ASM Diesel Engine

Reference

For ASM Diesel Engine Blockset 2.8.1 and ASM Diesel Engine Operator Blockset 2.8.1

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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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Important Notice

Contents

About This Reference

Content

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

Symbols

dSPACE user documentation uses the following symbols:

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

Naming conventions

dSPACE user documentation uses the following naming conventions:

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

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

Special folders

Some software products use the following special folders:

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

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

or

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

Documents folder A standard folder for user-specific documents.

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

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

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

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

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

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

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

Overview of the Diesel Engine Library

Diesel Engine Library

Introduction

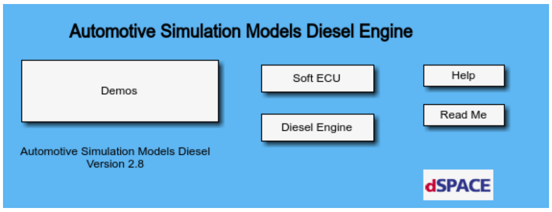
This topic gives you an overview of the ASM Diesel Engine Library.

Opening the library

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

Contents

The following illustration shows the first level of the library.



The library has three main subsystems.

Demos The Demos subsystem ready-to-use demo models that you can use to start modelling. Refer to Demos on page 143.

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 107.

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

Diesel Engine

Where to go from here

Information in this section

Air Path

Where to go from here

Information in this section

Air Filter

Description

The AIRFILTER block is connected to the turbocharger.

The AIRFILTER block calculates the pressure after the air filter as a function of the ambient pressure and the internal pressure drop. The pressure drop in the air filter depends on the air mass flow through the air filter:

$$p_{out} = p_{ambient} - f\left(\dot{m}_{in,\,airfilter}\right)$$

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 that contains signals of ASM components. Refer to ASMSignalBus (ASM User Guide 📖).
p_Out_AirFilter	[Pa]	Pressure after air filter

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

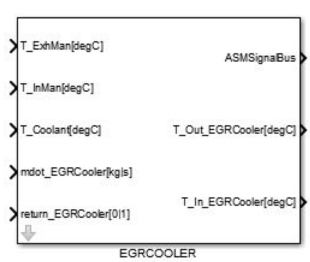
References

AirFilter Diesel (ModelDesk Parameterizing 📖)
History of the AIRFILTER Block...210

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 257.



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:

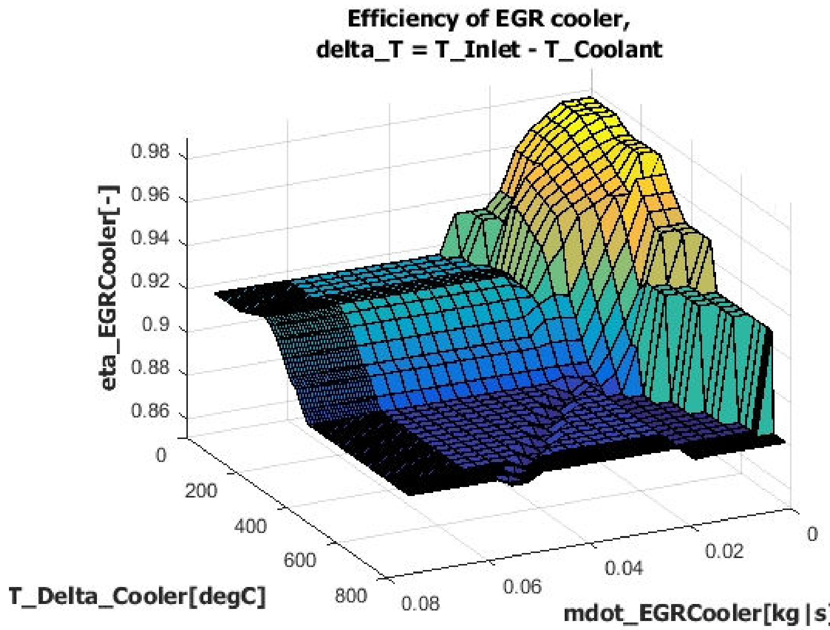
Name	Unit	Description
Map_eta_Cooler	[]	Efficiency of the EGR cooler: f(mdot_Cooler, T_delta(cooler-inlet to coolant))
Sw_State_Cooler	[0|1]	Switch for activating the EGR cooler: ▪ 0: Off ▪ 1: On

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

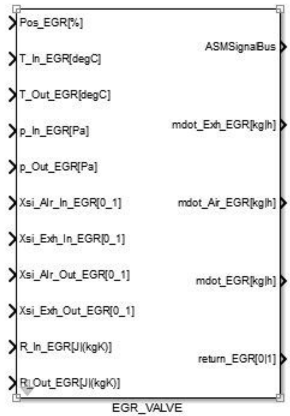
References

EGR Cooler Diesel (ModelDesk Parameterizing 📖)
EGRCooler V4 (ModelDesk Parameterizing 📖)
History of the EGR_COOLER Block..217

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

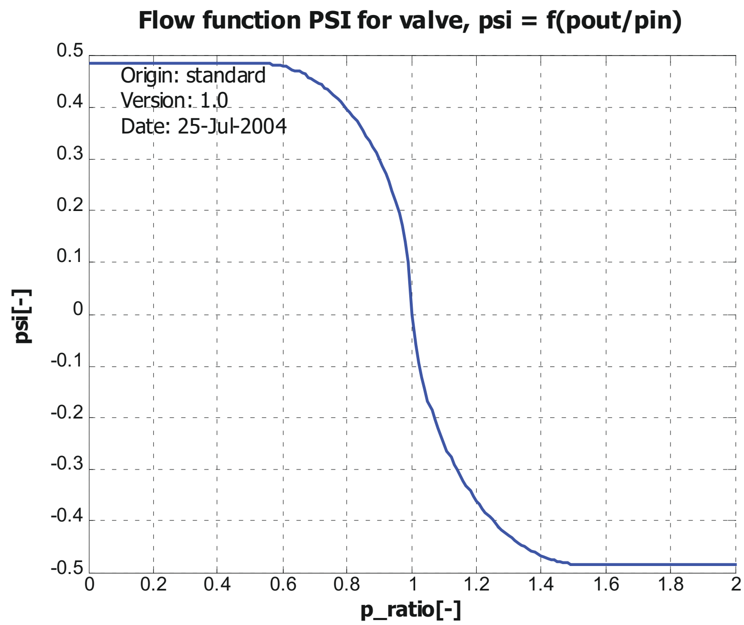
Parameters

The following table shows the parameters:

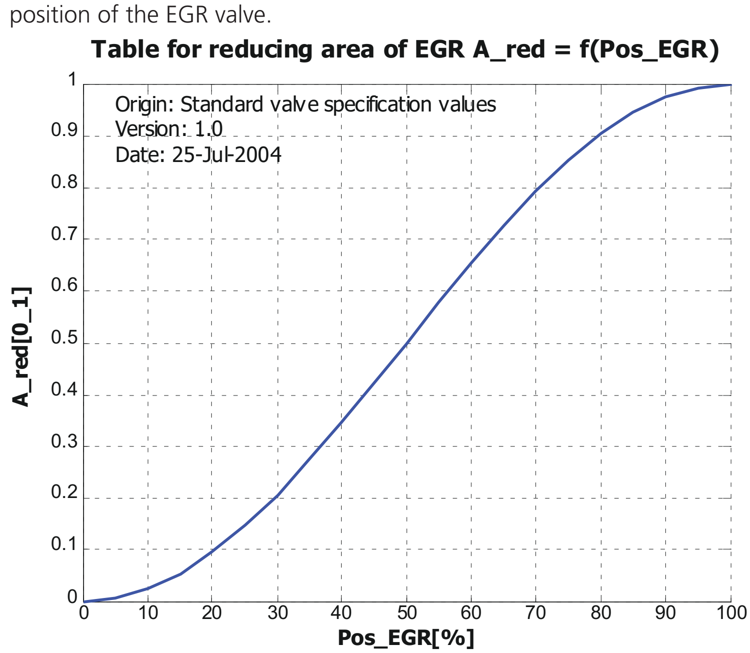
Name	Unit	Description
Const_A_max	[m^2]	Maximum flow area for the EGR
Map_A_Red	[]	Area reduce factor according to the EGR position (Map_A_red = f(Pos_EGR))
Map_Psi	[]	Flow function PSI for EGR = f(pout/pin)
Sw_State_Valve	[0|1]	Switch for activating the EGR valve: ▪ 0: Off ▪ 1: On

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.

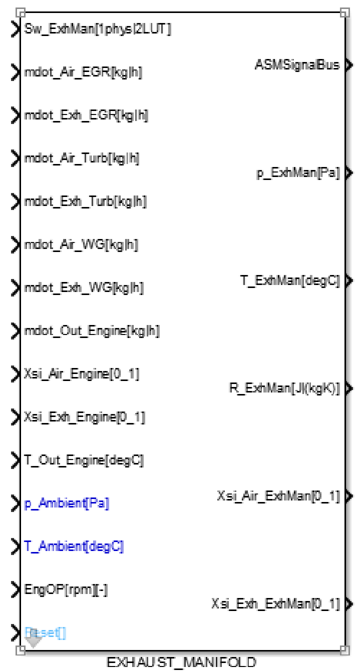
Related topics

References

Exhaust Manifold

Description

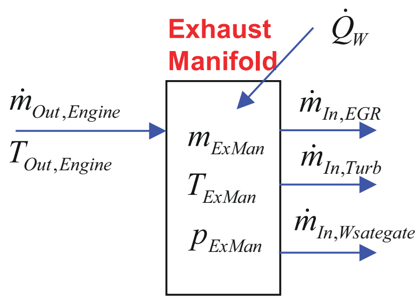
The EXHAUST_MANIFOLD block calculates manifold temperature and pressure as a function of air mass flows (in/out) and their corresponding temperatures.



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 174.

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 257.

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

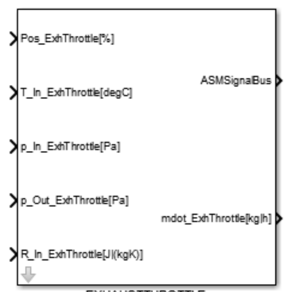
References

Exhaust Manifold Diesel (ModelDesk Parameterizing 📖)
Exhaust Manifold V10 (ModelDesk Parameterizing 📖)
History of the EXHAUST_MANIFOLD Block..223

Exhaust Throttle

Description

The exhaust throttle raises the pressure upstream of the low-pressure EGR valve to increase the rate of the low-pressure EGR.



EXHAUSTTHROTTLE

The EXHAUSTTHROTTLE block calculates the mass flow of exhaust gas depending on the pressure difference and its position. The exhaust throttle is modeled as an isentropic flow through an orifice with a variable cross-section.

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

$$\dot{m}_{ExhThrottle} = A(Pos_{ExhThrottle}) \cdot p_{In} \cdot \sqrt{\frac{2}{R \cdot T_{In}}} \cdot \Psi\left(\frac{p_{out}}{p_{in}}\right)$$

The flow function Ψ is defined as follows:

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

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

The cross-section can be defined by two ways, adjusting to the measurement data or by cosine function like:

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

Inports

The following table shows the inports:

Name	Unit	Description
p_In_ExhThrottle	[Pa]	Pressure upstream of the exhaust throttle
p_Out_ExhThrottle	[Pa]	Pressure downstream of the exhaust throttle
Pos_ExhThrottle	[%]	Position signal of the exhaust throttle
T_In_ExhThrottle	[°C]	Temperature upstream of the exhaust 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 📖).
mdot_ExhThrottle	[kg/h]	Mass flow through the exhaust throttle

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_A_max	[m^2]	Maximum flow area of the exhaust throttle
Map_A_Red	[0_1]	Reduced area of the exhaust throttle, f(Pos_ExhThrottle)
Map_Psi	[]	Flow function PSI , f(pout/pin)
Sw_State_ExhThrottle	[-]	Switch to activate the exhaust throttle: ▪ 0: Off ▪ 1: On

Related topics

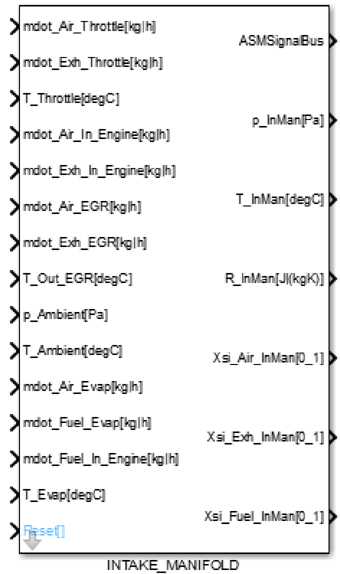
References

Exhaust Throttle (ModelDesk Parameterizing 📖)
Exhaust Throttle Diesel V4 (ModelDesk Parameterizing 📖)
Exhaustthrottle V5 (ModelDesk Parameterizing 📖)
History of the EXHAUSTTHROTTLE Block..222

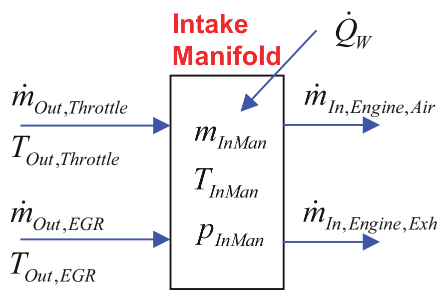
Intake Manifold

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.

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

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 257.

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

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

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 257.

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

Name	Unit	Description
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)]
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

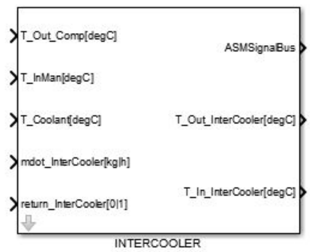
References

History of the INTAKE_MANIFOLD Block....228
Intake Manifold Diesel (ModelDesk Parameterizing 🕮)
Intake Manifold V8 (ModelDesk Parameterizing 🕮)

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

Parameters

The following table shows the parameters:

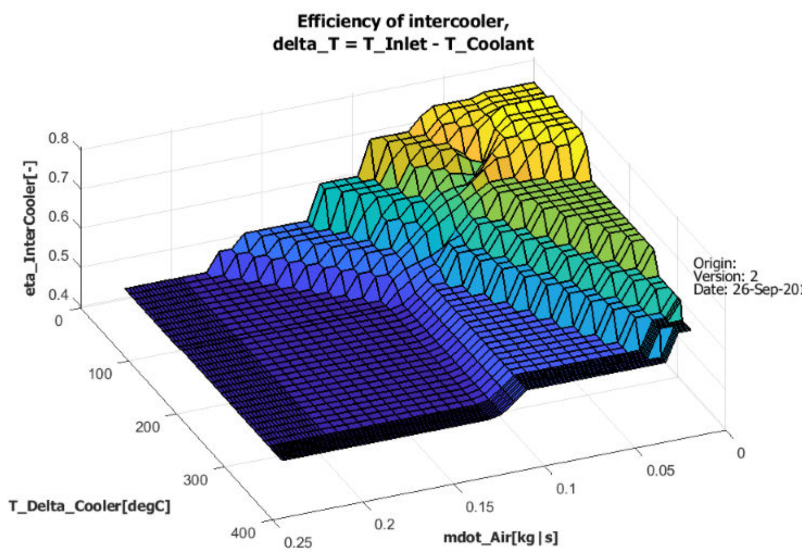
Name	Unit	Description
Map_eta_Cooler	[]	Efficiency of the intercooler, f(mdot_Cooler, T_delta(cooler inlet to coolant))
Sw_State_Cooler	[]	Switch for activating the intercooler: ▪ 0: Off ▪ 1: On

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

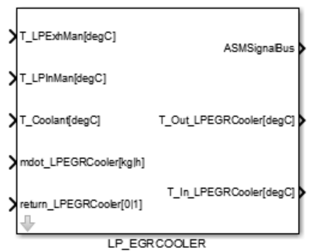
References

Low-Pressure EGR Cooler

Description

To achieve a lower inlet temperature for the compressor, the exhaust gas must be cooled.

