often used before the throttle in turbocharged engines.

The INTERCOOLER block calculates the output temperature of the cooler as a function of the temperature difference between input and coolant. The cooler efficiency is taken into account. It is dependent on the mass flow and the temperature difference between input and coolant. Pressure changes are not considered.

Inports

The following table shows the inports:

Name	Unit	Description
mdot_InterCooler	[kg/s]	Total mass flow through the intercooler
return_InterCooler	[1|0]	Flag to indicate the backflow over the intercooler
T_Coolant	[°C]	Coolant temperature (in most cases ambient temperature)
T_InMan	[°C]	Temperature of the accumulator connected to the output side
T_Out_Comp	[°C]	Temperature of the accumulator connected to the input 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 🕮).
T_In_InterCooler	[°C]	Temperature at the intercooler input side
T_Out_InterCooler	[°C]	Temperature after the intercooler

Name	Unit	Description
Sw_State_InterCooler	[0|1]	Switch for activating the intercooler: ▪ 0: Off ▪ 1: On

Parameters

The following table shows the parameters:

Name	Unit	Description
Map_eta_Cooler	[]	Efficiency of the intercooler, f(mdot_Cooler, T_delta(cooler inlet to coolant))
Sw_State_Cooler	[]	Switch for activating the intercooler: ▪ 0: Off ▪ 1: On

Processing information

Cooler efficiency is calculated from engine test bench measurement of the variables cooler input temperature (= compressor output temperature), cooler output temperature (= throttle input temperature), and coolant temperature.

$$\eta_{Cooler} = \frac{T_{Cooler,In} - T_{Cooler,Out}}{T_{Cooler,In} - T_{Coolant}}$$

The default map of the parameter Map_eta_InterCooler is shown in the following illustration.

Related topics

References

History of the INTERCOOLER Block..... 257

Intercooler Gasoline (ModelDesk Parameterizing 🕮)
Intercooler V5 (ModelDesk Parameterizing 🕮)

Intake Manifold

Description

The INTAKE_MANIFOLD block calculates the manifold temperature and pressure as a function of air mass flows (in/out) and their corresponding temperatures.

It is modeled as an open thermodynamic system, where the mass of gas can increase or decrease with time (filling and emptying model).

The two governing equations for such systems are the Conservation of Mass and the Conservation of Energy. Respecting heat losses through the manifold walls and assuming an ideal gas, the differential equations for the manifold can be derived.

Firstly, the manifold mass is calculated using the Conservation of Mass equation. Because EGR results in a mix of exhaust gas and fresh air, the Conservation of Mass equation for the intake manifold is split into two equations (one for fresh air and one for exhaust gas):

$$\frac{dm_{InMan,\,Air}}{dt} = \dot{m}_{Throttle,\,Out} + \dot{m}_{EGR,\,Out,\,Air} - \dot{m}_{Engine,\,In,\,Air}$$

$$\frac{dm_{InMan,\,Exhaust}}{dt} = \dot{m}_{EGR,\,Out,\,Exh} - \dot{m}_{Engine,\,In,\,Exh}$$

$$m_{InMan} = m_{InMan,\,Air} + m_{InMan,\,Exh}$$

Secondly, the intake manifold temperature follows from the Conservation of Energy equation.

$$\dot{T}_{InMan} = \frac{-c_{p,\,Air}\,\dot{m}_{In,\,Engine,\,Air}\,T_{InMan} - c_{p,\,Exh}\,\dot{m}_{In,\,Engine,\,Exh}\,T_{InMan}}{c_{v,\,InMan}\,m_{InMan}} + \frac{c_{p,\,Air}\,\dot{m}_{Out,\,Throttle}\,T_{Out,\,Throttle} + c_{p,\,Exh}\,\dot{m}_{Out,\,EGR,\,Exh}\,T_{Out,\,EGR} + c_{p,\,Air}\,\dot{m}_{Out,\,EGR,\,Air}\,T_{Out,\,EGR,\,Air}}{c_{v,\,InMan}\,m_{InMan}} - \frac{c_{v,\,InMan}\,T_{InMan}\left(\dot{m}_{Out,\,EGR,\,Exh} + \dot{m}_{Out,\,EGR,\,Air} + \dot{m}_{Out,\,Throttle} - \dot{m}_{In,\,Engine}\right)}{c_{v,\,InMan}\,m_{InMan}} - \frac{1}{c_v\,m_{InMan}}\left(T_{InMan} - T_{Ambient}\right)k_{InMan}\,A_{InMan}$$

Note

Here the mixing of fresh air with exhaust gas results in dynamic gas constants and capacity c_v: This approach is also shown in [Nyb01] on page 281.

$$c_{v,\,InMan} = \frac{m_{InMan,\,Air}}{m_{InMan}}c_{v,\,Air} + \frac{m_{InMan,\,Exh}}{m_{InMan}}c_{v,\,Exh}$$

$$R_{InMan} = \frac{m_{InMan,\,Air}}{m_{InMan}}R_{Air} + \frac{m_{InMan,\,Exh}}{m_{InMan}}R_{Exh}$$

The ideal gas law returns the manifold pressure.

$$P_{InMan} = \frac{R}{V_{InMan}}m_{InMan}\,T_{InMan}$$

Note

A general derivation of these equations can be found in [Hey88] on page 281.

Inports

The following table shows the inports:

Name	Unit	Description
mdot_Air_EGR	[kg/h]	Fresh air mass flow through the EGR
mdot_Air_Evap	[kg|h]	Mass flow of air from the tank evaporation system
mdot_Air_In_Engine	[kg/h]	Mass flow of fresh air into the engine
mdot_Air_Throttle	[kg/h]	Air mass flow through the throttle
mdot_Exh_EGR	[kg/h]	Exhaust mass flow through the EGR
mdot_Exh_In_Engine	[kg/h]	Mass flow of exhaust into the engine
mdot_Exh_Throttle	[kg/h]	Mass flow of exhaust through the throttle
mdot_Fuel_Evap	[kg/h]	Mass flow of fuel from the tank evaporation system
mdot_Fuel_In_Engine	[kg/h]	Mass flow of fuel into the engine
p_Ambient	[Pa]	Ambient pressure
Reset	[]	Reset all integrators to their initial conditions
T_Ambient	[°C]	Ambient temperature
T_Evap	[°C]	Output temperature of the tank evaporation system
T_Out_EGR	[°C]	Output temperature of the EGR
T_Throttle	[°C]	Output temperature of the throttle

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_InMan	[Pa]	Intake manifold pressure
R_InMan	[J/(kg K)]	Gas constant of the mixture in the intake manifold
T_InMan	[°C]	Intake manifold temperature

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_A_InMan	[m^2]	Area of the intake manifold
Const_k_InMan	[W/(K m^2)]	Coefficient of the heat transfer
Const_V_InMan	[m^3]	Volume of the intake manifold[1)]

Name	Unit	Description
NumberofIterations	[1_n]	Iteration number of the air path (for numerical oversampling)
StepSize	[s]	Simulating step size

[1] Small intake manifold volumes can lead to numerically instable systems. Therefore a minimum intake manifold volume of 2 liters is recommended.

Related topics

Basics

History of the INTAKE_MANIFOLD Block..... 256

References

Intake Manifold Gasoline (ModelDesk Parameterizing 🕮)

Mechanical Throttle

Description

The THROTTLE_MECHANICAL block calculates the position of a throttle valve according to a control signal. By switching off the supply of the throttle valve, a constant position (rest position) is specified.

Inports

The following table shows the inports:

Name	Unit	Description
Ctrl_Throttle	[0_1]	Control signal for actuation of throttle valve
Reset	[]	Reset integrators to their initial states
Sw_Supply	[0|1]	Switch supply of throttle valve ▪ 0: Off ▪ 1: On

Outports

The following table shows the outports:

Name	Unit	Description
Pos_Throttle	[%]	Position of throttle valve

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_Pos_Rest	[%]	Throttle valve rest position (supply switched off)
Const_PT1_p	[s]	PT1 constant for the dynamic behavior of throttle
NumberofIterations	[]	Iteration number of the air path, [1_n]
Map_Ctrl2Pos	[%]	Conversion from the control signal to the position of throttle, f(Ctrl_Throttle)
StepSize	[s]	Simulation step size
Sw_State_Throttle	[0|1]	Switch for activating the throttle valve: ▪ 0 :Off ▪ 1: On

Related topics

References

History of the THROTTLE_MECHANICAL Block..... 269
Throttle Mechanical Gasoline (ModelDesk Parameterizing 🕮)

Throttle Valve

Description

The THROTTLE_VALVE block calculates the air mass flow through the throttle valve, depending on the pressure difference and the throttle position.

The throttle is modeled as an isentropic flow through an orifice with a variable flow cross section. The cross section depends on the throttle angle $-Pos_{Throttle}$. A fully opened throttle lets the engine receive the required air mass flow, which results in the maximum engine torque.

The mass flow through the throttle can be written with the following equation:

$$\dot{m}_{Out,Throttle} = A(Pos_{Throttle}) \cdot P_{In} \cdot \sqrt{\frac{2}{R \cdot T_{In}}} \cdot \psi\left(\frac{P_{out}}{P_{in}}\right)$$

The flow function ψ is defined as follows:

$$\Psi\left(\frac{P_{out}}{P_{in}}\right) = \begin{cases} \sqrt{\frac{K}{K-1}\left[\left(\frac{P_{out}}{P_{in}}\right)^{\frac{2}{K}} - \left(\frac{P_{out}}{P_{in}}\right)^{\frac{K+1}{K}}\right]} & \frac{P_{out}}{P_{in}} \geq \left(\frac{2}{K-1}\right)^{\frac{K}{K-1}} \\ \left(\frac{2}{K+1}\right)^{\frac{1}{K-1}} \cdot \sqrt{\frac{K}{K+1}} & \frac{P_{out}}{P_{in}} < \left(\frac{2}{K-1}\right)^{\frac{K}{K-1}} \end{cases}$$

Where the flow function Ψ is limited to a specific value if the throttle mass flow reaches sonic speed. Ψ is not implemented analytically but as a look-up table.

The cross section is adjusted to the measured engine data during the parameterization process. It can be a cosine function like

$$A(Pos_{Throttle}) = \frac{1}{2}A_{max}(1 - cos(2 \cdot Pos_{Throttle}))$$

Note

The model does not take the temperature change of the air mass flow into account.

Inports

The following table shows the inports:

Name	Unit	Description
p_In_Throttle	[Pa]	Input pressure of throttle
p_Out_Throttle	[Pa]	Output pressure of throttle
Pos_Throttle	[%]	Position of throttle
R_Air	[J/(kg K)]	Specific gas constant of air
R_Exhaust	[J/(kg K)]	Specific gas constant of exhaust
R_Out_Throttle	[J/(kg K)]	Specific gas constant at the throttle output pressure
T_In_Throttle	[°C]	Input temperature of throttle
T_Out_Throttle	[°C]	Output temperature of throttle
Xsi_Air_In_Throttle	[0_1]	Mass fraction of air at the throttle input side
Xsi_Air_Out_Throttle	[0_1]	Mass fraction of air at the throttle output side
Xsi_Exh_In_Throttle	[0_1]	Mass fraction of exhaust gas at the throttle input side
Xsi_Exh_Out_Throttle	[0_1]	Mass fraction of exhaust gas at the throttle output side

Outports

The following table shows the outports:

Name	Unit	Description
mdot_Air_Throttle	[kg/h]	Mass flow of air through the throttle
mdot_Exh_Throttle	[kg/h]	Mass flow of exhaust gas through the throttle
mdot_Out_Throttle	[kg/h]	Mass flow through the throttle
return_Throttle	[1|0]	▪ 1: Pressure p2 after the valves is greater than pressure p1 before the valves ▪ 0: Otherwise
T_Throttle	[°C]	Output temperature at throttle

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_A_max	[m^2]	Maximum flow area of throttle valve
Map_A_Red	[0_1]	Table for reducing area of throttle, f(Pos_Throttle)
Map_Psi	[]	Flow function (psi) of throttle valve, f(pout/pin)

Related topics

References

History of the THROTTLE_VALVE Block 270
Throttle Valve Gasoline (ModelDesk Parameterizing 🕮)

Turbocharger

Description

In combustion engines, turbochargers are used to compress the air flowing into the engine. For information on the turbocharger, refer to Model Overview (ASM Turbocharger Reference 🕮) or Model Overview (ASM Turbocharger Light Reference 🕮).

Canister - Evaporator System

Description

The CANISTER block calculates the temperature, pressure, and mass concentration of gaseous fuel in the canister by using the mass inflows and outflows as well as the corresponding temperatures. The block is implemented as an accumulator using the laws of mass conservation and energy equilibrium.

The CANISTER block can calculate up to two substances: fuel and air.

$$\dot{m}_{Fuel,\,Canister} = \dot{m}_{Fuel,\,VaporControlValve} - \dot{m}_{Fuel,\,PurgeControlValve} - \dot{m}_{Fuel,\,VentShutValve}$$

$$m_{Fuel,\,Canister} = m_{Fuel,\,Canister,\,Init} + \int \dot{m}_{Fuel,\,Canister} dt$$

$$\dot{m}_{Air,\,Canister} = \dot{m}_{Air,\,VaporControlValve} - \dot{m}_{Air,\,PurgeControlValve} - \dot{m}_{Air,\,VentShutValve}$$

$$m_{Air,\,Canister} = m_{Air,\,Canister,\,Init} + \int \dot{m}_{Air,\,Canister} dt$$

The temperature in the canister is calculated by using the conversion of energy equation. For more information, refer to Intake Manifold on page 28.

The following formula shows the pressure calculation in the CANISTER block.

$$p_{Canister} = \frac{m_{Canister} R_{Canister} T_{Canister}}{V_{Canister}}$$

Inports

The following table shows the inports:

Name	Unit	Description
mdot_Fuel_Diffusion_VCV	[kg/s]	Diffusion mass of the fuel entering from the tank through the vapor control valve
mdot_PCV	[kg/s]	Mass flow through the purge control valve
mdot_VCV	[kg/s]	Mass flow through the vapor control valve
mdot_VSV	[kg/s]	Mass flow through the vent shut valve
p_Ambient	[Pa]	Ambient pressure
Reset	[0|1]	Reset of states
T_Ambient	[°C]	Ambient temperature

Name	Unit	Description
T_PCS	[°C]	Flow temperature the purge control valve
T_VCV	[°C]	Flow temperature the vapor control valve
T_VSV	[°C]	Flow temperature the vent shut valve
Xsi_Fuel_init	[0_1]	Initial fuel fraction
Xsi_Fuel_PCV	[0_1]	Fuel fraction of the flow through the purge control valve
Xsi_Fuel_VCV	[0_1]	Fuel fraction of the flow through the vapor control valve
Xsi_Fuel_VSV	[0_1]	Fuel fraction of the flow through the vent shut valve

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_Canister	[Pa]	Canister pressure
R_Canister	[J/(kgK)]	Gas constant of the mixture in the canister
T_Canister	[°C]	Canister temperature
Xsi_Fuel_Canister	[0_1]	Fuel fraction in canister

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_A_Canister	[m^2]	Surface of the canister for heat exchange
Const_V_Canister	[m^3]	Volume of the canister
Const_k_Canister	[W/(K*m2)]	Heat transfer coefficient the canister
ItNum	[]	Iteration number
StepSize	[s]	Simulation step size

Related topics

References

Canister (ModelDesk Parameterizing 🕮)
Evaporator Subsystem..... 198

Leak - Evaporator System

Description

The LEAK block calculates the mass flow through a potential leak in the tank on the basis of pressure difference and the size of the leak.

The LEAK block uses the following formula for valves to calculate the mass flow:

$$\dot{m}_{Valve} = A_{Valve}\, p_{Valve,In} \sqrt{\frac{2}{R_{Valve}\, T_{Valve}}}\, \Psi\left(\frac{p_{Valve,Out}}{p_{Valve,In}}\right)$$

For more information, refer to Throttle Valve on page 32.

In this implementation the size of the leak can be directly set via parameter. The default size of the leak is zero.

Inports

The following table shows the inports:

Name	Unit	Description
p_Ambient	[Pa]	Ambient pressure
p_Tank	[Pa]	Tank pressure
R_Tank	[J/(kgK)]	Gas constant of the mixture in the tank
T_Ambient	[°C]	Ambient temperature
T_Tank	[°C]	Tank temperature
Xsi_Fuel_Tank	[0_1]	Fuel fraction in the tank

Outports

The following table shows the outports:

Name	Unit	Description
ASMSignalBus	[]	Signal bus containing signals of ASM components, refer to ASMSignalBus (ASM User Guide 🕮)
mdot_Leak	[kg/s]	Mass flow through the leak
T_Leak	[°C]	Temperature of the leak flow
Xsi_Fuel_Leak	[0_1]	Fuel fraction of the leak

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_A_Red	[m^2]	Effective size of the leak
Map_Psi	[-]	Leak flow function = f(p_Out/ p_In)

Related topics

References

Evaporator Subsystem 198
Leak (ModelDesk Parameterizing 🕮)

Purge Control Valve - Evaporator System

Description

The PURGE_CONTROL_VALVE block calculates the mass flow between the canister and the intake manifold on the basis of pressure differences and the valve position.

The PURGE_CONTROL_VALVE block uses the following formula for orifices to calculate the mass flow:

$$\dot{m}_{Valve} = A_{Valve}\, p_{Valve,In} \sqrt{\frac{2}{R_{Valve}\, T_{Valve}}}\, \Psi\left(\frac{p_{Valve,Out}}{p_{Valve,In}}\right)$$

For more information, refer to Throttle Valve on page 32.

Inports

The following table shows the inports:

Name	Unit	Description
p_Canister	[Pa]	Canister pressure
p_InMan	[Pa]	Intake manifold pressure
Pos_PCV	[%]	Position of the purge control valve
R_Canister	[J/(kgK)]	Gas constant in the canister
R_InMan	[J/(kgK)]	Gas constant in the intake manifold

Name	Unit	Description
T_Canister	[°C]	Temperature in the canister
T_InMan	[°C]	Temperature in the intake manifold
Xsi_Fuel_Canister	[0_1]	Fuel fraction in the canister

Outports

The following table shows the outports:

Name	Unit	Description
ASMSignalBus	[]	Signal bus containing signals of ASM components, refer to ASMSignalBus (ASM User Guide 🕮)
mdot_PCV	[kg/s]	Mass flow through the purge control valve
T_PCV	[°C]	Temperature of flow through the purge control valve
Xsi_Fuel_PCV	[0_1]	Fuel fraction of flow through the purge control valve

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_A_max	[m^2]	Maximum size of the pressure control valve opening
Map_A_Red	[0_1]	Table for reducing the size of the opening of the pressure control valve A_Red = f(Pos_PressureControlValve)
Map_Psi	[-]	Valve flow function = f(p_Out/ p_ In)

Related topics

References

Evaporator Subsystem..... 198
Purge Control Valve (ModelDesk Parameterizing 🕮)

Tank Gasphase - Evaporator System

Description

The TANK_GASPHASE block calculates the temperature, pressure and mass concentration of the fuel in the tank on the basis of mass inflows and outflows and corresponding temperatures. The block is implemented as an accumulator that uses the laws of mass conservation and energy equilibrium. The diffusion of fuel from the liquid phase to the gas phase is considered by means of Fick's law.

The TANK_GASPHASE is located in the oversampled air path system of the gasoline demo model. However the Fuel Tank block (refer to Fuel Tank on page 76) is located in the Fuel System subsystem.

The following illustrations and formulas show how the two blocks interact.

$$\dot{m}_{Fuel,Tank_Gasphase} = \dot{m}_{Fuel,VaporControlValve} + \dot{m}_{Fuel,Vapor} + \dot{m}_{Fuel,Leak}$$

$$m_{Fuel,Tank_Gasphase} = m_{Fuel,Tank_Gasphase,Init} + \int \dot{m}_{Fuel,Tank_Gasphase} dt$$

$$\dot{m}_{Air,Tank_Gasphase} = \dot{m}_{Air,VaporControlValve} + \dot{m}_{Air,Leak}$$

$$m_{Air,Tank_Gasphase} = m_{Air,Tank_Gasphase,Init} + \int \dot{m}_{Air,Trank_Gasphase} dt$$

The temperature in the tank is calculated by using the conversion of energy equation. For more information, refer to Intake Manifold on page 28.

The pressure is calculated as follows:

$$p_{Tank_Gasphase} = \frac{m_{Tank_Gasphase} R_{Tank_Gasphase} T_{Tank_Gasphase}}{V_{Tank_Gasphase}}$$

The fuel vaporization calculation is based on Fick's law.

$$\dot{m}_{Fuel,Vapor} = \frac{\left(p_{Fuel,Vapor} - p_{Fuel,partial}\right) A_{Liquid} D_{\frac{Fuel}{Air}} h_{eff}}{T_{Tank} h_{Tank} R_{Tank}}$$

Inports

The following table shows the inports:

Name	Unit	Description
mdot_Fuel_Diffusion_VCV	[kg/s]	Diffusion mass of fuel from the tank through the vapor control valve
mdot_Leak	[kg/s]	Mass flow through the leakage
mdot_VCV	[kg/s]	Mass flow through the vapor control valve
p_Ambient	[Pa]	Ambient pressure
Reset	[0|1]	Reset of states
T_Ambient	[°C]	Ambient temperature
T_Fuel_Liquid	[°C]	Temperature of the liquid fuel in tank
T_Leak	[°C]	Leakage mass flow temperature
T_VCV	[°C]	Temperature of the mass flow through the vapor control valve
V_Tank_Vapor	[m^3]	Volume of the tank gas phase
Xsi_Fuel_Leak	[0_1]	Fuel fraction of the leakage mass flow
Xsi_Fuel_VCV	[0_1]	Fuel fraction of the vapor control valve mass flow

Outports

The following table shows the outports:

Name	Unit	Description
ASMSignalBus	[]	Signal bus containing signals of ASM components, refer to ASMSignalBus (ASM User Guide 🕮)
mdot_Fuel_Vapor	[kg/s]	Fuel vaporization mass flow
p_Tank	[Pa]	Tank pressure
R_Tank	[J/(kgK)]	Gas constant in the tank
T_Tank	[°C]	Temperature of the vaporized fuel
Xsi_Fuel_init	[0_1]	Initial fraction of vaporized fuel in the tank gas phase
Xsi_Fuel_Tank	[0_1]	Fraction of vaporized fuel in the tank gas phase

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_A_Liquid	[m^2]	Surface of the liquid fuel for vaporization
Const_A_TankGasphase	[m^2]	Surface of the tank for heat exchange with the ambient atmosphere
Const_dvH_Fuel	[J/mol]	Vaporization enthalpy of the fuel
Const_Factor_EffHeight	[]	Effective height factor for diffusion calculation
Const_k_TankGasphase	[W/(K*m^2)]	Heat transfer coefficient of the tank vapor phase
Const_M_Air	[kg/mol]	Molar mass of the fuel
Const_M_Fuel	[kg/mol]	Molar mass of the air
Const_p_Ref	[Pa]	Reference vapor pressure
Const_T_Ref	[K]	Reference temperature for the reference vapor pressure
ItNum	[]	Iteration number
StepSize	[s]	Simulation step size

Related topics

References

Evaporator Subsystem..... 198
Tank Gasphase (ModelDesk Parameterizing 🕮)

Vaporator Control Valve - Evaporator System

Description

The VAPOR_CONTROL_VALVE block calculates the air and fuel mass flow through the valve on the basis of pressure differences and the valve position. It is located between the TANK_GASPHASE block and the CANISTER block. The mass exchange by fuel diffusion is also considered.

The VAPOR_CONTROL_VALVE block uses the following formula for orifices to calculate the mass flow:

$$\dot{m}_{Valve} = A_{Valve} p_{Valve,In} \sqrt{\frac{2}{R_{Valve} T_{Valve}}} \Psi\left(\frac{p_{Valve,Out}}{p_{Valve,In}}\right)$$

For more information, refer to Throttle Valve on page 32.

The fuel mass exchanged via diffusion is calculated by the following formula:

$$\dot{m}_{Fuel,Diffusion} = \frac{(Xsi_{Tank} - Xsi_{Canister}) A_{Valve} D \frac{Fuel}{Air}}{\delta x_{Diffusion}}$$

Inports

The following table shows the inports:

Name	Unit	Description
p_Canister	[Pa]	Canister pressure
p_Tank	[Pa]	Tank pressure
Pos_VCV	[%]	Position of the vapor control valve
R_Canister	[J/(kgK)]	Gas constant in the canister
R_Tank	[J/(kgK)]	Gas constant in the tank
T_Canister	[°C]	Temperature in the canister
T_Tank	[°C]	Temperature in the tank
Xsi_Fuel_Canister	[]	Fuel fraction in the canister
Xsi_Fuel_Tank	[0_1]	Fuel fraction in the tank

Outports

The following table shows the outports:

Name	Unit	Description
ASMSignalBus	[]	Signal bus containing signals of ASM components, refer to ASMSignalBus (ASM User Guide 🕮)
mdot_Fuel_Diffusion_VCV	[kg/s]	Fuel mass exchange via diffusion
mdot_VCV	[kg/s]	Mass flow through the vapor control valve
T_VCV	[°C]	Temperature of the mass flow
Xsi_Fuel_VCV	[0_1]	Fuel fraction of the mass flow through the vapor control valve

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_A_max	[m^2]	Maximum flow area for the vapor control valve

Name	Unit	Description
Const_delta_x_Diffusion	[m^2]	Delta x for calculating the fuel diffusion over the vapor control valve
Map_A_Red	[0_1]	Table for reducing the size of the opening of the vapor control valve A_Red = f(Pos_VaporControlValve)
Map_Psi	[]	Vapor control valve flow function = f(p_Out/p_In)

Related topics

References

Evaporator Subsystem 198
Vapor Control Valve (ModelDesk Parameterizing 🕮)

Vent Shut Valve - Evaporator System

Description

The VENT_SHUT_VALVE block calculates the mass flow between the canister and the ambient atmosphere on the basis of pressure differences and the valve position. It also provides a buffer model for a fuel filter that modifies the fuel concentration of the valve mass flow. This is done by storing and releasing fuel in the filter.

The VENT_SHUT_VALVE block uses the following orifice equation to calculate the size of the valve opening:

$$\dot{m}_{Valve} = A_{Valve}\, p_{Valve,In} \sqrt{\frac{2}{R_{Valve}\, T_{Valve}}}\, \Psi\left(\frac{p_{Valve,Out}}{p_{Valve,In}}\right)$$

For more information, refer to Throttle Valve on page 32.

The fuel filter stores fuel when it is released by the vent shut valve (VSV) and releases the fuel again when the fuel flows into the canister via the VSV. The following illustration shows the release of fuel from the filter into the ambient atmosphere flowing into the canister:

The air mass flow and fuel mass flow through the fuel filter and VSV is calculated in the valve mass flow calculation depending on the difference between the ambient pressure and canister pressure. The quantity of fuel stored in the carbon filter depends on the fuel mass fraction in the canister and the fuel flow rate through the VSV.

The fuel mass released from the carbon filter during purging depends on the air mass flow rate through the VSV and the purge ratio of the carbon filter.

$$\Theta_{Filter} = \frac{1}{m_{Fuel,max}} \int \begin{cases} \dot{m}_{Valve}\, Xsi_{Fuel,Canister}\, StoRate_{Fuel}, & \dot{m}_{Valve} < 0 \\ \dot{m}_{Valve}\, RelRate_{Fuel}, & \dot{m}_{Valve} \geq 0 \end{cases}$$

Inports

The following table shows the inports:

Name	Unit	Description
p_Ambient	[Pa]	Ambient pressure
p_Canister	[Pa]	Pressure in the canister
Pos_VSV	[%]	Position of the vent shut valve
R_Canister	[J/(kgK)]	Gas constant in the canister
Reset	[0|1]	Reset of states
T_Ambient	[°C]	Ambient temperature
T_Canister	[°C]	Temperature in the canister
Xsi_Fuel_Canister	[0_1]	Fuel fraction in the canister

Outports

The following table shows the outports:

Name	Unit	Description
ASMSignalBus	[]	Signal bus containing signals of ASM components, refer to ASMSignalBus (ASM User Guide 🕮)
mdot_VSV	[kg/s]	Mass flow through the vent shut valve

Name	Unit	Description
T_VSV	[°C]	Temperature of mass flow through the vent shut valve
Xsi_Fuel_VSV	[0_1]	Fraction of fuel in the flow through the vent shut valve

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_A_max	[m^2]	Maximum size of the valve opening
Const_Theta_Fuel_Init	[0_1]	Initial fuel filling level of the vent shut valves filter
Const_m_Fuel_Max	[kg]	Fuel capacity of the vent shut valve
ItNum	[-]	Iteration number
Map_A_Red	[0_1]	Table for reducing the size of the vent shut valve opening A_Red = f(Pos_VentShutValve)
Map_Psi	[-]	Vent shut valve flow function = f(p_Out/ p_In)
Map_ReleaseRate_Fuel	[0_1]	Efficiency / purge ratio of the the vent shut valve for emptying
Map_StorageRate_Fuel	[0_1]	Efficiency / purge ratio of the the vent shut valve for filling
StepSize	[s]	Simulation step size

Related topics

References

Evaporator Subsystem 198
Vent Shut Valve (ModelDesk Parameterizing 🕮)

Common Engine Parameters

Where to go from here

Information in this section

Common Engine Parameters.....48
The **COMMON_ENGINE_PARAMETERS** block contains physical constants, such as fuel density or heat value of fuel.

Engine Setup.....50
The **ENGINE_SETUP** block contains the basic mechanical parameters of an engine. It also contains parameters which are used to control the engine and set the dimensions of the signals which are used inside the engine model.

Map X2Y.....53
These blocks map signals from one block to the signals of another block.

Common Engine Parameters

Description

The COMMON_ENGINE_PARAMETERS block contains physical constants, such as fuel density or heat value of fuel.

Outports

The following table shows the outports:

Name	Unit	Description
Air_Coeff	[]	Heywood coefficients for air
BulkModulus_Fuel	[]	Bulk modulus of fuel
CommonParameterEngineSignals	[]	Bus containing signals of the block
cp_Air	[J/kg K]	Specific heat capacity of air
cp_Exh	[J/kg K]	Specific heat capacity at constant pressure of exhaust
cp_Fuel	[J(kg K)]	Specific heat capacity at constant pressure of fuel
cv_Air	[J/kg K]	Specific heat capacity at constant volume of air

Name	Unit	Description
cv_Exh	[J/kg K]	Specific heat capacity at constant volume of exhaust gas
cv_Fuel	[J(kg K)]	Specific heat capacity at constant volume of fuel
Exhaust_Coeff	[]	Heywood coefficients for exhaust gas
Factor_Diffusion_FuelAir	[m^2/s]	Diffusion factor of the fuel into air during injection
Fuel_Coeff	[]	Heywood coefficients for fuel
kappa_Air	[]	Isentropic ratio of fresh air
kappa_Exhaust	[]	Isentropic ratio of exhaust gas
kappa_Fuel	[]	Isentropic ratio of fuel
L_St	[]	Stoichiometric air fuel ratio
LHV_Fuel	[J/kg]	Low heat value for fuel
R_Air	[J/kg K]	Gas constant of fresh air
R_Exhaust	[J/kg K]	Gas constant of exhaust
R_Fuel	[J/kg K]	Gas constant of fuel
R_Universal	[J/mol K]	Universal gas constant
rho_Fuel	[kg/m^3]	Fuel density

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_Air_Coeff	[]	Heywood coefficients for air
Const_BulkModulus_Fuel	[bar]	Bulk modulus of diesel fuel
Const_Exhaust_Coeff	[]	Heywood coefficients for exhaust
Const_Factor_Diffusion_FuelAir	[m^2/s]	Diffusion coefficient between fuel and air for evaporation
Const_Fuel_Coeff	[]	Heywood coefficients for fuel
Const_kappa_Air	[]	Isentropic ratio of fresh air
Const_kappa_Exhaust	[]	Isentropic ratio of exhaust gas
Const_kappa_Fuel	[]	Isentropic ratio of gaseous fuel
Const_L_st	[]	Stoichiometric ratio
Const_Q_LHV	[J/kg]	Lower heat value of fuel
Const_R_Air	[J/(kg K)]	Gas constant of fresh air
Const_R_Exhaust	[J/(kg K)]	Gas constant of exhaust
Const_R_Fuel	[J/(kg K)]	Gas constant of fuel
Const_rho_Fuel	[kg/m^3]	Fuel density
Const_Rm	[J/(mol K)]	Universal gas constant

Related topics

References

Common Engine Parameters (ModelDesk Parameterizing 🕮)
History of the COMMON_ENGINE_PARAMETERS Block..... 241

Engine Setup

Description

The ENGINE_SETUP block contains the basic mechanical parameters of an engine. It also contains parameters which are used to control the engine and set the dimensions of the signals which are used inside the engine model.

The Const_max_num_Inj_Direct, Const_max_num_Inj_Port, Const_max_num_InMan, Const_max_num_ExhMan, and Const_max_num_Cyl parameters specify the signal dimension in current compiled code and are used to match the signal sizes in the engine model to the soft ECU and the external model or the real ECU in the Interface_External_In. Make sure that these dimensions match those coming from the external model. The soft ECU will use the same values as used in this block if not specified otherwise. Also, the ASM models from the Operator libraries use these values to define the dimensional input to the S-function placed under their masks.

Note

If you change the number of cylinders manually, you also have to modify the following paramters:

- Numer of engine cylinders vector (Const_num_Cyl)
- Firing order of engine (Const_FiringOrder)
- Mapping of intake/exhaust manifold to cylinder (Map_ExhMan2Cyl, Map_InMan2Cyl)
- Vector with cylinder offsets (Const_CylinderOffset)

Note

If you change one of the Const_max_num parameters, some coherent parameters and matrices also need to be recalculated according to these values. Therefore you should run all functions in ASMProcessing again to have a consistent parameter set. Because of the changed signal dimension in the current compiled code you will need to update the input to the TA systems in the Interface_External_In to match the new dimension if you use an external model. For a real-time application or VEOS simulation, it is required to compile new code.