The LP_EGRCOOLER block calculates the output temperature of the cooler, which depends on 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_LPEGRCooler	[kg|h]	Mass flow through the cooler
return_Cooler	[1|0]	Flag indicating backflow through the cooler ▪ 1: Backflow ▪ 0: No backflow
T_Coolant	[°C]	Coolant temperature of low-pressure the EGR cooler (in most cases this is the water temperature)
T_LPExhMan	[°C]	Temperature of accumulator connected to the input side
T_LPInMan	[°C]	Temperature of 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_LP_EGRCooler	[°C]	Temperature at the input side of the low-pressure EGR cooler
T_Out_LP_EGRCooler	[°C]	Temperature at the output side of the low-pressure EGR cooler

Parameters

The following table shows the parameters:

Name	Unit	Description
Map_eta_LPEGRCooler	[]	Efficiency of the LPEGR cooler, f(mdot_Cooler, T_delta(cooler-inlet to coolant))
Sw_State_LPEGRCooler	[]	Switch to activate the low-pressure EGR cooler ▪ 0: Off ▪ 1: On

Processing information

Cooler efficiency is calculated from engine test bench measurement of the variables LP-EGR input temperature, LP-EGR output temperature and coolant temperature.

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

Related topics

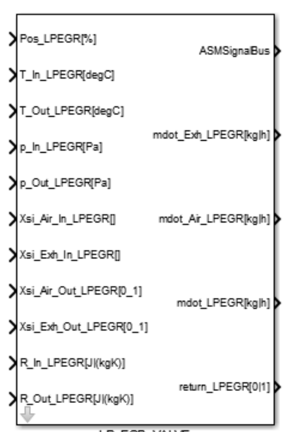
References

History of the LP_EGRCOOLER Block..230
LP EGR Cooler (ModelDesk Parameterizing 📖)

Low-Pressure EGR Valve

Description

A low-pressure EGR valve (LP EGR) is used to add a defined exhaust mass flow to the fresh air flow. This increases the EGR rate by cooling the exhaust gas more efficiently and also distributes the exhaust mass in the EGR flow evenly across the cylinders.



The **LP_EGR_VALVE** block calculates the air and the exhaust mass flow through the LPEGR valve as a function of pressure difference andposition of the valve.

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

The mass flow through the 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 in analytic way 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 LP EGR valve can be divided into fresh air and exhaust mass flow

The model does not take into account temperature changes in the air mass flow.

Inports

The following table shows the inports:

Name	Unit	Description
p_In_EGR	[Pa]	LP EGR input pressure
p_Out_EGR	[Pa]	LP EGR output pressure (= pressure after air filter)
Pos_LPEGR	[%]	Position of the LP EGR valve
Sw_State_LPEGR	[0|1]	Switch to activate the low-pressure EGR valve 0=Off|1=On ▪ 0: Off ▪ 1: Ctrl input
T_In_EGR	[°C]	LP EGR input temperature
T_Out_LPEGR	[°C]	Output temperature of the LP EGR valve (backward flow)
Xsi_Air_In_LPEGR	[0_1]	Input mass fraction of the air
Xsi_Exh_In_LPEGR	[0_1]	Input mass fraction of the exhaust gas
Xsi_Air_Out_LPEGR	[0_1]	Output mass fraction of the air (backward flow)
Xsi_Exh_Out_LPEGR	[0_1]	Output mass fraction of the exhaust gas (backward flow)

Name	Unit	Description
R_In_LPEGR	[J/(kg K)]	Input gas constant of the mass flow of LP EGR
R_Out_LPEGR	[J/(kg K)]	Output gas constant of the mass flow of LP 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_LPEGR	[kg/h]	Mass flow through the low-pressure EGR
mdot_Exh_LPEGR	[kg/h]	Exhaust mass flow through the low-pressure EGR
mdot_Air_LPEGR	[kg/h]	Fresh air mass flow through the low-pressure EGR
return_LPEGR	[0|1]	Flag indicating backflow through the low-pressure EGR valve ▪ 1: Backflow ▪ 0: No backflow

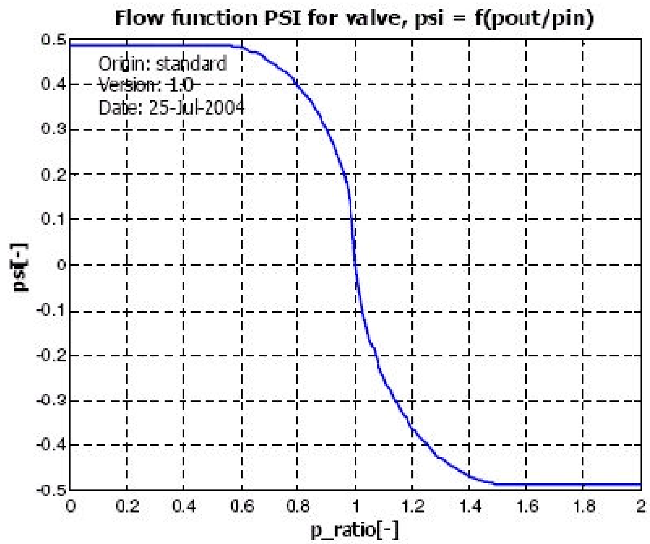
Parameters

The following table shows the parameters:

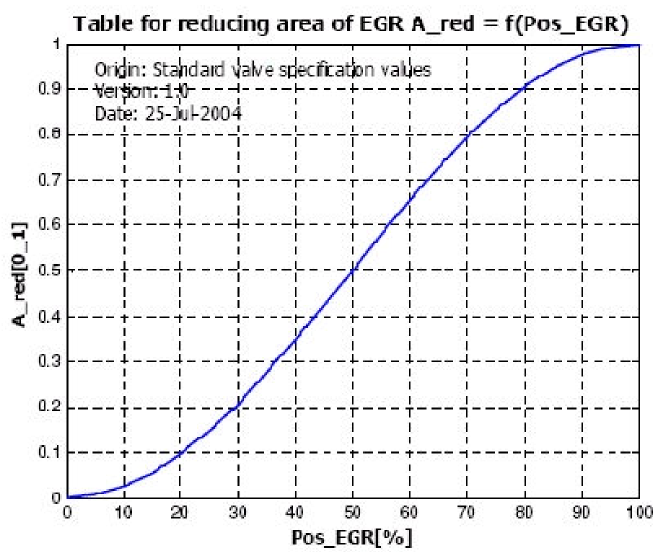
Name	Unit	Description
Const_A_max	[m^2]	Maximum flow area
Map_A_Red	[]	Reduced area as a function of the EGR position = f(Pos_LPEGR)
Map_Psi	[]	Flow function PSI for the EGR = f(pout/pin)

Processing information

The flow function Map_Psi and the cross-section of Map_A_Red LPEGR valve are generated during the parameterization. The following illustration shows the flow function curve.



The following illustration shows an example of the area reduction factor as a function of EGR position.



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

Related topics

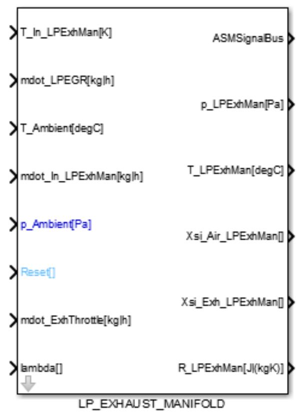
References

History of the LP_EGR_VALVE Block..231
LP EGR Valve Diesel (ModelDesk Parameterizing)

Low-Pressure Exhaust Manifold

Description

The LP_EXHAUST_MANIFOLD block calculates the temperature and pressure before the low-pressure EGR system. The block is implemented as a container with the low of conservation of mass and energy.



The ideal gas law is used to calculate the pressure in the low-pressure exhaust manifold:

$$p_{LPExhMan} = \frac{m_{LPExhMan} \cdot T_{LPExhMan} R_{Exhaust}}{V_{LPExhMan}}$$

The mass of the exhaust gas in the low-pressure exhaust manifold is calculated as:

$$\frac{dm_{LPExhMan}}{dt} \dot{m}_{LPExhMan, In} - \dot{m}_{LPEGR} - \dot{m}_{ExhThrottle}$$

$$m_{LPExhMan} = \int_{m_{LPExhMan, Init}}^{\infty} \frac{dm_{LPExhMan}}{dt} \cdot dt$$

$$m_{LPExhMan, Init} = \frac{p_{Ambient} \cdot V_{LPExhMan}}{T_{Ambient} \cdot R_{Exhaust}}$$

The law of conservation of energy is as follows:

$$c_{v, Exhaust} \cdot \frac{\partial(m_{LPExhMan} \cdot T_{LPExhMan})}{\partial t} = c_{v, Exhaust} \cdot T_{LPExhMan} \cdot \frac{\partial(m_{LPExhMan})}{\partial t} + c_{v, Exhaust} \cdot m_{LPExhMan} \cdot \frac{\partial(T_{LPExhMan})}{\partial t} = \dot{H}_{LPExhMan, In} - \dot{H}_{LPEGR} - \dot{H}_{ExhThrottle} - \dot{Q}_{Ambient}$$

This results in:

$$\dot{T}_{LPExhMan} = \frac{c_{p,Exhaust} \cdot \dot{m}_{LPExhMan,In} \cdot T_{LPExhMan,In}}{c_{v,Exhaust} \cdot m_{LPExhMan}} - \frac{c_{p,Exhaust} \cdot \dot{m}_{LPEGR} \cdot T_{LPExhMan}}{c_{v,Exhaust} \cdot m_{LPExhMan}} - \frac{c_{p,Exhaust} \cdot \dot{m}_{ExhThrottle} \cdot T_{LPExhMan}}{c_{v,Exhaust} \cdot m_{LPExhMan}} - \frac{\dot{Q}_{Ambient}}{c_{v,Exhaust} \cdot m_{LPExhMan}} - \left(\frac{T_{LPExhMan}}{m_{LPExhMan}} \cdot \frac{\partial(m_{LPExhMan})}{\partial t}\right)$$

The complete mass flow can be divided into fresh air and exhaust gas on the basis of lambda in the manifold.

$$\xi_{Air,LPExhMan} = \left(1 - \frac{1}{\lambda}\right)$$

$$\xi_{Exh,LPExhMan} = \frac{1}{\lambda}$$

Inports

The following table shows the inports:

Name	Unit	Description
mdot_ExhThrottle	[kg/h]	Mass flow of the exhaust throttle
mdot_In_LPExhMan	[kg/h]	Mass flow into the low-pressure exhaust manifold
mdot_LPEGR	[kg/h]	Mass flow of the low-pressure EGR
p_Ambient	[Pa]	Ambient pressure
Reset	[]	Reset all the integrators
T_Ambient	[°C]	Ambient temperature
T_In_LPExhMan	[K]	Temperature upstream of the low-pressure 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 📖).
p_LPExhMan	[Pa]	Pressure in the low-pressure exhaust manifold
T_LPExhMan	[°C]	Temperature in the low-pressure exhaust manifold
R_LPExhMan	[J/(kg K)]	Gas constant of the low-pressure exhaust manifold
Xsi_Exh_LPExhMan	[]	Mass fraction of the exhaust gas in the low-pressure exhaust manifold
Xsi_Air_LPExhMan	[]	Mass fraction of air in the low-pressure exhaust manifold

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_A_LPExhMan	[m^2]	Area of the low-pressure exhaust manifold
Const_k_LPExhMan	[W/(K m^2)]	Heat transfer coefficient

Name	Unit	Description
Const_V_LPExhMan	[m^3]	Volume of the low-pressure exhaust manifold
NumberofIterations	[]	Iteration number of AirPath
StepSize	[s]	Simulation step size

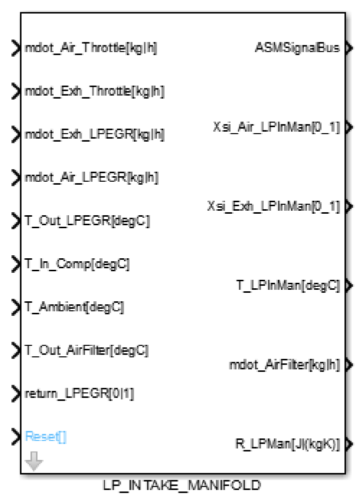
Related topics

References

Low-Pressure Intake Manifold

Description

The LP_INTAKE_MANIFOLD block calculates the temperature in the low-pressure intake manifold, i.e., the temperature before the compressor, and the mass flow of the air and exhaust gas going through the compressor. The values depend on the flow direction and are based on the laws of conservation of mass and energy.



The block consists of the following subsystems:

- Mass fraction
- Mass balance
- Heat capacity
- Energy balance

The following assumptions are made:

- 0-dimensional approach (gases are perfectly mixed)
- No fuel in low-pressure EGR

Mass fraction

The mass fraction of a component in a container is calculated as:

$$\zeta_i = \frac{m_i}{m_{Total}}$$

Because of the 0-dimensional approach where the gases perfectly mixed, the mass fraction at every iteration step in the entire low-pressure intake manifold is the same. This is summarized in the following equations:

$$\zeta_i = \frac{\dot{m}_i}{\dot{m}_{Total}}$$

$$\zeta_{Out} = \zeta_{In} = \xi_{LPEGR}$$

Resumed:

$$\zeta_i = \frac{\dot{m}_{i,In}}{\dot{m}_{Total,In}}$$

Thus, the mass fraction of the exhaust gas in the low-pressure intake manifold is a ratio of the incoming mass flow of the exhaust gas to the total incoming mass flow. The incoming mass flow is the mass flow through the air filter, low-pressure EGR or the backflow at the throttle valve.

$$\xi_{Exh,\ \_LPInMan} = \frac{\dot{m}_{Exh,In}}{\dot{m}_{Total,In}}$$
$$= \frac{\dot{m}_{Exh,Throttle,Backward} + \dot{m}_{Exh,LPEGR}}{\dot{m}_{Air,Throttle,Backward} + \dot{m}_{Exh,Throttle,Backward} + \dot{m}_{Airfilter} + \dot{m}_{Air,LPEGR} + \dot{m}_{Exh,LPEGR}}$$

The mass fraction of the fresh air in the low-pressure intake manifold can be calculated as follows:

$$\zeta_{Air,LPInMan} = 1 - \zeta_{Exh,\_LPInMan}$$

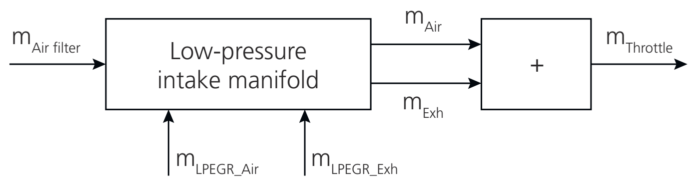
Heat capacity

This block calculates the isochoric heat capacity of the intake gas.

$$c_{v,LPInMan} = \frac{R_{Air}}{K_{Air} - 1} \cdot \xi_{Air} + \frac{R_{Exh}}{K_{Exh} - 1} \cdot \xi_{Exh}$$

Mass balance

The mass flow through the low-pressure EGR is calculated on the basis of the mass fractions. The following figure shows the mass flows through the low-pressure intake manifold:



The law of conservation of mass is applied:

$$\dot{m}_{AirFilter} - \dot{m}_{Throttle} + \dot{m}_{LPEGR} = 0$$

With:

$$\dot{m}_{LPEGR} = \dot{m}_{Air,\,LPEGR} + \dot{m}_{Exh,\,LPEGR}$$

$$\dot{m}_{Throttle} = \dot{m}_{Air,\,Throttle} + \dot{m}_{Exh,\,Throttle}$$

The mass flow through the air filter is:

$$\dot{m}_{Airfilter} = \dot{m}_{Air,\,Throttle} + \dot{m}_{Exh,\,Throttle} - \left(\dot{m}_{Air,\,LPEGR} + \dot{m}_{Exh,\,LPEGR}\right)$$

The mass flow through the throttle valve is:

$$\dot{m}_{Throttle,\,Air} = \begin{cases} \zeta_{Air} \cdot \dot{m}_{Throttle}, & \dot{m}_{Throttle} \geq 0 \\ \dot{m}_{Throttle,\,Air\_In}, & \dot{m}_{Throttle} < 0 \end{cases}$$

$$\dot{m}_{Throttle,\,Exh} = \begin{cases} \zeta_{Exh} \cdot \dot{m}_{Throttle}, & \dot{m}_{Throttle} \geq 0 \\ \dot{m}_{Throttle,\,Exh\_In}, & \dot{m}_{Throttle} < 0 \end{cases}$$

The mass flow through the low-pressure EGR valve is:

$$\dot{m}_{LPEGR,\,Air} = \begin{cases} \dot{m}_{LPEGR,\,Air\_In}, & \dot{m}_{LPEGR} \geq 0 \\ \zeta_{Air} \cdot \dot{m}_{LPEGR}, & \dot{m}_{LPEGR} < 0 \end{cases}$$

$$\dot{m}_{LPEGR,\,Exh} = \begin{cases} \dot{m}_{LPEGR,\,Exh\_In}, & \dot{m}_{LPEGR} \geq 0 \\ \zeta_{Exh} \cdot \dot{m}_{LPEGR}, & \dot{m}_{LPEGR} < 0 \end{cases}$$

The mass flow through the air filter is calculated as:

$$\dot{m}_{AirFilter,\,Air} = \begin{cases} \dot{m}_{AirFilter}, & \dot{m}_{AirFilter} \geq 0 \\ \zeta_{Air} \cdot \dot{m}_{AirFilter}, & \dot{m}_{AirFilter} < 0 \end{cases}$$

$$\dot{m}_{AirFilter,\,Exh} = \begin{cases} 0, & \dot{m}_{AirFilter} \geq 0 \\ \zeta_{Exh} \cdot \dot{m}_{AirFilter}, & \dot{m}_{AirFilter} < 0 \end{cases}$$

Energy balance

This subsystem calculates the temperature in the LP_INTAKE_MANIFOLD block on the basis of energy equilibrium:

$$c_{v,LP_{InMan}} \cdot \frac{\partial\left(m_{LP_{InMan}} \cdot T_{LP_{InMan}}\right)}{\partial t} = c_{v,LP_{InMan}} \cdot T_{LP_{InMan}} \cdot \frac{\partial\left(m_{LP_{InMan}}\right)}{\partial t}$$
$$+ c_{v,LP_{InMan}} \cdot m_{LP_{InMan}} \cdot \frac{\partial\left(T_{LP_{InMan}}\right)}{\partial t} = \dot{H}_{Air,AirFilter} + \dot{H}_{Exh,AirFilter}$$
$$+ \dot{H}_{Air,LPEGR} + \dot{H}_{Exh,LPEGR} - \dot{H}_{Air,Throttle} - \dot{H}_{Exh,Throttle} - \dot{Q}_{Ambient}$$

The mass of gas in the low-pressure intake manifold is assumed to be the same:

$$\frac{\partial\left(m_{LP_{InMan}}\right)}{\partial t} = 0$$

Resulting in:

$$\dot{T}_{LP_{InMan}} = \frac{\dot{H}_{Air,AirFilter} + \dot{H}_{Exh,AirFilter} + \dot{H}_{Air,LPEGR} + \dot{H}_{Exh,LPEGR} - \dot{H}_{Air,Throttle} - \dot{H}_{Exh,Throttle} - \dot{Q}_{Ambient}}{c_{v,LP_{InMan}} \cdot m_{LP_{InMan}}}$$

With:

$$\dot{H}_{Air,AirFilter} = \begin{cases} c_{p,Air} \cdot \dot{m}_{Air,AirFilter} \cdot T_{AirFilter}, & \dot{m}_{AirFilter} \geq 0 \\ c_{p,Air} \cdot \dot{m}_{Air,AirFilter} \cdot T_{LPInMan}, & \dot{m}_{AirFilter} < 0 \end{cases}$$

$$\dot{H}_{Exh,AirFilter} = \begin{cases} o, & \dot{m}_{AirFilter} \geq 0 \\ c_{p,Exh} \cdot \dot{m}_{Exh,AirFilter} \cdot T_{LPInMan}, & \dot{m}_{AirFilter} < 0 \end{cases}$$

$$\dot{H}_{Air,LPEGR} = \begin{cases} c_{p,Air} \cdot \dot{m}_{Air,LPEGR} \cdot T_{Exh}, & \dot{m}_{LPEGR} \geq 0 \\ c_{p,Air} \cdot \dot{m}_{Air,LPEGR} \cdot T_{LPInMan}, & \dot{m}_{LPEGR} < 0 \end{cases}$$

$$\dot{H}_{Exh,LPEGR} = \begin{cases} c_{p,Exh} \cdot \dot{m}_{Exh,LPEGR} \cdot T_{Exh}, & \dot{m}_{LPEGR} \geq 0 \\ c_{p,Exh} \cdot \dot{m}_{Exh,LPEGR} \cdot T_{LPInMan}, & \dot{m}_{LPEGR} < 0 \end{cases}$$

For the backflow through the throttle valve, it is assumed that the temperature in the compressor does not change. The temperature of the gas corresponds to the temperature on the intercooler inlet.

$$\dot{H}_{Air,Throttle} = \begin{cases} c_{p,Air} \cdot \dot{m}_{Air,Throttle} \cdot T_{LPInMan}, & \dot{m}_{Throttle} \geq 0 \\ c_{p,Air} \cdot \dot{m}_{Air,Throttle} \cdot T_{Intercooler,In}, & \dot{m}_{Throttle} < 0 \end{cases}$$

$$\dot{H}_{Exh,Throttle} = \begin{cases} c_{p,Exh} \cdot \dot{m}_{Exh,Throttle} \cdot T_{LPInMan}, & \dot{m}_{Throttle} \geq 0 \\ c_{p,Exh} \cdot \dot{m}_{Exh,Throttle} \cdot T_{Intercooler,In}, & \dot{m}_{Throttle} < 0 \end{cases}$$

$$\dot{Q}_{Ambient} = k_{LPInMan} \cdot A_{LP_{InMan}} \cdot \left(T_{LPInMan} - T_{Ambient}\right)$$

Inports

The following table shows the inports:

Name	Unit	Description
mdot_Air_LPEGR	[kg/h]	Mass flow of fresh air into the low-pressure EGR
mdot_Air_Throttle	[kg/h]	Mass flow of air through the throttle valve
mdot_Exh_LPEGR	[kg/h]	Mass flow of exhaust gas into the low-pressure EGR
mdot_Exh_Throttle	[kg/h]	Mass flow of the exhaust gas through the throttle valve

Name	Unit	Description
Reset	[]	Resets all integrators to their initial conditions
return_LPEGR	[1|0]	Indication of the backward flow: ▪ 0: Forward ▪ 1: Backward
T_Ambient	[°C]	Ambient temperature
T_Out_AirFilter	[°C]	Temperature of the air filter
T_Out_LPEGR	[°C]	Temperature of the low-pressure EGR
T_Out_LPInMan	[°C]	Outlet temperature of the low-pressure intake manifold (for the case of 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_AirFilter	[kg/h]	Mass flow through the air filter
R_LPMan	[J|(kg K)]	Gas constant of the low-pressure intake manifold
T_LPInMan	[°C]	Temperature in the low-pressure intake manifold
Xsi_Air_LPInMan	[]	Mass fraction of air in the low-pressure intake manifold
Xsi_Exh_LPInMan	[]	Mass fraction of exhaust gas in the low-pressure intake manifold

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_A_LPInMan	[m^2]	Area of the low-pressure intake manifold
Const_k_InMan	[W/(K m^2)]	Heat transfer coefficient
Const_V_LPInMan	[m^3]	Volume of the low-pressure intake manifold
NumberofIterations	[]	Iteration number of the air path
StepSize	[s]	Simulating step size

Related topics

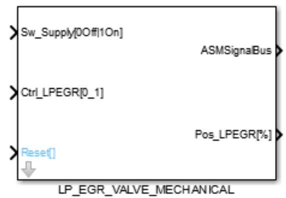
References

History of the LP_INTAKE_MANIFOLD Block..232
LP Intake Manifold Diesel (ModelDesk Parameterizing 🕮)
LP Intake Manifold V6 (ModelDesk Parameterizing 🕮)

Mechanical Low-Pressure EGR Valve

Description

The LP_EGR_VALVE_MECHANICAL block calculates the position of the low-pressure 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_LPEGR	[0_1]	Control signal (PWM) for the actuation of the low-pressure EGR valve
Reset	[]	Resetting integrators to their initial states: ▪ 0: Off ▪ 1: Reset
Sw_Supply	[]	Switching the supply of the low-pressure 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_LPEGR	[%]	Position of the low-pressure EGR valve

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_Pos_LPEGR_Rest	[%]	Rest position of the valve (supply switched off)
Const_t_PT1_Pos	[s]	PT1 constant for the dynamic behavior
Map_Ctrl2Pos	[%]	Conversion of the control signal (PWM) to the position, f(Ctrl_Valve)
NumberofIterations	[]	Iteration number of the AirPath
StepSize	[s]	Simulating the step size
Sw_State_LPEGR	[0|1]	Switch for activating the low-pressure EGR valve: ▪ 0: Off

Name	Unit	Description
		▪ 1: On

Related topics

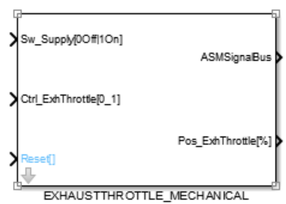
References

LP EGR Valve Mechanical (ModelDesk Parameterizing 📖)

Mechanical Exhaust Throttle

Description

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



Inports

The following table shows the inports:

Name	Unit	Description
Ctrl_ExhThrottle	[0_1]	Control signal (PWM) for actuating of the exhaust throttle
Reset	[-]	Reset integrators to their initial states: ▪ 0: Off ▪ 1: Reset
Sw_Supply	[0|1]	Switching the supply of the exhaust throttle: ▪ 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_ExhThrottle	[%]	Position of the exhaust throttle

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_Pos_ExhThrottle_Rest	[%]	Rest position of valve (supply switched off)
Const_t_PT1_Pos	[s]	PT1 constant for the dynamic behavior
Map_Ctrl2Pos	[%]	Conversion of control signal (PWM) to position, f(Ctrl_Valve)
NumberofIterations	[-]	Iteration number of AirPath
StepSize	[s]	Simulating the the step size
Sw_State_ExhThrottle	[0|1]	Switch to activate exhaust throttle: ▪ 0: Off ▪ 1: On

Related topics

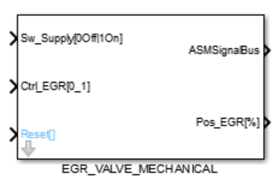
References

Exhaust Throttle Mechanical (ModelDesk Parameterizing 📖)

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

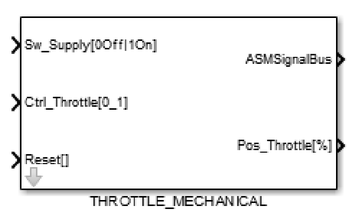
References

EGR Valve Mechanical (ModelDesk Parameterizing 📖)

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

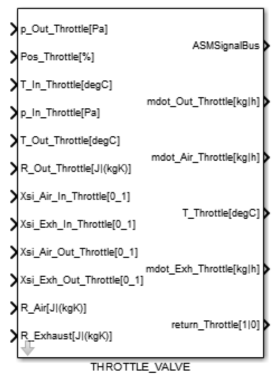
References

History of the THROTTLE_MECHANICAL Block........244
Throttle Mechanical Diesel (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..245
Throttle Valve Diesel (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 📖).

Common Engine Parameters

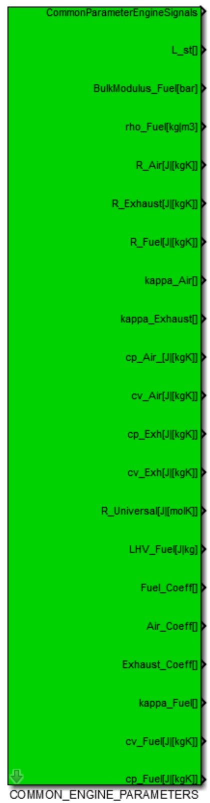
Where to go from here

Information in this section

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

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

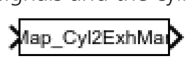
References

Map X2Y

Description

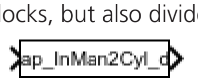
These blocks map signals from one block to the signals of another block. There are different blocks for signal mapping.