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_A_Piston	[m^2]	Piston area
Const_CylinderOffset	[deg]	Vector with cylinder offsets [1,...,20]
Const_FiringOrder	[]	Firing order of engine [1,...,20]
Const_i	[]	Factor for a four-stroke engine (0.5) or two-stroke engine (1)
Const_m_Air_ref	[kg]	Reference air mass
Const_max_num_Cyl	[]	Maximal number of cylinders with current compiled code
Const_max_num_ExhMan	[]	Maximum number of exhaust manifolds with current compiled code
Const_max_num_InMan	[]	Maximum number of intake manifolds with current compiled code
Const_max_num_Inj_Direct	[]	Maximal number of direct injections with current compiled code
Const_max_num_Inj_Port	[]	Maximal number of port injections with current compiled code
Const_max_num_PortInjector_PressureDrop	[]	Maximum number of pressure drops with current compiled code
Const_max_num_Rail	[]	Number of rail systems
Const_num_Cyl	[1_20]	Number of engine cylinders
Const_num_ExhMan	[]	Number of exhaust manifolds
Const_num_ExhSys	[]	Number of exhaust systems
Const_num_InMan	[]	Number of intake manifolds
Const_num_Inj_Direct	[]	Number of injections per cylinder
Const_num_Inj_Port	[]	Number of port injections per cylinder
Const_num_SCR_Cell	[]	Number of cells in the SCR catalyst
Const_Ratio_Comp	[]	Compression ratio
Const_V_Displ	[m^3]	Engine displacement
Map_ExhMan2Cyl	[]	Mapping of exhaust manifold to cylinder
Map_InMan2Cyl	[]	Mapping of intake manifold to cylinder

Name	Unit	Description
Sw_Turbo_Model	[1|2]	Switch for turbocharger model: ▪ 1: Physical-based model ▪ 2: Look-up table-based model
Sw_Turbo_Stage	[1|2]	Switch for turbocharger stages: ▪ 1: Single stage ▪ 2: Two stage

Related topics

References

Engine Setup Gasoline (ModelDesk Parameterizing 🕮)
Engine Setup Gasoline V4 (ModelDesk Parameterizing 🕮)
History of the ENGINE_SETUP Block..... 248

Map X2Y

Description

These blocks map signals from one block to the signals of another block. There are different blocks for signal mapping.

MAP_X2Y These blocks map the intake manifold signals to the cylinder signals and the cylinder signals to the exhaust manifold signals.

MAP_X2Y_DIV These blocks have the same functionality as the MAP_X2Y blocks, but also divide the mapped signals by number of cylinders per bank.

X2Y blocks These blocks map the intake manifold, EGR or throttle signals to the exhaust manifold, compressor, or turbine signals, or vice versa.

The following equation is used to assign the intake manifold pressures to the intake valves:

$$\begin{bmatrix} P_{In,\,InValve1} \\ P_{In,\,InValve2} \\ P_{In,\,InValve3} \\ P_{In,\,InValve4} \\ P_{In,\,InValve5} \\ P_{In,\,InValve6} \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \\ 1 & 0 \\ 0 & 1 \\ 1 & 0 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} P_{InMan1} \\ P_{InMan2} \end{bmatrix} = \begin{bmatrix} P_{InMan1} \\ P_{InMan2} \\ P_{InMan1} \\ P_{InMan2} \\ P_{InMan1} \\ P_{InMan2} \end{bmatrix}$$

With the transposed matrix, the mass flow of the single cylinder can be added to the total mass flow from the intake manifold.

$$\begin{bmatrix} \dot{m}_{Out,\ InMan1} \\ \dot{m}_{Out,\,InMan2} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 1 & 0 & 1 & 0 \\ 0 & 1 & 0 & 1 & 0 & 1 \end{bmatrix} \begin{bmatrix} \dot{m}_{InValve1} \\ \dot{m}_{InValve2} \\ \dot{m}_{InValve3} \\ \dot{m}_{InValve4} \\ \dot{m}_{InValve5} \\ \dot{m}_{InValve6} \end{bmatrix} =$$

$$\begin{bmatrix} \dot{m}_{InValve1} + \dot{m}_{InValve3} + \dot{m}_{InValve5} \\ \dot{m}_{InValve2} + \dot{m}_{InValve4} + \dot{m}_{InValve6} \end{bmatrix}$$

where:

$P_{In,\,InValve_i}$	is the pressure at the input side of intake valve *i*
P_{InMan_i}	is the pressure in the intake manifold *i*
$\dot{m}_{Out,\ InMan_i}$	is the total flow out of the intake manifold *i* over all connected intake valves
$\dot{m}_{InValve_i}$	is the mass flow over the intake valve *i*

Inports

The following table shows the inports:

Name	Unit	Description
Input	[]	Intake/exhaust manifold or cylinder signals.

Outports

The following table shows the outports:

Name	Unit	Description
Output	[]	Intake/exhaust manifold or cylinder signals.

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_max_num_Cyl	[]	Maximum number of cylinders.
Const_max_num_ExhMan	[]	Maximum number of exhaust manifolds.
Const_max_num_InMan	[]	Maximum number of intake manifolds.

Cooler

Where to go from here

Information in this section

Cooler.....56
The COOLER block calculates the cooling water temperature from the indicated mean torque and the friction torque.

Switches Cooler.....58
This block contains switches to specify the correct model setup.

Cooler

Description

The COOLER block calculates the cooling water temperature from the indicated mean torque and the friction torque.

It is assumed that the friction torque is completely dissipated to the cooling circuit and also that a fixed amount of the indicated mean torque is dissipated by the cooling system. This part can be seen as the wall heat losses from the cylinder to the cooling circuit.

The system is modeled with a thermostat valve that regulates the cooling water temperature. The temperature can also be set externally. The model contains two inputs for fan control and one input for an external heat source.

Inports

The following table shows the inports:

Name	Unit	Description
Fan1	[0_1]	Controller signal for first fan
Fan2	[0_1]	Controller signal for second fan
n_Engine	[rpm]	Engine speed
Q_dt_ext	[W]	External heat flow to the coolant
SW_T_Water_Mode	[1|2]	Switch for mode: ▪ 1: Temperature calculated internally ▪ 2: Temperature set externally
T_Ambient	[°C]	Ambient temperature
T_Coolant_ext	[°C]	External coolant temperature for user setting
T_Coolant_Init	[°C]	Initial coolant temperature
Trq_MeanFric_Engine	[Nm]	Mean friction torque
Trq_MeanInd_Engine	[Nm]	Mean indicated torque
Reset	[]	Reset all integrators to their initial conditions

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 🕮).
T_Coolant	[°C]	Coolant temperature

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_Eta_Coolant	[]	Fraction of indicated mean torque to be dissipated in the coolant
Const_P_Gain_Coolant_Controller	[W/K]	Thermostat gain
Const_Q_dt_Air	[W/K]	Coolant heat flow to environment
Const_Q_dt_Fan1	[W/K]	Coolant heat flow with first fan
Const_Q_dt_Fan2	[W/K]	Coolant heat flow with second fan
Const_T_Coolant_Set	[°C]	Set temperature for controller
Const_T_Coolant_LowLim	[K]	Lower limit of coolant
Const_T_Coolant_UpLim	[K]	Upper limit of coolant

Name	Unit	Description
Const_T_dt_Coolant	[K/J]	Inverse of coolant water heat capacity, defines energy flow from/to coolant water

Related topics

References

Cooler Gasoline (ModelDesk Parameterizing 🕮)
History of the COOLER Block 243

Switches Cooler

Description

This block contains switches to specify the correct model setup.

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_T_Water_Manual	[°C]	Constant temperature to be used when SW_T_Water_Mode is set to external.
SW_T_Water_Mode	[1|2]	Switch to enable or disable an internal or external coolant temperature: ▪ 1: Internal ▪ 2: External

Related topics

References

Cooler Gasoline (ModelDesk Parameterizing 🕮)

Exhaust System

Where to go from here

Information in this section

Catalyst.....59
The CATALYST block calculates the exhaust pressure, temperature, and lambda value downstream of the catalyst.

Lambda Sensor.....62
The LAMBDA_SENSOR block simulates the temperature of the heated exhaust gas oxygen sensor calculating the energy balance for the sensor.

Catalyst

Description

The CATALYST block calculates the exhaust pressure, temperature, and lambda value downstream of the catalyst.

The thermal model is based on the energy balance.

The lambda calculations take the oxygen storage capacity of the catalyst into account using a buffer model.

The following schematics shows the implementation of the lambda value calculation downstream of the catalyst. It uses a modified buffer model which was described in [Bra00].

If the upstream lambda value of the catalyst is larger than or equals **1**, oxygen is stored. Else, the release function is used. Θ describes the oxygen surface coverage of the catalyst material.

The following illustration shows the default parameterization for the rate functions.

The following illustration shows the physical structure of the catalyst thermal model:

The thermal model of the catalyst is based on the following assumptions:

- The temperature of the catalyst is equal to the exhaust gas temperature exiting the catalyst.
- The exhaust gas density is the density at the entrance of the catalyst.

- The exothermic reactions during catalyst operation, causing catalyst heating, are simplified.

Inports

The following table shows the inports:

Name	Unit	Description
EngineOP	[]	Engine operating point
lambda_in_Cat	[]	Catalyst upstream lambda value of exhaust gas
mdot_in_Cat	[kg/h]	Exhaust gas mass flow
p_Ambient	[Pa]	Ambient pressure
p_Out_Cat	[Pa]	Catalyst downstream pressure
Q_dt_ext	[W]	External heat flow to the coolant
Reset	[]	Reset of states
Sw_T_In_Cat	[1|2]	Switch for selecting temperature input of catalyst ▪ 1: Physical ▪ 2: Look-up table
T_Ambient	[°C]	Ambient temperature
T_in_Cat	[°C]	Catalyst upstream exhaust gas temperature

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 🕮).
lambda_Out_Cat	[]	Catalyst downstream lambda value of exhaust gas
p_In_Cat	[Pa]	Catalyst upstream pressure
T_Out_Cat	[°C]	Catalyst downstream exhaust gas temperature

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_Cap_IntHeat_Cat	[J/K]	Internal heat capacity of catalyst
Const_H_Cat	[J/K]	Constant heat of catalytic reaction
Const_Idx_EngOP	[]	Indexes to select engine operating point for maps
Const_m_O_Max_Cat	[kg]	Oxygen storage capacity of catalyst
Const_Res_Thermal_Cat	[K/W]	Thermal resistance of catalyst
Const_T_Out_Cat_LowLim	[K]	Lower limit of the temperature at outlet of catalyst
Const_T_Out_Cat_UpLim	[K]	Upper limit of the temperature at outlet of catalyst

Name	Unit	Description
Const_t_PT1_lambda_out_Cat	[s]	PT1 constant for delay of lambda after catalyst
Const_t_PT1_p_In_Cat	[]	PT1 constant for delay of catalyst pressure drop
Const_t_PT1_Qdot_Cat	[s]	PT1 constant for catalytic reaction heat release
Const_t_PT1_T_In_Cat	[s]	PT1 constant for delay of temperature before catalyst
Const_V_Exhaust_Cat	[m^3]	Exhaust volume in catalyst
Map_m_O_Cat_Red	[0_1]	Oxygen storage effective capacity as function of catalyst temperature (light off curve)
Map_p_Drop_Cat	[Pa]	Pressure drop map of catalyst as a function of inlet temperature and volumetric flow at the inport
Map_ReleaseRate_O_Cat	[]	Fraction of missing oxygen released as function of catalyst oxygen surface coverage (Θ)
Map_StorageRate_O_Cat	[]	Fraction of incoming oxygen stored as function of catalyst oxygen surface coverage (Θ)
Map_T_In_Cat	[°C]	Temperature map before catalyst as function of engine operating point

Related topics

References

Catalyst (ModelDesk Parameterizing 🕮)
History of the CATALYST Block..... 238

Lambda Sensor

Description

The LAMBDA_SENSOR block simulates the temperature of the heated exhaust gas oxygen sensor calculating the energy balance for the sensor. The exhaust gas temperature is taken into account. The lambda sensor can also be heated by a heater element.

The following equation describes the energy balance at the lambda sensor:

$$T_{Sensor} = T_{Ambient} + \int \frac{(T_{Exh} - T_{Sensor})k_{Sensor}A_{Sensor} + \frac{(Ctrl_{Sensor}U_{Heater,Max})^2}{R_{Heater}}}{m_{Sensor}cp_{Sensor}}$$

Inports

The following table shows the inports:

Name	Unit	Description
Ctrl_LambdaSensorHeater	[0_1]	Control signal for sensor heater
Reset	[]	Reset of states
T_Ambient	[°C]	Ambient temperature
T_Exhaust	[K]	Exhaust gas temperature

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 🕮).

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_A_Lambda_Sensor	[m^2]	Heat transfer surface area of sensor
Const_cp_Lambda_Sensor	[J/(kgK)]	Specific heat capacity of sensor
Const_k_Lambda_Sensor	[W/(m^2 K)]	Sensor heat transfer coefficient
Const_m_Lambda_Sensor	[kg]	Sensor mass
Const_R_Heater	[Ohm]	Heater resistance
Const_U_Heater_Max	[V]	Heater peak voltage

Related topics

References

History of the LAMBDA_SENSOR Block..... 258
Lambda Sensor (ModelDesk Parameterizing 🕮)

Fuel System

Where to go from here

Information in this section

CNG High-Pressure Line.....65
The CNG_HIGH_PRESSURE_LINE block calculates the high-pressure gas line temperature and pressure depending on gas mass flows (in/out) and their temperatures.

CNG Pressure Regulator.....66
The CNG_PRESSURE_REGULATOR block calculates the gas mass flow through the pressure regulator valve depending on the pressure difference between CNG_HIGH_PRESSURE_LINE and CNG_Rail, using a mechanically controlled model.

CNG Rail.....68
The CNG_RAIL block calculates rail temperature and pressure depending on gas mass flows (in/out) and their temperatures.

CNG Shutoff Valve.....70
The CNG_SHUTOFF_VALVE block calculates the gas mass flow through the tank shutoff valve depending on the pressure difference between CNG_TANK and CNG_HIGH_PRESSURE_LINE and valve actuation.

CNG Tank.....72
The CNG_TANK block simulates the tank pressure, depending on the gas mass flow into the high-pressure gas line.

Direct Injector.....74
In the DIRECTINJECTOR block, injected fuel mass is calculated according to injection time and rail pressure.

Fuel Tank.....76
The FUELTANK block calculates the fuel mass in the tank as a function of the currently injected fuel mass flow into the combustion engine.

High-Pressure Pump.....78
The HIGH_PRESSURE_PUMP block calculates the fuel flow to the rail as a function of pump speed pump volume and efficiencies.

High-Pressure Pump (Crank-Based).....80
The HPP_CRANKBASED block calculates the volume flow through the high pressure pump as a function of the crank angle.

Port Injector.....85
The block calculates the fuel quantity.

Port Injector Fuel Supply CNG Model.....87
In gasoline engines, a compressed natural gas system can be used to supply the port injector with fuel. For this purpose, two models are prepared.

Pressure Control Valve.....89
The flow through the pressure control valve is modeled as a map according to control signal and rail pressure.

Rail.....90
The RAIL block calculates the pressure in the rail as a function of the fuel mass flows out of and into the rail.

CNG High-Pressure Line

Description

The CNG_HIGH_PRESSURE_LINE block calculates the high-pressure gas line temperature and pressure depending on gas mass flows (in/out) and their temperatures.

The implementation is similar to CNG_Rail. For details, refer to CNG Rail on page 68. The modeling approach does not take any gas dynamic effects into account.

The values are physically based on mass flow and energy balance.

Inports

The following table shows the inports:

Name	Unit	Description
mdot_CNGPressureRegulator	[kg/h]	Gas mass flow through CNG pressure regulator
mdot_TankShutOffValve	[kg/h]	Gas mass flow through CNG shutoff valve

Name	Unit	Description
p_Ambient	[Pa]	Ambient pressure
Reset	[0|1]	Reset of states
T_Ambient	[°C]	Ambient temperature
T_CNGShutoffValve	[°C]	CNG shutoff valve output temperature

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_CNGHighPressureLine	[Pa]	Gas pressure of CNG high-pressure line
T_CNGHighPressureLine	[°C]	Gas temperature in CNG high-pressure line

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_A_CNGHPLine	[m^2]	High-pressure gas line area
Const_k_CNGHPLine	[W/(km^2)]	Heat transfer coefficient
Const_V_CNGHPLine	[m^3]	High-pressure gas line volume

Related topics

References

CNG High Pressure Line (ModelDesk Parameterizing 🕮)

CNG Pressure Regulator

Description

The CNG_PRESSURE_REGULATOR block calculates the gas mass flow through the pressure regulator valve depending on the pressure difference between CNG_HIGH_PRESSURE_LINE and CNG_Rail, using a mechanically controlled model.

For the valve model implementation, refer to CNG Shutoff Valve on page 70.

The mechanical control opens the valve depending on the difference between the actual CNG rail pressure and the pressure setpoint.

$$Ctrl_{Valve} = (p_{set} - p_{CNGRail})Const_{kP},\ p_{set} > p_{CNGRail}$$

$$Ctrl_{Valve} = 0,\ p_{set} \leq p_{CNGRail}$$

The pressure setpoint can be constant or specified by the external input.

A mechanical model converts the control signal to a valve position. If the valve supply is off, the valve is be closed.

$$Pos_{Valve} = f(Ctrl_{Valve})$$

Note

The model does not calculate a temperature change of the gas mass flow. The model supports only positive mass flow in one direction because the valve is a non-return valve.

Inports

The following table shows the inports:

Name	Unit	Description
p_CNGHighPressureLine	[Pa]	Gas pressure in CNG high-pressure line
p_CNGRail	[Pa]	Gas pressure in CNG rail
p_CNGRail_set	[Pa]	External gas pressure setpoint for CNG rail
Reset	[]	Reset of states
Sw_Supply	[0|1]	Switch for power supply: ▪ 0: Off ▪ 1: On
T_CNGHighPressureLine	[°C]	Gas temperature in CNG high-pressure line

Outports

The following table shows the outports:

Name	Unit	Description
ASMSignalBus	[]	Signal bus containing signals of ASM components, refer to ASMSignalBus (ASM User Guide 🕮)
mdot_CNGPressureRegulator	[kg/h]	Gas mass flow through CNG pressure regulator
T_Out_CNGPressureRegulator	[°C]	CNG pressure regulator output temperature

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_A_max	[m^2]	Maximum flow area of pressure regulator
Const_kP	[]	Mechanical pressure control constant
Const_PT1_p	[s]	PT1 constant for dynamic behavior of pressure regulator
Const_p_Set	[Pa]	Pressure setpoint constant
Map_A_Red	[0_1]	Table for reducing area of pressure regulator = f(Pos)
Map_Ctrl2Pos	[%]	Conversion from control signal to position of pressure regulator = f(Ctrl)
Map_Psi	[]	Flow function (psi) of pressure regulator = f(p_out/p_in)
Sw_p_Set	[0|1]	Switch for pressure setpoint selection: ▪ 0: External ▪ 1: Constant

Related topics

References

CNG Pressure Regulator (ModelDesk Parameterizing 🕮)

CNG Rail

Description

The CNG_RAIL block calculates rail temperature and pressure depending on gas mass flows (in/out) and their temperatures.

The values are physically based on mass flow and energy balance.

From the mass balance of the input and output massflow, the rail mass can be calculated in the following way:

$$m_{CNGRail} = m_{CNGRail,Init} + \int (\dot{m}_{in} - \dot{m}_{out})dt$$

$$m_{CNGRail,Init} = \frac{V_{CNGRail}\, p_{Ambient}}{R_{Fuel}\, T_{Ambient}}$$

The rail temperature is calculated from the energy balance:

$$T_{CNGRail} = T_{Ambient} + \int \frac{c_p(\dot{m}_{in}\, T_{in} - \dot{m}_{out}\, T_{CNGRail}) - c_v\, T_{CNGRail}(\dot{m}_{in} - \dot{m}_{out}) - \dot{Q}_{wall}}{c_v\, m_{CNGRail}} dt$$

$$\dot{Q}_{wall} = k_{CNGRail}\, A_{CNGRail}(T_{CNGRail} - T_{Ambient})$$

With the ideal gas law, one receives the rail pressure, which is used for calculating the gas mass flow through the port injector and into the engine:

$$p_{CNGRail} = \frac{m_{CNGRail}\, T_{CNGRail}\, R_{Fuel}}{V_{CNGRail}}$$

Note

This modeling approach does not take any gas dynamic effects into account.

Inports

The following table shows the inports:

Name	Unit	Description
mdot_CNGPressureRegulator	[kg/h]	Gas mass flow through CNG pressure regulator
mdot_Injector	[kg/h]	Gas mass flow through port injectors

Name	Unit	Description
p_Ambient	[Pa]	Ambient pressure
Reset	[0|1]	Reset of states
T_Ambient	[°C]	Ambient temperature
T_Out_CNGPressureRegulator	[°C]	Output temperature of CNG pressure regulator

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_Fuel	[Pa]	Gas pressure in CNG rail
T_Fuel	[°C]	Gas temperature in CNG rail

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_A_CNGRail	[m^2]	CNG rail area
Const_k_CNGRail	[W/(km^2)]	Heat transfer coefficient
Const_V_CNGRail	[m^3]	CNG rail volume

Related topics

References

CNG Rail (ModelDesk Parameterizing 🕮)

CNG Shutoff Valve

Description

The CNG_SHUTOFF_VALVE block calculates the gas mass flow through the tank shutoff valve depending on the pressure difference between CNG_TANK and CNG_HIGH_PRESSURE_LINE and valve actuation.

The mass flow through the valve can be written with the following equation:

$$\dot{m}_{Valve} = A_{max} A_{RED}(Pos_{Valve}) p_{in} \sqrt{\frac{2}{R \cdot T_{in}}} \Psi\left(\frac{p_{out}}{p_{in}}\right)$$

The flow function Ψ is defined as follows:

$$\Psi\left(\frac{p_{out}}{p_{in}}\right) = \begin{cases} \sqrt{\frac{\kappa}{\kappa - 1}\left[\left(\frac{p_{out}}{p_{in}}\right)^{\frac{2}{\kappa}} - \left(\frac{p_{out}}{p_{in}}\right)^{\frac{\kappa+1}{\kappa}}\right]} & \frac{p_{out}}{p_{in}} \geq \left(\frac{2}{\kappa - 1}\right)^{\frac{\kappa}{\kappa - 1}} \\ \left(\frac{2}{\kappa + 1}\right)^{\frac{1}{\kappa - 1}} \sqrt{\frac{\kappa}{\kappa + 1}} & \frac{p_{out}}{p_{in}} < \left(\frac{2}{\kappa - 1}\right)^{\frac{\kappa}{\kappa - 1}} \end{cases}$$

where the flow function Ψ is limited to a specific value if the orifice mass flow reaches sonic speed. Ψ is not implemented analytically, but as a look-up table.

The Map_A_Red cross section factor is adjusted with normalized default data and depends on the valve position. You are recommended to change the Const_A_max parameter instead of Map_A_Red to calibrate the effective cross section.

A mechanical model converts the control signal to a valve position. If the valve supply is off, the valve is closed.

$$Pos_{Valve} = f(Ctrl_{Valve})$$

Note

The model does not calculate a temperature change of the gas mass flow. The model supports only positive mass flow in one direction because the valve is a non-return valve.

Inports

The following table shows the inports:

Name	Unit	Description
Ctrl_CNGShutoffValve	[0_1]	External control signal for CNG shutoff valve
p_CNGHighPressureLine	[Pa]	Gas pressure in CNG high-pressure line
p_CNGTank	[Pa]	Gas pressure in CNG tank
Reset	[]	Reset of states

Name	Unit	Description
Sw_Supply	[0|1]	Switch for power supply: ▪ 0: Off ▪ 1: On
T_CNGTank	[°C]	Temperature of CNG tank

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 🕮).
mdot_CNGShutoffValve	[kg/h]	Gas mass flow through CNG shutoff valve
T_CNGShutoffValve	[°C]	CNG shutoff valve output temperature

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_A_max	[m^2]	Maximum flow area of tank shutoff valve
Const_PT1_p	[s]	PT1 constant for dynamic behavior of tank shutoff valve
Map_A_Red	[0_1]	Table for reducing area of tank shutoff valve, CNGShutoffValve
Map_Ctrl2Pos	[%]	Conversion from control signal to position of tank shutoff valve = f(Ctrl)
Map_Psi	[]	Flow function (psi) of tank shutoff valve = f(p_out/p_in)

Related topics

References

CNG Shutoff Valve (ModelDesk Parameterizing 🕮)

CNG Tank

Description

The CNG_TANK block simulates the tank pressure, depending on the gas mass flow into the high-pressure gas line.

$$p_{CNGTank} = \frac{(m_{CNGTank}\, R_{Gas}\, T_{CNGTank})}{V_{CNGTank}}$$

$$m_{CNGTank} = m_{Init,CNGTank} - \int \dot{m}_{Fuel}$$

Inports

The following table shows the inports:

Name	Unit	Description
mdot_Fuel	[kg/h]	Fuel mass flow of the fuel tank
Reset	[]	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 🕮).
p_CNGTank	[Pa]	Tank pressure
T_CNGTank	[°C]	Tank temperature

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_T_CNGTank	[°C]	Constant CNG tank temperature
Const_m_Init_CNGTank	[kg]	Starting fuel mass
Const_V_CNGTank	[l]	CNG tank volume

Related topics

References

CNG Tank (ModelDesk Parameterizing 🕮)

Direct Injector

Description

The DIRECTINJECTOR block calculates the fuel mass on the basis of the injection time and the rail pressure. The number of injections and cylinders has to be specified. There are two model approaches: a mean-value and a pulse-wise injection.

In the pulse-wise injection mode, the entire fuel mass is taken out of the rail in one sample time. In mean value mode, a continuous fuel flow is modeled.

Additionally, the mean value approach can switch between the homogeneous and the stratified injection mode.

The injection matrix contains the respective injections at the respective cylinders:

$$q_{Inj}\left[\frac{mm^3}{cyc}\right] = Map\left(t_{Inj}[\mu s], p_{Rail}[bar]\right)$$

Total injection quantity at respective cylinder per engine cycle:

$$q_{Inj,Cyl}\left[\frac{mm^3}{cyc}\right] = \Sigma_1^{num_Inj} q_{Inj,noPost}\left[\frac{mm^3}{cyc}\right]$$

Mean value approach

Mean injection quantity per engine cycle:

$$q_{Mean,Cyl}\left[\frac{mm^3}{cyc}\right] = \frac{\Sigma_1^{num_Cyl} q_{Inj,Cyl}\left[\frac{mm^3}{cyc}\right]}{num_Cyl}$$

Total injection quantity at respective cylinder per second:

$$q_{Inj,Cyl}\left[\frac{mm^3}{s}\right] = \frac{q_{Inj,Cyl}\left[\frac{mm^3}{cyc}\right] \cdot n_{Eng}\left[\frac{Rev}{min}\right] \cdot 0{,}5\left[\frac{cyc}{Rev}\right]}{60\left[\frac{s}{min}\right]}$$

Mass flow at respective cylinder per second:

$$\dot{m}_{Fuel,Cyc}\left[\frac{kg}{h}\right] = q_{Inj,Cyl}\left[\frac{mm^3}{s}\right] \cdot \rho_{Fuel}\left[\frac{kg}{m^3}\right] \cdot 3600\left[\frac{s}{h}\right] \cdot 10^{-9}\left[\frac{m^3}{mm^3}\right]$$

To switch between the stratified and the homogeneous mode, the Sw_Inj_Mode parameter is used:

- 0: Homogeneous
- 1: Stratified

$$Sw_{Inj,Mode}[0|1]: \varphi_{Main,Inj}[bTDC] \leq \varphi_{Main,Stratified2Homogen}[bTDC]$$

Mass flow at respective cylinder in the stratified mode:

$$\dot{m}_{Fuel,Stratified}\left[\frac{kg}{h}\right] = \begin{cases} \dot{m}_{Fuel}\left[\frac{kg}{h}\right], & Sw_{Inj,Mode} = 1 \\ 0, & Sw_{Inj,Mode} = 0 \end{cases}$$

Mass flow at respective cylinder in the homogeneous mode:

$$\dot{m}_{Fuel,Homogen}\left[\frac{kg}{h}\right] = \begin{cases} 0, & Sw_{Inj,Mode} = 1 \\ \dot{m}_{Fuel}\left[\frac{kg}{h}\right], & Sw_{Inj,Mode} = 0 \end{cases}$$

Total injection quantity per second:

$$q_{Inj,MeanValue}\left[\frac{mm^3}{s}\right] = \Sigma_1^{num_Cyl} q_{Inj,Cyl}\left[\frac{mm^3}{s}\right]$$

Pulse approach

Total injection quantity per second:

$$q_{Inj,Pulse}\left[\frac{mm^3}{s}\right] = \frac{\Sigma_1^{num_Cyl} q_{Inj,Cyl}\left[\frac{mm^3}{s}\right]}{StepSize[s]}$$

Inports

The following table shows the inports:

Name	Unit	Description
CrankAngle_Cyl	[deg]	Crank angle per cylinder, positive value is after TDC
n_Engine	[rpm]	Engine speed
p_Rail	[bar]	Rail pressure (absolute)
phi_Inj	[bTDC]	Injection start angle vector (cylinder 1, pulse 1, pulse 2, ..., cylinder n, pulse m)
t_Inj	[µs]	Injection time vector (cylinder 1, pulse 1, pulse 2, ..., cylinder n, pulse m)

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 🕮).
mdot_Fuel_Homogen	[kg/h]	Injection mass flow into cylinder (vector of number of cylinders)
mdot_Fuel_Stratified	[kg/h]	Injection mass flow into cylinder (vector of number of cylinders)
phi_Main_Inj	[bTDC]	Injection start angle of main injection (injection pulse with maximum t_Inj for this cylinder)
q_Inj	[mm^3/s]	Fuel flow through injectors (all cylinders, out of rail)
q_Inj_Cyl	[mm^3/cyc]	Injection quantity per cylinder (vector of number of cylinders)
q_Mean_Inj	[mm^3/cyc]	Mean injection quantity per cylinder and cycle

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_max_num_Cyl	[1_20]	Number of engine cylinders
Const_max_num_Inj_Direct	[1_8]	Number of injections per cylinder
Const_phi_Inj_MeasUpdate	[aTDC]	Crank angle when new injection pulse measurement is available
Const_Phi_Main_Inj_Stratified2Homogen	[bTDC]	Injection angle limit for homogeneous or stratified combustion (e.g., 180° bTDC)
Map_q_Inj	[mm^3/cyc]	Map of injection quantity = f(t_Inj, p_Rail)
StepSize	[sec]	Simulation step size
Sw_InjMode	[1|2]	Switch to select the injection mode ▪ 1: Mean injector fuel flow mode ▪ 2: Pulse-wise injection mode

Related topics

References

Directinjector Gasoline (ModelDesk Parameterizing 🕮)
History of the DIRECTINJECTOR Block..... 245

Fuel Tank

Description

The FUELTANK block calculates the fuel mass in the tank as a function of the currently injected fuel mass flow into the combustion engine.

The following equation describes the energy balance for the liquid fuel:

$$T_{Fuel} = T_{Ambient} + \int \frac{(T_{Coolant} - T_{Fuel})\, k_{Tank,\,Coolant}\, A_{Tank,\,Coolant} + (T_{Ambient} - T_{Fuel})\, k_{Tank,\,Ambient}\, A_{Tank,\,Ambient}}{m_{Fuel}\, cp_{Fuel}}$$

This is the physical modeling approach. Alternatively the selector for the tank temperature model can be used to calculate the fuel temperature with a coolant temperature based look-up table.

The free tank volume used for vaporization is calculated with the following formula:

$$V_{Tank,Vapor} = (1 - TankLevel)V_{Tank} + V_{Tank,VaporOffset}$$

Inports

The following table shows the inports:

Name	Unit	Description
mdot_Fuel	[kg/h]	Injected fuel mass flow
mdot_Fuel_Refilling	[kg/s]	Liquid fuel mass flow into the fuel tank during refilling
mdot_Fuel_Vapor	[kg/h]	Vaporized fuel mass flow
Reset_FuelTank	[0|1]	Reset of fuel tank
T_Ambient	[°C]	Ambient temperature

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 🕮).
T_Fuel_Liquid	[°C]	Fuel temperature
V_Tank_Vapor	[m^3]	Free volume in the tank

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_A_TankToAmbient	[m^2]	Surface area of the tank for heat exchange to ambient atmosphere
Const_A_TankToCoolant	[m^2]	Surface area of the tank for heat exchange to engine coolant
Const_k_TankToAmbient	[W/(K*m^2)]	Heat transfer coefficient for heat exchange to ambient atmosphere
Const_k_TankToCoolant	[W/(K*m^2)]	Heat transfer coefficient for heat exchange to engine coolant
Const_V_FuelTank	[L]	Fuel tank displacement
Const_V_FuelTank_Vapor_Offs	[L]	Remaining air volume in tank when it is completely filled.
Map_T_FuelTank	[°C]	Map of fuel temperature = f(engine coolant)
Sw_T_FuelTank	[1|2]	Selector for tank temperature modeling approach: ▪ 1: Physical modeling approach

Name	Unit	Description
		▪ 2: Look-up table modeling approach

Related topics

References

Fuel Tank Gasoline (ModelDesk Parameterizing 🕮)

High-Pressure Pump

Description

The high-pressure pump provides fuel to the common rail. It is driven by the crankshaft at a specific transmission ratio. Newer pumps may contain a fuel metering unit (also called a volume control valve) which decreases the amount of fuel which is pumped to the rail. This is used at high engine speeds to decrease energy losses.

The HIGH_PRESSURE_PUMP block calculates the fuel flow to the rail as a function of pump speed pump volume and efficiencies.

$$q_{Pump} = V_{PumpCylEff} \cdot Number_{PumpCyl} \cdot i_{HighPressPump} \cdot \frac{n_{Engine}}{60}$$

$$\cdot\, \eta_{FuelMeterUnit} \cdot \eta_{HighPressPump}$$

The effective pump volume is reduced by the fuel compressibility and dead volume of the pump:

$$V_{PumpCylEff} = V_{PumpCyl} - V_{FuelCompressibility} - V_{Dead}$$

$$V_{FuelCompressibility} = \frac{V_i \cdot (p_{Rail} - p_{Low})}{BulkModulus_{Fuel}}$$

$$V_{Dead} = Map(T_{Rail}, p_{Rail})$$

The maximum flow of the pump is decreased by an efficiency map. It depends on the pump speed and the rail pressure:

$$\eta_{HighPressPump} = Map\left(n_{HighPressPump}, p_{Rail}\right)$$

The fuel metering unit is modeled as a map according to the control signal:

$$\eta_{FuelMeterUnit} = Map\left(Ctrl_{HighPressPump}\right)$$

Inports

The following table shows the inports:

Name	Unit	Description
Const_BulkModulus_Fuel	[bar]	Fuel compressibility
Ctrl_FuelMeterUnit	[mA]	Control signal (current) of fuel metering unit for common rail
n_Engine	[rpm]	Engine speed
p_Rail	[bar]	Rail pressure (absolute)
T_Rail	[°C]	Rail temperature

Outports

The following table shows the outports:

Name	Unit	Description
q_HighPresPump	[mm^3/s]	Fuel flow through high pressure pump (into rail)

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_p_Low	[bar]	Pressure below which the influence of fuel compressibility is ignored
Const_i_HighPresPump	[]	Pump speed ratio
Const_num_PumpCyl	[]	Number of cylinders in high-pressure pump
Const_V_Pump	[m^3]	Pump volume (1 cylinder)
Map_eta_FuelMeterUnit	[0_1]	Fuel metering unit efficiency map = f(Ctrl_FuelMeterUnit)
Map_eta_HighPresPump	[0_1]	High-pressure pump efficiency map = f(omega_pump, p_Rail)
Map_V_dead	[mm^3]	Dead volume of a pump cylinder, Map[mm3]=f(T_Fuel,p_Rail)
Sw_Ctrl_Fuel_MeteringUnit	[1|2]	Switch for fuel metering unit: ▪ 1: On ▪ 2: Off

Related topics

References

High Pressure Pump Gasoline (ModelDesk Parameterizing 🕮)
High-Pressure Pump.....78

High-Pressure Pump (Crank-Based)

Description

The calculation of the crank-based high-pressure pump is based on the crank angle signal. The working principle is as follows.