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



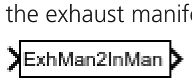
MAP_CYL2EXHMAN

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.



MAP_INMAN2CYL_DIV

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



EXHMAN2INMAN

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

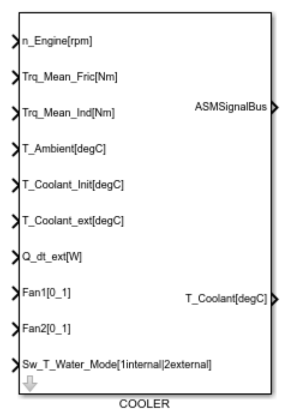
Where to go from here

Information in this section

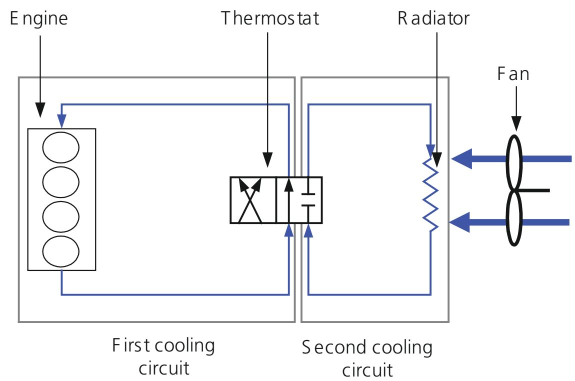
Cooler

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
Reset	[]	Reset all integrators to their initial conditions
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

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_dt_Coolant	[K/J]	Inverse of coolant water heat capacity, defines energy flow from/to coolant water
Const_T_Coolant_LowLim	[K]	Lower limit of coolant controller operation
Const_T_Coolant_Set	[°C]	Set temperature for controller
Const_T_Coolant_UpLim	[K]	Upper limit of coolant controller operation

Related topics

References

Cooler Diesel (ModelDesk Parameterizing 📖)
History of the COOLER Block..210

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 Diesel (ModelDesk Parameterizing 📖)

Exhaust System

Where to go from here

Information in this section

Catalyst (Former Version)

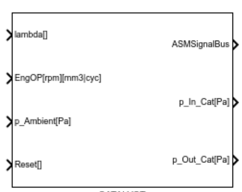
Description

Note

This block is part of a former verson and no longer used in the current Release. Use the **Catalyst** model from the ASM Diesel Exhaust Library instead. Refer to Exhaust Blocks (ASM Diesel Exhaust Reference 📖).

The **CATALYST** block simulates pre- and post- lambda of the catalyst with two second order delay elements.

For additional simulation of pressures and temperatures of the exhaust system, static maps are available. Here, the dynamic behavior is simulated with PT1 elements.



Inports

The following tables shows the inports:

Name	Unit	Description
EngOP	[rpm][mm3|cyc]	Engine operation point: n_Engine[rpm], q_Inj_1cyl[mm3/cyc]
lambda	[]	Lambda value after combustion process
p_Ambient	[Pa]	Ambient pressure
Reset	[]	Reset integrators to their initial conditions

Outports

The following table shows the outports:

Name	Unit	Description
p_In_Cat	[Pa]	Catalyst pressure before catalyst (after turbine)
p_Out_Cat	[Pa]	Catalyst pressure after catalyst

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_PT1_T_In_Cat	[s]	PT1 constant for delay of temperature/pressure before catalyst
Const_PT1_T_Out_Cat	[s]	PT1 constant for delay of temperature/pressure behind catalyst
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 behind 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 behind catalyst
Map_p_In_Cat	[Pa]	Pressure before catalyst map, [Pa] = f(n_engine, q_Inj_1cyl)
Map_p_Out_Cat	[Pa]	Pressure before catalyst map, [Pa] = f(n_engine, q_Inj_1cyl)
Map_T_Out_Cat	[°C]	Temperature behind catalyst map, [degC] = f(n_engine, q_Inj_1cyl)
Map_T_In_Cat	[°C]	Temperature before catalyst map [degC] = f(n_engine, q_Inj_1cyl)

Related topics

References

Diesel Oxidation Catalyst (ASM Diesel Exhaust Reference 🕮)

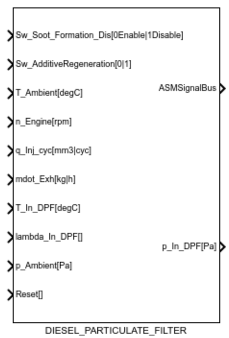
Diesel Particulate Filter (Former Version)

Description

Note

This block is part of a former verson and no longer used in the current Release. Use the DIESEL_PARTICULATE_FILTER block from the ASM Diesel Exhaust Library instead. Refer to Diesel Particulate Filter (ASM Diesel Exhaust Reference 📖).

The DIESEL_PARTICULATE_FILTER block calculates the exhaust pressure, temperature, and lambda value in the diesel particulate filter. The model is based on the energy balance and Arrhenius equation.



Inports

The following table shows the inports:

Name	Unit	Description
lambda_In_DPF	[]	Lambda value at inlet of DPF
mdot_Exh	[kg/h]	Exhaust mass flow
n_Engine	[rpm]	Engine Speed
p_Ambient	[Pa]	Ambient pressure
q_Inj_cyc	[mm^3/cyc]	Injection quantity per cylinder
Reset	[]	Reset integrators to their initial conditions
Sw_AdditiveRegeneration	[0|1]	Switch for mode: ▪ 0: DPF regeneration without additive ▪ 1: DPF regeneration with additive
Sw_Soot_Formation_Dis	[0|1]	Switch for mode: ▪ 0: Soot accumulation in DPF ▪ 1: NO soot accumulation in DPF
T_Ambient	[°C]	Ambient temperature
T_In_DPF	[°C]	Temperature at inlet of DPF

Outports

The following table shows the outports:

Name	Unit	Description
p_In_DPF	[Pa]	Pressure at inlet of DPF

Parameters

The following tables shows the parameters:

Name	Unit	Description
Const_Ap_Catalytic_Offs	[1/s]	Offset of soot oxidation frequency_Factor (Ap) for catalytic DPF
Const_Ap_Soot	[1/s]	Thermal_Frequency_Factor of Soot Oxidation
Const_Cap_IntHeat_DPF	[J/K]	Internal Heat Capacity of DPF
Const_Cap_SootHeat	[J/(kg K)]	Soot heat capacity in DPF
Const_Ep_Soot	[kJ/mol]	Thermal Activation Energy of Soot Oxidation
Const_H_Soot	[kJ/kg]	Soot Enthalpy
Const_m_Soot_DPF_Init	[g]	Initial soot mass in DPF
Const_p_Out_DPF_Offs	[Pa]	Pressure offset between outlet of DPF and ambient
Const_Res_Thermal_DPF	[K/W]	Thermal Resistance of DPF
Const_T_Out_DPF_Additive_Offs	[°C]	Temperature of DPF offset for additive regeneration
Const_T_Out_DPF_LowLim	[°C]	Lowlimit of the temperature at outlet of DPF
Const_T_Out_DPF_UpLim	[°C]	Uplimit of the temperature at outlet of DPF
Const_t_PT1_SootOxidation	[s]	PT1 constant for soot oxidation in DPF
Const_t1_PT2_lambda_Out_DPF	[]	Time constant 1 of the lambda sensor behind DPF
Const_t2_PT2_lambda_Out_DPF	[]	Time constant 2 of the lambda sensor behind DPF
Const_V_Exhaust_DPF	[m^3]	Exhaust Volume in DPF
Map_p_Diff_DPF	[Pa]	Pressure drop MAP of DPF
Map_p_Out_DPF_Offs	[Pa]	Pressure drop MAP of DPF
Map_psi_Soot	[]	Psi_Soot MAP of Exhaust before DPF

Related topics

References

Diesel Particulate Filter (ASM Diesel Exhaust Reference 📖)

Fuel System

Where to go from here

Information in this section

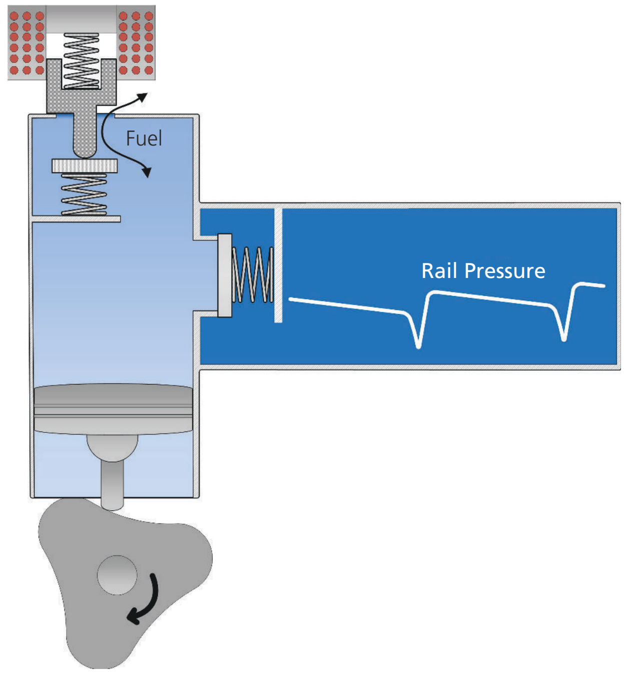
High-Pressure Pump (Crank-Based)

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:

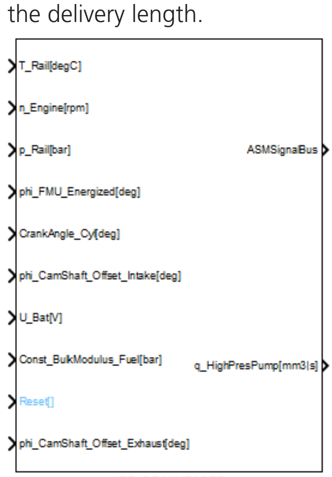


The HPP_CRANKBASED block calculates the volume flow through the high-pressure pump as a function of the crank angle.

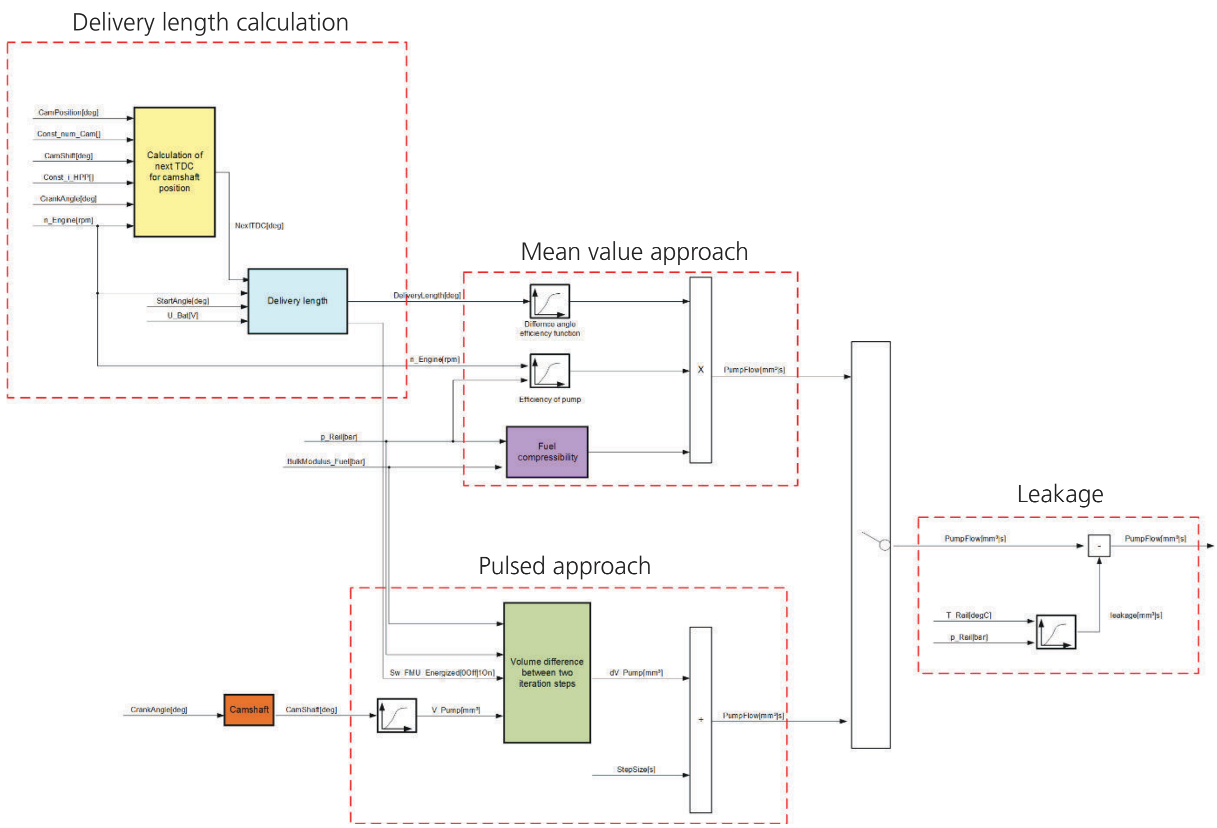
The block contains two modeling approaches:

- 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:

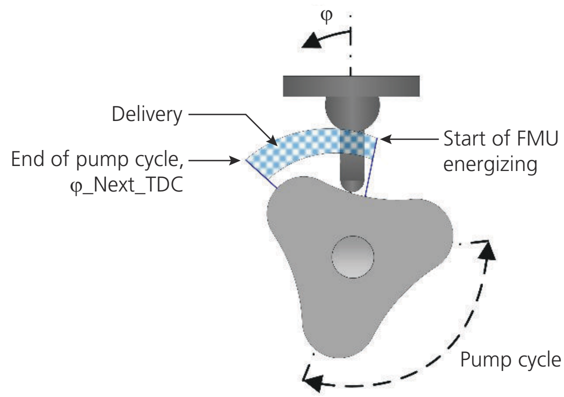
$$\varphi_{NextTDC}$$

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.

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

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

Related topics

References

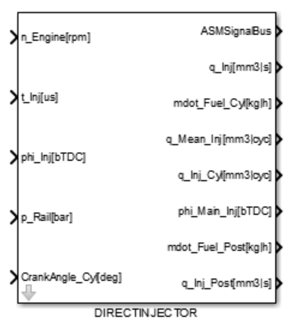
Direct Injector

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 block calculates the fuel flow for the regeneration of the diesel particulate filter (DPF) and the timing of the main injection.



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

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

Post-injection is identified by:

$$Idx_{Post}: \varphi_{Inj} \geq \varphi_{Inj,TrqEffLimit}$$

Herewith:

$$q_{Inj,Post}\left[\frac{mm^3}{cyc}\right] = q_{Inj}(Idx_{Post})\left[\frac{mm^3}{cyc}\right]$$

$$q_{Inj,noPost}\left[\frac{mm^3}{cyc}\right] = q_{Inj}(Idx_{noPost})\left[\frac{mm^3}{cyc}\right]$$

Total injection quantity at respective cylinder per engine cycle:

$$q_{Inj,Cyl}\left[\frac{mm^3}{cyc}\right] = \sum_1^{num\_Inj} q_{Inj,noPost}\left[\frac{mm^3}{cyc}\right]$$

Mean value approach

Mean injection quantity per engine cycle:

$$q_{Mean,Cyl}\left[\frac{mm^3}{cyc}\right] = \frac{\sum_1^{num\_Cyl} q_{Inj,Cyl}\left[\frac{mm^3}{cyc}\right]}{num\_Cyl}$$

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:

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

Total injection quantity per second:

$$q_{Inj,MeanValue}\left[\frac{mm^3}{s}\right] = \sum_1^{num\_Cyl} q_{Inj,Cyl}\left[\frac{mm^3}{s}\right]$$

Pulse approach

Total injection quantity per second:

$$q_{Inj,Pulse}\left[\frac{mm^3}{s}\right] = \frac{\sum_1^{num\_Cyl} q_{Inj,Cyl}\left[\frac{mm^3}{s}\right]}{StepSize[s]}$$

Post-injection

Total injection quantity per engine cycle:

$$q_{Inj,Post}\left[\frac{mm^3}{cyc}\right] = \sum q_{Inj,Post}\left[\frac{mm^3}{cyc}\right]$$

Mass flow of post-injection:

$$\dot{m}_{Fuel,Post}\left[\frac{kg}{h}\right] = \frac{q_{Inj,Post}\left[\frac{mm^3}{cyc}\right] \cdot n_{Eng}\left[\frac{Rev}{min}\right] \cdot 0{,}5\left[\frac{cyc}{Rev}\right] \cdot 3600\left[\frac{s}{h}\right] \cdot \rho_{Fuel}\left[\frac{kg}{m^3}\right] \cdot 10^{-9}\left[\frac{m^3}{mm^3}\right]}{60\left[\frac{s}{min}\right]}$$

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
mdot_Fuel_Cyl	[kg/h]	Injection mass flow into cylinder (vector of number of cylinders)
mdot_Fuel_Post	[kg/h]	Injection mass flow for post-injection (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 all the injectors (no post-injection). Depending on the selected injection mode, it is mean or pulse-wise.
q_Inj_Cyl	[mm^3/cyc]	Injection quantity per cylinder (vector of number of cylinders)
q_Inj_Post	[mm^3/s]	Fuel flow of post- injection
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	[20]	Maximum number of engine cylinders
Const_max_num_Inj_Direct	[8]	Maximum number of injections per cylinder
Const_phi_Inj_MeasUpdate	[aTDC]	Crank angle when new injection pulse measurement is available
Const_phi_Inj_TrqEffLimit	[bTDC]	Limit for calculation of torque effective fuel quantity
Map_q_Inj	[mm^3/cyc] = f(t_Inj, p_Rail)	Map of injection quantity
Sw_InjMode	[1|2]	Switch for injection mode: ▪ 1: Pulse approach ▪ 2: Mean value approach

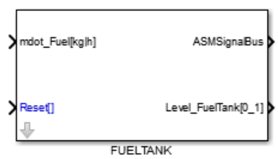
Related topics

References

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.



Inports

The following table shows the inports:

Name	Unit	Description
mdot_Fuel	[kg/h]	Injected fuel mass 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 📖).
Level_FuelTank	[0_1]	Level of fuel in tank

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_V_FuelTank	[l]	Fuel tank displacement

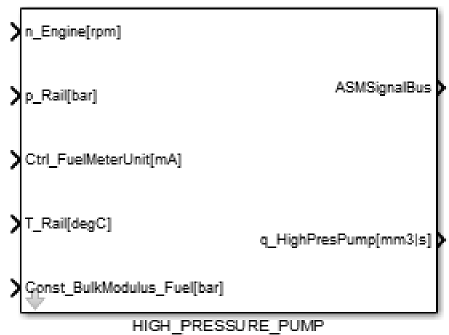
Related topics

References

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

Name	Unit	Description
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

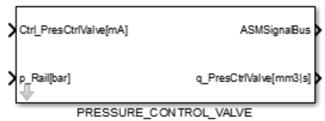
References

High Pressure Pump Diesel (ModelDesk Parameterizing 🕮)
History of the HIGH_PRESSURE_PUMP Block..225

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
q_PresCtrlValve	[mm^3/s]	Fuel flow through pressure control valve (out of rail)

Parameters

The following table shows the parameters:

Name	Unit	Description
Map_q_PresCtrlValve	[mm^3/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.......234
Pressure Control Valve Diesel (ModelDesk Parameterizing 📖)

Rail

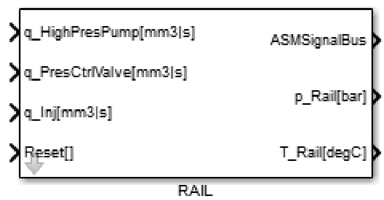
Description

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)

Name	Unit	Description
p_Rail_LowLim	[bar]	Minimum rail pressure
p_Rail_UpLim	[bar]	Maximum rail pressure

Related topics

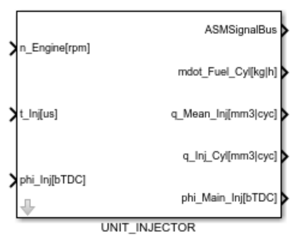
References

Common Rail Diesel (ModelDesk Parameterizing 📖)
History of the RAIL Block..235

Unit Injector

Description

This model calculates the fuel mass per engine cycle by the measured injection time, injection angle, and engine speed.



The fuel in every unit injector is compressed via the engine camshaft. When the solenoid valve opens, each unit injector forces fuel back into the return line, and when the solenoid valve closes, into the engine cylinder. The start of injection is defined by the solenoid closing point and the injected fuel quantity by the time the valve is closed.

To calculate the injected fuel mass, there are five look-up tables according to injection angle (valve closing position), injection time (time when valve is closed), and engine speed.

Inports

The following table shows the inports:

Name	Unit	Description
n_Engine	[rpm]	Engine speed
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
mdot_Fuel_Cyl	[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_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

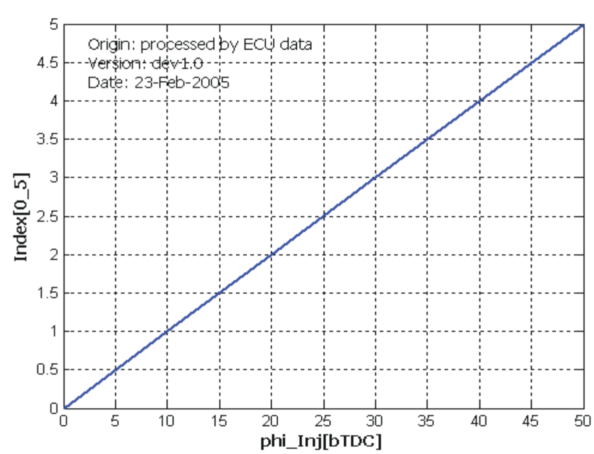
Parameters

The following table shows the parameters:

Name	Unit	Description
Const_max_num_Cyl	[20]	Maximum number of engine cylinders
Const_max_num_Inj_Direct	[8]	Maximum number of injections per cylinder
Map_m_Inj_0	[mg/cyc] = f(ms,rpm)	Fuel mass map for start of injection index 0
Map_m_Inj_1	[mg/cyc] = f(ms,rpm)	Fuel mass map for start of injection index 1
Map_m_Inj_2	[mg/cyc] = f(ms,rpm)	Fuel mass map for start of injection index 2
Map_m_Inj_3	[mg/cyc] = f(ms,rpm)	Fuel mass map for start of injection index 3
Map_m_Inj_4	[mg/cyc] = f(ms,rpm)	Fuel mass map for start of injection index 4
Map_m_Inj_5	[mg/cyc] = f(ms,rpm)	Fuel mass map for start of injection index 5
Map_m_Inj_index	[0_5] = f(degBTDC)	Map for selecting unit injector fuel mass map

Processing information

Several fuel mass maps can be implemented to calculate fuel mass according to injection time and engine speed. Based on the current injection angle, a linear interpolation between the precalculated fuel masses is performed using the map *Map_m_Inj_index*:



Map_m_Inj_0 … Map_m_Inj_5 maps contain only dummy data. A first approach for parameterization can be the calculation from ECU maps for injection time setpoint. This can be done using the ModelDesk's Processing component, refer to Basics of Processing (ModelDesk Processing 📖).

Related topics

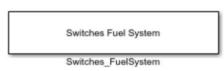
References

History of the UNIT_INJECTOR Block..245
Unit Injector Diesel (ModelDesk Parameterizing 📖)
Unit Injector Diesel V7 (ModelDesk Parameterizing 📖)

Switches Fuel System

Description

This block contains switches to specify the correct model setup.



Parameters

The following table shows the parameters:

Name	Unit	Description
Sw_FuelSystem	[1|2]	Switch to select between common rail system and unit-pump/unit-injector system ▪ 1: Common rail system ▪ 2: Unit injector

Related topics

References

Fuel System Variants Diesel (ModelDesk Parameterizing 📖)

Piston Engine

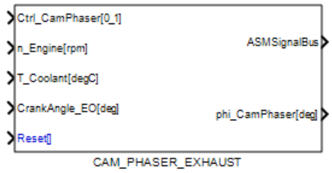
Where to go from here

Information in this section

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

Name	Unit	Description
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

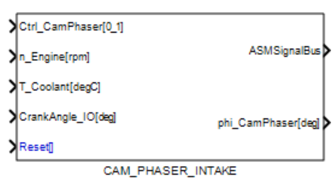
References

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

Name	Unit	Description
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

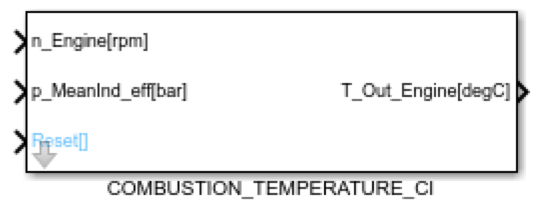
References

Cam Phaser Intake (ModelDesk Parameterizing 🕮)

Combustion 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

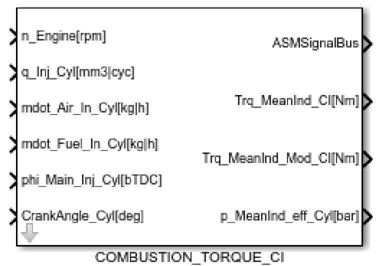
References

Combustion Temperature CI (ModelDesk Parameterizing 📖)
History of the COMBUSTION_TEMPERATURE_CI Block..212

Combustion Torque

Description

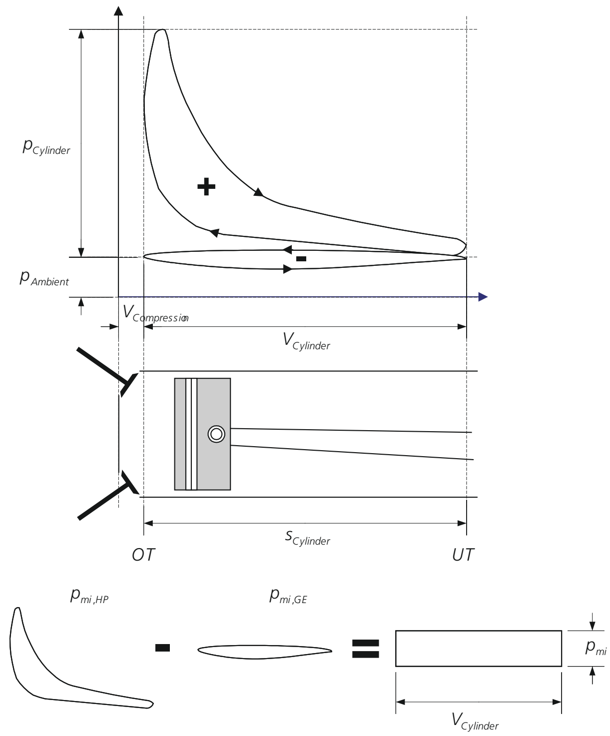
The combustion torque model calculates the mean indicated torque of the engine.



The optimum indicated combustion torque is calculated by a table 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 degrees equals one. The effect is that the mean indicated torque over one engine cycle is equal to the unmodulated mean value model.

If the injected fuel mass is zero, for example, during fuel cut off, the lambda value is set to 99.

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_Fuel_In_Cylinder	[kg/h]	Injection mass flow into cylinder (vector of number of cylinders)
mdot_Air_In_Cyl	[kg/h]	Mass flow of fresh air into the engine
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
Trq_MeanInd_CI	[Nm]	Mean indicated engine torque
Trq_MeanInd_Mod_CI	[Nm]	Modulated mean indicated engine torque
p_MeanInd_eff_Cyl	[bar]	Mean indicated pressure per cylinder

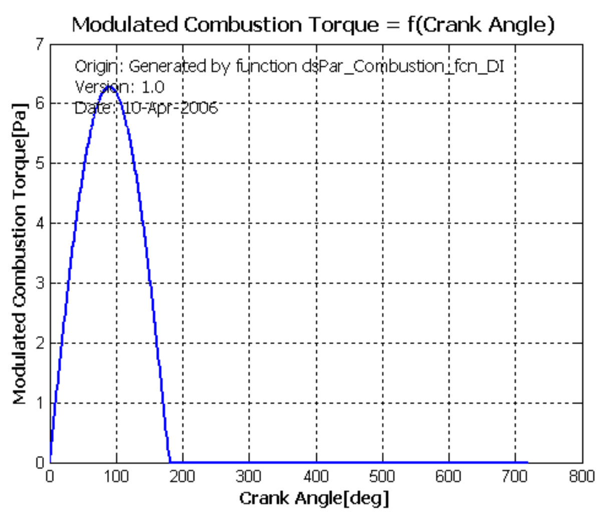
Parameters

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 combustion mode: ▪ 1: Modulated ▪ 2: Mean-value

Processing information

The next 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 100.