A number of different cams drive a single cylinder. A fuel metering unit (FMU), which is open on default, controls the delivered fuel quantity. If the FMU is not energized (open), the fuel is pumped from the low-pressure side of the pump into the pump cylinder and back. Therefore, no fuel is delivered to the high-pressure side. Once the FMU is actuated, the valve on the low-pressure side is closed. Thus, the pressure in the pump cylinder rises and opens the valve to the high-pressure side. The delivery of fuel to the common rail begins.

The following illustration shows the pump:

The **HPP_CRANKBASED** block calculates the volume flow through the high-pressure pump as a function of the crank angle.

The block contains two modeling approaches:

- A mean value modeling approach
- A pulsed modeling approach

The control signal of the pump is the beginning of energizing the FMU. The control signal is converted to the fuel delivery time in crank angle degrees (delivery length). The volume flowing through the pump is calculated based on the delivery length.

The following illustration shows the working principle of the model:

Delivery length

To calculate the delivery length, the position of the approaching cam is determined:

$\varphi_{NextTDC}$

The distance between this position and the angle of FMU energizing is the delivery length.

$$\varphi^*_{Delivery} = \varphi_{NextTDC} - \varphi_{Energized}$$

It is possible that the energizing the FMU and the approaching cam lie on different sides of the reference line. Because of this, it might be necessary to modulate the duration of the pump cycle.

See the following illustration:

$$\varphi_{Delivery} = mod\left(\varphi^*_{Delivery}, \varphi_{PumpCycle}\right)$$

Validation of delivery length

The delivery length is set to zero if it is greater than the length of the pump stroke.

$$\varphi_{delivered} = \begin{cases} \varphi_{delivered}, & \varphi \leq 0.5 \cdot \frac{720}{Number_{cam}} \\ 0, & \varphi > 0.5 \cdot \frac{720}{Number_{cam}} \end{cases}$$

Cut event handling

The pump model contains an algorithm to handle cut events. For example, when the end of the capture window of the I/O is located in the delivery phase of the pump. In such a case, the control signal becomes invalid. The model than holds the valid control signal until the end of the pump cycle.

Mean value approach

This approach uses the following equation to calculate the volume flow through the high pressure pump:

$$q_{Pump} = V_{Effective} \cdot Number_{Cam} \cdot i_{Engine} \cdot n_{Engine}$$

The effective volume is the volume of the pump cylinder if the FMU valve is closed. The compressibility of the fuel reduces the fuel flow.

$$V_{Effective} = V_{Closed} - V_{FuelCompressibility}$$

The compressibility volume is calculated as follows:

$$V_{FuelCompressibility} = \frac{V_{Closed} \cdot (p_{Rail} - p_{Low})}{BulkModulus_{Fuel}}$$

Pulsed approach

The volume flow is calculated as the difference of volumes at the current iteration step to the preceding one. The compressibility of the fuel reduces the fuel flow.

$$qdot = \frac{\left(V_{i-1} - V_{FuelCompressibility,i-1}\right) - \left(V_i - V_{FuelCompressibility,i}\right)}{StepSize}$$

The calculation of the pump volume is performed on the basis of a look-up table. The volume at the current iteration step is:

$$V_i = Map_{V_Cam}\left(\varphi_{CamShaft}\right)$$

The compressibility volume is calculated as follows:

$$V_{FuelCompressibility,i} = \frac{V_i \cdot (p_{Rail} - p_{Low})}{BulkModulus_{Fuel}}$$

The high pressure pump is driven by the camshaft, which in turn is driven by the crankshaft.

$$\varphi_{CamShaft} = mod\left(\varphi_{CrankAngle} - \varphi_{OffSet_{Init}}, \varphi_{PumpCycle}\right)$$

$\varphi_{PumpCycle}$ is the duration of a pump cycle.

$$\varphi_{PumpCycle} = \frac{720}{number_{cams}}$$

Step size correction

The higher the engine speed, the lower the number of data points captured during a pump cycle. The pulsed approach calculates the fuel flow on the basis of the difference of the capture points. Thus, the accuracy of the pulsed approach depends strongly on the engine speed. The accuracy of the mean-value approach has a lower dependency of the engine speed, because the entire pump cycle is used as reference. To improve the accuracy of the pulsed model, the volume flows of both approaches are compared. If the volume flow of the pulsed approach differs from the volume flow of the mean-value approach, the difference is delivered in the end of a pump cycle.

Inport

The following table shows the inports:

Name	Unit	Description
Const_BulkModulus_Fuel	[bar]	Bulk modulus of fuel
CrankAngle_Cyl	[deg]	Angular position of crankshaft
n_Engine	[rpm]	Engine speed
p_Rail	[bar]	Rail temperature
phi_CamShaft_Offset_Exhaust	[deg]	Exhaust camshaft offset due to valve train variability
phi_CamShaft_Offset_Intake	[deg]	Intake camshaft offset due to valve train variability
phi_FMU_energized	[deg]	Start of FMU control
Reset	[]	Reset integrators to their initial states

Name	Unit	Description
T_Rail	[°C]	Rail temperature
U_Battery	[V]	Battery voltage

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_HighPresPump	[mm^3/s]	Fuel flow through high-pressure pump (into rail)

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_i_HighPresPump	[]	Transmission ratio n_HighPresPump = i_HighPresPump x n_Engine
Const_max_num_HPPCam	[]	Maximum number of high-pressure cams with current compiled code The value is in the range 1...8.
Const_n_Engine_LowLim	[rpm]	Engine speed below which high pressure pump is deactivated
Const_num_Cam	[]	Number of cams of high-pressure pump
Const_p_Low	[bar]	Pressure below which the influence of fuel compressibility is ignored
Const_phi_Camshaft_InitOffs	[deg]	Initial offset of cam TDC to engine TDC1 The value is in the range (-720 to 720)/NumberCam before engine TDC1.
Const_V_Pump	[m^3]	Pump cylinder volume (1 cylinder)
Map_eta_CamAngle	[0_1]	Influence of FMU actuation on volumetric efficiency of pump, Map_eta_CamAngle[0_1]=f(deg)
Map_qdot_Leak	[mm^3/s]	Leakage of high-pressure pump, Map_qdot_Leak[mm3|s] = f(p_Rail, T_Rail)
Map_V_Cam	[m^3]	Volume of pump cylinder caused by movement of cam, f(deg)
Map_ValveDelay	[s]	Mechanical retard of fuel metering unit, Map_ValveDelay[s] = f(n_Engine, U_Bat)
Sw_CamShaft	[0|1]	Specifies which Cam Shaft drives the high pressure pump ▪ 0: Intake ▪ 1: Exhaust
Sw_HPP_mode	[1|2]	Switch for mode of crank-based high-pressure pump: ▪ 1: MeanValue ▪ 2: Pulsed
Sw_LeakageCalculation	[0|1]	Switch for leakage calculation: ▪ 0: Off

Name	Unit	Description
Vector_Cam_Offset	[deg]	▪ 1: On Vector indicating cam-TDC position relative to engine TDC1

Related topics

Basics

History of the HPP_CRANKBASED Block..... 253

References

HPP Crankbased Gasoline (ModelDesk Parameterizing 🕮)

Port Injector

Description

The fuel system calculates the fuel mass flow by the measured injection time. The flow is calculated by a linear gain offset relation. The measured injection time is reduced by the offset time because a real injection system needs a short time to open the fuel injector.

The block can also calculate a lesser fuel quantity if the pressure difference between injector fuel supply and the intake manifold is too low.

The following illustration gives an impression of the relationship between the injection time, the offset time, and the fuel mass:

The fuel mass flow is calculated from the following equation.

$$\dot{m}_{Fuel} = in_{Engine} m_{Fuel}$$

Inports

The following table shows the inports:

Name	Unit	Description
n_Engine	[rpm]	Engine speed
p_Fuel	[Pa]	Fuel pressure
p_InMan	[Pa]	Intake manifold pressure
t_Inj	[s]	Injection time
Vbat	[V]	Battery voltage

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 🕮).
mdot_Inj	[kg/h]	Injected fuel mass flow

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_mdot_fuel_Gain	[kg/s]	Gain of the fuel injection system
Map_mdot_fuel_Offset	[s]	Offset time of the fuel injection system. Map_mdot_fuel_Offset = f(Battery voltage [V])
Map_mdot_Fuel_Gain_Red	[0_1]	Influence of injector difference pressure on fuel massflow

Related topics

References

History of the PORTINJECTOR Block..... 259
Manifold Injector Gasoline (ModelDesk Parameterizing 🕮)
Manifold Injector Gasoline V4 (ModelDesk Parameterizing 🕮)

Port Injector Fuel Supply CNG Model

Port injector fuel supply models

In gasoline engines, a compressed natural gas system can be used to supply the port injector with fuel. For this purpose, two models are prepared. They can be implemented in the ASM Gasoline Engine model without the need to change the rest of the model.

- PortInjectorFuelSupply: This is a default model for fuel supply. The fuel pressure is set to a fixed value and does not change.
- PortInjectorFuelSupply_CNGSystem: This model contains a compressed natural gas system, which uses the CNG blocks to regulate the fuel pressure for the port injector.

For an overview of the subsystems, refer to the following illustration.

For information on how to replace the model, refer to How to Replace the Port Injector Fuel Supply Model (ASM Gasoline Engine Model Description 🕮).

PortInjectorFuelSupply_CNGSystem

The PortInjectorFuelSupply_CNGSystem is a demo model for CNG fuel supply. A CNG tank is sealed by a CNG shutoff valve. If the CNG shutoff valve is opened, it allows the gas to flow through the CNG high-pressure line. After the CNG high-pressure line, the CNG pressure regulator reduces the gas pressure to a set value. The gas flows through the CNG pressure regulator into the CNG rail.

When the engine is started, the valve opens. The fuel pressure in the CNG rail is used to supply the port injectors with fuel.

For a schematic of the PortInjectorFuelSupply_CNGSystem in ModelDesk, refer to the following illustration:

Inports The following table shows the inports:

Name	Unit	Description
mdot_Injector	[kg/h]	Mass flow of port injectors
p_Ambient	[Pa]	Ambient pressure
Reset	[0|1]	Reset of states
Sw_Supply	[0|1]	Switch for power supply: ▪ 0: Off ▪ 1: On
T_Ambient	[°C]	Ambient temperature

Outports The following table shows the outports:

Name	Unit	Description
p_Fuel	[Pa]	Gas pressure

Related topics

References

CNG High-Pressure Line....65
CNG Pressure Regulator....66
CNG Rail....68
CNG Shutoff Valve....70
CNG Tank....72

Pressure Control Valve

Description

The pressure control valve is used to control the rail pressure. Fuel may flow back from the rail to the fuel reservoir through the pressure control valve. The pressure control valve is also used for fast pressure drops in the rail.

The flow through the pressure control valve is modeled as a map according to control signal and rail pressure.

Inports

The following table shows the inports:

Name	Unit	Description
Ctrl_PresCtrlValve	[mA]	Pressure control valve control signal
p_Rail	[bar]	Rail pressure (absolute)

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_PresCtrlValve	[mm³/s]	Fuel flow through pressure control valve (out of rail)

Parameters

The following table shows the parameters:

Name	Unit	Description
Map_q_PresCtrlValve	[mm³/s]	Map of pressure control valve flow
Sw_Ctrl_Fuel_PresCtrlValve	[]	Switch for the pressure control valve: ▪ 1: On ▪ 2: Off

Related topics

References

History of the PRESSURE_CONTROL_VALVE Block..... 260
Pressure Control Valve Gasoline (ModelDesk Parameterizing 🕮)

Rail

Description

Fuel for injections is stored at high pressures in the common rail. The fuel is supplied by the high-pressure pump. Injectors take the injected fuel from the rail. Additionally rail leakage is taken into account.

The rail is modeled as a chamber with a constant volume according to the following equation:

$$p_{Rail} = \frac{E_{Fuel}}{V_{Rail}} \int q(t)dt = \frac{1}{C_H} \int \sum q_i(t)dt$$

The RAIL block calculates the pressure in the rail as a function of the fuel mass flows out of and into the rail.

You can set the rail temperature yourself. It is not used in the model.

Inports

The following table shows the inports:

Name	Unit	Description
Map_q_RailLeak	[mm^3/s]	Leakage fuel flow
q_HighPresPump	[mm^3/s]	Fuel flow through high pressure pump (into rail)
q_Inj	[mm^3/s]	Fuel flow through injectors (all cylinders, out of rail)
q_PresCtrlValve	[mm^3/s]	Fuel flow through pressure control valve (out of rail)
Reset	[]	Reset all integrators to their initial conditions

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_Rail	[bar]	Rail pressure (absolute)
T_Rail	[°C]	Rail temperature

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_p_Rail_Init	[bar]	Initial rail pressure
Const_T_Rail	[°C]	Rail temperature
Const_V_Rail	[m^3]	Rail volume
Map_q_RailLeak	[mm^3/s]	Rail leakage map = f(p_Rail, T_Rail)
p_Rail_LowLim	[bar]	Minimum rail pressure
p_Rail_UpLim	[bar]	Maximum rail pressure

Related topics

References

Common Rail Gasoline (ModelDesk Parameterizing 🕮)
History of the RAIL Block 261

Piston Engine

Where to go from here

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This block contains switches to specify the correct model setup.

Camshaft Phaser Exhaust

Description

The CAM_PHASER_EXHAUST block calculates the exhaust camshaft angle.

The cam phaser adjusts the camshaft offset according to the received control signal. Depending on engine speed and coolant temperature a maximum camphase change rate is found in look-up tables. Different change rates for increasing and decreasing camphase are implemented. The minimum and maximum angle is applied to the calculation of the camshaft angle as a saturation value to the integrator. Thus, the mechanical limits of the variable valve train actuator are considered. The phi_CamPhaser[deg] signal can be used to shift the phase of the RTI cam generation block to manipulate the encoder signal accordingly.

Inports

The following table shows the inports:

Name	Unit	Description
CrankAngle_EO	[deg]	Crank angle when the exhaust valve opens
Ctrl_CamPhaser	[0_1]	Control signal for the cam phaser
n_Engine	[rpm]	Engine speed
Reset	[]	Reset of states
T_Coolant	[°C]	Coolant temperature

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 🕮).
phi_CamPhaser	[deg]	Angle of valve phasing in degree crank angle

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_phi_CamPhaser	[deg]	Constant shift angle of the camshaft
Const_phi_CamPhaser_Init	[deg]	Initial angle of CamPhaser
Const_phi_CamPhaser_LowLim	[deg]	Lower limit of CamPhaser
Const_phi_CamPhaser_UpLim	[deg]	Upper limit of CamPhaser
Map_Ctrl_CamPhaser_influence	[-]	Influence of control signal on CamPhaser shift speed = f(Ctrl_CamPhaser)
Map_Omega_Decrease_CamPhaser_Max	[deg/s]	Maximum off shifting speed = f(n_Engine,T_Coolant)
Map_Omega_Increase_CamPhaser_Max	[deg/s]	Maximum on shifting speed = f(n_Engine,T_Coolant)
Sw_phi_CamPhaser	[0|1]	Selector for CamPhaser angle ▪ 0: Calculated ▪ 1: Constant

Related topics

References

Cam Phaser Exhaust (ModelDesk Parameterizing 🕮)

Camshaft Phaser Intake

Description

The CAM_PHASER_INTAKE block calculates the intake camshaft angle.

The cam phaser adjusts the camshaft offset according to the received control signal. Depending on engine speed and coolant temperature, a maximum camphase change rate is found in look-up tables. Different change rates for increasing and decreasing camphase are implemented. The minimum and maximum angle is applied to the calculation of the camshaft angle as a saturation value to the integrator. Thus, the mechanical limits of the variable valve train actuator are considered. The phi_CamPhaser[deg] signal can be used to shift the phase of the RTI cam generation block to manipulate the encoder signal accordingly.

Inports

The following table shows the inports:

Name	Unit	Description
CrankAngle_EO	[deg]	Crank angle when the exhaust valve opens
Ctrl_CamPhaser	[0_1]	Control signal for the cam phaser
n_Engine	[rpm]	Engine speed
Reset	[]	Reset of states
T_Coolant	[°C]	Coolant temperature

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 🕮).
phi_CamPhaser	[deg]	Angle of valve phasing in degree crank angle

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_phi_CamPhaser	[deg]	Constant shift angle of the camshaft
Const_phi_CamPhaser_Init	[deg]	Initial angle of cam phaser
Const_phi_CamPhaser_LowLim	[deg]	Lower limit of cam phaser
Const_phi_CamPhaser_UpLim	[deg]	Upper limit of cam phaser
Map_Ctrl_CamPhaser_influence	[]	Influence of control signal on cam phaser shift speed = f(Ctrl_CamPhaser)
Map_Omega_Decrease_CamPhaser_Max	[deg/s]	Maximum off shifting speed = f(n_Engine,T_Coolant)
Map_Omega_Increase_CamPhaser_Max	[deg/s]	Maximum on shifting speed = f(n_Engine,T_Coolant)
Sw_phi_CamPhaser	[0|1]	Selector for cam phaser angle: ▪ 0: Calculated ▪ 1: Constant

Related topics

References

Cam Phaser Intake (ModelDesk Parameterizing 🕮)

Combustion Mode Switch

Description

The COMBUSTION_MODE_SWITCH block merges the results of the combustion blocks. The combustion blocks are evaluating the variables, which are describing the mean value combustion process of the engine in case of a homogeneous or stratified driven engine.

The results of both engine modes are merged, in order to simulate a smooth transition between both combustion modes. The switch block is not intended to simulate a mixed combustion mode.

Inports

The following table shows the inports:

Name	Unit	Description
T_Out_CI	[°C]	Engine output temperature (stratified mode)
T_Out_SI	[°C]	Engine output temperature (homogeneous mode)
Trq_MeanFric_Engine	[Nm]	Mean friction torque
Trq_MeanInd_CI	[Nm]	Mean indicated engine torque (stratified mode)
Trq_MeanInd_Mod_CI	[Nm]	Modulated mean induced engine torque (stratified mode)
Trq_MeanInd_Mod_SI	[Nm]	Modulated mean induced engine torque (homogeneous mode)
Trq_MeanInd_SI	[Nm]	Mean indicated engine torque (homogeneous mode)
Trq_Pump_Engine	[Nm]	Mean pump torque

Outports

The following table shows the outports:

Name	Unit	Description
T_Out_Engine	[°C]	Engine output temperature
Trq_MeanEff_Mod_Engine	[Nm]	Modulated mean effective engine torque
Trq_MeanInd_Engine	[Nm]	Mean indicated engine torque

Related topics

References

Combustion Mode Switch V4 (ModelDesk Parameterizing 🕮)
History of the COMBUSTION_MODE_SWITCH Block..... 239

Combustion Temperature CI

Description

The COMBUSTION_TEMPERATURE_CI block calculates the combustion temperature of the engine.

The combustion temperature is calculated by a table depending on the engine speed and the mean indicated pressure.

Inports

The following table shows the inports:

Name	Unit	Description
n_Engine	[rpm]	Engine speed.
p_MeanInd_eff	[bar]	Mean indicated pressure.
Reset	[]	Reset of states.

Outports

The following table shows the outports:

Name	Unit	Description
T_Out_Engine	[°C]	Engine output temperature.

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_PT1	[s]	PT1 constant for dynamic engine temperature behavior
Map_T_EngOut	[°C]	Engine output temperature [°C] = f(n_Engine, p_MeanInd_Eng)

Related topics

References

Combustion Temperature CI (ModelDesk Parameterizing 🕮)
History of the COMBUSTION_TEMPERATURE_CI Block..... 240

Combustion Temperature SI

Description

The COMBUSTION_TEMPERATURE_SI block calculates the combustion temperature of the engine.

The combustion temperature is calculated by a table subject to the engine speed and the mean indicated pressure.

Inports

The following table shows the inports:

Name	Unit	Description
n_Engine	[rpm]	Engine speed.
p_MeanInd_eff	[bar]	Mean indicated pressure.
Reset	[]	Reset of states.

Outports

The following table shows the outports:

Name	Unit	Description
T_Out_Engine	[°C]	Engine output temperature.

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_PT1	[s]	PT1 constant for dynamic engine temperature behavior.
Map_T_EngOut	[°C]	Engine output temperature. [°C] = f(n_Engine, p_MeanInd_Eng)

Related topics

References

Combustion Temperature SI (ModelDesk Parameterizing 🕮)
History of the COMBUSTION_TEMPERATURE_SI Block..... 240

Stratified Combustion Torque

Description

The stratified combustion torque model calculates the mean indicated torque of the engine.

The optimum indicated combustion torque is calculated by a table according to the engine speed and the mean injection quantity. If two efficiency tables are used, the optimum indicated combustion torque can be reduced if the engine controller sets a different injection angle or a different lambda to their optimum values. The model calculates the actual mean indicated torque by multiplying these efficiencies by the optimum mean indicated torque. Outside the combustion torque model, the mean friction torque is subtracted from the mean indicated torque. The result is the mean effective torque, which is the engine output to the crankshaft.

The next illustration shows you the definition of the mean indicated pressure. As you can see, the mean indicated pressure contains the high-pressure cycle in which compression, combustion, and expansion take place. It also contains the gas exchange cycle, in which the unburned air/fuel mass flow flows into the cylinder and the burned gas mixture is ejected from the cylinder.

The high-pressure cycle produces positive work, the gas exchange cycle requires work. The mean indicated torque is the average of these two parts and characterizes the working cycle at each working point.

To simulate crank angle based torque modulation, the mean indicated torque is modulated with respect to the cylinder-specific crank angle. A function is therefore multiplied by the mean indicated torque, whose integral over a complete engine cycle of 720° equals one. The effect is that the mean indicated torque over one engine cycle is equal to the unmodulated mean value model.

The model is also capable to evaluate the gas exchange and compression torque based on the crank angle separately with the PUMP_TORQUE block.

Inports

The following table shows the inports:

Name	Unit	Description
CrankAngle_Cyl	[deg]	Crank angle per cylinder, positive value is after TDC
mdot_Air_In_Cyl	[kg/h]	Mass flow of fresh air into the engine
mdot_Fuel_In_Cyl	[kg/h]	Injection mass flow into cylinder (vector of number of cylinders)
n_Engine	[rpm]	Engine speed
phi_Main_Inj	[bTDC]	Injection start angle of main injection (injection pulse with maximum t_Inj for this cylinder)
q_Inj_Cyl	[mm^3/cyc]	Injection quantity per cylinder (vector of number of cylinders)

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_MeanInd_eff_Cyl	[bar]	Mean indicated pressure per cylinder
Trq_MeanInd_CI	[Nm]	Mean indicated engine torque
Trq_MeanInd_Mod_CI	[Nm]	Modulated mean induced engine torque

Parameters

The following table shows the parameters:

Name	Unit	Description
Map_eta_lambda	[]	Lambda efficiency table
Map_eta_phi	[]	Injection angle efficiency = f(phi_Inj - phi_inj_opt)
Map_p_MeanInd	[]	Mean indicated pressure map, p_IndMean = f(n_engine,q_Inj_Engine)
Map_phi_opt	[bTDC]	Optimum injection angle map = f(n_engine, q_Inj_Engine)
Map_Trq_Comb_Mod	[]	Map for modulated combustion torque = f(CrankAngle)
Sw_Trq_Comb_Mode	[1|2]	Switch for combusition mode: ▪ 1: Modulated ▪ 2: Mean value

Processing information

The following illustration shows the form function which modulates the combustion torque with respect to the cylinder-specific crank angle. The function is multiplied by the mean indicated torque.

The model is also capable to evaluate the gas exchange and compression torque based on the crank angle separately with the PUMP_TORQUE block. If this option is used, the mean indicated pressure map for the combustion torque block must be adapted to exclude the gas exchange torque. Run the corresponding combustion parameterization function again to respect the new setting.

For further information on the PUMP_TORQUE block, refer to Pump Torque on page 111.

Related topics

References

Combustion Torque CI V7 (ModelDesk Parameterizing 🕮)
History of the COMBUSTION_TORQUE_x Block..... 240
Pump Torque..... 111

Homogeneous Combustion Torque

Description

The combustion torque model calculates the mean indicated torque of the engine.

The optimum indicated combustion torque is calculated by a table based on the engine speed and the relative air mass flow. If two efficiency tables are used the optimum indicated combustion torque can be reduced if the engine controller sets a different ignition angle or a different lambda to the ones from the parameterization measurement. The model calculates the actual mean indicated torque by multiplying these efficiencies by the optimum mean indicated torque. Outside the combustion torque model, the mean friction torque is subtracted from the mean indicated torque. The result is the mean effective torque, which is the engine output to the crankshaft.

The next illustration shows you the definition of the mean indicated pressure. The mean indicated pressure contains the high-pressure cycle in which compression, combustion, and expansion take place. It also contains the gas exchange cycle, in which the unburned air/fuel mass flow flows into the cylinder and the burned gas mixture is ejected from the cylinder.

The high-pressure cycle produces positive work, the gas exchange cycle requires work. The mean indicated torque is the average of these two parts and characterizes the working cycle at each working point.

The mean effective pressure is calculated by the following equation:

$$p_{me} = p_{mi}\left(n_{Engine}, p_{Manifold}\right) \cdot \eta_{\lambda}(\lambda) \cdot \eta_{ign}\left(t_{ign}\right) - p_{mr}\left(n_{Engine}, T_{Engine}\right)$$

The mean indicated pressure is multiplied by the two efficiencies mentioned above. The mean friction pressure is subtracted, leading to the mean effective pressure. This is used to calculated the mean effective torque with

$$T_{eff} = \frac{p_{me} \cdot i \cdot V_D}{2\pi}$$

To simulate crank angle based torque modulation, the mean indicated torque is modulated with respect to the cylinder-specific crank angle. A function is multiplied by the mean indicated torque, whose integral over a complete engine cycle of 720 ° equals one. The effect is that the mean indicated torque over one engine cycle is equal to the unmodulated mean value model.

Inports

The following table shows the inports:

Name	Unit	Description
CrankAngle_Cyl	[deg]	Crank angle per cylinder
mdot_Air_In_Cyl	[kg/h]	Engine intake air mass
mdot_Fuel_Homogen_Cyl	[kg/h]	Fuel Mass flow
mdot_Fuel_In_Cyl	[kg/h]	Mass flow of vaporized fuel into the engine
n_Engine	[rpm]	Engine speed
phi_Ign_Cyl	[bTDC]	Ignition angle per cylinder
relAirmass_Cyl	[]	Relative air mass

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_MeanInd_eff_Cyl	[bar]	Mean indicated pressure per cylinder
Trq_MeanInd_Mod_SI	[Nm]	Mean indicated torque per cylinder
Trq_MeanInd_SI	[Nm]	Mean indicated torque

Parameters

The following table shows the parameters:

Name	Unit	Description
Map_eta_lambda	[]	Table with lambda efficiency = f(1/lambda)
Map_eta_phi	[]	Table with ignition angle efficiency = f(optimum ignition angle – ignition angle)
Map_p_MeanInd	[Pa]	Table for mean indicated pressure = f(Engine speed, relAirmass)
Map_phi_opt	[rad]	Table with optimum ignition angle = f(Engine speed, lambda_a)
Map_Trq_Comb_Mod	[]	Table for modulation of mean indicated torque
Sw_Trq_Comb_Mode	[1|2]	Switch for combustion mode: ▪ 1: Modulated ▪ 2: Mean value

Processing information

The model is also capable to evaluate the gas exchange and compression torque based on the crank angle separately with the PUMP_TORQUE block. If this option will be utilized , the mean indicated pressure map for the combustion torque block needs to be adapted, in order to exclude the gas exchange torque. Please run the corresponding combustion parameterization function again to respect the new setting.

For further information on the PUMP_TORQUE block, refer to Pump Torque on page 111.

Related topics

References

Combustion Torque SI (ModelDesk Parameterizing 🕮)
Combustion Torque SI V9 (ModelDesk Parameterizing 🕮)
History of the COMBUSTION_TORQUE_x Block..... 240
Pump Torque..... 111

Cylinder Inlet

Description

The cylinder inlet represents the inlet and outlet behavior of the piston engine.

The CYLINDER_INLET block calculates the relative air mass and air/exhaust mass flow into the engine.

The relative air mass is the output of the volumetric efficiency map. The mass flow into the engine (air + exhaust) is the theoretical maximum airflow multiplied by the relative air mass.

The exhaust flow ratio is used to calculate the exhaust mass flow and fresh air mass flow.

The following equation shows the definition of the volumetric efficiency:

$$\lambda_A = \frac{m_{Engine}}{m_{theor}} = \frac{m_{Engine}}{\rho_{InMan} \cdot V_{Engine}}$$

With

$$\dot{m}_{engine} = i \cdot n \cdot m_{engine}$$

and the ideal gas law

$$p = \rho RT$$

the equation can be written as

$$\lambda_A(p_{man}, n) = \frac{\dot{m}_{engine}}{\frac{p_{man}}{RT_{man}} \cdot V_d \cdot i \cdot n}$$

Inports

The following table shows the inports:

Name	Unit	Description
n_Engine	[rpm]	Engine speed
p_InMan	[Pa]	Intake manifold pressure
R_InMan	[J/(kg K)]	Gas constant of mixture in intake manifold
T_InMan	[°C]	Intake manifold temperature
Xsi_Exh_InMan	[0_1]	Mass fraction of exhaust in the intake manifold
Xsi_Fuel_InMan	[0_1]	Mass fraction of fuel in the intake manifold

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 🕮).
mdot_Air_In_Engine	[kg/h]	Mass flow of fresh air into the engine
mdot_Exh_In_Engine	[kg/h]	Mass flow of exhaust into the engine
mdot_Fuel_In_Engine	[kg/h]	Mass flow of vaporized fuel into the engine
RelAirmass	[]	Relative cylinder air mass

Parameters

The following table shows the parameters:

Name	Unit	Description
Map_VolEff	[]	Volumetric efficiency = f(n_Engine, p_InMan)

Processing information

During the parameterization, the volumetric efficiency is calculated as a map based on the engine speed and the manifold pressure. The mass flow into the piston engine is calculated from the measured fresh air mass flow and a calculated exhaust mass flow from the EGR valve.

$$\dot{m}_{Engine} = \dot{m}_{Engine,In,Air} + \dot{m}_{Engine,In,EGR}$$

Related topics

References

Cylinder Inlet Gasoline (ModelDesk Parameterizing 🕮)
Cylinder inlet V6 (ModelDesk Parameterizing 🕮)
History of the CYLINDER_INLET Block..... 244

Crankcase

Description

The CRANKCASE block contains maps as functions of the engine speed for the simulation of oil pressure and crankcase pressure. The engine oil temperature is also available as a function of the coolant temperature.

Inports

The following table shows the inports:

Name	Unit	Description
n_Engine	[rpm]	Engine speed
T_Water	[°C]	Engine water temperature

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_T_Oil_Gain	[]	Gain to convert water to oil temperature
Map_p_Crankcase	[Pa]	Crankcase relative pressure map = f(n_engine)
Map_p_Oil	[Pa]	Oil pressure map = f(n_engine)

Related topics

References

Crankcase Gasoline (ModelDesk Parameterizing 🕮)
History of the CRANKCASE Block 245

Friction Torque

Description

The friction torque comes from a table according to the engine speed and the engine temperature.

The friction torque reduces the mean indicated torque and leads to the mean engine torque, which accelerates the crankshaft.

Inports

The following table shows the inports:

Name	Unit	Description
n_Engine	[rpm]	Engine speed
T_Water	[°C]	Engine water temperature

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_MeanFric_Engine	[Nm]	Mean friction torque

Parameters

The following table shows the parameters:

Name	Unit	Description
Map_Trq_Friction	[Nm]	Friction torque map = f(n_engine, T_Water)

Processing information

The friction torque is calculated from a wide open throttle (WOT) measurement during parameterization. The engine is driven without combustion by an external machine for this measurement. The required torque for every engine speed is measured and it is assumed that this matches the friction torque.

Related topics

References

Friction Torque Gasoline (ModelDesk Parameterizing 🕮)
Friction Torque Gasoline V3 (ModelDesk Parameterizing 🕮)
History of the FRICTION_TORQUE Block..... 252

Mass Fraction

Description

The MASS_FRACTION block calculates the overall mass flow, lambda, and gas concentration of the engine.

The overall mass flow is calculated by the sum of all individual mass flows. The gas concentration of air, fuel, and exhaust describe the mass fractions after combustion.

Inports

The following table shows the inports:

Name	Unit	Description
mdot_Air_In_Engine	[kg/h]	Mass flow of the air entering the engine.
mdot_Exh_In_Engine	[kg/h]	Mass flow of the exhaust gas entering the engine.

Name	Unit	Description
mdot_Fuel_In_Engine	[kg/h]	Mass flow of the fuel entering the engine.

Outports

The following table shows the outports:

Name	Unit	Description
lambda_Out_Engine	[]	Lambda after combustion.
mdot_Out_Engine	[kg/h]	Mass flow exiting the engine.
Xsi_Air_Out_Engine	[0_1]	Air mass fraction exiting the engine.
Xsi_Exh_Out_Engine	[0_1]	Exhaust gas mass fraction exiting the engine.
Xsi_Fuel_Out_Engine	[0_1]	Fuel mass fraction exiting the engine.

Related topics

References

History of the MASS_FRACTION Block..... 258

Pump Torque

Description

The PUMP_TORQUE block evaluates the gas exchange and compression torque for each cylinder of the engine. The mean value contains the sum of all cylinders, which can be processed with the current combustion and friction torque.

In the following the gas exchange torque and compression/expansion torque of the cylinder will be called pump torque.

The mean value of the gas exchange work can be calculated by using

$$T_{GasExchange} = (p_{Exhaust} - p_{Intake})\frac{V_{Display}}{4\pi}$$

To calculate the gas exchange force as well as the force during the compression/expansion stroke based on the cylinder angle the model detects the actual stroke (index *i*) for each cylinder and evaluates the corresponding pump piston force

$$F_{Pump,i} = \Delta p_{Cylinder,i} A_{piston}$$

based on the following table:

$\Delta p_{Cylinder,exp} = p_{Cylinder} - p_{Crankcase}$	Expansion stroke	$0° \leq \varphi < 180°$
$\Delta p_{Cylinder,exh} = p_{Exhaust} - p_{Crankcase}$	Exhaust stroke	$180° \leq \varphi < 360°$
$\Delta p_{Cylinder,int} = p_{Intake} - p_{Crankcase}$	Intake stroke	$360° \leq \varphi < 540°$
$\Delta p_{Cylinder,comp} = p_{Cylinder} - p_{Crankcase}$	Compression stroke	$540° \leq \varphi < 720°$

Assuming an adiabatic process in derivation of the equation

$$p_1 V_1^{\kappa} = const$$

is as the following

$$p_1 V_1^{\kappa} = p_2 V_2^{\kappa}$$

Thus, for expansion/compression, it applies:

$$p_{BDC} \cdot V_1^{\kappa} = p(\varphi) \cdot V(\varphi)^{\kappa}$$

According to the equation the cylinder pressure during the compression/compression, the stroke can be calculated as the following:

$$p(\varphi) = p_{BDC}\left(\frac{V_{BDC}}{V(\varphi)}\right)^{\kappa} = p_{InMan}\left(\frac{V_{disp} + V_{cyl}(\varphi = 0)}{V_{cyl}(\varphi)}\right)^{\kappa}$$

With a power balance on the piston by means of the second Lagrange method for a motored engine

$$\underbrace{F_{Pump}\frac{\dot{s}}{\dot{\varphi}}}_{T_{Pump}} - T_{Load} - T_{Friction} = T_{Mass}$$

where:

T_{Pump}	is the pump torque
T_{Load}	is the load torque
$T_{Friction}$	is the friction torque
T_{Mass}	is the mass torque

Hence, the pumping torque can be evaluated with

$$T_{Pump,i} = F_{Pump,i}\frac{\dot{s}}{\dot{\varphi}}$$

where:

s is the piston stroke

φ is the crank angle

By analyzing the kinematics of the piston the piston stroke yields

$$s(\varphi) = r(1 - \cos(\varphi)) + l - \sqrt{l^2 - r^2\sin(\varphi)^2}$$

and the ratio of piston and crank velocity can be expressed as

$$\frac{\dot{s}}{\dot{\varphi}} = \frac{r^2\sin(2\varphi)}{2\sqrt{l^2 - r^2\sin(\varphi)^2}} + \sin\varphi$$

where:

r is the crank radius

l is the conrod length

Inports

The following table shows the inports:

Name	Unit	Description
CrankAngle_Cyl	[deg]	Vector with crank angle for each cylinder
p_Ambient	[Pa]	Ambient pressure
p_Crankcase_Rel	[Pa]	Crankcase relative pressure
p_ExhMan	[Pa]	Exhaust manifold pressure
p_InMan	[Pa]	Intake manifold pressure
Reset	[]	Reset of states
SW_Trq_PumpCompression_Mode	[1|2]	Switch to enable or disable compression torque modulation ▪ 1: On ▪ 2: Off
SW_Trq_PumpGasExchange_Mode	[1|2]	Switch to enable or disable gas exchange torque modulation ▪ 1: On ▪ 2: Off

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_Mean_Pump	[Nm]	Mean engine pump torque
Trq_Pump	[Nm]	Time-dependent pump torque

Parameters

The following table shows the parameters:

Name	Unit	Description
Map_ds_dphi	[m/rad]	d_s_Piston/d_Crankangle = f(Crank angle)
Map_s_piston	[m]	Piston stroke, s_piston = f(Crank angle)

Processing information

The variables can be depicted for fixed intake and exhaust pressure as shown in the following figure.

Note

If the gas exchange torque mode is used, the mean indicated pressure map for the combustion torque block must be adapted to exclude the gas exchange torque. Run the corresponding combustion parameterization function again to respect the new setting.

Related topics

References

History of the PUMP_TORQUE Block 260
Pump Torque Gasoline (ModelDesk Parameterizing 🕮)

Wall Film

Description

The WALL_FILM model describes the fuel transport from the injection valve to the cylinder by means of a mean value approach.

Some of the injected fuel feeds the cylinder directly, while the rest contributes to the formation of a wall film on the intake manifold wall. Liquid from the wall film evaporates through time, thus participating in the air fuel mixture process and entering the cylinder.

The wall film model consists of two parameters, one that divides the injected fuel mass into the directly injected fuel to the cylinder and the rest, which flows to the wall film. The other parameter describes the time when the fuel evaporates from the wall film back to the air fuel mixture.

The air fuel mixture $m_{Fuel/total}$ which flows into the engine can be written with the following equation:

$$\dot{m}_{Fuel,\,total} = (1 - \mathrm{X}) \cdot \dot{m}_{Fuel,\,in} + \frac{1}{\tau} m_{Wall}$$

The next four equations show the different mass flows and their definition.

$$\dot{m}_{Fuel,\,Cylinder} = (1 - \mathrm{X}) \cdot \dot{m}_{Fuel,\,in}$$

$$\dot{m}_{Fuel,\,Wall} = \mathrm{X} \cdot \dot{m}_{Fuel,\,in}$$

$$\dot{m}_{Wall,\,Cylinder} = \frac{1}{\tau} m_{Wall}$$

$$\dot{m}_{Fuel,\,total} = \dot{m}_{Fuel,\,Cylinder} + \dot{m}_{Wall,\,Cylinder}$$

The wall film mass can be formulated as a mass conservation equation.

$$\frac{dm_{Wall}}{dt} = \mathrm{X} \cdot \dot{m}_{Fuel,In} - \frac{1}{\tau} m_{Wall}$$

Inports

The following table shows the inports:

Name	Unit	Description
mdot_Inj	[kg/h]	Fuel mass flow from injector
Reset	[]	Reset of states
Sw_WallFilm_Mode	[1|2]	Switch for enable or disable wall film model ▪ 1: On ▪ 2: Off
T_Coolant	[°C]	Engine coolant temperature

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 🕮).
mdot_Inj_wall	[kg/h]	Fuel mass flow after wall film model

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_T_Water_WallFilmOff	[°C]	Temperature threshold to disable the wall film model
Map_tau	[s]	Map with time constant for fuel evaporation from wall film depending on the water temperature
Map_X	[]	Map with mass fraction from fuel mass flow which will be consumed by the wall film depending on the water temperature

Related topics

References

History of the WALL_FILM Block..... 270
Wall Film Gasoline (ModelDesk Parameterizing 🕮)

Switches Wall Film Mode

Introduction

This block contains switches to specify the correct model setup.

Parameters

The following table shows the parameters:

Name	Unit	Description
SW_WallFilm_Mode	[1|2]	Switch to enable or disable combustion wall film simulation ▪ 1: On ▪ 2: Off

Related topics

References

Wall Film Gasoline (ModelDesk Parameterizing 🕮)

Switches Pump Torque

Description

This block contains switches to specify the correct model setup.

Parameters

The following table shows the parameters:

Name	Unit	Description
SW_Trq_PumpCompression_Mode	[1|2]	Switch to enable or disable compression torque modulation ▪ 1: On ▪ 2: Off
SW_Trq_PumpGasExchange_Mode	[1|2]	Switch to enable or disable gas exchange torque modulation ▪ 1: On ▪ 2: Off

Related topics

References

Pump Torque Gasoline (ModelDesk Parameterizing 🕮)

Switches

Switches

Introduction	This topic shows the switches of the ASM Gasoline Engine Library.
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Soft ECU

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Ambient Conditions

Description

The AMBIENT_CONDITIONS block switches the ambient pressure and temperature input signals.

Ambient pressure and temperature are switched between:

- Measurement signals
- Constant values
- A map-based calculation based on altitude

Inports

The following table shows the inports:

Name	Unit	Description
p_Ambient_Env	[Pa]	Ambient pressure
p_Ambient_meas	[Pa]	Measurement ambient pressure
Sw_Replace_Env	[]	Switch to replace environment parameters with measurement data: ▪ 0: Disabled ▪ 1: Enabled
T_Ambient_Env	[°C]	Ambient temperature
T_Ambient_meas	[°C]	Measurement ambient temperature

Outports

The following table shows the outports:

Name	Unit	Description
p_Ambient	[Pa]	Ambient pressure
T_Ambient	[°C]	Ambient temperature

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_p_Ambient	[Pa]	Constant ambient pressure
Const_T_Ambient	[°C]	Constant ambient temperature
Sw_Const_Ambient	[0|1]	Switch for constant ambient condition: ▪ 0: On ▪ 1: Off

Camshaft Phaser Exhaust Control

Description

The CAM_PHASER_EXHAUST_CONTROL block controls the camshaft phase angle.

The controller itself is a PI Controller with anti-wind-up capability. The setpoint can be a map that depends on the desired engine torque and engine speed, a constant, or an external input.

Inports

The following table shows the inports:

Name	Unit	Description
n_Engine	[rpm]	Engine speed
phi_EO	[deg]	Exhaust valve opening point
phi_EO_Set_Ext	[deg]	External input for exhaust valve opening setpoint
Reset	[]	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 activeTrq_Engine_Ind_Set
Trq_Engine_Ind_Set	[Nm]	Induced engine torque setpoint

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_CamPhaser	[0_1]	Control signal for cam phaser

Parameters

The following table shows the parameters:

Name	Unit	Description
Sw_phi_EO_Set	[1|2|3]	Selector for exhaust valve open setpoint ▪ 1: Map ▪ 2: Constant ▪ 3: External
Map_phi_EO_Set	[]	Exhaust valve open setpoint map
Const_phi_EO_Set	[]	Exhaust valve open setpoint constant
Sw_Control	[0|1]	Switch to activate controller ▪ 0: Off ▪ 1: On
Sw_Invert_Control	[1|2]	Switch to invert camshaft control ▪ 1: Normal ▪ 2: Inverted
Const_P	[]	P Gain for camshaft controller
Const_I	[]	I Gain for camshaft controller
Const_PI_UpLim	[]	Upper Limit of the PI controller output
Const_PI_LowLim	[]	Lower Limit of the PI controller output
Const_Ctrl_Init	[0_1]	Initial control signal also used when engine is not running

Related topics

References

Cam Phaser Exhaust Control (ModelDesk Parameterizing 🕮)

Camshaft Phaser Intake Control

Description

The CAM_PHASER_INTAKE_CONTROL block controls the camshaft phase angle.

The controller itself is a PI controller with anti-wind-up capability. The setpoint can be a map that depends on the desired engine torque and engine speed, a constant, or an external input.

Inports

The following table shows the inports:

Name	Unit	Description
n_Engine	[rpm]	Engine speed
phi_EO	[deg]	Intake valve opening point
phi_EO_Set_Ext	[deg]	External input for intake valve opening setpoint
Reset	[]	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
Trq_Engine_Ind_Set	[Nm]	Induced engine torque setpoint

Outports

The following table shows the outports:

Name	Unit	Description
ASMSignalBus	[]	Signal bus containing signals of ASM components, refer to ASMSignalBus (ASM User Guide 🕮).
Ctrl_CamPhaser	[0_1]	Control signal for camshaft phaser

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_Ctrl_Init	[0_1]	Initial control signal also used when engine is not running
Const_I	[]	I Gain for camshaft controller
Const_P	[]	P Gain for camshaft controller
Const_phi_EO_Set	[]	Intake valve open setpoint constant
Const_PI_LowLim	[]	Lower Limit of the PI controller output
Const_PI_UpLim	[]	Upper Limit of the PI controller output
Map_phi_EO_Set	[]	Intake valve open setpoint map
Sw_Control	[0|1]	Switch to activate controller ▪ 0: Off ▪ 1: On
Sw_Invert_Control	[1|2]	Switch to invert camshaft control ▪ 1: Normal ▪ 2: Inverted
Sw_phi_EO_Set	[1|2|3]	Selector for intake valve open setpoint ▪ 1: Map-based ▪ 2: Constant ▪ 3: External

Related topics

References

Cam Phaser Exhaust Control (ModelDesk Parameterizing 🕮)

Crank Angle Calculation

Description

The CRANK_ANGLE block calculates the angle of the crankshaft for each cylinder. The default value for zero degrees corresponds to the top dead center position of the cylinder, which is in the working cycle. Other cylinders are calculated as an offset (720 divided by the number of cylinders) to this cylinder.

Inports

The following table shows the inports:

Name	Unit	Description
n_Engine	[rpm]	Engine speed
Reset	[0|1]	Reset all integrators to their initial conditions

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 🕮).
CrankAngle_Cyl	[deg]	Crank angle, which runs from 0 to 720 degrees

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_phi_start	[deg]	Start angle of crank angle integration
StepSize	[s]	Iteration step size

Related topics

References

Crank Angle (ModelDesk Parameterizing 🕮)

Direct Injector Timing

Description

The DIRECTINJECTOR_TIMING calculates the injection angles and times for the direct injectors. Depending on the specified injection quantity and the engine speed the injection quantity and the injection angle for each injection is estimated. The injection time finally depends on the quantity and the rail pressure.

Up to 8 injections per cycle per cylinder are supported.

Via the Set_Post_Inj[0Off|1On] inport the quantity of the last active injection can be replaced by the input q_Inj_post[mm3|cyc]. Constant or external values can be used for testing injection quantities, injection times, and injection angles.

The number of injections supported by the current compiled code is a mask parameter whereas the number of the active injection and the index of the main injection is received by goto from connections of the **SOFTECU_SETUP** block.

The injection signals are updated separately for every cylinder according the Trigger_Inj_update_Cyl inport. For the engine states 0 (Engine off) and 4 (shutdown), the injection times are set to zero.

Inports

The following table shows the inports:

Name	Unit	Description
n_Engine	[rpm]	Engine speed
p_Rail	[bar]	Rail pressure
phi_Inj_Ext	[bTDC]	External injection angle (injection 1 ... injection 8)
q_Inj_Set	[mm^3/cyc]	Injection quantity setpoint (per cylinder per cycle)
q_Inj_post	[mm^3/cyc]	External input for post-injection quantity
q_Inj_Pulse_Ext	[mm^3/cyc]	External input to set injection pulse quantity (injection 1 ... injection 8)
Set_Post_Inj	[0|1]	Switch to active external set of post-injection ▪ 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
t_Inj_Direct_Ext	[µs]	External input to set injection time (injection 1 ... injection 8)
Trigger_Inj_update_Cyl	[0|1]	Trigger for injection calculation (cylinder 1, ..., cylinder n)

Outports

The following table shows the outports:

Name	Unit	Description
phi_Inj	[bTDC]	Injection angle (cylinder 1 pulse 1, cylinder 1 pulse 2, ..., cylinder n, pulse m)

Name	Unit	Description
t_Inj	[µs]	Injection time (cylinder 1 pulse 1, cylinder 1 pulse 2, ..., cylinder n, pulse m)

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_max_num_Cyl	[]	Maximum number of cylinder with compiled code
Const_max_num_Inj_Direct	[]	Maximum number of direct injection with compiled code
Const_max_num_Rail	[]	Maximum number of rails with compiled code
Const_phi_Inj_Set	[bTDC]	Constant to set injection angle (Injection 1 ... Injection 8)
Const_q_Inj_Pulse_Set	[mm^3/cyc]	Constant to set pulse injection quantity (Injection 1 ... Injection 8)
Const_t_Inj_Set	[µs]	Constant vector to set pulse injection time (Injection 1 ... Injection 8)
Map_InjRelation	[]	Injection relation map to assign the injection signal to the cylinder (cylinder index injection signal 1,cylinder index injection signal 2,...)
Map_Inj2Cyl	[]	Mapping Matrix from injection times (calculation depends on rail pressure) to cylinder
Map_phi_Inj_Direct_1	[bTDC]	Map injection angle injection 1 = f(n_Engine;q_Mean_Inj_Set)
Map_phi_Inj_Direct_2	[bTDC]	Map injection angle injection 2 = f(n_Engine;q_Mean_Inj_Set)
Map_phi_Inj_Direct_3	[bTDC]	Map injection angle injection 3 = f(n_Engine;q_Mean_Inj_Set)
Map_phi_Inj_Direct_4	[bTDC]	Map injection angle injection 4 = f(n_Engine;q_Mean_Inj_Set)
Map_phi_Inj_Direct_5	[bTDC]	Map injection angle injection 5 = f(n_Engine;q_Mean_Inj_Set)
Map_phi_Inj_Direct_6	[bTDC]	Map injection angle injection 6 = f(n_Engine;q_Mean_Inj_Set)
Map_phi_Inj_Direct_7	[bTDC]	Map injection angle injection 7 = f(n_Engine;q_Mean_Inj_Set)
Map_phi_Inj_Direct_8	[bTDC]	Map injection angle injection 8 = f(n_Engine;q_Mean_Inj_Set)
Map_q_Inj_Direct_1_rel	[]	Relative injection quantity injection 1 = f(n_Engine;q_Mean_Inj_Set)
Map_q_Inj_Direct_2_rel	[]	Relative injection quantity injection 2 = f(n_Engine;q_Mean_Inj_Set)
Map_q_Inj_Direct_3_rel	[]	Relative injection quantity injection 3 = f(n_Engine;q_Mean_Inj_Set)
Map_q_Inj_Direct_4_rel	[]	Relative injection quantity injection 4 = f(n_Engine;q_Mean_Inj_Set)
Map_q_Inj_Direct_5_rel	[]	Relative injection quantity injection 5 = f(n_Engine;q_Mean_Inj_Set)
Map_q_Inj_Direct_6_rel	[]	Relative injection quantity injection 6 = f(n_Engine;q_Mean_Inj_Set)
Map_q_Inj_Direct_7_rel	[]	Relative injection quantity injection 7 = f(n_Engine;q_Mean_Inj_Set)
Map_q_Inj_Direct_8_re	[]	Relative injection quantity injection 8 = f(n_Engine;q_Mean_Inj_Set)
Map_t_Injection	[s]	Injection Timing Map, = f(q_Inj_Mean, p_Rail)
Sw_phi_Inj	[1|2|3]	Switch to select injection angle ▪ 1: Map ▪ 2: Constant ▪ 3: External
Sw_q_Inj_Pulse	[1|2|3]	Switch to select pulse injection quantity ▪ 1: Calculated ▪ 2: Constant

Name	Unit	Description
Sw_t_Inj	[1|2|3]	▪ 3: External Switch to select injection time ▪ 1: Calculated ▪ 2: Constant ▪ 3: External

Related topics

References

Directinjector Timing (ModelDesk Parameterizing 🕮)
SoftECU Setup (ASM Base InCylinder Reference 🕮)

EGR Rate Control

Description

The EGR_RATE_CONTROL block controls the EGR rate by the EGR valve. The EGR rate setpoint depends on the specified induced engine torque and the engine speed. For testing, a constant or an external setpoint can be used. The controller itself is a PI Controller with anti-wind-up capability.

Inports

The following table shows the inports:

Name	Unit	Description
n_Engine	[rpm]	Engine speed
mdot_Comp	[kg/h]	Mass flow through compressor
mdot_EGR	[kg/h]	Mass flow through the EGR valve
p_ExhMan	[Pa]	Exhaust manifold pressure
p_InMan	[Pa]	Intake manifold pressure
Rate_EGR_Set_Ext	[%]	External input for EGR Rate setpoint

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
Trq_Engine_Ind_Set	[Nm]	Induced engine torque setpoint

Outports

The following table shows the outports:

Name	Unit	Description
Ctrl_EGR	[0_1]	Control signal of EGR valve

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_I_Rate_EGR	[]	I gain for rate-based EGR position controller
Const_P_Rate_EGR	[]	P gain for rate-based EGR position controller
Const_PT1_Rate_EGR	[s]	PT1 constant for EGR rate calculation
Const_Rate_EGR_Set	[%]	EGR rate setpoint constant
Map_Rate_EGR_Set	[%]	EGR rate setpoint map = f(n_Engine, Trq_Engine_Ind)
StepSize	[s]	Simulation step size
Sw_Rate_EGR	[1|2|3]	Switch to select EGR rate setpoint ▪ 1: Map ▪ 2: Constant ▪ 3: External

Related topics

References

EGR Rate Control (ModelDesk Parameterizing 🕮)

Engine Operation

Description

The ENGINE_OPERATION detects the engine operating state from the ignition, starter request switch, and engine speed. It also activates the starter and the main relay (terminal 87).

Five different engine states are possible:

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

The duration of the states and the speed limits for switching can be parameterized.

Inports

The following table shows the inports:

Name	Unit	Description
n_Engine	[rpm]	Engine speed
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

Outports

The following table shows the outports:

Name	Unit	Description
Sw_MainRelay	[0|1]	Activate switch for main relay from ECU
Sw_Starter	[0|1]	Starter activate switch (output of ECU)
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

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_n_Engine_EngineOn	[rpm]	Minimum engine speed for engine operating mode is on
Const_t_Starter_max	[s]	Maximum duration of starter enable
Const_n_Engine_Off	[rpm]	Engine speed at which engine is assumed to be off in shutdown state
Const_t_Shutdown	[s]	Duration of shutdown state
StepSize	[s]	Sample time

Related topics

References

Engine Operation (ModelDesk Parameterizing 🕮)

Engine Torque Set

Description

The ENGINE_TORQUE_SET block calculates the desired induced engine torque. The driver's desired effective engine torque depends on the accelerator pedal position and engine speed. It is combined with the frictions loss, which depends from engine temperature and engine speed to the desired induced engine torque.

Inports

The following table shows the inports:

Name	Unit	Description
n_Engine	[rpm]	Engine speed
Pos_AccPedal	[%]	Accelerator pedal position
T_Coolant	[°C]	Coolant temperature

Outports

The following table shows the outports:

Name	Unit	Description
Trq_Driver_Ind_Set	[Nm]	Induced engine torque setpoint of driver
Trq_Friction	[Nm]	Friction torque

Parameters

The following table shows the parameters:

Name	Unit	Description
Map_Trq_Driver	[Nm]	Requested driver torque map = f(Pos_AccPedal, n_Engine)
Map_Trq_Friction	[Nm]	Engine friction torque map = f(n_Engine, T_Engine)

Related topics

References

Engine Torque Set (ModelDesk Parameterizing 🕮)

Engine Torque Set Intervention

Description

The ENGINE_TORQUE_SET_INTERVENTION block calculates the desired indicated engine torque depending on the driver's requirement and an external intervention.

The block can be connected with the SoftECU_Transmission block and allows for a torque reduction during the gearshift process.

Inports

The following table shows the inports:

Name	Unit	Description
Factor_Trq_Engine_Red[%]	[%]	Engine torque reduction factor
Mode_BSG	[-1|0|1|2|3|4|5]	Belt-driven starter generator mode ▪ -1: Not available ▪ 0: Stop engine ▪ 1: Start engine ▪ 2: Generation ▪ 3: Recuperation ▪ 4: Boost ▪ 5: Idle
Trq_BSG	[Nm]	Electric machine torque
Trq_Driver_Ind_Set	[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
ASMSignalBus	[]	Signal bus that contains signals of ASM components. Refer to ASMSignalBus (ASM User Guide 🕮).
Trq_Ind_Set	[Nm]	Induced engine torque setpoint

Related topics

References

History of the ENGINE_TORQUE_SET_INTERVENTION Block..... 251

Idle Speed Control

Description

The IDLE_SPEED_CONTROL lifts the specified induced engine torque to the current engine losses to keep the specified engine idle speed. The engine idle speed setpoint depends on the engine temperature. The idle speed controller consists of a PI control with anti-wind-up capability and a feed forward controller to compensate the friction losses. The output is limited with the allowed maximum engine torque, which depends on the engine speed.

Inports

The following table shows the inports.

Name	Unit	Description
n_Engine	[rpm]	Engine speed
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
T_Coolant	[°C]	Coolant temperature
Trq_Ind_Set	[Nm]	Induced engine torque setpoint
Trq_Friction	[Nm]	Friction torque

Outports

The following table shows the outports:

Name	Unit	Description
Trq_Engine_Ind_Max	[Nm]	Induced engine torque setpoint
Trq_Engine_Ind_Set	[Nm]	Induced engine torque setpoint

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_I_Idle	[]	I gain for idle speed controller
Const_P_Idle	[]	P gain for idle speed controller
Map_n_EngineIdle_Set	[rpm]	Target idle speed = f(T_Engine)

Name	Unit	Description
Map_Trq_Engine_Max	[Nm]	Maximum allowed engine torque map = f(n_Engine)
StepSize	[s]	Sample time

Related topics

References

History of the IDLE_SPEED_CONTROL Block..... 255
Idle Speed Control (ModelDesk Parameterizing 🕮)

Ignition Set

Description

The IGNITION_SET block calculates the ignition angles setpoint. Depending on the set induce engine torque and the engine speed the ignition angles setpoint is estimated.

For testing, you can use constant or external values for ignition angle. The ignition angle is provided separate for each cylinder and updated according the trigger input.

Inports

The following table shows the inports:

Name	Unit	Description
n_Engine	[rpm]	Engine speed
phi_Ign_Ext	[bTDC]	External setpoint for ignition angle
relAirmass	[]	Relative air mass flow
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
Trigger_Inj_update_Cyl	[0|1]	Trigger for injection calculation (cylinder 1, ..., cylinder n)

Outports

The following table shows the outports:

Name	Unit	Description
phi_Ign	[bTDC]	Ignition angle vector (cylinder 1, ..., cylinder n)
t_Ign	[µs]	Ignition time vector (cylinder 1, ..., cylinder n)

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_phi_Ign_Set	[bTDC]	Set ignition angle
Const_t_Ign	[µs]	Duration of ignition
Map_phi_Ign_opt	[deg]	Optimum ignition angle = f(n_Engine, Trq_Engine)
Sw_phi_Ign	[1|2|3]	Switch to select ignition angle ▪ 1: Map ▪ 2: Constant ▪ 3: External

Related topics

References

Ignition Set (ModelDesk Parameterizing 🕮)

Injector Mode

Description

The INJECTOR_MODE block controls the injectors. It can be selected if port or direct injectors are used. In case of direct injector for low engine speeds and low injection quantities the stratified injection mode is activated. In all other cases the homogeneous mode is active.

The following illustration shows the switch condition between the modes depending on engine speed and desired induced engine torque.

Inports

The following table shows the inports:

Name	Unit	Description
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
n_Engine	[rpm]	Engine speed
Trq_Engine_Ind_Set	[Nm]	Induced engine torque setpoint

Outports

The following table shows the outports:

Name	Unit	Description
Sw_Injection_Mode	[1|2]	Injection mode: ▪ 1: Homogeneous ▪ 2: Stratified
Sw_Injector	[1|2]	Switch to select injector ▪ 1: Port injector ▪ 2: Direct injector

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_n_Engine_Strat_Off	[Nm]	Engine speed below which stratified mode is disabled
Const_n_Engine_Strat_On	[Nm]	Engine speed above which stratified mode is enabled
Const_Trq_Strat_Off	[Nm]	Indicated engine torque below which stratified mode is disabled
Const_Trq_Strat_On	[Nm]	Indicated engine torque above which stratified mode is enabled
Sw_Injector	[1|2]	Switch to select injector: ▪ 1: Port injector ▪ 2: Direct injector
Sw_Mode_Strat	[1|2]	Switch to allow activation of stratified mode: ▪ 1: On ▪ 2: Off

Related topics

References

History of the INJECTOR_MODE Block..... 256
Injector Mode (ModelDesk Parameterizing 🕮)

Injection Quantity

Description

The INJECTION_QUANTITY block estimates the injection quantity from the desired induced engine torque and the engine speed. For testing, a constant or an external setpoint can be used.

Inports

The following table shows the inports.

Name	Unit	Description
n_Engine	[rpm]	Engine speed
q_Inj_Set_Ext	[]	External setpoint for the injection quantity
Trq_Engine_Ind_Set	[Nm]	Induced engine torque setpoint

Outports

The following table shows the outports.

Name	Unit	Description
q_Inj_set	[mm^3/cyc]	Injection quantity setpoint

Parameters

The following table shows the parameters.

Name	Unit	Description
Const_q_Inj_Set	[mm^3/cyc]	Set injection quantity
Map_Trq2Quant	[mm^3/cyc]	Torque to quantity conversion map = f(Trq_Engine_Ind_Set, n_Engine)
Sw_q_Inj	[1|2|3]	Switch to select injection quantity ▪ 1: Map ▪ 2: Constant ▪ 3: External

Related topics

References

Injection Quantity (ModelDesk Parameterizing 🕮)

Lambda Control

Description

The LAMBDA_CONTROL block calculates the injection quantity for homogeneous combustion mode. Depending on the set lambda and the intake air mass flow the injection quantity per cylinder per cycle is estimated.

The lambda setpoint depends on the set induced engine torque and the engine speed. For testing, you can use constant or external values for lambda setpoint or injection quantity.

Inports

The following table shows the inports:

Name	Unit	Description
Lambda_Set_Ext	[]	External setpoint for lambda
mdot_Air_In	[kg/h]	Air mass flow into the engine
n_Engine	[rpm]	Engine speed
q_Inj_Set_Ext	[mm^3/cyc]	External setpoint for injection quantity
Trq_Engine_Ind_Set	[Nm]	Induced engine torque setpoint

Outports

The following table shows the outports:

Name	Unit	Description
q_Inj_Set	[mm^3/cyc]	Injection quantity setpoint (per cylinder per cycle)

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_Lambda_Set	[]	Lambda setpoint constant
Const_q_Inj_Set	[mm^3/cyc]	Set injection quantity
Map_Lambda_Set	[]	Lambda setpoint map = f(n_Engine,TrqEngine)
Sw_Lambda_Set	[1|2|3]	Switch to select lambda set ▪ 1: Constant ▪ 2: Map ▪ 3: External
Sw_q_Inj	[1|2|3]	Switch to select injection quantity ▪ 1: Calculated ▪ 2: Constant ▪ 3: External

Related topics

References

History of the LAMBDA_CONTROL Block 258
Lambda Control (ModelDesk Parameterizing 🕮)

Port Injector Timing

Description

The PORTINJECTOR_TIMING block calculates the injection angles and times for the port injectors. Depending on the set injection quantity and the engine speed the injection quantity and the injection angle for each injection pulse is estimated. The injection time is calculated according the injector characteristic.

Up to 4 injections per cycle per cylinder are supported. For testing or debugging, you can use constant or external values for injection quantity, injection time and injection angle.

The block can calculate a higher injection time to account for lesser fuel quantity if the pressure difference between injector fuel supply and the intake manifold is too low.

The number of injections supported by the current compiled code is a mask parameter where as the number of the active injection and the index of the main injection is received by goto from connections from the SOFTECU_SETUP block.

The injection signals are updated separately for every cylinder according the Trigger_Inj_update_Cyl input port. For engine state 0 (Engine off) and 4 (Engine shutdown) the injection times are set to zero.

Inports

The following table shows the inports:

Name	Unit	Description
n_Engine	[rpm]	Engine speed
phi_Inj_Ext	[bTDC]	External injection angle (injection 1... injection n)
p_InMan	[Pa]	Intake manifold pressure
p_Fuel	[Pa]	Fuel pressure
q_Inj_Pulse_Ext	[mm^3/cyc]	External input so set injection pulse quantity (injection 1... injection n)
q_Inj_Set	[mm^3/cyc]	Injection quantity setpoint (per cylinder per cycle)
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
t_Inj_Port_Ext	[µs]	External setpoint for injection time (cylinder 1, ..., cylinder n)
Trigger_Inj_update_Cyl	[0|1]	Trigger for injection calculation (cylinder 1, ..., cylinder n)

Outports

The following table shows the outports:

Name	Unit	Description
phi_Inj_Port	[bTDC]	Port injection angle vector (cylinder 1 pulse 1, cylinder 1 pulse 2, ..., cylinder n, pulse m)
t_Inj_Port	[µs]	Port injection time vector (cylinder 1 pulse 1, cylinder 1 pulse 2, ..., cylinder n pulse m)

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_max_num_Cyl	[]	Maximum number of cylinder supported by the current compiled code
Const_max_num_Inj_Port	[]	Maximum number of injections supported by the current compiled code
Const_max_num_PortInjector_PressureDrop	[]	Maximum number of pressure drops
Const_mdot_Fuel_Gain	[mm^3/s]	Injector flow function gain
Const_mdot_Fuel_Offset	[s]	Injector flow function time offset
Const_phi_Inj_Set	[bTDC]	Constant to set injection angle
Const_q_Inj_Pulse_Set	[mm^3/cyc]	Constant to set pulse injection quantity
Const_t_Inj_Set	[µs]	Constant to set injection time
Map_Inj2Cyl	[]	Mapping matrix from injection signals
Map_InjRelation	[]	Vector with index of Cylinder to which the injections belongs to
Map_mdot_Fuel_Gain_Red	[0_1]	Influence of difference pressure on injected fuel mass
Map_phi_Inj_Port_1	[bTDC]	Map injection angle injection 1
Map_phi_Inj_Port_2	[bTDC]	Map injection angle injection 2
Map_phi_Inj_Port_3	[bTDC]	Map injection angle injection 3
Map_phi_Inj_Port_4	[bTDC]	Map injection angle injection 4
Map_q_Inj_Port_1_rel	[]	Relative Injection quantity injection 1
Map_q_Inj_Port_2_rel	[]	Relative Injection quantity injection 2
Map_q_Inj_Port_3_rel	[]	Relative Injection quantity injection 3
Map_q_Inj_Port_4_rel	[]	Relative Injection quantity injection 4
Sw_phi_Inj	[1|2|3]	Switch to select injection angle ▪ 1: Map ▪ 2: Constant ▪ 3: External
Sw_q_Inj_Pulse	[1|2|3]	Switch to select pulse injection quantity ▪ 1: Map ▪ 2: Constant ▪ 3: External
Sw_t_Inj	[1|2|3]	Switch to select injection time ▪ 1: Map ▪ 2: Constant ▪ 3: External

Related topics

References

History of the PORTINJECTOR_TIMING Block..... 259

Portinjector Timing (ModelDesk Parameterizing 🕮)

Rail Control

Description

The RAIL_CONTROL block controls the rail pressure via the fuel metering unit and the pressure control valve. The rail pressure setpoint depends on the specified induced engine torque and the engine speed. A constant or an external setpoint can be used for testing. Each controller is a PI controller with anti-wind-up capability. For high injection quantities at high engine speed the fuel metering unit is used to control the rail pressure. The pressure control valve is then closed completely. Otherwise, the fuel metering unit is opened completely and the pressure is controlled by the pressure control valve.