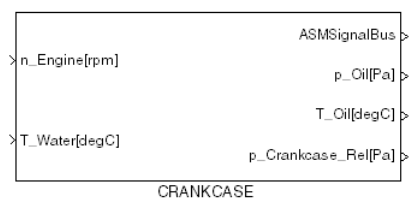
Related topics

References

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)

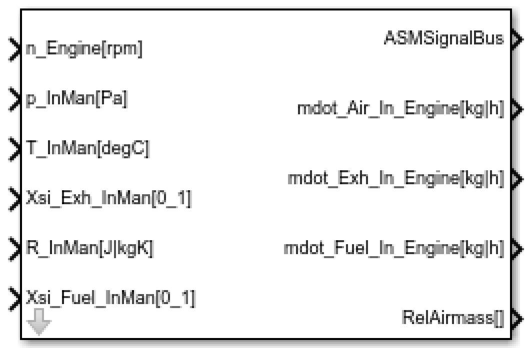
Related topics

References

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

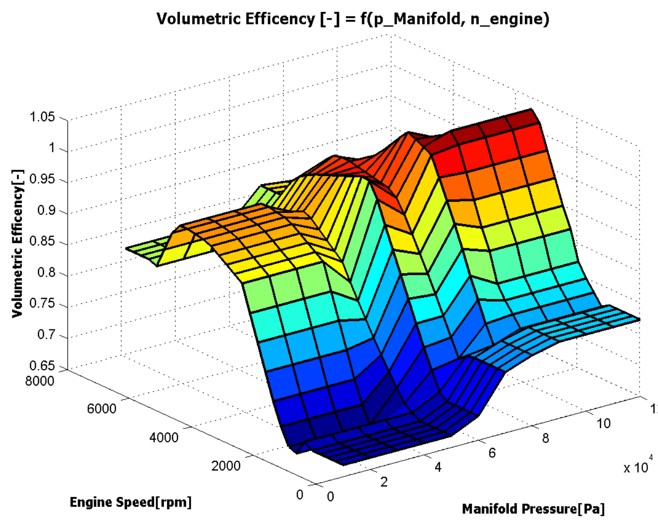
The following table shows the parameters:

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.

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



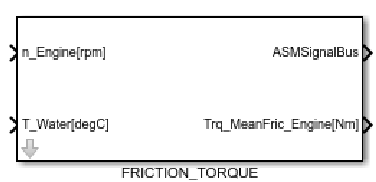
Related topics

References

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

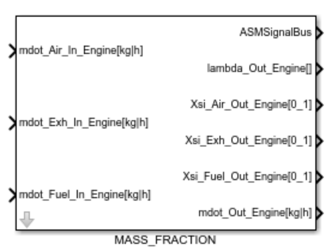
References

Friction Torque Diesel (ModelDesk Parameterizing 📖)
History of the FRICTION_TORQUE Block..224

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.
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

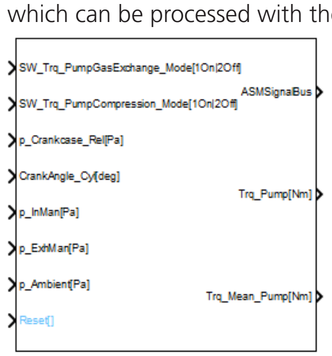
References

History of the MASS_FRACTION Block..234

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

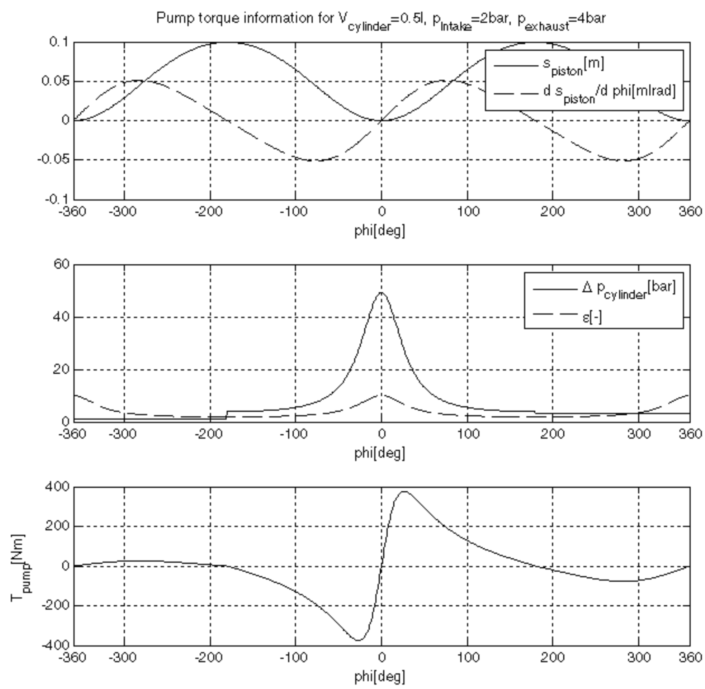
Parameters

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

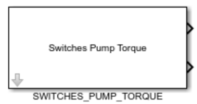
References

Pump Torque..100
Pump Torque Diesel (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 Diesel (ModelDesk Parameterizing 📖)

Switches

Switches

Introduction

This topic shows the switches of the ASM Diesel Engine Library.

Switches

It contains the following switches:

- Switches Cooler on page 63
- Switches Fuel System on page 86
- Switches Pump Torque on page 104

Soft ECU

Where to go from here

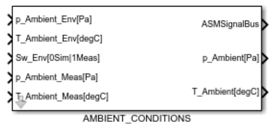
Information in this section

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

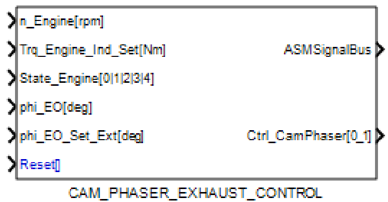
The following table shows the parameters:

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

Name	Unit	Description
		▪ 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

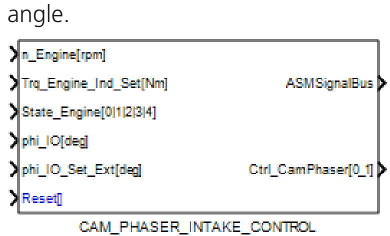
References

Cam Phaser Intake 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

Name	Unit	Description
		▪ 3: External

Related topics

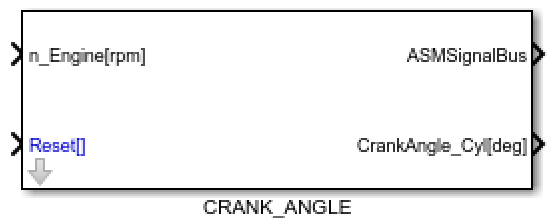
References

Cam Phaser Intake 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 📖)

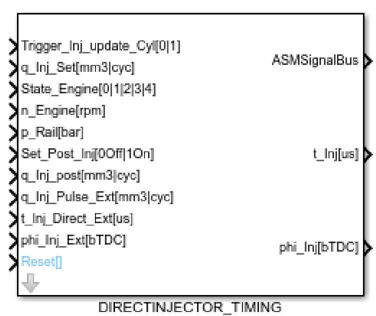
Direct Injector Timing

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)
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

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

Related topics

References

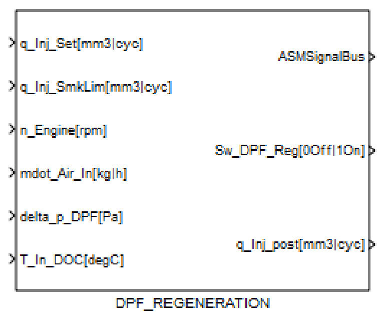
Directinjector Timing (ModelDesk Parameterizing 🕮)
SoftECU Setup (ASM Base InCylinder Reference 🕮)

DPF Regeneration

Description

The DPF_REGENERATION observes the pressure drop over the diesel particulate filter (DPF) and enables post-injections to regenerate the DPF if the pressure drop is too large.

The post-injection quantity is set so that the gas mass flow temperature in the DOC is lifted up to the temperature which is required to start regeneration.



Inports

The following table shows the inports:

Name	Unit	Description
delta_p_DPF	[Pa]	Pressure drop over DPF
mdot_Air_In	[kg/h]	Air mass flow into the engine
n_Engine	[rpm]	Engine speed
q_Inj_Set	[mm^3/cyc]	Injection quantity setpoint (per cylinder per cycle)
q_Inj_SmkLim	[mm^3/cyc]	Maximum allowed injection quantity to avoid smoke
T_In_DOC	[°C]	Temperature at DOC input side

Outports

The following table shows the outports:

Name	Unit	Description
q_Inj_post	[mm^3/cyc]	External input for post-injection quantity
Sw_DPF_Reg	[0|1]	Switch to activate DPF regeneration ▪ 0: Off ▪ 1: On

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_delta_p_DPF_RegOff	[Pa]	DPF delta pressure switch regeneration off
Const_delta_p_DPF_RegOn	[Pa]	DPF delta pressure switch regeneration on

Name	Unit	Description
Const_T_DOC_In_RegOff	[°C]	DOC input temperature switch regeneration off
Const_T_DOC_In_RegOn	[°C]	DOC input temperature switch regeneration on
Map_q_inj_DPF_reg	[]	Fuel flow map for regeneration qinj_DPF_reg = f(T_InDOC, m_dot_AirIn)

Related topics

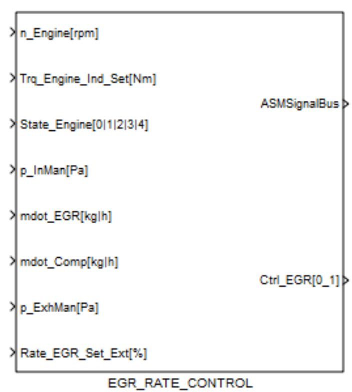
References

DPF Regeneration (ModelDesk Parameterizing)
History of the DPF_REGENERATION Block..217

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

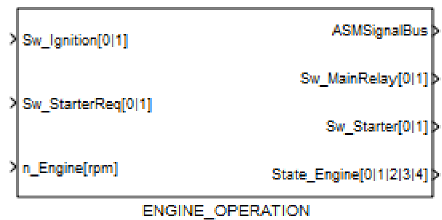
Description

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

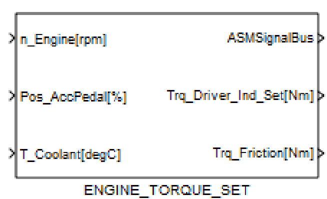
References

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

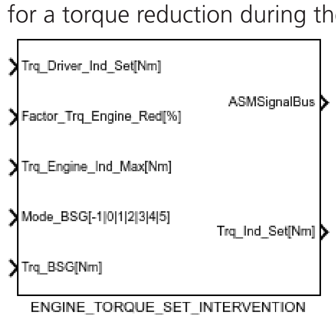
Engine Torque Set (ModelDesk Parameterizing 📖)

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

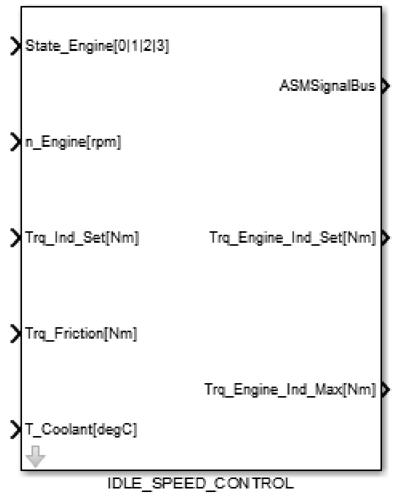
References

History of the ENGINE_TORQUE_SET_INTERVENTION Block..221

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

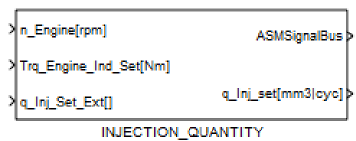
References

History of the IDLE_SPEED_CONTROL Block..227
Idle Speed Control (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)

Name	Unit	Description
Sw_q_Inj	[1|2|3]	Switch to select injection quantity ▪ 1: Map ▪ 2: Constant ▪ 3: External

Related topics

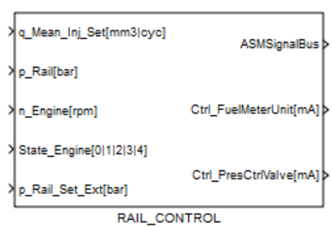
References

Injection Quantity (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

Name	Unit	Description
		▪ 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

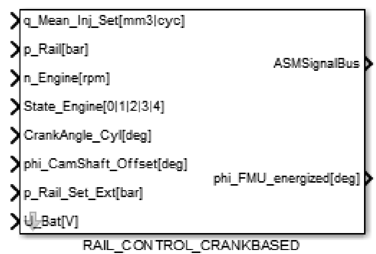
References

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

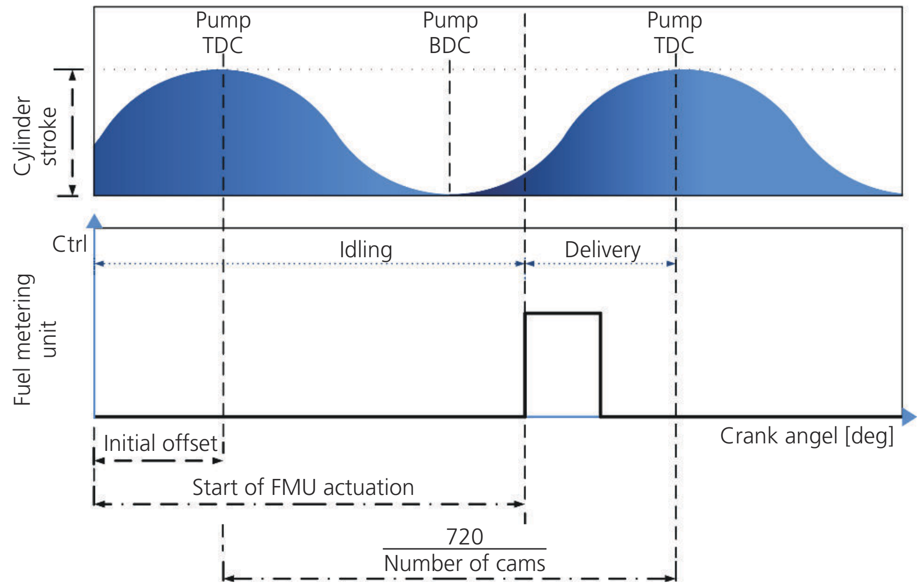
Energizing the FMU close to the bottom dead center (BDC) raises the rail pressure due to the increased volume of the high-pressure pump. In this way, the fuel flow through the high-pressure pump is increased. Vice versa, energizing the FMU close to the top dead center (TDC) causes the rail pressure to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

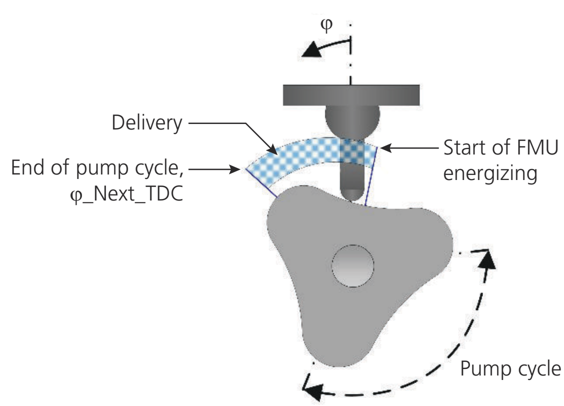
$$\varphi_{Energized^*} = \left[0.5 \cdot \frac{720}{Number_{Cam}} \leq \varphi_1 \leq 1 \cdot \frac{720}{Number_{Cam}}, \ldots, (Number_{Cam} - 0.5) \cdot \frac{720}{Number_{Cam}} \leq \varphi_{Number_{Cam}} \leq 720\right] + \varphi_{Init}$$

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:

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

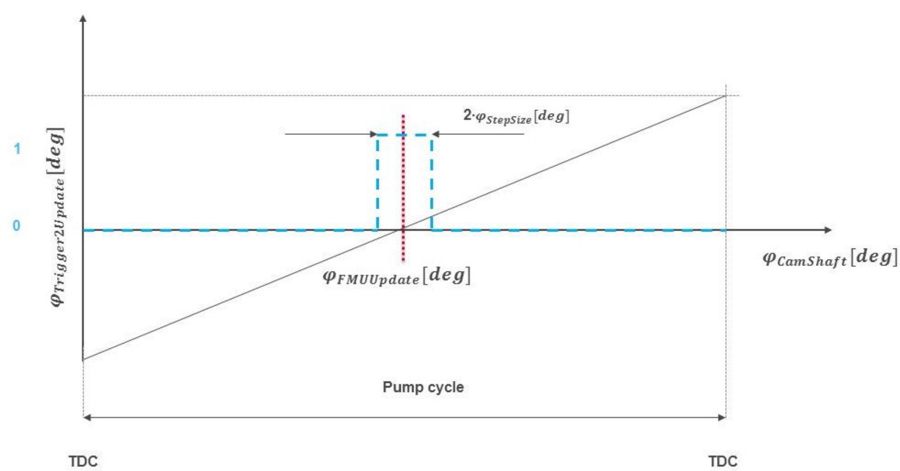
When $\varphi_{Trigger2Update}$ is close to zero, this indicates the trigger proximity. To ensure that $\varphi_{Trigger2Update}$ is captured it is hold for two iteration steps.