Inports

The following table shows the inports.

Name	Unit	Description
n_Engine	[rpm]	Engine speed
p_Rail	[bar]	Rail pressure
p_Rail_Set_Ext	[bar]	External rail pressure setpoint
q_Mean_Inj_Set	[mm^3/cyc]	Injection quantity setpoint (per cylinder per cycle)
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

Outports

The following table shows the outports.

Name	Unit	Description
Ctrl_FuelMeterUnit	[mA]	Control signal of fuel metering unit for common rail
Ctrl_PresCtrlValve	[mA]	Control signal of pressure control valve for common rail

Parameters

The following table shows the parameters.

Name	Unit	Description
Const_disable_FMU_n_Engine	[rpm]	Engine speed below which fuel metering unit is disabled
Const_disable_FMU_q_Inj	[mm^3/cyc]	Injected fuel quantity below which fuel metering unit is disabled
Const_enable_FMU_n_Engine	[rpm]	Engine speed above which fuel metering unit is enabled
Const_enable_FMU_q_Inj	[mm^3/cyc]	Injected fuel quantity above which fuel metering unit is enabled
Const_I_FMU	[]	I gain for fuel metering unit controller
Const_I_max_FMU	[mA]	Maximum current for fuel metering unit
Const_I_max_PCV	[mA]	Maximum current for pressure control valve
Const_I_PCV	[]	I gain pressure control valve controller
Const_P_FMU	[]	P gain for fuel metering unit controller
Const_P_PCV	[]	P gain pressure control valve controller
Const_p_Rail_Set	[bar]	Rail pressure setpoint constant
Map_p_Rail_Set	[bar]	Rail pressure setpoint map = f(n_Engine, q_Mean_Inj)
StepSize	[s]	Sample time
Sw_p_Rail	[1|2|3]	Switch to select rail pressure setpoint ▪ 1: Map ▪ 2: Constant ▪ 3: External

Related topics

References

Rail Control (ModelDesk Parameterizing 🕮)

Rail Control Crank-Based

Description

The RAIL_CONTROL_CRANKBASED block serves as a controller for the HPP_CRANKBASED block. It controls the rail pressure by calculating the fuel metering unit's (FMU) setpoint of actuation. The rail pressure setpoint depends on the engine's operating point. A constant or an external setpoint can be used for testing. The controller can be considered a PI controller with inverted behavior, an anti-wind-up, and a PWM-to-crank-angle-signal converter. The point of FMU actuation is calculated before the compression stroke of the pump and kept until the point of triggering. The point of triggering can also be set externally. Additionally, it can be disabled, so the rail pressure is controlled continuously.

Control strategy

Energizing the FMU close to the bottom dead center (BDC) raises the rail pressure due to the increased volume of the high-pressure pump. In this way, the fuel flow through the high-pressure pump is increased. Vice versa, energizing the FMU close to the top dead center (TDC) causes the rail pressure to drop.

This results in the following control strategies:

- $p_{Rail} < p_{Rail_Set}$ (rail pressure must rise): Control signal of FMU strives for zero (inverted behavior, because $p_{RailDiff} = p_{Rail_Set} - p_{Rail}$ strives for maximum) -> FMU is energized close to BDC -> Fuel flow through the high-pressure pump rises
- $p_{Rail} > p_{Rail_Set}$ (rail pressure must drop): Control signal of FMU strives for one (inverted behavior, because $p_{RailDiff} = p_{Rail_Set} - p_{Rail}$ strives for minimum) -> FMU is energized close to TDC -> Fuel flow through the high-pressure pump drops

FMU energizing

Short-term energizing in the compression stroke of the pump closes the valve on the low-pressure side of the high-pressure pump. Rising pressure in the pump cylinder keeps the valve closed. The camshaft is rigidly connected to the crankshaft. The top dead center (TDC) of the pump can be offset to the reference TDC of the engine.

The control signal of the pump is a vector containing the angles of the FMU energizing.

$$\varphi_{Energized*} = \left[0.5 \cdot \frac{720}{Number_{Cam}} \leq \varphi_1 \leq 1 \cdot \frac{720}{Number_{Cam}}, \ldots, (Number_{Cam} - 0.5) \cdot \frac{720}{Number_{Cam}} \leq \varphi_{Number_{Cam}} \leq 720\right] + \varphi_{Init}$$

The initial offset is defined as the angle between the axis of movement of the pump and the cam approaching against the moving direction of the camshaft.

$$-\frac{720}{Number_{Cam}} \leq \varphi_{Init} \leq \frac{720}{Number_{Cam}}$$

$$\varphi_{Energized} = mod\left(\varphi_{Energized*}, \frac{360}{i_{HighPresPump}}\right)$$

See the following illustration:

Trigger

The working principle of the trigger is the following. An angle to trigger the FMU energizing is set.

$\varphi_{FMUUpdate}$

If this angle is not set externally, it is the BDC of the pump. The point when the camshaft angle is in the trigger proximity is to be determined. This is done by the following equation:

$$\varphi_{Trigger2Update} = \varphi_{CamShaft}(t) - \varphi_{FMUUpdate} - \varphi_{PumpCycle}$$
$$\leq \varphi_{Trigger2Update} \leq \varphi_{PumpCycle}$$

When $\varphi_{Trigger2Update}$ is close to zero, this indicates the trigger proximity. To ensure that $\varphi_{Trigger2Update}$ is captured it is hold for two iteration steps.

$$\varphi_{Trigger2Update} = \left|\varphi_{CamShaft}(t) - \varphi_{FMUUpdate}\right|$$

$$\varphi_{StepSize} = 360[deg]*\frac{n_{Engine}[rpm]}{60}*StepSize[s]$$

As long as $\varphi_{Trigger2Update}$ is smaller than $\varphi_{StepSize}$ a trigger signal to energize the FMU is passed.

$$Trigger[0Hold|1Pass] = IS\left(\varphi_{Trigger2Update} \leq \varphi_{StepSize}\right])$$

Inports

The following table shows the inports:

Name	Unit	Description
CrankAngle_Cyl	[deg]	Angular position of crankshaft
n_Engine	[rpm]	Engine speed
p_Rail	[bar]	Rail pressure
p_Rail_Set_Ext	[bar]	External rail pressure setpoint
phi_CamShaft_Offset	[deg]	Camshaft offset due to valve train variability

Name	Unit	Description
q_Mean_Inj_Set	[mm^3/cyc]	Injection quantity setpoint (per cylinder per cycle)
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 active
U_Bat	[V]	Battery voltage

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 🕮).
phi_FMU_energized	[deg]	Start of fuel metering unit's control

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_I_FMU	[]	I gain for fuel metering unit controller
Const_i_HighPresPump	[]	Transmission ratio i, n_HighPresPump = i*n_Engine
Const_max_num_HPPCam	[]	Maximum number of high-pressure cams with current compiled code. The value is between 1 and 8.
Const_num_Cam	[]	Number of cams of high-pressure pump
Const_P_FMU	[]	P gain for fuel metering unit controller
Const_p_Rail_Set	[bar]	Rail pressure setpoint constant
Const_phi_FMU_Update	[deg]	External angle to trigger the calculation for FMU energizing
Map_p_Rail_Set	[bar]	Rail pressure setpoint map [bar] = f(n_engine, q_Mean_Inj)
Map_phi_FMU_energized	[deg]	PWM-to-crank-angle conversion
Map_phi_FMU_FF	[deg]	Rail control feed forward map phi_FMU_FF[deg] = f(n_Engine, q_Mean_Inj)
Map_ValveDelay	[s]	Mechanical retard of fuel metering unit, f(n_Engine, U_Bat)
StepSize	[s]	Sample time
Sw_p_Rail	[1|2|3]	Switch to select rail pressure setpoint: ▪ 1: Map ▪ 2: Constant ▪ 3: External
Sw_phi_FMU_Update	[1|2]	Switch source of trigger update: ▪ 1: Internal

Name	Unit	Description
Sw_TriggerMode	[0|1]	▪ 2: External Switch control mode: ▪ 0: Continuous ▪ 1: Discontinuous
Vector_Cam_Offset	[deg]	Vector indicating cam TDC position relative to engine TDC1

Related topics

References

History of the RAIL_CONTROL_CRANKBASED Block..... 261
Rail Control Crankbased (ModelDesk Parameterizing 🕮)

Relative Air Mass Calculation

Description

The REL_AIRMASS_CALCULATION block calculates the relative airmass. From engine speed and intake air mass flow, the air mass per cycle is estimated. It is compared to the reference air mass flow.

Inports

The following table shows the inports:

Name	Unit	Description
mdot_Air_In	[kg/h]	Air mass flow into the engine
n_Engine	[rpm]	Engine speed

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 🕮).
RelAirmass	[]	Relative air mass flow

Relative Air Mass Map-Based

Description

The REL_AIRMASS_MAPBASED block calculates the relative air mass.

The volumetric efficiency is estimated based on engine speed and intake manifold conditions.

The theoretical maximum airflow into the engine is multiplied with the volumetric efficiency. It is then divided by the reference airflow providing the relative air mass.

This is done by copying the volumetric efficiency look-up table values from the CYLINDER_INLET block of the corresponding piston engine to this block.

This approach yields better results for gasoline engines in transient operation, because the momentum of the intake manifold does not affect the calculated flow into the cylinder.

Inports

The following table shows the inports:

Name	Unit	Description
n_Engine	[rpm]	Engine speed
p_InMan	[Pa]	Intake manifold pressure
T_InMan	[°C]	Temperature in the intake manifold

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 🕮).
mdot_In_Engine	[kg/h]	Calculated air mass flow into the engine
RelAirmass	[]	Relative air mass flow

Parameters

The following table shows the parameters:

Name	Unit	Description
Map_VolEff_Cyl	[]	Volumetric efficiency

Related topics

References

History of the REL_AIRMASS_MAPBASED Block..... 263
Rel Airmass Mapbased (ModelDesk Parameterizing 🕮)

SoftECU Setup

Description

The SOFTECU_SETUP block provides dimension information, for example, how many cylinder injections the engine has. It can also determine how many cylinder injections are compiled in the current code. This allows simulating engines with different number of cylinders or injections without recompiling code.

The absolute number of port injections is limited to 4.

The absolute number of direct injections is limited to 8.

The absolute number of cylinders is limited to 20 by the computation power for real-time simulation and unlimited for Simulink simulation.

Note

If the model is not able to run in real-time, reduce the maximal number of direct injections to the actual number of injections.

The injection with the biggest fuel quantity has to be selected as main injection. It must not become zero at any operating point.

Inports

The following table shows the inports:

Name	Unit	Description
active_ExhMan_vector	[]	Number of active exhaust manifolds [1,2].
active_InMan_vector	[]	Number of active intake manifolds [1,2.]
Const_CylinderOffset	[deg]	Vector with cylinder offsets [1,...,20].
Const_num_Cyl	[]	Number of cylinders [1,...,20].
Const_num_Cyl_vector	[0|1]	Number of engine cylinders vector [1,...,20].
Const_num_Inj_Direct	[]	Number of direct injections [1,...,20].
Const_num_Inj_Port	[]	Number of port injections [1,...,4].

Outports

The following table shows the outports:

Name	Unit	Description
active_ExhMan_vector	[]	Number of active exhaust manifolds [1,2].
active_InMan_vector	[]	Number of active intake manifolds [1,2].
Const_CylinderOffset	[deg]	Vector with cylinder offsets [1,...,20].
Const_Ind_Inj_Direct_main	[]	Index of main direct injection.
Const_Ind_Inj_Port_main	[]	Index of the main port injection.
Const_max_num_Inj_Direct	[]	Maximum number of direct injection per cylinder with current compiled code.
Const_max_num_Inj_Port	[]	Maximum number of port injections per cylinder with current compiled code.
Const_num_Cyl	[]	Number of active cylinders.
Const_num_Cyl_vector	[0|1]	Number of engine cylinders vector [1,...,20].
Const_num_Inj_Direct	[]	Number of active direct injections.
Const_num_Inj_Port	[]	Number of active port injections.
Const_num_Rail	[]	Number of rails.
Vector_active_Cyl	[]	Vector indicating active cylinder (1 ... Const_max_num_Cyl) ▪ 0: Cylinder is inactive ▪ 1: Cylinder is active
Vector_active_Inj_Direct	[]	Vector indicating active direct injections (1 ... Const_max_num_Inj_Direct) ▪ 0: Inactive

Name	Unit	Description
		▪ 1: Active
Vector_active_Inj_Port	[]	Vector indicating active port injections (1 ... Const_max_num_Inj_Port) ▪ 0: Inactive ▪ 1: Active
Vector_active_Rail	[]	Vector indicating active rails (1 ... Const_max_num_Rail) ▪ 0: Inactive ▪ 1: Active
Vector_max_active_Inj_Direct	[]	Vector counting up to maximum number of direct injection of the complete engine with current compiled code (1...Const_max_num_Cyl * Const_max_num_Inj_Direct).
Vector_max_active_Inj_Port	[]	Vector counting up to maximum number of port injection of the complete engine with current compiled code (1 ... Const_max_num_Cyl * Const_max_num_Inj_Port).
Vector_max_Cyl	[]	Vector counting cylinder (1 ... Const_max_num_Cyl).
Vector_max_Inj_Direct	[]	Vector counting direct injections (1 ... Const_max_num_Inj_Direct).
Vector_max_Inj_Port	[]	Vector counting port injections (1... Const_max_num_Inj_Port).
Vector_max_Rail	[]	Vector counting up to maximum number of rails with current compiled code.

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_Ind_Inj_Direct_main	[]	Index of main direct injection.
Const_Ind_Inj_Port_main	[]	Index of main port injection.
Const_max_num_Cyl	[]	Maximum number of cylinders with current compiled code.
Const_max_num_Inj_Direct	[]	Maximum number of direct injections per cylinder with compiled code.
Const_max_num_Inj_Port	[]	Maximum number of port injections per cylinder with compiled code.
Const_max_num_Rail	[]	Maximum number of rails.

Related topics

References

History of the SOFTECU_SETUP Block 265
SoftECU Setup (ModelDesk Parameterizing 🕮)

Start-Stop System

Description

The START_STOP block simulates the start-stop system ECU, which shuts down and restarts the engine automatically. A start-stop system is used to reduce the fuel consumption and emissions by reducing the engine idling time.

The block can control vehicles equipped with manual as well as automatic transmissions. Depending on the transmission type, different conditions are assessed and the start-stop commands are sent accordingly.

These conditions can be categorized into system and operator conditions. Once the system conditions are fulfilled, the ECU waits for the appropriate driver action, i.e., operator conditions to start-stop the engine. Unlike the operator conditions, the system conditions are independent from the transmission type.

The following table illustrates the system conditions:

System Stop Conditions	Description
Warm engine	Engine temperature lies within the operating range. Two threshold parameters (Const_T_Coolant_LowLim and Const_T_Coolant_UpLim) are used to check for the correct temperature of the engine.
Convenient ambient temperature	The outside temperature lies within a convenient range. Two threshold parameters (Const_T_Ambient_LowLim and Const_T_Ambient_UpLim) are used to check for a convenient ambient temperature.
Minimum speed	A minimum speed (Const_v_Vehicle_LowLim parameter) was reached since the last engine stop. This condition can be used to deactivate the system when driving with relatively low speeds, for example during parking.

When the system conditions are fulfilled, the following operator conditions are checked to stop the engine:

Transmission Type	Operator Stop Conditions
Manual	▪ Neutral gear is engaged ▪ Clutch is released ▪ Vehicle is not moving
Automatic	▪ Selector lever is in D-Position ▪ Brake is pressed ▪ Vehicle is not moving

Once the stop conditions are fulfilled, the ECU additionally waits for a certain time before turning the engine off. This time can be parameterized (Const_t_Stop_Offs parameter) and used to avoid unintended short stops.

After the engine stops, the ECU remains active and monitors the system state as well as the driver actions. The system stop conditions must remain valid, otherwise the ECU starts the engine automatically (for example, if the temperature drops too low). The engine is also started in response to the driver actions. The operator actions needed to start the engine are listed in the table below:

Transmission Type	Operator Start Conditions
Manual	▪ Clutch is pressed ▪ Gear is engaged
Automatic	▪ Brake is released

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

Inports

The following table shows the inports:

Name	Unit	Description
Gear	[]	Gear
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
Sw_Ignition_Driver	[0|1]	Ignition signal, based on driver's requirement: ▪ 0: Off ▪ 1: On
Sw_StarterReq_Driver	[0|1]	Starter request signal, based on driver's requirement: ▪ 0: Starter is off ▪ 1: Starter is on
Sw_Transmisson_Mode	[1|2]	Transmission mode switch: ▪ 1: Manual ▪ 2: Automatic

Name	Unit	Description
T_Ambient	[°C]	Ambient temperature
T_Coolant	[°C]	Coolant temperature
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 🕮).
State_StartStop	[1|2|3|4]	Start-stop state: ▪ 1: Off ▪ 2: Not ready (conditions are not fulfilled) ▪ 3: Ready to stop the engine (wait for driver action) ▪ 4: Engine actively stopped by the system
Sw_Ignition	[0|1]	Ignition signal (terminal 15) generated by start-stop system: ▪ 0: Off ▪ 1: On
Sw_StarterReq	[0|1]	Starter request signal (usually sent to engine ECU) generated by start-stop system: ▪ 0: Off ▪ 1: On

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_Pos_BrakePedal_UpLim	[%]	Brake pedal position threshold for pressed brake pedal
Const_Pos_ClutchPedal_LowLim	[%]	Clutch pedal position threshold for released clutch pedal
Const_T_Ambient_LowLim	[°C]	Ambient temperature threshold for cold climate
Const_T_Ambient_UpLim	[°C]	Ambient temperature threshold for warm climate
Const_T_Coolant_LowLim	[°C]	Coolant temperature threshold for cold engine
Const_T_Coolant_UpLim	[°C]	Coolant temperature threshold for warm engine
Const_t_StarterReq	[s]	Duration of starter activation request
Const_t_Stop_Offs	[s]	Waiting time to stop the engine after the conditions were fulfilled
Const_v_Vehicle_LowLim	[km/h]	Lowest vehicle speed driven since last automatic engine stop
StepSize	[s]	Simulation step size
Sw_StartStop	[0|1]	Start stop activation switch: ▪ 0: Off ▪ 1: On

Related topics

References

History of the START_STOP Block..... 265
Start Stop (ModelDesk Parameterizing 🕮)

Switch Injection

Description

The SWITCH_INJECTION block steers which injection quantities are used for port and direct injector.

If port injector is active, the homogeneous injection quantity is used for the port injector and the direct injector injection quantity is set to zero.

If direct injector is active, the port injector injection quantity is set to zero. The applied direct injector injection quantity depends on the injection mode, and can be the homogeneous or the stratified injection quantity.

Inports

The following table shows the inports:

Name	Unit	Description
q_Inj_Hom_Set	[mm^3/cyc]	Homogeneous injection quantity setpoint
q_Inj_Strat_Set	[mm^3/cyc]	Stratified injection quantity setpoint
Sw_Injection_Mode	[1|2]	Injection mode ▪ 1: Homogeneous ▪ 2: Stratified
Sw_Injector	[1|2]	Switch to select injector ▪ 1: Port injector ▪ 2: Direct injector

Outports

The following table shows the outports:

Name	Unit	Description
q_Inj_Direct_Set	[mm^3/cyc]	Direct injector injection quantity setpoint
q_Inj_Port_Set	[mm^3/cyc]	Port injector injection quantity setpoint

Throttle Control

Description

The THROTTLE_CONTROL block controls the relative air mass via the throttle. The relative air mass setpoint depends on the specified induced engine torque and the engine speed. A constant or an external setpoint can be used for testing. The controller is a PI controller with anti-wind-up capability. If the engine state is off, the throttle is closed.

Inports

The following table shows the inports.

Name	Unit	Description
n_Engine	[rpm]	Engine speed
RelAirmass	[]	Relative air mass flow
RelAirmass_Set_Ext	[]	External input for relative air mass setpoint
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
Trq_Engine_Ind_Set	[Nm]	Induced engine torque setpoint

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_Throttle	[0_1]	Control signal of electrical throttle valve

Parameters

The following table shows the parameters.

Name	Unit	Description
Const_I_Throttle	[]	I gain for throttle controller
Const_P_Throttle	[]	P gain for throttle controller
Const_RelAirmass_Set	[]	Const relative air mass setpoint
Map_RelAirmass_Set	[]	Relative air mass setpoint map = f(n_Engine, Trq_Eng_Ind)
StepSize	[s]	Sample time
Sw_RelAirmass	[1|2|3]	Switch to select relative air mass setpoint ▪ 1: Map ▪ 2: Constant ▪ 3: External

Related topics

References

Throttle Control (ModelDesk Parameterizing 🕮)

Trigger Injection Update

Description

The TRIGGER_INJ_UPDATE block provides a trigger signal for each cylinder at a defined crank angle. It can be used to freeze the injection signals and keep them constant during one cycle.

Inports

The following table shows the inports:

Name	Unit	Description
CrankAngle_Cyl	[aTDC]	Vector with crank angles for each cylinder
n_Engine	[rpm]	Engine speed

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 🕮).
Trigger_Inj_update_Cyl	[0|1]	Trigger for injection calculation (cylinder 1, ..., cylinder n)

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_phi_Inj_Update	[deg]	Crank angle to trigger injection and ignition update
StepSize	[s]	Sample time

Related topics

References

Trigger Inj Update (ModelDesk Parameterizing 🕮)

Demos

Where to go from here

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ASM Modules..... 168
To describe the modules of the model.

Subsystems..... 189
To describe the subsystems inside the ASM modules.

Engine Gasoline

Where to go from here

Information in this section

Basics on the Engine Gasoline Demo Model..... 166
Gives you basic information about the Engine Gasoline Demo Model.

Overview of the Engine Gasoline Demo..... 166
Gives you an overwiew of the Engine Gasoline Demo Model and the ASM modules used.

Basics on the Engine Gasoline Demo Model

Introduction

This topic gives you basic information about the Engine Gasoline Demo Model.

Basics

The ASM Gasoline Engine Model is a Simulink model used to simulate turbocharged gasoline engines with manifold or direct injection in combination with a drivetrain model including automatic and manual transmission.

Overview of the Engine Gasoline Demo

Introduction

This topic gives you an overwiew of the Engine Gasoline Demo Model and the ASM modules used.

Opening the model

Refer to How to Start with an ASM Demo Model via MATLAB (ASM Gasoline Engine 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 174
- Electric Machine Simple Module on page 173
- Engine Gasoline Module on page 175
- Drivetrain Basic Module on page 171
- Vehicle Dynamics Basic Module on page 187
- Driver Basic Module on page 168
- Environment Basic Module on page 180
- Start System Module on page 183
- Torque Manager P0 Module on page 184

ASM Modules

Where to go from here

Information in this section

Driver Basic Module 168
To implement controlled longitudinal maneuvers, such as following a velocity profile.

Drivetrain Basic Module 171
To implement a longitudinal model of the vehicle drivetrain which transfers the torque from the engine to the wheel.

Electric Machine Simple Module 173
To implement a mockup of an electric motor.

Electrical System Basic Module 174
To implement constant values of the voltage, state of charge and temperature of a low and a high voltage battery.

Engine Gasoline Module 175
To implement a gasoline engine.

Environment Basic Module 180
To implement reference values to the driver and other model parts, for example to follow a reference velocity profile or an engine speed set.

Start System Module 183
To implement a start system for switching the engine on and off.

Torque Manager P0 Module 184
To implement the hybrid manager for an internal combustion engine with a belt starter generator.

Vehicle Dynamics Basic Module 187
To calculate the vehicle speed based on the traction and load torque from the external driving resistances.

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 189

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
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

Name	Unit	Description
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
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

Name	Unit	Description
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 Basic Module

Description

This is a longitudinal model of the vehicle drivetrain that transfers the torque from the engine to the wheel. It consists of simple manual and automatic transmission models. The model also includes a control strategy for automatic gear shift and a lockup clutch.

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

Inports Control

The following table shows the port of the Interface_External_In:

Name	Unit	Description
Gear_Maneuver	[]	Gear stimulus from the maneuver
Gear_Max	[0|1_n]	Gear set point defined by the maneuver input: ▪ 0: Off ▪ 1_n
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
Pos_AccPedal	[%]	Position of the accelerator pedal
Reset_States	[0|1]	Reset states
SelectorLever	[-3|-2|-1|0|1]	Selector lever position: ▪ -3: TipShift ▪ -2: Park ▪ -1: Reverse ▪ 0: Neutral

Name	Unit	Description
		▪ 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_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_TipShift	[-1|0|1]	TipShift request signal: ▪ -1: Down shift ▪ 0: Off ▪ 1: Up shift

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

Name	Unit	Description
Ctrl_Lockup_Clutch	[0_1]	Position of the clutch
Ctrl_Parking_Pawl	[0|1]	Parking pawl control signal
Factor_Trq_Engine_Red	[%]	Engine torque reduction factor
Gear	[]	Gear

Outports Control

The following table shows the ports of the Interface_External_Out:

Name	Unit	Description
Ctrl_Parking_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
Gear	[]	Gear
n_Engine_Set	[rpm]	Set point for the speed of the combustion engine
omega_Wheel	[rad/s]	Wheel speed
Pos_ClutchPedal	[%]	Clutch pedal position
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_EM	[Nm]	Torque EM
Trq_MeanEff_Engine_Mod	[Nm]	Mean effective engine torque (modulated)

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_EM	[rad/s]	Speed of the electric machine
n_EM	[rpm]	Speed of the electric machine
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

Electric Machine Simple Module

Description

The electric machine serves as a mockup of an electric motor. The desired torque is routed through as the output torque. The current is always zero.

It can be exchanged with a more complex ASM module.

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
Trq	[Nm]	Desired torque

Outports Plant

The following table shows the ports of the Interface_External_Out:

Name	Unit	Description
I_DCLink	[A]	DCLink current
I_EM	[A]	EM current
Trq_EM	[Nm]	Torque EM

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 Gasoline Module

Description

This module simulates a gasoline engine.

The engine model consists of components for:

- Air path inlcuding a turbocharger.
- Fuel system.
- Piston system including the combustion process.
- Cooling system.
- Exhaust system.
- Soft ECU.

It is modelled as a mean value engine model with additional combustion torque modulation. The mean value model means that the processes in the engine are averaged over an engine cycle.

The engine is controlled by a soft ECU. The soft ECU collects models for the simulation of the gasoline engine model if no real ECU is available. Its inputs are common sensor and the outputs are common actuators signals.

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

Subsystems

The module contains the following subsystems:

- Air Path Subsystem on page 193
- Air Path Control Subsystem on page 215
- Cooling Subsystem on page 197
- Evaporator Subsystem on page 198
- Exhaust System Subsystem on page 202
- Fuel System Subsystem on page 203
- Piston Engine Subsystem on page 207
- Soft ECU Gasoline Subsystem on page 210
- Torque Control Subsystem on page 217

Inports Control

The following table shows the ports of the Interface_External_In:

Name	Unit	Description
EngOPNum	[]	Engine operating point number
Factor_Trq_Engine_Red	[%]	Engine torque reduction factor
Gear	[]	Gear
HybridMode_ICE	[0|1|2|3]	Hybrid mode of the combustion engine: ▪ 0: ICE off

Name	Unit	Description
		▪ 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
Mode_Transmission	[1|2]	Transmission mode switch: ▪ 1: Manual ▪ 2: Automatic
n_Engine	[rpm]	Speed of the combustion engine
p_Ambient	[Pa]	Ambient pressure
Pos_AccPedal	[%]	Position of the accelerator pedal
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
StarterReq_ICE	[0|1]	Starter request: ▪ 0: Off ▪ 1: On
Sw_DriveMode	[0|1|2]	Drive mode: ▪ 0: Hybrid ▪ 1: ICE only ▪ 2: EM only
Sw_Testbench	[0|1]	Switch to activate the test bench: ▪ 0: Off ▪ 1: On
T_Ambient	[°C]	Ambient temperature
Trq_BSG	[Nm]	Torque of the belt-driven starter generator (BSG)
Trq_Request_ICE	[Nm]	Torque request ICE

Name	Unit	Description
V_Bat_LV	[V]	Voltage of low voltage battery
v_Vehicle	[km/h]	Vehicle velocity

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

Name	Unit	Description
CrankAngle_Cyl	[deg]	Crank angle per cylinder, positive value is after TDC
Ctrl_CamPhaser_Exhaust	[0_1]	Control signal of the variable-geometry turbocharger (VGT)
Ctrl_CamPhaser_Intake	[0_1]	Control signal for the cam phaser of the intake cam shaft
Ctrl_Comp_Bypass	[0_1]	Control signal for the low-pressure compressor bypass valve
Ctrl_Comp_Bypass_HP	[0_1]	Control signal for the high-pressure compressor bypass valve
Ctrl_EGR	[0_1]	Control signal of the electrical EGR valve
Ctrl_FuelMeterUnit	[mA]	Control signal of the fuel metering unit (high-pressure pump) for the common rail system
Ctrl_PCV	[0_1]	Control signal for the tank evaporation pressure control valve
Ctrl_PresCtrlValve	[mA]	Control signal of the pressure control valve in the common rail system
Ctrl_Throttle	[0_1]	Control signal of the electrical throttle valve
Ctrl_VCV	[0_1]	Control signal for the tank evaporation vapour control valve
Ctrl_VSV	[0_1]	Control signal for the tank evaporation vent shut valve
Ctrl_VTG_HP	[0_1]	Control signal of the high-pressure variable-geometry turbocharger (VGT)
Ctrl_WGate	[0_1]	Control signal of the turbocharger with the wastegate valve
Ctrl_WGate_HP	[0_1]	Control signal of high-pressure turbocharger with the wastegate valve
Fan1	[0_1]	Control signal of the first fan in the engine cooling system
Fan2	[0_1]	Control signal of the second fan in the engine cooling system
n_Engine_Idle_Set	[rpm]	Set point for the idle speed of the combustion engine
p_Ambient	[Pa]	Ambient pressure

Name	Unit	Description
phi_FMU_Energized	[deg]	Crank angle to the energize fuel metering unit (Common rail system in the combustion engine)
phi_Ign	[rad]	Vector with crank angles for the start of the fuel ignition
phi_Inj	[bTDC]	Vector with crank angles for the start of the fuel injection
PulseState	[]	Pulse state
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_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_MainRelay	[0|1]	Switch to activate the main relay of the ECU
Sw_Starter	[0|1]	Starter activate switch: ▪ 0: Off ▪ 1: On
T_Ambient	[°C]	Ambient temperature
t_Inj_Direct	[us]	Injection time vector
t_Inj_Port	[us]	Injection time vector per cylinder for manifold injection
UpdateCounter	[]	Update counter
UpdateState	[]	Update state (For details, refer to .)

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 the combustion engine

Name	Unit	Description
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	[1Off|2NotReady|3Ready|4EngStopped]	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 the combustion engine
p_Ambient	[Pa]	Ambient pressure
Pos_AccPedal	[%]	Position of the accelerator pedal
Reset_States	[0|1]	Reset states
s_Total_Vehicle_Road	[m]	Driven distance of the vehicle
T_Ambient	[°C]	Ambient temperature
V_Bat_LV	[V]	Voltage of low voltage battery
v_Vehicle	[km/h]	Vehicle velocity

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

Name	Unit	Description
Pos_EGR	[%]	EGR valve position, 0 means the valve is closed
Pos_Throttle	[%]	Position of throttle valve

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]	Engine friction torque
Trq_MeanEff_Engine	[Nm]	Mean effective engine torque
Trq_MeanEff_Engine_Mod	[Nm]	Mean effective engine torque (modulated)

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

Name	Unit	Description
Sw_Replace_Env	[0|1]	Switch for replacing the ambient conditions: ▪ 0: Off - source is parameters ▪ 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

Name	Unit	Description
		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
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

Name	Unit	Description
v_Vehicle_Ref	[km/h]	Reference vehicle velocity
v_Vehicle_Preview_Ref	[km/h]	Preview reference vehicle velocity

Start System Module

Description

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

Name	Unit	Description
		▪ 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
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 P0 Module

Description

This module contains the hybrid manager for an internal combustion engine with a belt starter generator.

The electric machine is coupled directly to the crankshaft via the belt.

The hybrid manager actuates the electric machine.

- Start/stop automation of the engine if it has reached operation temperature.
- Create more torque if gas pedal is fully pressed
- Recuperate energy during braking

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
Gear_Drivetrain	[]	Gear
n_Engine	[rpm]	Speed of combustion engine
n_EM	[rad/s]	Speed of the electric machine
Omega_In_Diff	[rad/s]	Differential input speed
Pos_AccPedal	[%]	Position of the accelerator pedal
Pos_BrakePedal	[%]	Brake pedal position
Pos_ClutchPedal	[%]	Clutch pedal position
Reset_States	[0|1]	Reset states
SOC_Bat_HV	[%]	State of charge of high-voltage battery
State_ICEngine	[0|1|2|3|4]	ICE state: ▪ 0: Off or error ▪ 1: Ignition on ▪ 2: Starter on ▪ 3: Running ▪ 4: Shut down
Sw_Ignition	[0|1]	Ignition signal - terminal 15: ▪ 0: Off ▪ 1: On
Sw_Starter	[0|1]	Switch for starter activation: ▪ 0: Off ▪ 1: On
Sw_StarterReq	[0|1]	Starter request signal (usually sent to engine ECU): ▪ 0: Off ▪ 1: On
T_Coolant_ICE	[°C]	Temperature of the engine coolant
Trq_EM	[Nm]	Torque EM
Trq_Max_Brake	[Nm]	Maximum brake torque
v_Vehicle	[km/h]	Vehicle velocity

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

Name	Unit	Description
Ignition_ICE	[0|1]	Ignition ICE: ▪ 0: Off

Name	Unit	Description
		▪ 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
Starter_Drivetrain	[0|1]	Engine starter switch: ▪ 0: Off ▪ 1: On
StarterReq_ICE	[0|1]	Starter request ICE: ▪ 0: Off ▪ 1: On
State_HybridEngine	[0|1|2|3|4]	State hybrid engine
Trq_Request_EM	[Nm]	Torque request EM

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
Starter_Drivetrain	[0|1]	Engine starter switch: ▪ 0: Off ▪ 1: On

Name	Unit	Description
StarterReq_ICE	[0|1]	Starter request ICE ▪ 0: Off ▪ 1: On
State_DCLink	[0Off|1On]	State DC link
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..... 189
Subsystems of the Engine Gasoline Module..... 192

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 (ASM Drivetrain Basic Reference 🕮)
- Gear Shifter (ASM Drivetrain Basic Reference 🕮)

Subsystems of the Engine Gasoline Module

Where to go from here

Information in this section

Air Path Subsystem..... 193
The air path simulates the compressor, the intercooler, the throttle, and the intake manifold dynamics on the intake side, and the turbine, the EGR with cooler, and the exhaust manifold on the exhaust side.

Cooling Subsystem..... 197
This **COOLER** block describes the engine cooling system. It contains a basic cooler model.

Evaporator Subsystem..... 198
The **Evaporator** system contains a passive tank evaporation system.

Exhaust System Subsystem..... 202
This model describes the engine exhaust system. It contains models for a catalyst with oxygen storage capacity and a lambda sensor.

Fuel System Subsystem..... 203
The fuel system model is provided by ASM for a common-rail system. The common-rail system consists of several modules like the high pressure pump, fuel metering unit, pressure control valve and injector.

Piston Engine Subsystem..... 207
In the **Piston Engine** subsystem, the engine combustion block describes the air flow through the inlet valve and the torque generated by the combustion process.

Soft ECU Gasoline Subsystem..... 210
The **SOFT_ECU_GASOLINE** block serves as basic gasoline engine ECU controller software without any diagnostics and is used to test the engine model in closed-loop operation when no real ECU is connected.

Air Path Control Subsystem..... 215
The **AirPathControl** collects the controller for the air path. The external setpoint of the controller are connected with to the measurement

interface that for test purpose the measurement data could be used as setpoint.

Torque Control Subsystem.....217
In the **TorqueControl** block the induced engine torque setpoint is estimated.

Air Path Subsystem

Overview

The air path simulates the compressor, the intercooler, the throttle, and the intake manifold dynamics on the intake side, and the turbine, the EGR with cooler, and the exhaust manifold on the exhaust side.

The turbocharger is modeled as a compressor and turbine connected via a turbocharger shaft. For a detailed explanation of the modeling approach, refer to Model Overview (ASM Turbocharger Reference 🕮) or Model Overview (ASM Turbocharger Light Reference 🕮).

The intercooler cools the air flow from the compressor according to the efficiency and temperature difference between the input and coolant temperature. The

throttle is modeled as an orifice with a variable cross section which limits the fresh air flow into the intake manifold.

In the intake manifold, the mass of the manifold is calculated from mass flow balance and the temperature of the manifold from energy balance (in: throttle, EGR, out: engine). The pressure follows from the ideal gas equation.

The same simulation approach is used for the exhaust manifold (in: engine, out: EGR, turbine). In contrast to the throttle, the mixing of fresh air with exhaust is calculated.

The EGR cooler cools the air flow from combustion according to the efficiency and temperature difference between input and coolant. The EGR is simulated as an orifice with variable cross section. The EGR position can increase the air flow into the intake manifold.

The next illustration is a schematic of the air path simulation approach with physical turbocharger:

In the basic turbocharger, the compressor is simulated by several look-up tables. For further information, refer to Basic Turbocharger (ASM Turbocharger Reference 🕮). The shaft and turbine are not simulated. The exhaust manifold is therefore also simulated by look-up tables.

The next illustration is a schematic of the air path simulation approach with a basic turbocharger:

Tip

A state space representation with the algebraic equations used for this approach can be found in the Equations of Air Path with Map-Based Turbocharger on page 277.

Inports

The following table shows the inports:

Name	Unit	Description
CommonParameterEngine	[]	Bus signals of CommonEngineParameters
Ctrl_CompByp_HP	[0_1]	Control signal for high-pressure stage compressor bypass
Ctrl_EGR	[0_1]	Control signal (PWM) of electrical EGR valve
Ctrl_PCV	[0_1]	Control signal of the pressure control valve for the tank evaporation
Ctrl_Throttle	[0_1]	Control signal (PWM) of electrical throttle valve
Ctrl_VCV	[0_1]	Control signal of the vapor control valve for the tank evaporation
Ctrl_VSV	[0_1]	Control signal of the vent shut valve for the tank evaporation
Ctrl_VTG	[0_1]	Control signal of variable turbine geometry
Ctrl_VTG_HP	[0_1]	Control signal of high-pressure turbine variable turbine geometry
Ctrl_WGate	[0_1]	Control signal of wastegate valve
Ctrl_WGate_HP	[0_1]	Control signal of high-pressure wastegate valve
EngineSetup	[]	Bus signals of EngineSetup
EngOP	[rpm][]	Engine operating point: n_Engine[rpm],relative airmass
lambda	[]	Lambda value after combustion process
mdot_Fuel_In_Engine	[kg|h]	Mass flow of the vaporized fuel into the engine
mdot_In_Engine_Air	[kg/h]	Mass flow of fresh air into the engine
mdot_In_Engine_Exh	[kg/h]	Mass flow of exhaust into the engine

Name	Unit	Description
mdot_Out_Engine	[kg/h]	Mass flow out of the piston engine (exhaust gas)
n_Engine	[rpm]	Engine speed
p_Ambient	[Pa]	Ambient pressure
p_ExhSystem	[Pa]	Exhaust system back pressure (pressure after turbine)
Pos_EGR_Meas	[%]	Measured throttle position at real EGR valve
Pos_Throttle	[%]	Throttle position
Reset	[]	Reset of states
SetupEngine	[]	Bus signal of the EngineSetup
Sw_MainRelay	[0_1]	Activates main relay from ECU
Switches_AirPath	[]	Bus Signals of Switches_AirPath
T_Ambient	[°C]	Ambient temperature
T_Coolant	[°C]	Coolant temperature
T_Out_Engine	[°C]	Engine output temperature
XsiAir_ExhMan	[0_1]	Mass fraction of air in the exhaust manifold
XsiExh_ExhMan	[0_1]	Mass fraction of exhaust gas in the exhaust manifold
XsiFuel_ExhMan	[0_1]	Mass fraction of fuel in the exhaust manifold

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 🕮).
mdot_Fuel_Vapor	[kg/h]	Vaporized fuel from the tank that is burned in the engine
mdot_Out_EGR	[kg/h]	Mass flow through the EGR valve
p_ExhMan	[Pa]	Exhaust manifold pressure
p_InMan	[Pa]	Intake manifold pressure (pressure before piston engine)
R_InMan	[J/(kg K)]	Gas constant of mixture in intake manifold
ratio_m_Exh_InMan	[0_1]	Ratio of exhaust mass to complete mass in intake manifold
Sw_Turbo_Model	[1|2]	Selector for the turbocharger model ▪ 1: Physical-based model ▪ 2: Look-up table-based model
T_InMan	[°C]	Intake manifold temperature
T_Out_Turb	[°C]	Compressor output temperature
Xsi_Exh_InMan	[0_1]	Mass fraction of the exhaust in the intake manifold
Xsi_Fuel_InMan	[0_1]	Mass fraction of the fuel in the intake manifold

Blocks

- Evaporator Subsystem on page 198
- EGR Valve (Mechanical) on page 18

- EGR Valve on page 20
- EGR Cooler on page 16
- Intercooler on page 26
- Exhaust Manifold on page 23
- Intake Manifold on page 28
- Mechanical Throttle on page 31
- Throttle Valve on page 32
- Turbocharger on page 34
- Air Filter on page 15

Cooling Subsystem

Overview

This COOLER block describes the engine cooling system. It contains a basic cooler model.

Inports

The following table shows the inports:

Name	Unit	Description
Fan1	[0_1]	Controller signal for first fan
Fan2	[0_1]	Controller signal for second fan
n_Engine	[rpm]	Engine speed
Q_dt_ext	[W]	External heat flow to the coolant
SW_T_Water_Mode	[1|2]	Switch for mode ▪ 1: Temperature calculated internally ▪ 2: Temperature set externally
T_Ambient	[°C]	Ambient temperature
T_Coolant_ext	[°C]	External coolant temperature for user setting
T_Coolant_Init	[°C]	Initial coolant temperature

Name	Unit	Description
Trq_MeanFric_Engine	[Nm]	Mean friction torque
Trq_MeanInd_Engine	[Nm]	Mean indicated torque

Outports

The following table shows the outports:

Name	Unit	Description
T_Coolant	[°C]	Coolant temperature

Blocks

- Cooler on page 56

Evaporator Subsystem

Description

The Evaporator system contains a passive tank evaporation system.

In gasoline engines, a tank evaporation system is used to check the tank for leakages and to prevent the vaporizing fuel from contaminating the environment.

Thre are two prepared models. You can implement them in the ASM Gasoline Engine model without the need to change the rest of the model.

- Evap_Interface:

  This is a default model for the evaporation system. The mass flow into the intake manifold is always zero. If an evaporation system is not needed, this model saves computation time.
- Evap_Evaporator_System:

  This model contains an evaporation system which calculates the mass flow of vaporized fuel from the fuel tank to the intake manifold depending on the actuation of the valves.

For an overview of the subsystems, refer to the following illustration.

For information on how to replace the model, refer to How to Replace the Evaporator Models (ASM Gasoline Engine Model Description 🕮)

The following illustration shows an overview of the implementation and the most important physical values:

For an overview of the subsystem, refer to the following illustrations of the **Evap** subsystem:

Inports

The following table shows the inports:

Name	Unit	Description
Ctrl_PCV	[0_1]	Control signal for the pressure control valve

Name	Unit	Description
Ctrl_VCV	[0_1]	Control signal for the vapor control valve
Ctrl_VSV	[0_1]	Control signal for the vent shut valve
p_Ambient	[Pa]	Ambient pressure
p_InMan	[Pa]	Intake manifold pressure
R_InMan	[J/(kgK)]	Gas constant in the intake manifold
Reset	[0|1]	Reset of states
T_Ambient	[°C]	Ambient temperature
T_Fuel_Liquid	[°C]	Temperature of the fuel in the tank
T_InMan	[°C]	Temperature in the intake manifold
V_Tank_Vapor	[m^3]	Free volume in the tank

Outports

The following table shows the outports:

Name	Unit	Description
mdot_Air_Out_Evap	[kg/h]	Air flow into the intake manifold from the evaporation system
mdot_Fuel_Out_Evap	[kg/h]	Fuel flow into the intake manifold from the evaporation system
mdot_Fuel_Vapor	[kg/h]	Fuel vaporization from the fuel tank
T_Out_Evap	[°C]	Flow temperature leaving the evaporation system

Blocks

- CANISTER (refer to Canister - Evaporator System on page 34)
- LEAK (refer to Leak - Evaporator System on page 37)
- PURGE_CONTROL_VALVE (refer to Purge Control Valve - Evaporator System on page 38)
- TANK_GASPHASE (refer to Tank Gasphase - Evaporator System on page 39)
- VAPOR_CONTROL_VALVE (refer to Vaporator Control Valve - Evaporator System on page 42)
- VENT_SHUT_VALVE (refer to Vent Shut Valve - Evaporator System on page 44)

Related topics

HowTos

How to Replace the Evaporator Models (ASM Gasoline Engine Model Description 🕮)

References

Canister (ModelDesk Parameterizing 🕮)
Leak (ModelDesk Parameterizing 🕮)
Purge Control Valve (ModelDesk Parameterizing 🕮)
Tank Gasphase (ModelDesk Parameterizing 🕮)
Vapor Control Valve (ModelDesk Parameterizing 🕮)
Vent Shut Valve (ModelDesk Parameterizing 🕮)

Exhaust System Subsystem

Overview

This model describes the engine exhaust system. It contains models for a catalyst with oxygen storage capacity and a lambda sensor.

The following illustration shows the exhaust system model.

Inports

The following table shows the inports:

Name	Unit	Description
EngOP[rpm]	[]	Engine operating point
Lambda	[]	Delayed lambda value
mdot_Out_EGR	[kg/h]	Mass flow through EGR (air and exhaust)
mdot_Out_Engine	[kg/h]	Mass flow out of the piston engine (exhaust gas)
p_Ambient	[Pa]	Ambient pressure
Reset	[]	Reset of states

Blocks

- Catalyst on page 59
- Lambda Sensor on page 62

Fuel System Subsystem

Overview

The fuel system model is provided by ASM for a common-rail system. The common-rail system consists of several modules like the high pressure pump, fuel metering unit, pressure control valve and injector. In the following , the common-rail system is described. For a detailed description of this kind of fuel system, refer to Direct Injector on page 74.

The common rail fuel system provides fuel for injection stored at high pressures in one chamber for all cylinders. This chamber is called the common rail. Common-rail systems enable fuel to be stored at high pressures independently of engine speed.

The fuel system contains a high-pressure pump, a pressure control valve, injectors, and the rail itself. The following illustration shows the Simulink **FuelSystem** block.

The following illustration shows a scheme of a common-rail fuel system.

The following illustration shows the Simulink **FuelSystem** model.

The common-rail system consists of:

- High-pressure system
- Rail
- Direct injector

The high-pressure system compresses the fuel to the required pressure in the rail. There are two models of the high-pressure system:

- Current-based
- Crank-based

The two systems differ in terms of how the way the rail pressure is regulated.

In the current-based approach, the regulation is based on two components:

- HIGH_PRESSURE_PUMP
- PRESSURE_CONTROL_VALVE

The process can be simplified as follows: The high-pressure pump builds up the pressure in the rail and the pressure control valve reduces it. The control signal for both components is the current signal. In the crank-based approach, the fuel

is delivered to the rail as needed. Here, the control signal is the crank angle degree. The model consists of one component (HPP_CRANKBASED).

Inports

The following table shows the inports:

Name	Unit	Description
CrankAngle_Cyl	[aTDC]	Crank angle per cylinder, positive value is after TDC
Ctrl_FuelMeterUnit	[mA]	Control signal (current) of fuel metering unit for common rail
Ctrl_PresCtrlValve	[mA]	Control signal (current) of pressure control valve for common rail
mdot_Fuel_Vapor	[kg/h]	Vaporized fuel that is burned in the engine
n_Engine	[rpm]	Engine speed
p_Ambient	[Pa]	Ambient pressure
p_InMan	[Pa]	Intake manifold pressure
phi_CamShaft_Offset_Exhaust	[deg]	Angle of the exhaust valve phasing in degree
phi_CamShaft_Offset_Intake	[deg]	Angle of the intake valve phasing in degree
phi_FMU_energized	[deg]	Start of energization of fuel metering unit
phi_Inj_Direct	[bTDC]	Injection start angle vector (cylinder 1, pulse 1, pulse 2, ..., cylinder n, pulse m)
Reset	[]	Reset all integrators to initial states
Sw_MainRelay	[0_1]	Activates main relay from ECU
T_Ambient	[°C]	Ambient temperature
t_Inj_Direct	[µs]	Injection time vector per cylinder for direct injection
t_Inj_Port	[s]	Injection time vector per cylinder for manifold injection
U_Bat	[]	Battery voltage

Outports

The following table shows the outports:

Name	Unit	Description
mdot_Fuel_Homogen	[kg/h]	Injected fuel mass for homogeneous combustion
mdot_Fuel_Stratified	[kg/h]	Injected fuel mass for stratified combustion
phi_Main_Inj	[aTDC]	Injection angel of main injection
q_Inj_Cyl	[mm^3/cyc]	Injection quantity per cylinder (vector of number of cylinders)
T_Fuel_Liquid	[°C]	Temperature of the liquid fuel in the tank
V_Tank_Vapor	[m^3]	Free volume in the tank

Blocks

- Rail on page 90
- High-Pressure Pump on page 78
- Pressure Control Valve on page 89

- High-Pressure Pump (Crank-Based) on page 80
- Direct Injector on page 74
- Port Injector on page 85
- Fuel Tank on page 76
- Select Fuel Injection (Former Version) on page 220
- Port Injector Fuel Supply CNG Model on page 87
- CNG High-Pressure Line on page 65
- CNG Pressure Regulator on page 66
- CNG Rail on page 68
- CNG Shutoff Valve on page 70
- CNG Tank on page 72

Piston Engine Subsystem

Overview

In the **Piston Engine** subsystem, the engine combustion block describes the air flow through the inlet valve and the torque generated by the combustion process. The effective torque consists of the mean indicated torque and the friction torque. The effects of the injection angle and of the air/fuel ratio are included as two efficiencies. The following illustration shows the subsystems.

The combustion torque is modeled as a mean value. To simulate the individual cylinder torques, a crank angle based function is multiplied by the mean indicated torque.

Inports

The following table shows the inports:

Name	Unit	Description
CrankAngle_Cyl	[aTDC]	Crank angle per cylinder, positive value is after TDC
Ctrl_CamPhase_Exhaust	[0_1]	Control signal for the exhaust cam phaser
Ctrl_CamPhase_Intake	[0_1]	Control signal for the intake cam phaser
mdot_Fuel_Homogen	[kg/h]	Injected fuel mass for homogeneous combustion
mdot_Fuel_Stratified	[kg/h]	Injected fuel mass for stratified combustion
mdot_In_Engine_Fuel	[kg/h]	Mass flow of the vaporized fuel into the engine
n_Engine	[rpm]	Engine speed
p_Ambient	[Pa]	Ambient pressure

Name	Unit	Description
p_ExhMan	[Pa]	Exhaust manifold pressure
p_InMan	[Pa]	Intake manifold pressure (pressure before piston engine)
phi_Ign_Cyl	[rad]	Ignition angle per cylinder
phi_Main_Inj	[bTDC]	Injection angel of main injection
q_Inj_Cyl	[mm^3/cyc]	Injection quantity per cylinder (vector of number of cylinders)
R_InMan	[J/(kg K)]	Gas constant of mixture in intake manifold
Reset	[]	Reset states
T_Coolant	[°C]	Coolant water temperature
T_InMan	[°C]	Intake manifold temperature
Xsi_Exh_InMan	[0_1]	Exhaust gas fraction in the intake manifold
Xsi_Fuel_InMan	[0_1]	Fuel fraction in the intake manifold

Outports

The following table shows the outports:

Name	Unit	Description
lambda_Out_Engine	[]	Lambda value after combustion process
mdot_In_Engine_Air	[kg/h]	Mass flow of fresh air into the engine
mdot_In_Engine_Exh	[kg/h]	Mass flow of exhaust into the engine
mdot_In_Engine_Fuel	[kg/h]	Mass flow of the vaporized fuel into the engine
mdot_Out_Engine	[kg/h]	Mass flow out of the piston engine (exhaust gas)
phi_CamShaft_Offset_Exhaust	[deg]	Angle of the exhaust valve phasing in degree crank angle
phi_CamShaft_Offset_Intake	[deg]	Angle of the intake valve phasing in degree crank angle
RelAirmass	[]	Relative airmass of combustion process
T_Out_Engine	[°C]	Engine output temperature
Trq_MeanEff_Engine_Mod	[Nm]	Mean effective engine torque
Trq_MeanFric_Engine	[Nm]	Mean friction torque
Trq_MeanInd_Engine	[Nm]	Mean induced engine torque
Xsi_Air_Comb	[0_1]	Mass fraction of the air after the combustion
Xsi_Exh_Comb	[0_1]	Mass fraction of the exhaust gas after the combustion
Xsi_Fuel_Comb	[0_1]	Mass fraction of the fuel after the combustion

Blocks

- Wall Film on page 115
- Cylinder Inlet on page 106
- Stratified Combustion Torque on page 99
- Combustion Temperature CI on page 97
- Homogeneous Combustion Torque on page 103
- Combustion Temperature SI on page 98
- Friction Torque on page 109

- Crankcase on page 108
- Pump Torque on page 111
- Combustion Mode Switch on page 96
- Camshaft Phaser Intake on page 94
- Camshaft Phaser Exhaust on page 93
- Mass Fraction on page 110

Soft ECU Gasoline Subsystem

Overview

The SOFT_ECU_GASOLINE block serves as basic gasoline engine ECU controller software without any diagnostics and is used to test the engine model in closed-loop operation when no real ECU is connected. Its inputs are standard sensor signals and the outputs are standard actuators.

The soft ECU can be divided into three sections with the following functionalities:

- Pre-calculation and operation mode selection
- Control algorithms
- Signal selection

The following illustration shows these three sections and the contained subsystems.

Pre-calculation and operation mode selection This part manages the sensor data preparation for the control algorithms and detects the current engine operating point. The section contains the following subsystems:

- SoftECU_EngOperation - Engine operation detection
- SoftECU_Trq_Engine - Engine torque calculation and engine operation mode detection
- RelAirmass Calculation - Calculation of relative air mass from the current throttle air mass flow

In SoftECU_EngOperation, the engine operation state is detected from the ignition and starter request switch and engine speed. It also activates the starter and the main relay (terminal 87). Four different engine states are possible.

- Engine off = 0
- Ignition on = 1
- Ignition on and starter activated = 2
- Engine is running = 3
- Ignition is switched of, shutdown active = 4

The SoftECU_Trq_Engine contains all torque-based functions. The setpoint is calculated from the engine speed and accelerator pedal position. For small accelerator pedal positions, the idle speed controller is active. Additionally, the engine operation mode detection is preformed. This function detects the combustion mode (stratified or homogeneous combustion) depending on the requested engine torque and the current engine speed. The following illustration shows the switch conditions.

In RelAirmass Calculation, the actual relative air mass is calculated.

Control algorithms This part holds all control algorithm for offline operation of the engine model. The section contains the following subsystems.

- Homogeneous Mode - Enabled subsystem for homogeneous engine operating point controller.
- Stratified Mode - Enabled subsystem for stratified engine operating point controller.

- SoftECU_AirPath - Controller for engine air path
- RailPressure Control - Controller for rail pressure
- SoftECU APU - Calculation of the cylinder individual crank angle

In Homogeneous Mode, the engine is operated with a stoichiometric air/fuel ratio. This subsystem is enabled by a signal from SoftECU_Trq_Engine if a homogeneous operation mode has been detected. The stratified mode will be disabled while the homogeneous mode is activated. The subsystem contains controllers for injection time calculation for manifold injection, ignition angle calculation, controller for the throttle position from the desired engine torque and injection time calculation for direct injection.

In Stratified Mode, the engine is operated with a lean air/fuel ratio. This subsystem is enabled by a signal from SoftECU_Trq_Engine if a stratified operation mode has been detected. The homogeneous mode will be disabled while the stratified mode is activated. The subsystem contains controllers for injection time calculation for direct injection and ignition angle calculation.

The SoftECU_AirPath contains control functions for the EGR valve and the turbine of the turbocharger (wastegate or VGT).

Signal selection This part selects the corresponding control signals for homogeneous or stratified engine operation mode.

Inports

The following table shows the inports:

Name	Unit	Description
CrankAngle_Cyl	[aTDC]	Vector with crank angles for each cylinder
Factor_Trq_Engine_Red	[%]	Engine torque reduction factor when shifting gears
Gear	[]	Gear
mdot_EGR	[kg/h]	Mass flow through the EGR valve
mdot_Out_Throttle	[kg/h]	Mass flow through the throttle
n_Engine	[rpm]	Engine speed
p_ExhMan	[Pa]	Exhaust manifold pressure
p_Fuel	[Pa]	Port injector input pressure
p_in_Throttle	[Pa]	Input pressure of throttle
p_InMan	[Pa]	Intake manifold pressure
p_Rail	[bar]	Rail pressure
phi_CamShaft_Offset	[deg]	Camshaft offset due to valve train variability
Pos_AccPedal	[%]	Accelerator pedal position
Pos_BrakePedal	[%]	Brake pedal position
Pos_ClutchPedal	[%]	Clutch pedal position
Reset	[]	Reset of states
SelectorLever	[-3|-2|-1|0|1]	Selector lever position: ▪ -3: TipShift ▪ -2: Park ▪ -1: Reverse

Name	Unit	Description
		▪ 0: Neutral ▪ 1: Drive
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
T_Ambient	[°C]	Ambient temperature
T_Coolant	[°C]	Coolant temperature
T_InMan	[°C]	Temperature in the intake manifold
U_Bat	[V]	Battery voltage
v_Vehicle	[km/h]	Vehicle velocity

Outports

The following table shows the outports:

Name	Unit	Description
CrankAngle_Cyl	[aTDC]	Vector with crank angles for each cylinder
Ctrl_EGR	[0_1]	Control signal of electrical EGR valve
Ctrl_FuelMeterUnit	[mA]	Control signal of fuel metering unit for common rail
Ctrl_PresCtrlValve	[mA]	Control signal of pressure control valve for common rail
Ctrl_TC_Signals	[0_1]	Turbocharger control signal bus
Ctrl_Throttle	[0_1]	Control signal of electrical throttle valve
phi_FMU_energized	[deg]	Start of fuel metering unit's control
phi_Ign	[bTDC]	Ignition angle vector (cylinder 1, ..., cylinder n)
phi_Inj_Direct	[bTDC]	Direct injection angle vector (cylinder 1 pulse 1, cylinder 1 pulse 2, ..., cylinder n pulse m)
Sw_MainRelay	[0|1]	Activate switch for main relay from ECU
Sw_Starter	[0|1]	Starter activate switch (output of ECU)
t_Inj_Direct	[us]	Direct injection time vector (cylinder 1 pulse 1, cylinder 1 pulse 2, ..., cylinder n pulse m)
t_Inj_Port	[us]	Port injection time vector (cylinder 1 pulse 1, cylinder 1 pulse 2, ..., cylinder n pulse m)

Blocks and subsystems

- SoftECU Setup on page 154.
- Engine Operation on page 132.
- Injector Mode on page 139.
- Relative Air Mass Calculation on page 152.
- Crank Angle Calculation on page 127.
- Start-Stop System on page 157.
- Air Path Control Subsystem on page 215.

- Torque Control Subsystem on page 217.
- FuelSystem Control.

Related topics

References

History of the SOFT_ECU_GASOLINE Block..... 264

Air Path Control Subsystem

Overview

The **AirPathControl** collects the controller for the air path. The external setpoint of the controller are connected with to the measurement interface that for test purpose the measurement data could be used as setpoint.

Inports

The following table shows the inports:

Name	Unit	Description
mdot_Comp	[kg/h]	Mass flow through compressor
mdot_EGR	[kg/h]	Mass flow through the EGR valve
n_Engine	[rpm]	Engine speed
p_ExhMan	[Pa]	Exhaust manifold pressure
p_InMan	[Pa]	Intake manifold pressure
RelAirmass	[]	Relative air mass flow
State_Engine	[0|1|2|3|4]	Engine state ▪ 0: Engine off ▪ 1: Ignition on ▪ 2: Ignition on and starter activated

Name	Unit	Description
		▪ 3: Engine is running ▪ 4: Ignition is switched off, shutdown active
Sw_Injection_Mode	[1|2]	Injection mode ▪ 1: Homogeneous ▪ 2: Stratified
Trq_Engine_Ind_Set	[Nm]	Induced engine torque setpoint

Outports

The following table shows the outports:

Name	Unit	Description
Ctrl_EGR	[0_1]	Control signal of electrical LP EGR valve
Ctrl_TC_Signals	[]	Turbocharger control signal bus
Ctrl_Throttle	[0_1]	Control signal of electrical throttle valve
phi_EO_Set	[deg]	Exhaust valve open setpoint
phi_IO_Set	[deg]	Inlet valve open setpoint

Blocks

- EGR Rate Control on page 131
- Throttle Control on page 162
- VVT Setpoint (ASM Base InCylinder Reference 🕮)

Torque Control Subsystem

Description

In the TorqueControl block the induced engine torque setpoint is estimated. The driver desired toque is lifted by the idle speed controller to keep the idle speed.

Inports

The following table shows the inports:

Name	Unit	Description
n_Engine	[rpm]	Engine speed
Pos_AccPedal	[%]	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
T_Coolant	[°C]	Coolant temperature

Outports

The following table shows the outports:

Name	Unit	Description
Trq_Engine_Ind_Set	[Nm]	Induced engine torque setpoint

Blocks

- Engine Torque Set on page 134
- Engine Torque Set Intervention on page 135
- Idle Speed Control on page 136

Blocks from Former Versions

Introduction

The following topics provide information on blocks that are used in previous library versions.

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Catalyst (Former Version).....219
This is a former version of the CATALYST block.

Select Fuel Injection (Former Version).....220
The SELECTFUELINJECTION block switches between the results of the injector blocks depending on whether the engine is driven with a direct injection or a port injection system.

SoftECU Gasoline Engine Former Version.....221
The SOFT_ECU_GASOLINE_12_0 block is used to test the engine model in closed-loop operation when no real ECU is connected.

Catalyst (Former Version)

Description

The catalyst consists of two second-order delay elements which delay the lambda signal from the combustion simulation.

The delay elements are used for modeling pre- and post catalyst oxygen sensors by assuming different time constants for the delay elements.

Inports

The following table shows the inports:

Name	Unit	Description
Lambda	[]	Delayed lambda value
Reset	[]	Resets all integrators in the block to their initial conditions

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 🕮).

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_T1_lambda_In_Cat	[]	Time constant 1 of the lambda sensor before catalyst
Const_T1_lambda_Out_Cat	[]	Time constant 1 of the lambda sensor after catalyst
Const_T2_lambda_In_Cat	[]	Time constant 2 of the lambda sensor before catalyst
Const_T2_lambda_Out_Cat	[]	Time constant 2 of the lambda sensor after catalyst

Related topics

References

Catalyst Gasoline V4 (ModelDesk Parameterizing 🕮)

Select Fuel Injection (Former Version)

Description

The SELECTFUELINJECTION block switches between the results of the injector blocks depending on whether the engine is driven with a direct injection or a port injection system.

The SELECTFUELINJECTION block was moved to a former version. In the demo model the results of the port and direct injection system are added as sum, so that both injectors can be used at the same time, depending on the control strategy.

Inports

The following table shows the inports:

Name	Unit	Description
mdot_Fuel	[kg/h]	Total injection mass flow into cylinder (vector of number of cylinders)
mdot_Fuel_Homogen_In	[kg/h]	Injection mass flow into cylinder (vector of number of cylinders) (homogeneous mode)
mdot_Fuel_Stratified_In	[kg/h]	Injection mass flow into cylinder (vector of number of cylinders) (stratified mode)
q_Inj_Cyl_In	[mm^3/cyc]	Injection quantity per cylinder (vector of number of cylinders)
Sw_Injection	[0|1]	Switch to select the injection model ▪ 0: Direct injection ▪ 1: Port injection

Outports

The following table shows the outports:

Name	Unit	Description
mdot_Fuel_Homogen	[kg/h]	Injection mass flow into cylinder (vector of number of cylinders) (homogeneous mode)
mdot_Fuel_Stratified	[kg/h]	Injection mass flow into cylinder (vector of number of cylinders) (stratified mode)
mdot_Fuel_Total	[kg/h]	Total injection mass flow into cylinder (vector of number of cylinders)
q_Inj_Cyl	[mm^3/cyc]	Injection quantity per cylinder (vector of number of cylinders)

SoftECU Gasoline Engine Former Version

Description

The SOFT_ECU_GASOLINE block serves as basic gasoline engine ECU controller software without any diagnostics and is used to test the engine model in closed-loop operation when no real ECU is connected. Its inputs are standard sensor signals and the outputs are standard actuators.

The soft ECU can be divided into three sections with the following functionalities:

- Pre-calculation and operation mode selection
- Control algorithms
- Signal selection

The following illustration shows these three sections and the contained subsystems:

The first section *pre-calculation and operation mode selection* manages the sensor data preparation for the control algorithms and detects the current engine operating point. The section contains the following subsystems.

- SoftECU_EngOperation - Engine operation detection
- SoftECU_Trq_Engine - Engine torque calculation and engine operation mode detection
- RelAirmass Calculation - Calculation of relative air mass from the current throttle air mass flow

In *SoftECU_EngOperation*, the engine operation state is detected from the ignition and starter request switch and engine speed. It also activates the starter and the main relay (terminal 87). Different engine states are possible:

- Engine off = 0
- Ignition on = 1
- Ignition on and starter activated = 2
- Engine is running = 3
- Ignition is switched of, shutdown active = 4

The *SoftECU_Trq_Engine* contains all torque-based functions. The setpoint is calculated from the engine speed and accelerator pedal position. For small accelerator pedal positions, the idle speed controller is active. Additionally, the engine operation mode detection is performed. This function detects depending on the requested engine torque and the current engine speed the combustion mode (stratified or homogeneous combustion). The following illustration shows the switch conditions:

In *RelAirmass Calculation*, the actual relative air mass is calculated.

The second section *control algorithms* holds all control algorithm for offline operation of the engine model. The section contains the following subsystems.

- Homogeneous Mode - Enabled subsystem for homogeneous engine operating point controller.
- Stratified Mode - Enabled subsystem for stratified engine operating point controller.
- SoftECU_AirPath - Controller for engine air path
- RailPressure Control - Controller for rail pressure
- SoftECU APU - Calculation of the cylinder individual crank angle

In *Homogeneous Mode*, the engine is operated with a stoichiometric air/fuel ratio. This subsystem is enabled by a signal from SoftECU_Trq_Engine if a homogeneous operation mode has been detected. The stratified mode will be disabled while the homogeneous mode is activated. The subsystem contains

controllers for injection time calculation for manifold injection, ignition angle calculation, controller for the throttle position from the desired engine torque and injection time calculation for direct injection.

In *Stratified Mode*, the engine is operated with a lean air/fuel ratio. This subsystem is enabled by a signal from SoftECU_Trq_Engine if a stratified operation mode has been detected. The homogeneous mode will be disabled while the stratified mode is activated. The subsystem contains controllers for injection time calculation for direct injection and ignition angle calculation.

The *SoftECU_AirPath* contains control functions for the EGR valve and the turbine of the turbocharger (wastegate or VGT).

The last section *Signal selection* selects the corresponding control signals for homogeneous or stratified engine operation mode.