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

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

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

Related topics

References

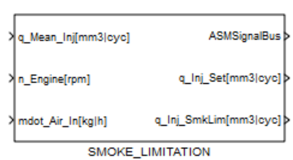
History of the RAIL_CONTROL_CRANKBASED Block..236
Rail Control Crankbased (ModelDesk Parameterizing 📖)

Smoke Limitation

Description

The SMOKE_LIMITATION calculates the maximum allowed injection quantity to avoid smoke.

This injection quantity depends on the intake air mass flow and the engine speed. You can use constant values for the maximum allowed injection quantity for testing purpose. The set injection quantity is limited by the maximum allowed injection quantity to avoid smoke.



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
q_Mean_Inj	[mm^3/cyc]	Mean injection quality per cycle per cylinder

Outports

The following table shows the outports:

Name	Unit	Description
q_Inj_Set	[mm^3/cyc]	Injection quantity setpoint (per cylinder per cycle)
q_Inj_SmkLim	[mm^3/cyc]	Maximum allowed injection quantity to avoid smoke

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_q_Inj_SmkLim_Set	[mm^3/cyc]	Set smoke limitation injection quantity
Map_q_Inj_SmkLim	[mm^3/cyc]	Smoke limitation map q_inj_SmkLimit = f(n_Engine,m_dot_InAir)
Sw_q_Inj_SmkLim	[1|2]	Select smoke limitation injection quantity ▪ 1: Map ▪ 2: Set

Related topics

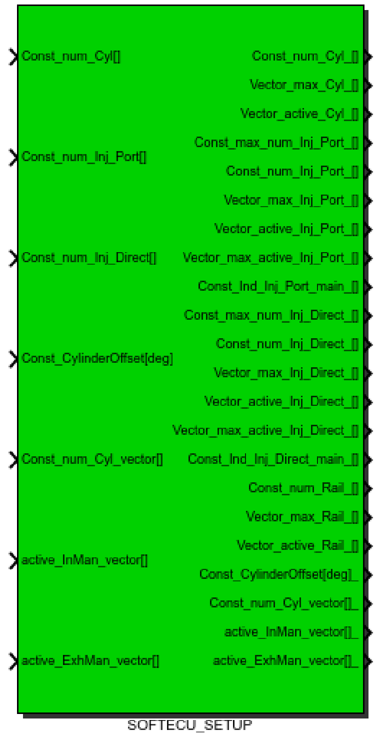
References

Smoke Limitation (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].

Name	Unit	Description
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 ▪ 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..240
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.

System Stop Conditions	Description
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:

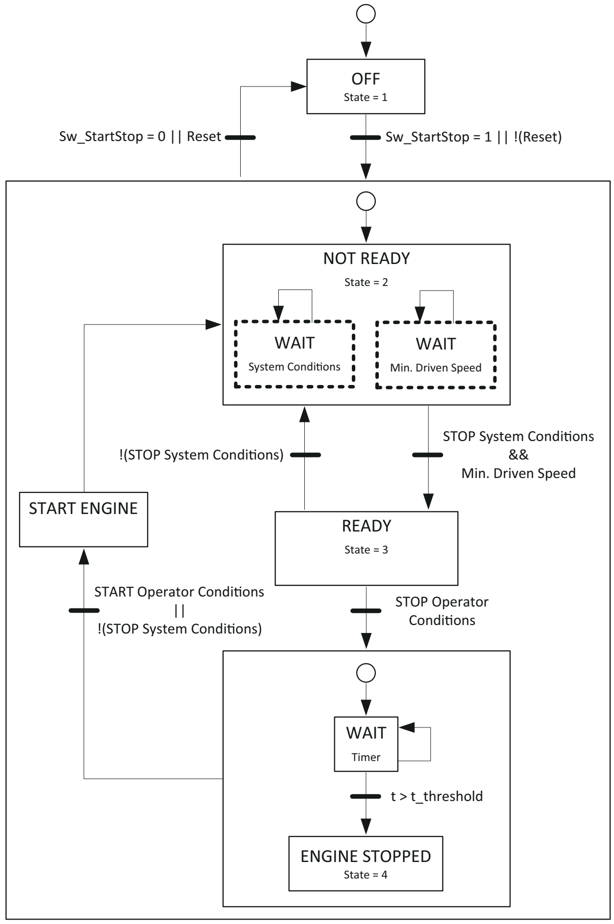
Transmission Type	Operator Stop Conditions
Manual	▪ Neutral gear is engaged ▪ Clutch is released ▪ Vehicle is not moving
Automatic	▪ Selector lever is in D-Position ▪ Brake is pressed ▪ Vehicle is not moving

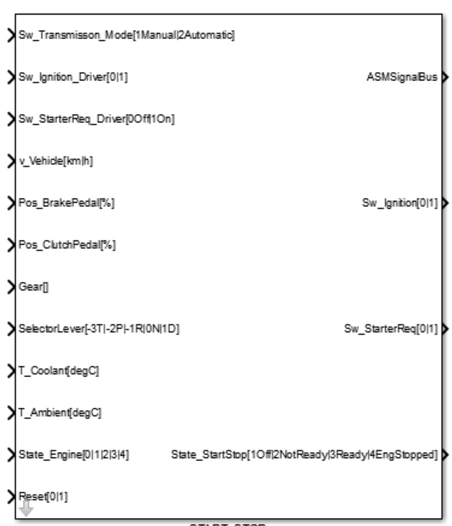
Once the stop conditions are fulfilled, the ECU additionally waits for a certain time before turning the engine off. This time can be parameterized (**Const_t_Stop_Offs** parameter) and used to avoid unintended short stops.

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
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

Name	Unit	Description
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

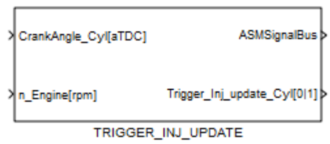
References

Start Stop (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

Information in this section

Engine Diesel

Where to go from here

Information in this section

Basics on the Engine Diesel Demo Model

Introduction

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

Basics

The ASM Diesel Engine Model is a Simulink model used to simulate turbocharged diesel engines in combination with a drivetrain model including automatic and manual transmission.

Overview of the Engine Diesel Demo

Introduction

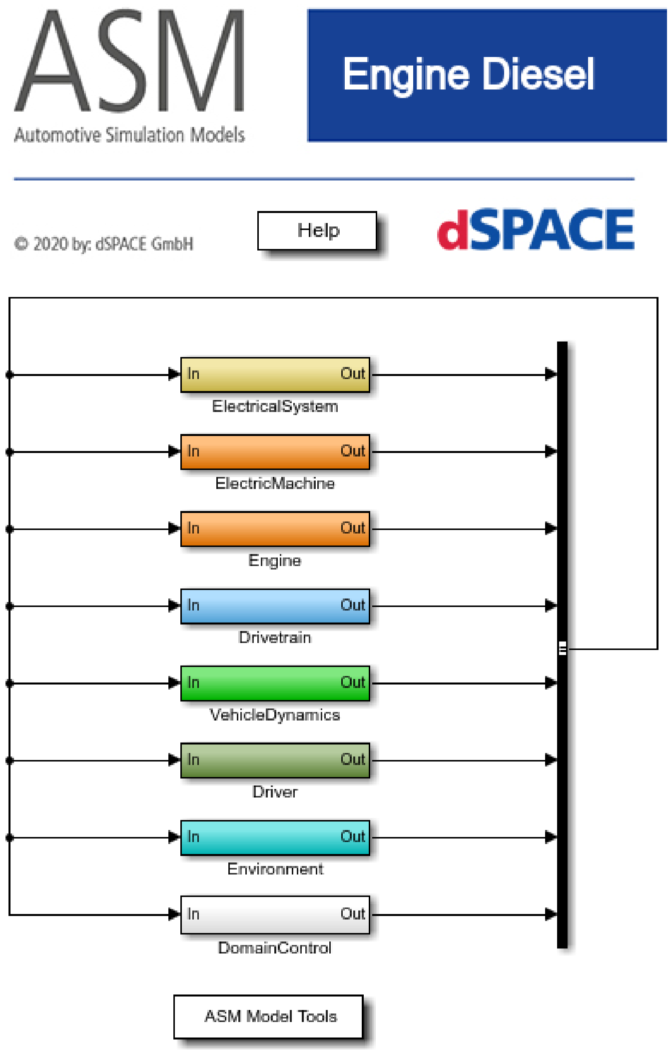
This topic gives you an overwiew of the Engine Diesel Demo Model and the ASM modules used.

Opening the model

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

Structure

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



The model consists of the following ASM modules:

- Electrical System Basic Module on page 153
- Electric Machine Simple Module on page 152
- Engine Diesel Module on page 154
- Drivetrain Basic Module on page 150
- Vehicle Dynamics Basic Module on page 168
- Driver Basic Module on page 147
- Environment Basic Module on page 160
- Start System Module on page 163
- Torque Manager P0 Module on page 165

The engine, the drivetrain and the vehicle dynamic blocks are connected via shaft speeds and shaft torques. This makes it easy to extend the engine model by adding other models. The ASM engine model can be used in combination with real controllers in a hardware-in-the-loop environment, or for simulating an engine in combination with software controller algorithms. The two blocks to the left and right of the model blocks manage the signal mapping from and to the I/O. They also manage the signal flow to and from the soft ECU for Simulink simulation.

The engine model contains components for an air path with a throttle and a manifold, and a piston engine which includes the air intake and combustion simulation. It also contains a fuel system, an engine coolant, and an exhaust system. The drivetrain model consists of a crankshaft, a manual transmission with a clutch, an automatic transmission with a lockup clutch and a torque converter, a differential, and a starter. A test bench model makes it possible to use the engine model without the drivetrain at a fixed engine speed and at a fixed engine torque. The vehicle dynamics block calculates the driving resistances of the vehicle, so only longitudinal vehicle dynamics are taken into account.

Note

The drivetrain and vehicle dynamics blocks do not include the spring and damping effects of the drivetrain and the chassis.

The environment is divided into driver, maneuver, and road systems.

Related topics

HowTos

How to Start with an ASM Demo Model via MATLAB (ASM Diesel Engine Model Description 🕮)

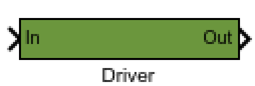
ASM Modules

Where to go from here

Information in this section

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 170

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

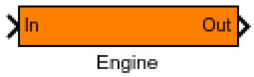
The following table shows the ports of the Interface_External_Out:

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 Diesel Module

Description

This module simulates a turbocharged diesel engine.



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

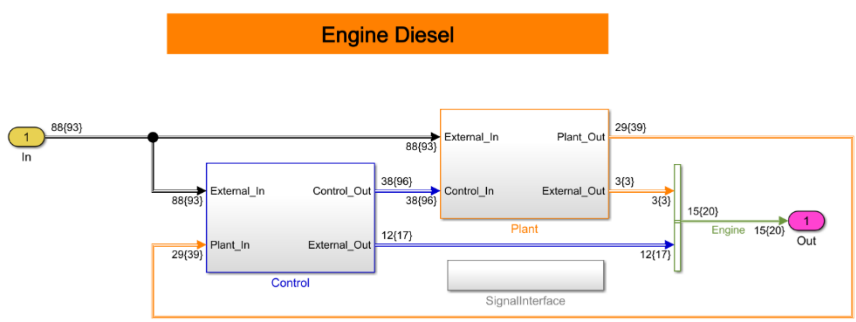
The engine model consists of components for:

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

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

The ASM Engine Diesel module consists of the following systems:

- Control: Contains the soft ECU and an interface for the real ECU.
- Plant: Contains the dynamic model of the diesel engine.
- Signal interface: Provides the interface for the ModelDesk plotting, i.e. displaying of the simulation results in ModelDesk.