Inports

The following table shows the inports:

Name	Unit	Description
mdot_Out_Throttle	[kg/h]	Air mass flow through throttle (HFM sensor)
n_Engine	[rpm]	Engine speed
p_Ambient	[Pa]	Ambient pressure
p_InMan	[Pa]	Intake manifold pressure
p_Rail	[bar]	Rail pressure (absolute)
Pos_AccPedal	[%]	Position of the accelerator pedal
Pos_EGR	[%]	EGR valve position, 0 means valve is closed
Reset	[]	Resets all integrators in the block to their initial conditions
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
T_Coolant	[°C]	Coolant water temperature
T_InMan	[°C]	Intake manifold temperature

Outports

The following table shows the outports:

Name	Unit	Description
CrankAngle_Cyl	[aTDC]	Crank angle per cylinder, positive value is after TDC
Ctrl_EGR	[0_1]	Control signal (PWM) of electrical EGR valve
Ctrl_FuelMeterUnit	[mA]	Control signal (current) of fuel metering unit for common rail
Ctrl_PresCtrlValve	[mA]	Control signal (current) of pressure control valve for common rail
Ctrl_TC	[0_1]	Control signal (PWM) of electrical VGT or wastegate valve

Name	Unit	Description
phi_Ign	[rad]	Ignition angle
phi_Inj	[bTDC]	Injection start angle vector (cylinder 1, pulse 1, pulse 2, ..., cylinder n, pulse m)
Pos_Throttle	[%]	Control signal of throttle valve
Sw_MainRelay	[0_1]	Activate switch for main relay from ECU
Sw_Starter_Mode	[0|1]	Starter activate switch (output of ECU)
t_Inj	[µs]	Injection time per cylinder for manifold injection
t_Inj_Direct	[µs]	Injection time per cylinder for direct injection

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_enable_FMU_n_Engine	[rpm]	Minimum engine speed to enable fuel metering unit
Const_enable_FMU_q_Inj	[mm^3/cyc]	Minimum injected fuel quantity to enable fuel metering unit
Const_I_Idle	[]	I gain for idle speed controller
Const_I_max_Ctrl_FuelMeterUnit	[mA]	Maximum current for fuel metering unit
Const_I_max_Ctrl_PresCtrlValve	[mA]	Maximum current for pressure control valve
Const_I_p_rail_FMU_set	[]	I gain for rail pressure controller FMU
Const_I_p_rail_set	[]	I gain for rail pressure controller
Const_I_p_Turbo_Set	[]	I gain for turbo pressure controller
Const_I_Pos_EGR_set	[]	I gain for EGR position controller
Const_I_Throttle	[]	I gain for throttle controller
Const_Lambda_Set	[]	Constant lambda setpoint
Const_m_Air_max	[kg]	Maximum air mass flow through the throttle
Const_max_num_Cyl	[1_20]	Maximum number of cylinders
Const_max_num_Inj	[1_8]	Maximum number of injections
Const_mdot_fuel_Gain	[s]	Offset time of the fuel injection system
Const_mdot_fuel_Offset	[kg/s]	Gain of the fuel injection system
Const_n_Engine_EngineOn	[rpm]	Minimum engine speed for engine operation mode is on
Const_n_Engine_UpLim	[rpm]	Engine speed limit. The soft ECU stops injection if the engine reaches this speed limit.
Const_P_Idle	[]	P gain for idle speed controller
Const_P_p_Turbo_Set	[]	P gain for turbo pressure controller
Const_P_Pos_EGR_set	[]	P gain for EGR position controller
Const_P_p_rail_FMU_set	[]	P gain for rail pressure controller FMU
Const_P_p_rail_set	[]	P gain for rail pressure controller
Const_P_Throttle	[]	P gain for throttle controller
Const_phi_Inj_Cylx	[bTDC]	Start angles of injection pulses for every cylinder for stratified mode. Length is Const_num_Inj.

Name	Unit	Description
Const_phi_Inj_Cylx_homogen	[bTDC]	Start angles of injection pulses for every cylinder for homogeneous mode. Length is Const_num_Inj.
Const_PosThrottle_Min	[%]	Minimum accelerator pedal position for enable of idle speed control
Const_q_Inj_Cylx_rel	[bTDC]	Distribution of t_Mean_Inj to injection vector for every cylinder [-]. Length is Const_num_Inj, sum of elements is 1.
Map_Lambda_Set	[]	Lambda setpoint map Map_Lambda_Set = f(n_Engine,Trq_Engine)
Map_n_Engine_StratifiedSwitch	[rpm]	Engine speed values for switching between stratified and homogeneous model
Map_n_EngineIdle_Set	[rpm]	Target idle speed map, n_EngineIdle Map_n_EngineIdle_Set = f(T_EngineCoolant)
Map_q_inj_Smoke_Limit	[mm^3/cyc]	Smoke limitation map Map_q_inj_Smoke_Limit = f(n_Engine, mdot_In_Air)
Map_p_InMan_Set	[Pa]	Turbo pressure setpoint map Map_p_InMan_Set = f(n_Engine, q_Inj_1cyl)
Map_p_rail_set	[Pa]	Static rail pressure setpoint map Map_p_rail_set = f(n_Engine, q_Inj_1cyl)
Map_phi_ign_opt	[rad]	Table with optimum ignition angle f = (Engine speed, lambda_a)
Map_Pos_EGR_Set	[Pa]	Static EGR position setpoint map Map_Pos_EGR_Set = f(n_Engine, q_Inj_1cyl)
Map_RelAirmass_Set	[]	Torque to relative airmass conversion map Map_RelAirmass_Set = f(Trq_MeanEff_Eng)
Map_t_Injection	[µs]	Injection timing map Map_t_Injection = f(q_Injection, p_Rail)
Map_Trq_Driver	[Nm]	Requested driver torque map Map_Trq_Driver = f(Pos_AccPed, n_engine)
Map_Trq_Engine_Max	[Nm]	Maximum allowed engine torque table Map_Trq_Engine_Max = f(n_engine)
Map_Trq2Quant	[mm^3/cyc]	Torque to quantity conversion map Map_Trq2Quant = f(Trq_MeanEff_Eng)
Map_Trq_Engine_StratifiedSwitch	[Nm]	Engine torque values for switching between stratified and homogeneous model
Map_VolEff	[]	Volumetric efficiency
StepSize	[s]	Simulation step size
Sw_Lambda_Set	[]	Switch to select lambda setpoint source ▪ 1: Map ▪ 2: Const

Related topics

References

Soft ECU Gasoline V12 (ModelDesk Parameterizing 🕮)

New Features/Migration History of the ASM Engine Gasoline 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 🕮).

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General Changes to the ASM Engine Gasoline Blockset

Release 2020-A

V engine capability Vector capability was introduced for all combustion blocks to simulate V engines. You can select possible V engine parameterizations for the **ENGINE_SETUP** block in ModelDesk.

Release 2019-B

ASM Engine Testbench has new functionalities. Refer to Changes to all ASM Products (ASM User Guide 🕮).

Release 2018-B

Resettable delay The **Unit Delay Resettable** block from the slupdate library was replaced with the **Delay** block from the Discrete Simulink library. The blocks behave in exactly the same way. This was done to avoid warnings. The **Unit Delay Resettable** block will be discontinued by MATLAB in the future.

This applies to the following blocks:

- CYLINDER_INLET
- DIRECTINJECTOR
- DIRECTINJECTOR_TIMING
- EGR_RATE_CONTROL
- ENGINE_OPERATION
- HPP_CRANKBASED
- IGNITION_SET
- INJECTOR_MODE
- PORTINJECTOR_TIMING
- PUMP_TORQUE
- RAIL_CONTROL
- RAIL_CONTROL_CRANKBASED
- TRIGGER_INJ_UPDATE

Release 2018-A

Variable valve train The demo models contains a blockset for simulating variable valve actuation. The camshaft phase can be adjusted by a cam phaser block. In the Gasoline Engine model, this does not affect the engine output. The

blockset consists of mechanical models for simulating the change rate of the camshaft offset. There are also control blocks for controlling the camshaft phaser. The control algorithm is based on the operatign point of the engine.

The following blocks were added to the library:

- CAM_PHASER_INTAKE_CONTROL
- CAM_PHASER_INTAKE
- CAM_PHASER_EXHAUST_CONTROL
- CAM_PHASER EXHAUST

Reset All blocks that contain integrators and memory blocks are reset at the same time when the reset is active. Even if the simulation contains an NaN or Inf value, the simulation is restored when you click the Reset button in the ControlDesk layout.

The Reset inport was added. The affected blocks are:

- CYLINDER_INLET
- PUMP_TORQUE
- DIRECTINJECTOR
- CATALYST
- IGNITION_SET
- INJECTOR_MODE
- PORTINJECTOR_TIMING
- RAIL_CONTROL
- TRIGGER_INJ_UPDATE
- ENGINE_OPERATION
- DIRECTINJECTOR_TIMING
- EGR_RATE_CONTROL
- RAIL_CONTROL_CRANKBASED

Integrators The continuous integrators are replaced by discrete integrators. The affected blocks are:

- CATALYST
- COOLER
- LAMBDA_SENSOR
- FUELTANK
- RAIL
- CNG_HIGH_PRESSURE_LINE
- CNG_PRESSURE_REGULATOR
- CNG_RAIL
- CNG_SHUTOFF_VALVE
- CNG_TANK

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:

- AIRFILTER
- CNG_SHUTOFF_VALVE
- COOLER
- CNG_PRESSURE_REGULATOR
- COMBUSTION_TORQUE_CI
- COMBUSTION_TORQUE_SI
- CRANKCASE
- CYLINDER_INLET
- DIRECTINJECTOR
- DIRECTINJECTOR_TIMING
- EGRCOOLER
- EGR_RATE_CONTROL
- EGR_VALVE
- ENGINE_TORQUE_SET
- EXHAUST_MANIFOLD
- FRICTION_TORQUE, FRICTION_TORQUE_3_0
- HIGH_PRESSURE_PUMP
- HPP_CRANKBASED, HPP_CRANKBASED_1_0
- IGNITION_SET
- INJECTION_QUANTITY
- INJECTOR_4_0
- INJECTOR_MODE
- INTERCOOLER
- LAMBDA_CONTROL
- PORTINJECTOR
- PORTINJECTOR_TIMING
- PRESSURE_CONTROL_VALVE
- PUMP_TORQUE
- RAIL
- RAIL_CONTROL
- RAIL_CONTROL_CRANKBASED
- REL_AIRMASS_MAPBASED
- SOFT_ECU_GASOLINE_12_0
- THROTTLE_MECHANICAL
- THROTTLE_VALVE
- WALL_FILM

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:

- EGR_VALVE
- ENGINE_SETUP

- EXHAUST_MANIFOLD
- HPP_CRANKBASED
- INTAKE_MANIFOLD
- RAIL_CONTROL_CRANKBASED
- THROTTLE_MECHANICAL

Release 2016-A

MDL_PAR Environment New parameters and signals have been introduced to make it possible to mix stimulated and controlled signals. The new parameters describe different simulation modes. These can be used in all maneuver types for the manual or automatic control of the engine model in HIL and Simulink simulation.

For example, it is now possible to use the stimulus accelerator and brake pedals while the driver controls the selector lever or the gear as well as the clutch pedal.

Scope handling During migration, all disabled scopes within the model need to be restored to ensure that the model works properly, including the new scope handling procedure. You might have to disable these scopes again after migration. You can easily disable scopes via the Scope Handling GUI button provided by ASM. This makes direct use of the commenting feature in Simulink.

Release 2015-B

New blocks The following blocks are new to the blockset:

- CNG_PRESSURE_REGULATOR
- CNG_SHUTOFF_VALVE
- CNG_HIGH_PRESSURE_LINE
- CNG_TANK
- CNG_RAIL

Test cycles The Ftp_75 test cycle has been updated with an engine switch-off phase. After a total duration of 1369 seconds, the engine is switched off for 10 minutes. This is then followed by a warm engine restart.

Moreover, the new test cycle WLTC (Worldwide Harmonized Light Vehicle Test Procedure) with three classes (depending on the power-to-mass ratio) has been implemented. The new test cycles can be found in the test cycles folder of the new engine demos.

Release 7.3

An integrator reset has been inserted to support a global reset in the ASM mean value engine models.

The library blocks have been adapted to support reverse engine rotations, for example, for start-stop applications.

Release 6.6

The ASM Engine Gasoline Operator Blockset is new. It is the operator version of the ASM Engine Gasoline 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 AIRFILTER Block

Release 2016-A

A memory block was removed from the library block and placed before the **mdot_AirFilter[kg|h]** inport of the library block.

Related topics

References

Air Filter..... 15

History of the AMBIENT_CONDITIONS Block

Release 2020-B

This block is new. You can use it for switching the ambient temperature and pressure between constant conditions, measurement data, and calculated values based on altitude.

Related topics

References

Ambient Conditions..... 123

History of the CATALYST Block

Release 2018-B

A new inport was added to the block: **p_Ambient[Pa]**. It is used to initialize the integrator of the **CATALYST/Pressure_Drop/PT1** block. Until now, the integrator was initialized with a constant block. During migration, a constant block with the

original value is added to the new p_Ambient[Pa] inport to obtain the same functionality as before.

Until now, the PT1 block in Mapbased_T_In_Cat had incorrect connections. Therefore, the Mapbased_T_In_Cat block could not be used in the simulation. This was corrected.

Release 2018-A

The Forward Euler block from the ASM Utils Library had a fixed sample time of 0.001 seconds. The integrator of the Forward Euler block was replaced by a discrete integrator with inherited sample time.

Release 2016-B

A new catalyst model has been implemented, which considers oxygen storage and heat balance. The former version of the block is changed to the CATALYST_4_0. During migration, the library link of the block is changed to CATALYST_4_0.

Release 7.3

The block has been adapted to support engine reset functionality.

Release 6.4

The Const_T1_lambda_sens_a_Cat, Const_T2_lambda_sens_a_Cat, Const_T1_lambda_sens_b_Cat, and Const_T2_lambda_sens_b_Cat parameters have been moved from the PT2 mask to a constant block.

Related topics

References

Catalyst 59

History of the COMBUSTION_MODE_SWITCH Block

Release 2020-A

The mass fraction and lambda calculations are now performed by different blocks and their equations.

Release 7.2

The Xsi_i_ExhMan output is added to provide a sufficient interface for the physical turbocharger.

Release 7.1

A lambda calculation which includes injection mass flows (stratified and homogeneous) was added. This means that the lambda value is not zero if the injected fuel mass is zero, for example, in the event of a fuel cut-off.

Release 6.5

The COMBUSTION_MODE_SWITCH block improves switching between stratified and homogeneous combustion.

Related topics

References

Combustion Mode Switch.....96

History of the COMBUSTION_TEMPERATURE_CI Block

Release 2020-A

This block is new. It calculates the combustion temperature that was previously calculated in the COMBUSTION_TORQUE_CI block.

Related topics

References

Combustion Temperature CI.....97

History of the COMBUSTION_TEMPERATURE_SI Block

Release 2020-A

This block is new. It calculates the combustion temperature that was previously calculated in the COMBUSTION_TORQUE_CI block.

Related topics

References

Combustion Temperature SI.....98

History of the COMBUSTION_TORQUE_x Block

Release 2020-A

The blocks now have the same block structure.

The calculations for combustion temperature and overall lambda values were moved to other blocks.

The V engine support is now taken into account for all equations.

Release 2013-A

Calculation of a modulated cylinder pressure (p_MeanInd_Cyl_Mod[bar]) has been introduced and included in the ASMSignalBus.

Release 7.3

The block has been adapted to support engine reset functionality.

An engine temperature map has been connected to cylinder pressure, which is scaled with efficiencies. This avoids calculation of high temperatures in incombustible conditions.

The **Map_phi_inj_opt** parameter has been renamed **CombustionTorque** so that workspace parameters are unique in the model

Release 7.0

The evaluation of the mean temperature has been modified together with some internal block adaptations without any functional changes.

Release 6.6

The block was updated to correct the lambda value calculation. The **lambda_Cyl** signal is added to the **ASMSignalbus**.

Related topics

References

Homogeneous Combustion Torque 103
Stratified Combustion Torque 99

History of the COMMON_ENGINE_PARAMETERS Block

Release 2016-B

In dSPACE Release 2015-B and Release 2016-A, the internal calculations of **cpFuel** and **cvFuel** in the **COMMON_ENGINE_PARAMETERS** block were connected to the wrong outports. This is now corrected under the mask of the block.

However, to keep simulation results reproducible, the connections to the outports **cp_Fuel[J|[kgK]]** and **cv_Fuel[J|[kgK]]** are interchanged during migration so that **cp_Fuel[J|[kgK]]** is connected to the **cv_Fuel** Goto tag, for example. You can manually undo this so that **cp_Fuel[J|[kgK]]** is connected to **cp_Fuel**.

Note

This is necessary only if the CNG system of the ASM Gasoline Engine Blockset is used.

Release 2015-B

The Const_kappa_Fuel parameter has been added for calculations with gaseous fuel.

For this, the block has been expanded by the corresponding outports:

- kappa_Fuel[]
- cv_Fuel[J|[kgK]]
- cp_Fuel[J|[kgK]]

Release 2014-B

The Const_Rm and Const_Q_LHV parameters are added in the pre-migrate variant.

Related topics

References

Common Engine Parameters.....48

History of the COMMON_GASOLINE_PARAMETERS Block

Release 2014-B

The COMMON_GASOLINE_PARAMETERS block is discontinued. It is split up into the COMMON_ENGINE_PARAMETERS and ENGINE_SETUP blocks.

The original parameters are assigned to the new blocks. The COMMON_GASOLINE _PARAMETERS block has been converted to a regular Common_Gasoline_Parameters Simulink subsystem containing the new blocks.

Release 2014-A

The parameter Const_num_Inj_Port has been introduced due to the SoftECU update.

Release 7.3

Goto/from tags have been moved out of the library block.

Parameters for pump torque support have been inserted.

Injection matrix definition has been inserted in the common parameters block.

Release 7.2

The polynomial coefficients for evaluating the specific enthalpy and specific heat capacity for a gas composition in the engine air path are introduced. The names of engine- and fuel-specific constants are also unified.

Release 7.1	The block and signal names for the label Const_num_Cyl are now the same. No functional changes were made.
Release 6.4	For using the same real-time code with different cylinder counts, a new parameter, Const_num_Cyl_vector, has been added to the COMMON_GASOLINE_PARAMETERS block. This parameter is a vector of length 20. For each cylinder, there is a vector element containing a value of 1. For example, if there are four cylinders, the first four vector elements each contain a 1, the remaining elements contain a 0.
Release 6.2	The Mux block has been replaced by the BusCreator block for creating bus signals.

History of the COOLER Block

Release 7.3	The block has been adapted to support engine reset functionality. Negative engine speed is taken into account.
Release 6.5	The COOLER block contained incorrect unit conversion in the power calculation. This has been fixed. To achieve the same model behavior after migration, scaling for inports and parameters has been inserted. If you use ModelDesk to parameterize the engine model, the ModelDesk and ASMParameterization projects must be updated manually before generating initialization files and downloading parameters to the Simulink model or real-time hardware to achieve the same model behavior with the current parameter set. The following steps have to be performed: 1. Adapt the parameters in the ASMParameterization project ▪ Open the ASMParameterization project. ▪ Navigate to the Parameters – EngineGasoline – Cooler page. ▪ Open the parameter file. ▪ Change the following parameters: ▪ Const_T_dt_Coolant.v by a factor of 1/(2*pi) ▪ Const_P_Gain_Coolant_Controller.v by a factor of (2*pi) ▪ Const_Q_dt_Fan1.v, Const_Q_dt_Fan2.v by a factor of (2*pi) ▪ Save the ModelDesk project. 2. Adapt the cooler parameters in the ModelDesk project. ▪ Open the ModelDesk project. ▪ Navigate to the Engine Gasoline – Cooler Gasoline parameter page.

- Change the following parameters:
  - Time constant of basic cooler by a factor of 1/(2*pi)
  - Proportional gain for temperature controller by a factor of (2*pi)
  - Gain for air cooling with fan / with external fan1 / with external fan2 by a factor of (2*pi)

  This has to be done in all COOLER parameter M files in the project.
- Save the ModelDesk project.

3. Generate initialization files from either ASMParameterization or ModelDesk for all variants.
4. Remove the changes which were inserted in the post-migration file:
   - In the Simulation.current directory of the project, open the _asmmigrate300post\IniFiles\asmmigrate300_cooler_ini.m file.
   - Remove the passage inside the marks

     `%=== START COOLER PARAMETER SCALING ===%` and

     `%=== END COOLER PARAMETER SCALING ===%`

Related topics

References

Cooler 56

History of the CYLINDER_INLET Block

Release 2020-A

Memory blocks for loop prevention were moved to the demo model.

The parameter for relative air mass calculation was replaced by an ENGINE_SETUP signal.

V engine support is now taken into account for all equations.

Release 7.3

Saturation for n_engine has been added to avoid backward rotation in the cylinder inlet and thus reverse engine mass flow during start-stop applications.

Related topics

References

Cylinder Inlet 106

History of the CRANKCASE Block

Release 7.3	To simulate the pump torque effect, a crankcase block has been integrated to simulate the crankcase pressure of the engine.
Related topics	References Crankcase..... 108

History of the DIRECTINJECTOR Block

Release 2016-B	To improve the turnaround time of the simulation model, the **Const_Inj_Matrix** parameter (routed by the GoToFrom connection of the **ENGINE_SETUP** block) has been deleted. The block requires the **ENGINE_SETUP** block of the current release (Version 5.0). The **DIRECTINJECTOR** block includes the **Sw_InjMode** parameter to switch the injection mode from mean to pulse. Until now, this was located in the **SWITCHES_INJ_MODE** block.
Release 2015-B	The block has been fixed for use with 20 cylinders. There was a bug assigning the injection supposed to be in cylinder 20 to cylinder 19.
Release 7.3	To define the injection matrix uniquely in the model, the parameter has been moved to the **COMMON_PARAMETERS** block. Negative engine speed is taken into account by evaluating the absolute value of the engine speed.
Release 7.2	**MDL.Const.rho_Fuel** in **ASMSignalCollector** is replaced by a corresponding Goto-From connection.
Release 6.6	Evaluation of the mean injected volumetric fuel mass flow q_Inj[mm3|s] has been improved.
Release 6.5	The pulsed injection mode has been updated, such that the enable flag is generated at a crank angle corresponding to the **Angle_Cyl** input signal. The **Const_phi_Inj_MeasUpdate** variable has to be initialized in [aTDC].

Release 6.4	The parameters of the number of cylinders and the number of injections have been replaced by the maximal number of cylinders and the maximal number of injections.
Release 6.2	The simulation step size and the iteration number of **For Iterator** subsystems have been added to the masks of this block. Now all the parameters of a library block are parameterized via the mask.
Related topics	References Direct Injector 74

History of the EGR_COOLER Block

Release 2017-B	The efficiency map that is based on the engine operating point (Map_eta_Cooler parameter) was removed. The Map_eta_Cooler_phy parameter (efficiency map based on the physical model) was renamed to Map_eta_Cooler. The new Sw_State_Cooler parameter was introduced to switch off the EGR cooler. The p_In_EGRCoorler inport and p_Out_EGRCooler outport were removed, because the process in the model is isobaric. The unit of the mass flow entering the block was changed from [kg/s] to [kg/h]. A former version block (**EGRCOOLER_4_0**) was created.
Release 7.2	The cooler's efficiency can now also be calculated by a map which is a function of the mass flow through the cooler and the temperature difference between the coolant and the incoming gas. The new map, which is a function of the mass flow through the cooler and the temperature difference between the coolant and the incoming gas, is parameterized with default data. If you want to use the new approach, it is recommended to copy and adapt the related parameterization function from the current demo model and create new initialization files with ASMParameterization.

Release 7.0

Internal block adaptations have been performed without any functional changes. Vector-based massflow calculations are now possible.

Related topics

References

EGR Cooler 16

History of the EGR_RATE_CONTROL Block

Release 2020-B

The data type of the **State_Engine[0|1|2|3|4]** inport was changed from *uint8* to *double*.

Related topics

References

EGR Rate Control 131

History of the EGR_VALVE Block

Release 2017-B

The former **EGR_VALVE** block is split into a physical model (**EGR_VALVE** in dSPACE Release 2017-B) and a mechanical model (**EGR_VALVE_MECHANICAL**).

The new **EGR_VALVE** block is vectorial, i.e., it can simulate multiple branches of the air path simultaneously.

The mass flows of the air and the exhaust gas are calculated on the basis of the mass fractions. The direction of the mass flow is switched on the basis of the pressure difference on both sides of the valve. The T_Out_EGR[degC] outport was removed, because the process in the model is isothermal.

A former version block (**EGR_VALVE_5_0**) was created.

Release 2016-B

The **Ctrl2Pos_EGR** parameter has been renamed to **Map_Ctrl2Pos**.

The **Map_A_red** parameter has been renamed to **Map_A_Red**.

Release 2015-A

The internal variable **PsiFun** has been renamed to **MapPsi**, to provide generic function sets for valves in ModelDesk Processing. No functional change has been performed.

Release 7.3

The block has been adapted to support engine reset functionality.

Internal subsystems have been restructured without any functional change. Some trace paths of internal block variables have therefore changed. If those variables are connected in a ControlDesk layout, the connections must be updated.

Release 7.2

The lower saturation value of lambda is changed from 0 to 1 for evaluating the mass flow components to avoid negative air mass flow during EGR actuation with lambda less than 1.

Related topics

References

EGR Valve 20

History of the EGR_VALVE_MECHANICAL Block

Release 2017-B

The new **EGR_VALVE_MECHANICAL** block calculates the position of the EGR valve according to a control signal. By switching off the supply of the valve, a constant position (rest position) is specified.

Related topics

References

EGR Valve (Mechanical) 18

History of the ENGINE_SETUP Block

Release 2020-A

The block has new parameters to support V engines:

- Const_max_num_InMan
- Const_max_num_ExhMan
- Const_num_InMan

- Const_num_ExhMan
- Map_InMan2Cyl
- Map_ExhMan2Cyl

Calculations for active V engine components and cylinder distributions were added to the block.

Release 2019-A

The error message that is displayed when a dimension parameter is changed (e.g., by ModelDesk download) was improved and standardized.

Release 2016-B

There is a new version of this block and the former version is changed to ENGINE_SETUP_4_0. During migration, the library link of the ENGINE_SETUP block is changed to ENGINE_SETUP_4_0. For the new features of the block, use the ENGINE_SETUPblock together with a current version of the injector blocks (DIRECTINJECTOR, UNIT_INJECTOR) as these work as a pair with ENGINE_SETUP.

To improve the turnaround time of the simulation model, the Const_Inj_Matrix parameter has been deleted. In addition, the corresponding outport of the parameter is used for the new signal active_Inj_Direct[].

The signal Sw_Turbo_Stage[:1SingleStage|2TwoStage] was renamed to Sw_Turbo_Stage[1SingleStage|2TwoStage]. Several outports were also renamed.

Release 2016-A

The Const_num_Cyl_vector parameter was removed.

Release 2015-B

The ENGINE_SETUP block now has additional switches for parameterization with ModelDesk:

- Const_max_num_PortInjector_PressureDrop
- Sw_Turbo_Stage[1SingleStage|2TwoStage]
- Sw_Turbo_Model [1phys|2LUT]

Until now, this parameterization was done by the SWITCHES_TURBO block.

The Sw_Turbo_Model_[1phys|2LUT] and Sw_Turbo_Stage_[1SingleStage|2TwoStage] outports are new. These changes have an effect in the engine model if the turbocharger model contains the Turbo_Adv model and/or the Turbo_2Stage model.

The turbo model can now be switched from the ModelDesk Engine Setup page if the turbocharger model included in the engine model contains the components.

Release 2015-A

New parameters (Const_max_num_Rail, Const_num_SCR_Cell, Const_num_ExhSys) are introduced in the pre-update variant of the ASM project

(…`\Simulation\_asmmigratepre\IniFiles\mig1400\enggas\mig1400_engine_setup.m`). For detailed information on pre-update variants, refer to Project Consistency (ASM User Guide 🕮).

Release 2014-B

The ENGINE_SETUP block is new. It contains the basic mechanical parameters of the engine. It also contains parameters used to control the engine and set the dimensions of the signals used inside the EngineGasoline model.

The Const_max_num_Inj_Direct and Const_max_num_Inj_Port are added in the pre-migrate variant.

The parameter value of MDL.EngineGasoline.Const.Const_max_num_Cyl is assigned to the MDL.EngineGasoline.Setup.Const_max_num_Cyl parameter in the postmigrate variant.

The parameter value of MDL.EngineGasoline.Const.Const_max_num_Inj.v is assigned to MDL.EngineGasoline.Setup.Const_max_num_Inj_Direct in the postmigrate variant.

The Const_max_num_Inj_Direct, Const_max_num_Inj_Port and Const_max_num_Cyl parameters are used to match the signal sizes in the engine model to the external model or the real ECU in the MDL_In system. Also, the ASM models from the Operator libraries will use these values to define the dimensional input to the S-function placed under their masks.

The functionality to write these values with ModelDesk is new. Therefore they have to be manually specified in ModelDesk after migration of the ModelDesk project. In the MATLAB/Simulink model, this is automatically done in the pre- and postmigrate inifiles written by the ASM migration. After executing go for the second time in MATLAB (migration is completed), check the model structure for these values and enter them in the corresponding engine setup gasoline page in ModelDesk. Model structure:

MDL.EngineGasoline.Setup.Const_max_num_Cyl

MDL.EngineGasoline.Setup.Const_max_num_Inj_Port

MDL.EngineGasoline.Setup.Const_max_num_Inj_Direct

Related topics

References

Engine Setup 50

History of the ENGINE_TORQUE_SET_INTERVENTION Block

Release 2020-B

The electric machine torque from the belt-integrated starter generator is now taken into consideration for the combustion torque request during battery charging.

Release 2016-B

The ENGINE_TORQUE_SET_INTERVENTION block has been introduced to facilitate the engine torque intervention during the gearshift process.

Related topics

References

Engine Torque Set Intervention..... 135

History of the EXHAUST_MANIFOLD Block

Release 2017-B

In this version, the sum blocks of the incoming mass flows and the enthalpy flows inside the energy balance are vectorial, i.e., the EXHAUST_MANIFOLD block can simulate several benches of the air path simultaneously.

The block differentiates between the air and the exhaust gas in the calculation of the temperature and the pressure.

It has new outports for the gas constant (R_ExhMan[J|(kgK)]) as well as the mass fractions of the air (Xsi_Air_ExhMan[0_1]) and the exhaust gas (Xsi_Exh_ExhMan[0_1]) inside the exhaust manifold.

A former version block (EXHAUST_MANIFOLD_7_0) was created.

Release 7.4

A reset condition has been inserted to switch between the map-based and physical turbocharger approach during simulation.

Release 7.3

The block has been adapted to support engine reset functionality.

Internal subsystems have been restructured without any functional change. Some trace paths of internal block variables have therefore changed. If those variables are connected in a ControlDesk layout, the connections must be updated.

Release 7.1	The block name Const_k_InMan[???] was changed to Const_k_InMan[W|(m2K)] to correct the unit. Data connections for this variable in ControlDesk might be corrupted after updating this block.
Release 7.0	The integrator lower limits have been set to zero. Summation blocks have been inserted to allow vector-based massflow inputs.
Release 6.6	The block is internally restructured without influencing its functionality.
Related topics	References Exhaust Manifold.....23

History of the FRICTION_TORQUE Block

Release 2020-A	The name of the block in the ASMSignalBus has been changed from Friction_Torque to Friction. The signal name on the bus has also been renamed from Trq_Engine_MeanFric[Nm] to Trq_Fric_Engine[Nm]. During the migration process, the original signal names are restored.
Release 2014-B	The look-up table in the FRICTION_TORQUE block is calculated as a map for friction torque and not as a map for friction pressure.
Release 7.3	The friction torque evaluation has been adapted to also process negative engine speeds, for example, for start-stop applications.
Related topics	References Friction Torque.....109

History of the HIGH_PRESSURE_PUMP Block

Release 2014-B

The parameter of the discontinued SWITCHES_FUEL_METER_UNIT_1_0 block has been moved to the HIGH_PRESSURE_PUMP block. In former versions, the SWITCHES_FUEL_METER_UNIT parameter was an inport to the HIGH_PRESSURE_PUMP model. Thus, in the postmigrate variant of the HIGH_PRESSURE_PUMP, the setting of the new to old parameter structure takes place and the old inport is terminated in the model. The Map_V_dead and Const_p_Low parameters are added during premigration.

Related topics

References

High-Pressure Pump.....78

History of the HPP_CRANKBASED Block

Release 2019-B

The HPP_CRANKBASED block can now handle negative values of the phi_FMU_Energized control signal.

Release 2019-A

The error message that is displayed when a dimension parameter is changed (e.g., by ModelDesk download) was improved and standardized.

Release 2016-B

StepSize_Correction is introduced to stabilize the rail pressure. The stabilization is required while using the pulsed high-pressure pump at high engine speeds. The DeliveryLength_Correction is extended by the UpdateState_Correction, which is necessary for the mean-value approach.

The Sw_FMU_Energized[0Off|1On] signal is delayed by an iteration step during the calculation of the volume flow in the pulsed mode.

Release 2016-A

The calculation of delivery length was modified. The variable is calculated with the approaching cam instead of the past one.

There are two new block parameters:

- With the new Const_phi_Camshaft_InitOffs parameter, the offset of the camshaft against the crankshaft can be varied more easily.
- With the new Const_max_num_HPPCam parameter, a maximum number of cams can be defined. This way, the maximum size of the vector can be defined. With this parameter, you can switch between different variants with different numbers of high-pressure cams.

The sorting algorithm of the FMU control signal in ascending order was removed. Instead of this algorithm, the ranges of the current compression stroke are defined. The element of the phi_FMU_Energized[deg] control signal that fits the range is used for the calculation of the delivery length.

Cut event handling was introduced. An event is cut when the control signal to energize the fuel metering unit is interrupted by the end of the capture window of the I/O.

Two new parameters are introduced to the pre-migrate variant of the block (`_asmmigratepre` folder): Const_phi_Camshaft_InitOffs and Const_max_num_HPPCam.

The Const_phi_Camshaft_InitOffs parameter is initialized with the value **8**, which is the maximum size of the phi_FMU_energized[deg] vector. It is recommended to reduce the value to the number of cams of the high-pressure pump. In this case, code generation is required.

Several signals in the ASMSignalBus have been renamed.

The Sw_Mode_FMU_Control parameter was removed.

Release 2015-B

The block has been modified to also account for negative TDC offset definitions.

In order to take pump cycles without FMU actuation into account, the vector containing the FMU actuation information will now be reordered. Based on that, the pump block will consider only the actuation signals that belong to the current pump cycle.

Release 2015-A

A former version of this block has been created: HPP_CRANKBASED_1_0

Release 2014-B

The HPP_CRANKBASED block includes a new model for a high-pressure pump of a fuel system. It calculates the volume flow through the high-pressure pump as a function of the crank angle.

The block contains two modeling approaches:

- A mean value modeling approach
- A pulsed modeling approach

Both approaches use the fuel delivery time as the source of volume calculation. The control signal of this pump is the start of the energization (closing) of the fuel metering unit in degrees of the crank angle.

Related topics

References

High-Pressure Pump (Crank-Based) 80

History of the IDLE_SPEED_CONTROL Block

Release 2020-B	The data type of the **State_Engine[0|1|2|3|4]** inport was changed from *uint8* to *double*.
Release 2020-A	The size of the **Map_Trq_Engine_Max** parameter was changed from [14,2] to [21,2] values.
Release 2016-B	During migration, the **Trq_Engine_Ind_Max[Nm]** outport is terminated.
Release 7.3	This block is new.
Related topics	References Idle Speed Control..... 136

History of the IGNITION_SET Block

Release 2020-B	The data type of the **State_Engine[0|1|2|3|4]** inport was changed from *uint8* to *double*.
Related topics	References Ignition Set..... 138

History of the INJECTOR Block

Release 2015-A	A former version of this block has been created: **Injecor_4_0**.
Release 2014-A	The parameter **Const_num_Inj_Port** has been introduced due to the SoftECU update.

Release 2013-A

Because the dead time (offset time) of an injector depends on the battery voltage, a look-up-table has been introduced for this dependency.

Due to the new dependency of the offset time on the battery voltage, the required map is evaluated with respect to the offset time, which you have to parameterize.

Release 7.3

Negative engine speed is taken into account by evaluating the absolute value of the engine speed.

History of the INJECTOR_MODE Block

Release 2020-B

The data type of the State_Engine[0|1|2|3|4] inport was changed from *uint8* to *double*.

Release 2016-B

The Sw_Mode_Strat parameter has been added to the block to conveniently deactivate stratified mode.

Related topics

References

Injector Mode..... 139

History of the INTAKE_MANIFOLD Block

Relase 2017-B

In this version, the sum blocks of the incoming mass flows and the enthalpy flows inside the energy balance are vectorial, i.e., the INTAKE_MANIFOLD block can simulate multiple branches of the air path simultaneously.

The block considers the mass flow of the fuel, which can come from fuel evaporation system.

The ratio_m_Exh_InMan[0_1] outport was removed. Use the Xsi_Exh_InMan[0_1] outport instead.

A former version block (INTAKE_MANIFOLD_6_0) was created.

Release 7.3

The block has been adapted to support engine reset functionality.

Release 7.0	The integrator lower limits have been set to zero. Summation blocks have been inserted to allow vector-based massflow inputs.
Release 6.6	The block is internally restructured without influencing its functionality.
Related topics	References Intake Manifold.....28

History of the INTERCOOLER Block

Release 2017-B	The efficiency map that is based on the engine operating point (Map_eta_Cooler parameter) was removed. The Map_eta_Cooler_phy parameter(efficiency map based on the physical model) was renamed to Map_eta_Cooler. The new Sw_State_Cooler parameter was introduced to switch off the intercooler. The p_In_InterCooler inport and p_Out_InterCooler outport was removed, because the process in the model is isobaric. The unit of the mass flow entering the block was changed from [kg/s] to [kg/h]. A former version block (**INTERCOOLER_5_0**) was created.
Release 2013-A	In the intercooler subsystem, the threshold switches have been changed from 0 to 0.5.
Release 7.2	The cooler's efficiency can now also be calculated by a map which is a function of the mass flow through the cooler and the temperature difference between the coolant and the incoming gas. The new map, which is a function of the mass flow through the cooler and the temperature difference between the coolant and the incoming gas, is parameterized with default data. If you want to use the new approach, it is recommended to copy and adapt the related parameterization function from the current demo model and create new initialization files with ASMParameterization.

Release 7.0

Internal block adaptations have been performed without any functional changes. Vector-based massflow calculations are now possible.

Related topics

References

Intercooler 26

History of the LAMBDA_CONTROL Block

Release 2018-B

Division by zero is now avoided if lambda is set to zero by the simulation.

Related topics

References

Lambda Control 142

History of the LAMBDA_SENSOR Block

Release 2016-B

A new lambda sensor has been developed to consider sensor heating.

Related topics

References

Lambda Sensor 62

History of the MASS_FRACTION Block

Release 2020-A

This block is new. It is used to compute the mass flow and gas components during combustion. It includes calculations of mass fractions for unburned fuel, unburned air, exhaust, and lambda.

Related topics

References

Mass Fraction..... 110

History of the PORTINJECTOR Block

Release 2016-A

Internal calculation of **q_Mean_Inj[mm3|cyc]** was introduced to the block and added to the ASMSignalCollector.

Release 2015-B

The block can now calculate a lower fuel quantity if the pressure difference between the fuel supply and the intake manifold is low. This is used in compressed natural gas engines.

The **Map_mdot_Fuel_Gain_Red** parameter has been added. Two new inports for fuel pressure difference calculation have been created: **p_InMan[Pa]** and **p_Fuel[Pa]**.

The new parameters and inputs will be set up so that the new functionality has no effect.

Release 2015-A

A new block has been introduced to replace the old **INJECTOR** block. The internal interpretation of the injector offset time has been changed for consistency reasons.

Related topics

References

Port Injector..... 85

History of the PORTINJECTOR_TIMING Block

Release 2015-B

The block can now calculate a higher injection time to account for a lower fuel quantity if the pressure difference between the injector fuel supply and the intake manifold is too low.

The **Map_mdot_Fuel_Gain_Red** parameter has been added. Two new inports for fuel pressure difference calculation have been created: **p_InMan[Pa]** and **p_Fuel[Pa]**.

The PORTINJECTOR_TIMING block can be used with multiple air intake engine setups, such as V-engines. The Map_Inj2Cyl and Const_max_num_PortInjector_PressureDrop parameters are used to assign the intake manifold, injection and cylinder.

The new parameters and inputs will be set up so that the new functionality has no effect.

Related topics

References

Port Injector Timing..... 143

History of the PRESSURE_CONTROL_VALVE Block

Release 2018-A

The Sw_PresCtrlValve[1On|2Off] inport was removed. Instead, there is a new parameter: Sw_PresCtrlValve. In previous versions, the parameter was located in an external SWITCHES_PRES_CTRL_VALVE block, which does not exist anymore. There are former versions of the two new blocks: SWITCHES_PRES_CTRL_VALVE_2_0 and PRESSURE_CONTROL_VALVE_4_0.

During migration, the library link of the PRESSURE_CONTROL_VALVE block is changed to the PRESSURE_CONTROL_VALVE_4_0 block.

Related topics

References

Pressure Control Valve..... 89

History of the PUMP_TORQUE Block

Release 2020-A

The torque calculation now supports two stroke engines.

Release 2014-B

The calculation of the compression and the implementation of the piston pressure difference have been modified.

Release 7.3

The PUMP_TORQUE block calculates the engine pump torque (gas exchange and compression torque) throughout the entire engine cycle. Torque is evaluated

synchronously to the crank angle. The torque generation can be enabled separately by using the appropriately switches.

Related topics

References

Pump Torque..... 111

History of the RAIL Block

Release 2014-B

The block has a new parameter: Const_T_Rail.

The Const_T_Rail parameter is added in the pre-migrate variant.

Related topics

References

Rail..... 90

History of the RAIL_CONTROL Block

Release 2020-B

The data type of the State_Engine[0|1|2|3|4] inport was changed from *uint8* to *double*.

Related topics

References

Rail Control..... 146

History of the RAIL_CONTROL_CRANKBASED Block

Release 2020-B

The data type of the State_Engine[0|1|2|3|4] inport was changed from *uint8* to *double*.

Release 2019-A	The error message that is displayed when a dimension parameter is changed (e.g., by ModelDesk download) was improved and standardized.
Release 2018-A	There is a new inport: phi_CamShaft_Offset_Exhaust[deg]. The phi_CamShaft_Offset[deg] inport has been renamed to phi_CamShaft_Offset_Intake[deg].
Release 2016-B	Bubble sort has been removed.
Release 2016-A	The phi_FMU_Energized[deg] outport signal is sorted in ascending order and modulated to a 720-degree crank angle. There are two new block parameters: ▪ With the new Const_max_num_HPPCam parameter, a maximum number of cams can be defined. This way, the maximum size of the vector can be defined. With this parameter, you can switch between different variants with different numbers of high-pressure cams. ▪ With the Const_i_HighPresPump parameter, the transmission ratio between the engine and pump can be set. To initialize the model with the correct initial conditions, a memory block is applied to the Trigger[0Hold|1Pass] signal. The phi_FMU_energized[deg] outport was renamed phi_FMU_Energized[deg]. The block now has a new parameter in the pre-migrate variant (`_asmmigratepre` folder): Const_max_num_HPPCam The parameter is initialized with the value **8**, which is the maximum size of the phi_FMU_energized[deg] vector. It is recommended to reduce the value to the number of cams of the high-pressure pump. In this case, code generation is required. There are two new parameters in the postmigrate variant (`_asmmigratepost` folder): Const_i_HighPresPump and Const_num_Cam. The new parameters are mapped with the parameters of the HPP_CRANKBASED block.
Release 2015-B	The Const_disable_FMU_q_Inj, Const_enable_FMU_n_Engine, and Const_enable_FMU_q_Inj parameters have been removed, as these thresholds have no functional influence anymore. The change has no functional effect on the model behavior. The Map_eta_DeltaAngle parameter has been renamed to Map_phi_FMU_energized. The change has no functional effect on the model behavior.

The **Map_phi_FMU_FF** parameter has been added in order to improve the control strategy by means of a feedforward table.

The **Sw_phi_FMU_Update** parameter has been added in order to improve the pulsed control mode with a defined pump angle update of the control variable within a pump cycle.

The **Map_ValveDelay** parameter has been added in order to account for delays in the valve actuation.

The inactive elements in the phi_**FMU_energized** output vector are now replaced by 999, in parallel to the I/O behavior. A crank angle of 999 will be interpreted as invalid in the high pressure pump plant model. Consequently, the corresponding pump cycle will not deliver any fuel to the high pressure rail.

Release 2014-B

This block is new. It serves as the controller for the **HPP_CRANKBASED** block.

It controls the rail pressure by calculating the fuel metering unit's (FMU's) setpoint of actuation. The rail pressure setpoint depends on the engine's operating point. A constant or an external setpoint can be used for testing.

The controller is a PI controller with subsequent linear control to angle conversion. A trigger mode can be enabled to calculate the start of the FMU actuation before the working cycle and to keep that starting point until the next pump's working cycle.

Related topics

References

Rail Control Crank-Based..... 147

History of the REL_AIRMASS_MAPBASED Block

Release 2017-A

A calculation and an outport for the mass flow into the engine were added. The actual mass flow into the engine might differ from the mass flow through the throttle valve. Using the mass flow through the throttle valve as the mass flow into the engine causes an incorrect injection calculation at transient operating points and produces oscillations on fixed operating points.

Release 2016-A

The **REL_AIRMASS_MAPBASED** block was introduced to improve the transient behavior of ASM Gasoline Engine. It is based on using a look-up table to negate the effects of changing pressure in the intake manifold. These would lead to the calculation of incorrect injection quantities in the soft ECU model.

Related topics

References

Relative Air Mass Map-Based..... 153

History of the SOFT_ECU_GASOLINE Block

Release 2014-A

The SOFT_ECU subsystem has been modularized and the former implementation has been moved to a former version. The new SOFT_ECU implementation is subdivided into separate library links for the controllers.

All controllers have been revised and you can now modify and extend the controller structure according to the current application. The new SOFT_ECU implementation is not updated in the model automatically, so that model behavior remains unchanged after migration. To use the new blocks, the SOFT_ECU subsystem must be replaced manually and the ASMPara project must be adapted.

Release 2013-A

The signals phi_Inj and phi_Ign in the ASMSignalCollector of the DirectInjection control block were swapped. These connections have been corrected.

Release 7.3

The block has been adapted to support engine reset functionality.

The Const_mdot_fuel_Gain, Const_mdot_fuel_Offset, Map_VolEff, Const_m_air_max parameters have been renamed SoftECU so that workspace parameters are unique in the model.

The crank angle splitter in SoftAPU has been corrected to evaluate the cylinder-specific crank angle.

The crank angle integration in SoftAPU for negative engine speeds has been corrected.

Release 7.2

The fixed fuel density is replaced by the gasoline common parameter using a From-Goto connection with the HomogeneousMode/SoftECU_InjectionTime/Calc_q_Injection_Homogen block. This parameter influences the evaluation of the injection timing map (HomogeneousMode/SoftECU_Injection/Injection Timing/Injection Timing Map). As the same map is used in the stratified mode, no migration is needed to maintain the stratified mode's simulation behavior. As the same From-Goto connection is used in the fuel system of the engine, this modification should enhance the control quality.

Release 6.6	The anti-windup implementation has been improved for the idle speed controller.
Release 6.4	The parameters of the number of cylinders and the number of injections have been replaced by the maximal number of cylinders and the maximal number of injections.
Release 6.2	The simulation step size and the iteration number of **For Iterator** subsystems have been added to the mask of this block. Now all the parameters of a library block are parameterized via the mask.
Related topics	References Soft ECU Gasoline Subsystem 210

History of the SOFTECU_SETUP Block

Release 2020-A	New signals from the engine are routed through.
Release 2016-B	The unit of the **Const_CylinderOffset** signal has been corrected from [] to [deg]. The underscores in the names of other inports have been removed.
Related topics	References SoftECU Setup 154

History of the START_STOP Block

Release 2020-B	The data type of the **State_Engine[0|1|2|3|4]** inport was changed from *uint8* to *double*.
Release 2017-A	A start-stop engine soft ECU was added to the engine soft ECU. It can be used to simulate the basic functionality of a start-stop system. To activate the system, you have to set the corresponding switch in the block.

Related topics

References

Start-Stop System..... 157

History of the SWITCHES_AIRPATH Block

Release 7.2

The Sw_TCStage and Sw_TurbineTypeHP switches are added to control the two-stage turbocharger.

History of the SWITCHES_DIRECT_INJ_MODE Block

Release 7.3

The switch from SWITCHES_FUELSYSTEM has been moved to support the multi-instance feature.

History of the SWITCHES_EGR_COOLER Block

Release 7.3

The switch from SWITCHES_AIRPATH has been moved to support the multi-instance feature.

History of the SWITCHES_EGR_VALVE Block

Release 7.3

The switch from SWITCHES_AIRPATH has been moved to support the multi-instance feature.

History of the SWITCHES_FUEL_METER_UNIT_BLOCK

Release 2014-B

The block has been discontinued. The block's parameter has been moved to the HIGH_PRESSURE_PUMP block.

Release 7.3	The switch from SWITCHES_FUELSYSTEM has been moved to support the multi-instance feature.

History of the SWITCHES_INJECTION Block

Release 7.3	The switch from SWITCHES_FUELSYSTEM has been moved to support the multi-instance feature.

History of the SWITCHES_INJ_MODE Block

Release 2016-B	The block was discontinued and changed to SWITCHES_INJ_MODE_1_0. During migration, the library link of the SWITCHES_INJ_MODE block is changed to SWITCHES_INJ_MODE_1_0. The switch has been moved to the DIRECTINJECTOR block.

History of the SWITCHES_INTERCOOLER Block

Release 7.3	The switch from SWITCHES_AIRPATH has been moved to support the multi-instance feature.

History of the SWITCHES_PRES_CTRL_VALVE Block

Release 2018-A	There is a former version of the SWITCHES_PRES_CTRL_VALVE block. During migration, the library link of the SWITCHES_PRES_CTRL_VALVE block is changed to the SWITCHES_PRES_CTRL_VALVE_2_0 block. The SWITCHES_PRES_CTRL_VALVE block was discontinued, i.e., it does not exist in the current Release and later.
Release 7.3	The switch from SWITCHES_FUELSYSTEM has been moved to support the multi-instance feature.

History of the SWITCHES_THROTTLE Block

Release 2014-B	The block has been discontinued.
Release 7.3	The switch from SWITCHES_AIRPATH has been moved to support the multi-instance feature.

History of the SWITCHES_TRQ_COMB_MODE Block

Release 7.3	The switch from SWITCHES_AIRPATH has been moved to support the multi-instance feature.

History of the SWITCHES_TURBO Block

Release 7.4	The link to the former version has been moved due to ModelDesk conformity by using the MAPS_TC parameter page.

History of the SWITCHES_WALL_FILM_MODE Block

Release 7.3	The switch from SWITCHES_AIRPATH has been moved to support the multi-instance feature.

History of the THROTTLE Block

Release 2014-B	The THROTTLE block no longer exists. It is replaced by two new blocks: THROTTLE_MECHANICAL and THROTTLE_VALVE. The original parameters are assigned to the new blocks. The THROTTLE block has been converted to a regular Simulink subsystem containing the new blocks.

Release 7.3

The direction of the mass flow through the throttle valve is calculated from the pressure states. The calculation of the mass flow now also includes the temperatures and pressures with respect to the flow direction.

Internal subsystems have been restructured without any functional change. Some trace paths of internal block variables have therefore changed. If those variables are connected in a ControlDesk layout, the connections must be updated.

Release 7.0

Saturations have been removed to allow backflow through the throttle and consequently pressure balancing in the intake manifold during engine standstill.

History of the THROTTLE_CONTROL Block

Release 2020-B

The data type of the State_Engine[0|1|2|3|4] inport was changed from *uint8* to *double*.

Related topics

References

Throttle Control..... 162

History of the THROTTLE_MECHANICAL Block

Release 2017-B

The THROTTLE_MECHANICAL block has a new Sw_State_ValveMechanical parameter (mask value Sw_State_Throttle) to switch off the model.

Release 2014-B

This is a new block for the calculation of the throttle valve position according to a control signal.

A switch for Pos_Throttle[%] has been added to the MDL_In block:

- When switching on **SoftECU**, the throttle position is calculated by the THROTTLE_MECHANICAL block.

- When switching on **RealECU**, the throttle position must be defined from outside the model, for example, by a real throttle valve or an external model.

Related topics

References

Mechanical Throttle 31

History of the THROTTLE_VALVE Block

Release 2014-B

This block is the successor of the THROTTLE block. Among other modifications, the Map_A_Red parameter of the THROTTLE_VALVE block has been scaled to one.

The Const_A_max is added in the pre-migrate variant.

Related topics

References

Throttle Valve 32

History of the TURBO_CONTROL Block

Release 2015-A

The block has been expanded and moved to the ASM Turbocharger Library.

History of the WALL_FILM Block

Release 2020-A

The integrator was changed from continuous to discrete and now has an external reset.

Release 2015-B

The Reset inport to this block had no effect and was fixed to work correctly.

Release 7.4

The extrapolation method for the time delay map has been changed to interpolation-extrapolation due to ModelDesk conformity.

Related topics

References

Wall Film 115

History of the Engine Gasoline Demo Model

Release 2020-B

P0 hybrid with belt-integrated starter generator A belt-integrated starter generator for simulating a hybrid vehicle with a P0 topology has been introduced to the model. You can parameterize the different driving modes and torque request maps in ModelDesk.

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.

Release 2020-A

Mapping blocks for V engine capability Different mapping blocks were introduced to combine, split, or route vector signals through the model.

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.

Measurement data handling The exchange of measurement data from ModelDesk to the ASM Engine Testbench and ASM Optimizer is now based on ModelDesk measurement data files (MD) files and not separately created measurement files (M) files.

Release 2018-A

HighPressureSystem The original HighPressurePump system of FuelSystem was renamed to HighPressureSystem. HighPressureSystem includes components for generating (regulating) pressure in the rail.

The current-based HighPressureSystem system contains the current-based highpressure pump (HIGH_PRESSURE_PUMP) and the pressure control valve, which is not required for the crank-angle-based high-pressure pump (HPP_CRANKBASED). If the crank-angle-based HighPressureSystem is selected, the model does not contain the PRESSURE_CONTROL_VALVE block.

ASM Driver A new longitudinal driver model based on a different control strategy was introduced. The new model simulates a more realistic pedal actuation. Refer to Driver (ASM Environment Reference 🕮).

Release 2017-B

AirPath The tags of the Goto/From blocks in the AirPath are not specific for a certain engine type anymore. The tags are renamed from TAG_EngineGasoline_* to TAG_Engine_*.

The GotoTagVisibility blocks have to be used.

Engine The EngineOperationPoint system is added to get the operating point of the engine in the ASMSignalBus.

Environment The ambient conditions pressure and temperature were added to the Road subsystem of the Environment system.

The switch for replacing the conditions with the measured data and the new AMBIENT bock were added.

The switch was moved from Environment/Maneuver to Environment/Road.

In the Road subsystem, the ambient conditions are added to the ASMSignalBus.

FuelConsumption The FuelConsumption system (ASM_EngineGasoline / MDLUserInterface / EngineGasoline / MDL_DISP / FuelConsumption) was modified.

The fuel consumption is summarized in one system with outputs be[g|kWh] (brake specific fuel consumption), FuelConsumption[L|100km], FuelConsumptionAver[L|100km] and FuelConsumption[L|h].

The FuelConsumptionAver[L|100km] signal is the fuel consumption averaged over the driving distance.

There is a new FuelConsumption signal. If the velocity of the vehicle is below a threshold value (default value is 1 km/h), the fuel consumption is given in [L/h], otherwise in [L/100 km].

Release 2017-A

Start-stop system soft ECU A start-stop system soft ECU was added to the engine soft ECU. The system shuts down and restarts the engine automatically and can control vehicles equipped with manual as well as automatic transmissions. The dashboard layout in the ControlDesk project was extended to show the start-stop system status.

PORTINJECTOR Division by zero is now avoided in the signal bus during the calculation of q_Mean_Inj[mm3|cyc].

Release 2016-B

Rail control Depending on the high-pressure pump used in the model, there is a current- or a crank-angle-based rail pressure controller.

Exhaust system The ExhaustSystem model has been restructured because of the new CATALYST and LAMBDA_SENSOR blocks.

Fuel system Now, the port injector and the direct injector can both be active at the same time. The amount of fuel injected into the cylinders is the sum of both injectors.

Switches of the turbo Instead of routing the entire signal bus of the ENGINE_SETUP block to the AirPath model via the GoToFrom connection, only the switches of the turbocharger model are routed. This modification improves the turnaround time of the model significantly.

Torque intervention during gearshift The engine and transmission soft ECUs are interconnected, so that an engine torque intervention can be realized during the gearshift process. The amount of the intervened torque can be parameterized in the TORQUE_INTERVENTION_CONTROL block from the SoftECU_Transmission.

Environment signal routing The routing of the environment signals has been revised and restructured. The signal routing from the MDLUserInterface to the other demo parts is now clearer and easier to track. Moreover, the signals provided to the soft ECU models have been revised and some of them have been replaced with sensor signals from ASMSignalBus.

Maneuver control The new maneuver control has been integrated in the new demo. With the new implementation, it is now possible to start, stop and reset the maneuver during the simulation on dSPACE platforms using only ModelDesk.

Release 2016-A

MDL_PAR Environment New parameters and signals were introduced to make it possible to mix stimulated and controlled signals. The new parameters describe different simulation modes. These can be used in all maneuver types for the manual or automatic control of the engine model in HIL and Simulink simulation.

For example, it is now possible to use the stimulus accelerator and brake pedals while the driver controls the selector lever or the gear as well as the clutch pedal.

Signal conditioning The I/O interface of the MDL_In subsystem now has an algorithm to process the I/O signal for the HPP_CRANKBASED block. Besides

the state information of the high-pressure pump (UpdateCounter, UpdateState, PulseState), it also considers the leading edge of the control signal. The block outport is an eight-dimensional vector. If the control signal of the pump has fewer signals, it must be extended to the expected size with dummies (e.g.: 999).

Demo parameterization Demo parameterization is now also possible for a small 1.5 l, four-cylinder turbocharged gasoline engine.

Release 2014-B

FuelSystem The FuelSystem model now contains two high-pressure pump models, one current-based and one crank-angle-based.

You can open the High-Pressure Pump library by clicking Open High Pressure Pump Models next to the HighPressurePump subsystem in the model. You can replace the HighPressurePump model via drag & drop of the block from the library.

/MDLUserInterface/Environment/MDL_PAR The signal routing has been restructured.

/MDL/Environment The signal routing has been restructured.

/MDL/Environment/Driver The SignalSelection block is no longer linked to an ASM library. It is now a Simulink subsystem.

Cooling System The signal routing has been restructured.

Throttle valve position A switch for Pos_Throttle[%] has been added to the MDL_In block:

- When switching on **`SoftECU`**, the throttle position is calculated by the THROTTLE_MECHANICAL block.
- When switching on **`RealECU`**, the throttle position must be defined from outside the model, for example, by a real throttle valve or an external model.

HighPressurePump The default high-pressure pump model is now HPP_CRANKBASED (crank-angle-based high-pressure pump) and not HIGH_PRESSURE_PUMP (current-based high-pressure pump).

Release 7.4

MDLUserInterface/Engine Gasoline/MDL_MEAS The structure of the measurement interface feature has been changed: New subsystem MDL_MEAS.

MDLUserInterface /Environment/MDL_PAR The structure of the support of the measurement interface feature has been changed. The definition of unit for the ambient temperature has been changed from [mbar] to [Pa] for consistency.

MDL/Environment/ Maneuver The structure of the support of the measurement interface feature has been changed.

MDL/Engine/Cooling System The structure of the support of the measurement interface feature has been changed: Adaptation of Goto/From block tags.

MDL/Environment/Road The definition of unit for the ambient temperature has been changed from [mbar] to [Pa].

MDL/Engine/AirPath/Turbo The inport at the MAPS_TC block has been changed.

Release 7.0

The demo model now supports plotting of simulation data in ModelDesk. The ModelDesk_Plotting block has been added to the MDL_UserInterface subsystem.

Appendix

Where to go from here

Information in this section

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Equations of Air Path with Map-Based Turbocharger

Introduction

The following equations are used for the air path model with map-based turbocharger.

Equations

State space equation:

$$\begin{bmatrix} \dot{m}_{InMan} \\ \dot{T}_{InMan} \end{bmatrix} =$$

$$\begin{bmatrix} \dot{m}_{Out,Throttle} + \dot{m}_{Out,EGR} - \dot{m}_{In,Engine} \\ \frac{c_p}{c_v m_{InMan}}\left(\dot{m}_{Out,Throttle}\, T_{Out,Throttle} + \dot{m}_{Out,EGR}\, T_{Out,EGR} - \dot{m}_{In,Engine}\, T_{InMan}\right) \\ -c_v\left(T_{InMan}\left(\dot{m}_{Out,Throttle} + \dot{m}_{Out,EGR} - \dot{m}_{In,Engine}\right)\right) - \frac{1}{c_v m_{InMan}}(T_{InMan} - T_{Ambient}) k_{InMan}\, A_{InMan} \end{bmatrix}$$

with the equation for pressure in the intake manifold (ideal gas law):

$$p_{InMan} = \frac{R}{V_{InMan}} m_{InMan} T_{InMan}$$

Algebraic equations:

$$\dot{m}_{In,\,Engine} = \lambda_A\left(p_{InMan}, n_{Engine}\right)\frac{p_{InMan}}{RT_{InMan}} V_d in_{Engine}$$

$$\dot{m}_{Out,\,EGR} = A_{EGR,\,max} g\left(Pos_{EGR}\right)\Psi\left(\frac{p_{InMan}}{p_{ExMan}}\right)$$

$$T_{Out,\,EGR} = T_{In,\,EGR} = T_{ExMan} - \eta_{EGRcooler}\left(n_{Engine}, q_{Inj,\,Engine}\right)\left(T_{ExMan} - T_{Ambient}\right)$$

$$\dot{m}_{Out,\,Throttle} = A_{Throttle,\,max} f\left(Pos_{Throttle}\right)\Psi\left(\frac{p_{InMan}}{p_{Out,\,Comp}}\right)$$

$$T_{Out,\,Throttle} = T_{In,\,Throttle} = T_{Out,\,Comp} - \eta_{Intercooler}\left(n_{Engine}, q_{Inj,\,Engine}\right)\left(T_{Out,\,Comp} - T_{Ambient}\right)$$

$$p_{ExMan} = p_{ExMan}\left(n_{Engine}, q_{Inj,\,Engine}\right)$$

$$p_{Out,\,Comp} = p_{Out,\,Comp}\left(n_{Engine}, q_{Inj,\,Engine}\right)$$

$$T_{Out,\,Comp} = T_{Out,\,Comp}\left(n_{Engine}, q_{Inj,\,Engine}\right)$$

Note

First-order time delay for compressor pressure and temperature to avoid algebraic Loop between compressor and throttle.

Equations of Air Path with Physical Turbocharger

Introduction

The following equations are used for the air path model with physical turbocharger.

Equations

State space equation:

$$\begin{bmatrix} \dot{m}_{InMan} \\ \dot{T}_{InMan} \\ \omega_{TC} \\ \dot{m}_{ExMan} \\ \dot{T}_{ExMan} \end{bmatrix} =$$

$$\begin{bmatrix} \dot{m}_{Out,Throttle} + \dot{m}_{Out,EGR} - \dot{m}_{In,Engine} \\ \frac{c_p}{c_v m_{InMan}}\left(\dot{m}_{Out,Throttle}\, T_{Out,Throttle} + \dot{m}_{Out,EGR}\, T_{Out,EGR} - \dot{m}_{In,Engine}\, T_{InMan}\right) \\ -\frac{1}{m_{InMan}}\left(T_{InMan}\left(\dot{m}_{Out,Throttle} + \dot{m}_{Out,EGR} - \dot{m}_{In,Engine}\right)\right) - \frac{1}{c_v m_{InMan}}(T_{InMan} - T_{Ambient}) k_{InMan}\, A_{InMan} \\ \sqrt{\frac{2}{J}\int\left(Pow_{Turb} - Pow_{Comp} - Trq_{Fric}\omega_{TC}\right)dt} \\ \dot{m}_{Out,Engine} + \dot{m}_{In,EGR} - \dot{m}_{In,Turb} \\ \frac{c_p}{c_v m_{ExMan}}\left(\dot{m}_{Out,Engine}\, T_{Out,Engine} + \dot{m}_{In,EGR}\, T_{In,EGR} - \dot{m}_{In,Turb}\, T_{ExMan}\right) \\ -\frac{1}{m_{InMan}}\left(T_{ExMan}\left(\dot{m}_{Out,Engine} - \dot{m}_{In,EGR} - \dot{m}_{In,Turb}\right)\right) - \frac{1}{c_v m_{ExMan}}(T_{ExMan} - T_{Ambient}) k_{ExMan}\, A_{ExMan} \end{bmatrix}$$

with the equation for pressure in the intake manifold and exhaust manifold:

$$p_{InMan} = \frac{R}{V_{InMan}} m_{InMan}\, T_{InMan}$$

$$p_{ExMan} = \frac{R}{V_{ExMan}} m_{ExMan}\, T_{ExMan}$$

Algebraic equations:

$$\dot{m}_{In,Engine} = \lambda_A\left(p_{InMan}, n_{Engine}\right)\frac{p_{InMan}}{RT_{InMan}} V_d in_{Engine}$$

$$\dot{m}_{In,EGR} = \dot{m}_{Out,EGR} = A_{EGR,max} g(Pos_{EGR}) p_{in}\sqrt{\frac{2}{RT_{in}}}\Psi\left(\frac{p_{InMan}}{p_{Out,Comp}}\right)$$

$$T_{Out,EGR} = T_{In,EGR} = T_{ExMan} - \eta_{EGRcooler}\left(n_{Engine}, q_{Inj,Engine}\right)$$
$$(T_{ExMan} - T_{Ambient})$$

$$\dot{m}_{Comp} = \dot{m}_{Out,Throttle} = A_{Throttle,max} f(Pos_{Throttle}) p_{in}\sqrt{\frac{2}{RT_{in}}}\Psi\left(\frac{p_{InMan}}{p_{Out,Comp}}\right)$$

$$T_{Out,Throttle} = T_{In,Throttle} = T_{Out,Comp} - \eta_{Intercooler}\left(n_{Engine}, q_{Inj,Engine}\right)$$
$$\left(T_{Out,Comp} - T_{Ambient}\right)$$

$$Pow_{Comp} = \dot{m}_{Comp} \cdot c_{p,air} \cdot \frac{1}{\eta_{Comp,is}(\dot{m}_{Comp,red}, \eta_{TC,red})} \cdot T_{In,Comp} \cdot \left(\Pi_{Comp}(\dot{m}_{Comp,red}, \eta_{TC,red})^{\frac{K-1}{K}} - 1\right)$$

$$T_{Out,Comp} = T_{In,Comp} \cdot \left(1 + \frac{1}{\eta_{Comp,is}(\dot{m}_{Comp,red}, \eta_{TC,red})} \cdot \left(\Pi_{Comp}(\dot{m}_{Comp,red}, \eta_{TC,red})^{\frac{K-1}{K}} - 1\right)\right)$$

$$p_{Out,Comp} = p_{Ambient}\Pi_{Comp}(\dot{m}_{Comp,red}, \eta_{TC,red})$$

$$\dot{m}_{Turb} = \dot{m}_{Turb,red}(\Pi_{Turb}, Ctrl_{TC}) \frac{\frac{p_{In,Turb}}{p_{Turb,ref}}}{\sqrt{\frac{T_{In,Turb}}{T_{Turb,ref}}}}$$

$$Pow_{Turb} = \dot{m}_{Turb} \cdot c_{p,air} \cdot \eta_{Turb,is}(\dot{m}_{Turb,red}, \eta_{TC,red}) \cdot T_{In,Turb} \cdot \left(1 - \left(\frac{1}{\Pi_{Turb}}\right)^{\frac{K-1}{K}}\right)$$

$$T_{Out,Turp} = T_{In,Turb} \cdot \left(1 + \eta_{Turb,is}(\dot{m}_{Turb,red}, \eta_{TC,red}) \cdot \left(\left(\frac{1}{\Pi_{Turb}}\right)^{\frac{K-1}{K}} - 1\right)\right),$$

$$T_{In,Turb} = T_{ExMan}$$

$$\dot{m}_{Out,Engine} = \dot{m}_{In,Engine} + \dot{m}_{In,Fuel}(t_{In,Fuel}, p_{Rail})$$

$$T_{Out,Engine} = T_{Out,Engine}(p_{MainInd}(n_{Engine}, q_{Inj,Engine}), n_{Engine})$$

with definition of standardized variables:

$$\Pi_{Turb} = \frac{p_{ExMan}}{p_{Ambient}}$$

$$n_{TC,red} = \frac{n_{TC}}{\sqrt{\frac{T_{In,Comp}}{T_{Comp,ref}}}}$$

Note

First-order time delay for compressor pressure and temperature to avoid algebraic loop between compressor and throttle.

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