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 174
- Cooling System Subsystem on page 178
- Exhaust Subsystem on page 179
- Fuel System Subsystem on page 182

- Piston Engine Subsystem on page 185
- Soft ECU Diesel Subsystem on page 187
- Air Path Control Subsystem on page 191
- Fuel System Control Subsystem on page 193
- Soft ECU SCR Subsystem on page 196
- Torque Control Subsystem on page 195

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 ▪ 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 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

Name	Unit	Description
		▪ 0: Neutral ▪ 1: Drive
StarterReq_ICE	[0|1]	Starter request ICE: ▪ 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	[degC]	Ambient temperature
Trq_BSG	[Nm]	Torque of the belt-driven starter generator (BSG)
Trq_Request_ICE	[Nm]	Torque request ICE
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	[deg]	Crank angle
Ctrl_AirRegulationValve	[0_1]	Control signal of the air regulation valve (SCR supply system)
Ctrl_CamPhaser_Exhaust	[0_1]	Control signal for the cam phaser of the exhaust cam shaft
Ctrl_CamPhaser_Intake	[0_1]	Control signal for the cam phaser of the intake cam shaft
Ctrl_Comp_Bypass	[0_1]	Control signal the for 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_EngineCoolantValve	[0_1]	Control signal to heat the system using the engine coolant
Ctrl_ExhThrottle	[]	Control signal of the exhaust throttle (low-pressure EGR system)
Ctrl_FuelMeterUnit	[mA]	Control signal of fuel the metering unit (high-pressure pump) for common rail system
Ctrl_Heater_AdBlueTank	[0_1]	Control signal of the AdBlue tank heater

Name	Unit	Description
Ctrl_Heater_DOC	[0_1]	Control signal of the Diesel Oxidation Catalyst (DOC) heater
Ctrl_Heater_PumpHose	[0_1]	Control signal of the pump hose heater (Selective Catalytic Reduction (SCR) supply system)
Ctrl_Heater_SCR	[0|1]	Control signal of the Selective Catalytic Reduction (SCR) catalyst heater
Ctrl_InjectionValve	[0_1]	Control signal of the injection valve
Ctrl_LPEGR	[0_1]	Control signal for the actuation of the low-pressure EGR valve (Exhaust gas recirculation)
Ctrl_PresCtrlValve	[mA]	Control signal of the pressure control valve in common rail system
Ctrl_PressureLineHeater	[0_1]	Control signal for the pressure line heater
Ctrl_Pump	[0_1]	Control signal of the pump ([-1_0]: Backward flow, [0_1]: Forward flow) in the Selective Catalytic Reduction (SCR) supply system
Ctrl_RevertingValve	[0|1]	Control signal for the reverting valve (0: From tank to pump hose, 1: From pump hose to tank) in the Selective Catalytic Reduction (SCR) supply system
Ctrl_SuctionLineHeater	[0_1]	Control signal for the suction line heater in Selective Catalytic Reduction (SCR) supply system
Ctrl_SupplyModuleHeater1	[0_1]	Control signal for the supply module heater #1 in Selective Catalytic Reduction (SCR) supply system
Ctrl_SupplyModuleHeater2	[0_1]	Control signal for the supply module heater # 2 in Selective Catalytic Reduction (SCR) supply system
Ctrl_Throttle	[0_1]	Control signal of the electrical throttle valve
Ctrl_VentValve	[0_1]	Control signal of the vent valve in the Selective Catalytic Reduction (SCR) supply system
Ctrl_VTG	[0_1]	Control signal of the variable-geometry turbocharger (VGT)
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

Name	Unit	Description
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]	Setpoint for idle the speed of the combustion engine
p_Ambient	[Pa]	Ambient pressure
phi_FMU_Energized	[deg]	Crank angle to energize the fuel metering unit (Common rail system in the combustion engine)
phi_Inj_Direct	[bTDC]	Vector with crank angles for the start of the fuel injection
PulseState	[]	Pulse state (For details see SoftAPU)
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
UpdateCounter	[]	Update counter (For details, refer to the documentation of SoftAPU)
UpdateState	[]	Update state (For details, refer to the documentation of SoftAPU)

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 idle speed of combustion engine
n_Engine_Meas	[rpm]	Measured speed of combustion engine
p_Ambient	[Pa]	Ambient pressure
Pos_AccPedal_Meas	[%]	Measured accelerator pedal position
State_ICEngine	[0|1|2|3|4]	ICE state: ▪ 0: Off or Error ▪ 1: Ignition on ▪ 2: Starter on ▪ 3: Running ▪ 4: Shutdown
State_StartStop	[1|2|3|4]	Start-stop state: ▪ 1: Off ▪ 2: Not ready ▪ 3: Ready to stop the engine ▪ 4: Engine actively stopped by the system
Sw_Replace_Env	[0|1]	Switch for replacing the ambient conditions ▪ 0: Off - source is parameters ▪ 1: On - source is measurements
Sw_Starter	[0|1]	Starter activate switch: ▪ 0: Off ▪ 1: On
T_Ambient	[°C]	Ambient temperature
Trq_MeanEff_Engine_Meas	[Nm]	Measured mean effective engine torque
Trq_Shift_Request	[Nm]	Torque intervention during gear shift

Inports Plant

The following table shows the ports of the Interface_External_In:

Name	Unit	Description
n_Engine	[rpm]	Speed of the combustion engine
p_Ambient	[Pa]	Ambient pressure
Pos_AccPedal	[%]	Position of the accelerator pedal

Name	Unit	Description
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_ExhThrottle	[%]	Position signal of the exhaust throttle
Pos_LPEGR	[%]	Position of the low-pressure EGR valve
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_MeanEff_Engine	[Nm]	Mean effective engine torque
Trq_MeanEff_Engine_Mod	[Nm]	Mean effective engine torque (modulated)
Trq_Fric_Engine	[Nm]	Engine friction

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

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_Engine	[0|1|2|3|4]	Engine state: ▪ 0: Engine off ▪ 1: Ignition on ▪ 2: Ignition on and starter activated ▪ 3: Engine is running ▪ 4: Ignition is switched off, shutdown active
Sw_Replace_Env	[0|1]	Switch for replacing the ambient conditions: ▪ 0: Off - source is parameters ▪ 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

Name	Unit	Description
		▪ 3: Open clutch ▪ Reference gear
Mode_SelectorLever	[1|2]	Switch for mode signal of the selector lever source: ▪ 1: Stimulus ▪ 2: Driver
Mode_StartButtonState	[1|2]	Controls whether the signal for the activation of the start button is calculated by the soft ECU or provided by a stimulus signal: ▪ 1: Stimulus ▪ 2: Soft ECU
n_Engine_Set	[rpm]	Setpoint for the speed of the combustion engine
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

Name	Unit	Description
Sw_TipShift_Maneuver	[-1|0|1]	TipShift request stimulus signal from the maneuver: ▪ -1 : Down shift ▪ 0: Off ▪ 1: Up shift
Sw_TorqueController	[0|1]	Switch to activate the torque controller: ▪ 0: Off ▪ 1: On
T_Ambient	[°C]	Ambient temperature
v_Vehicle_Ref	[km/h]	Reference vehicle velocity
v_Vehicle_Preview_Ref	[km/h]	Preview reference vehicle velocity

Start System Module

Description

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

Name	Unit	Description
SelectorLever	[-3|-2|-1|0|1]	Selector lever position ▪ -3: TipShift ▪ -2: Park ▪ -1: Reverse ▪ 0: Neutral ▪ 1: Drive
State_Engine	[0|1|2|3|4]	Engine state ▪ 0: Engine off ▪ 1: Ignition on ▪ 2: Ignition on and starter activated ▪ 3: Engine is running ▪ 4: Ignition is switched off, shutdown active
State_StartButton	[-1|0|1|2]	State of the start button ▪ -1: Power off ▪ 0: Accessory on ▪ 1: Power on ▪ 2: Starter on
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

Name	Unit	Description
		▪ 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 ▪ 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

Name	Unit	Description
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_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
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

Name	Unit	Description
omega_Wheel	[rad/s]	Wheel speed
Trq_Max_Brake	[Nm]	Maximum brake torque
v_Vehicle	[km/h]	Vehicle velocity in km/h
v_Vehicle	[m/s]	Vehicle velocity in m/s

Subsystems

Introduction

The following subsystems are contained inside the ASM modules.

Where to go from here

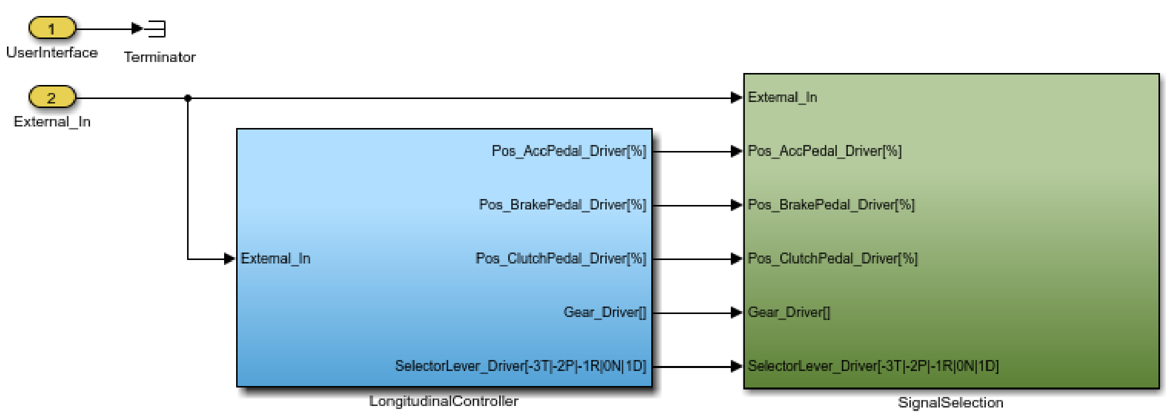
Information in this section

Subsystems of the Driver Basic Module

Driver Subsystem

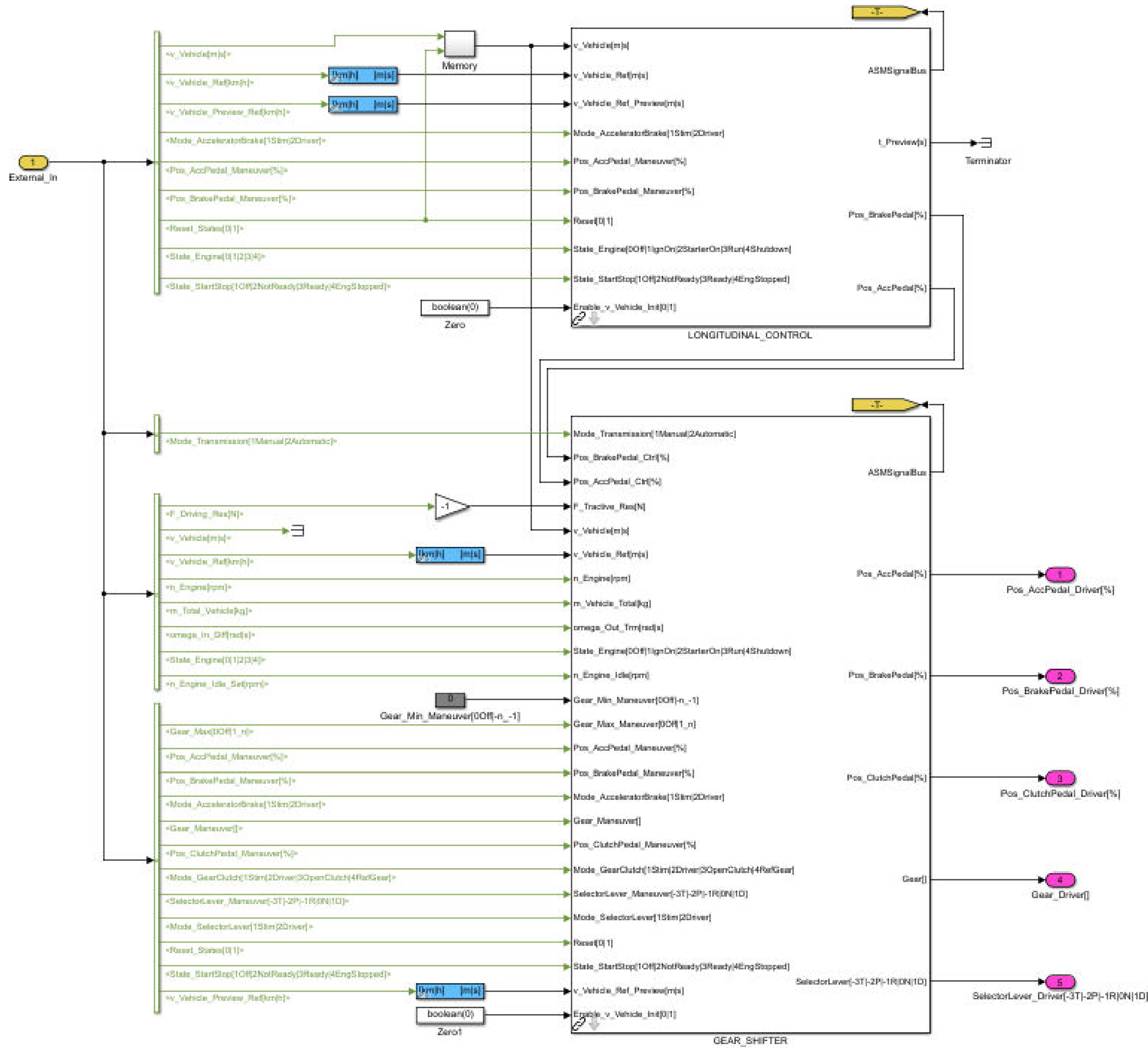
Overview

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



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

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



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

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

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

Simulation scenarios

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

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

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

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

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

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

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

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

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

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

Subsystems

The following list contains all the model's subsystems:

- Longitudinal Control (ASM Drivetrain Basic Reference 📖)
- Gear Shifter (ASM Drivetrain Basic Reference 📖)

Subsystems of the Engine Diesel Module

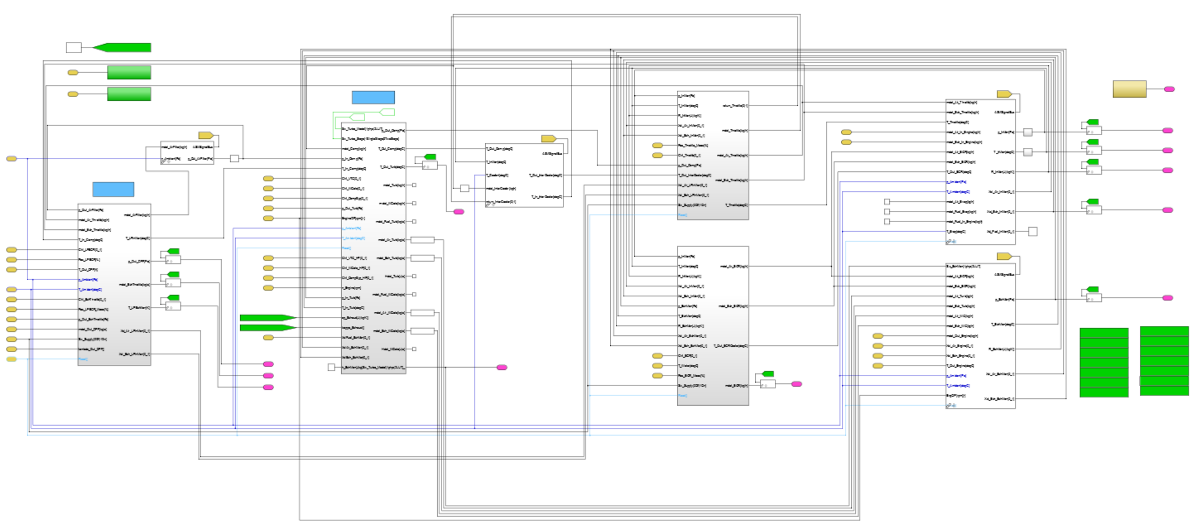
Where to go from here

Information in this section

Air Path Subsystem

Overview

The **Air Path** model 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 Turbocharger on page 51.

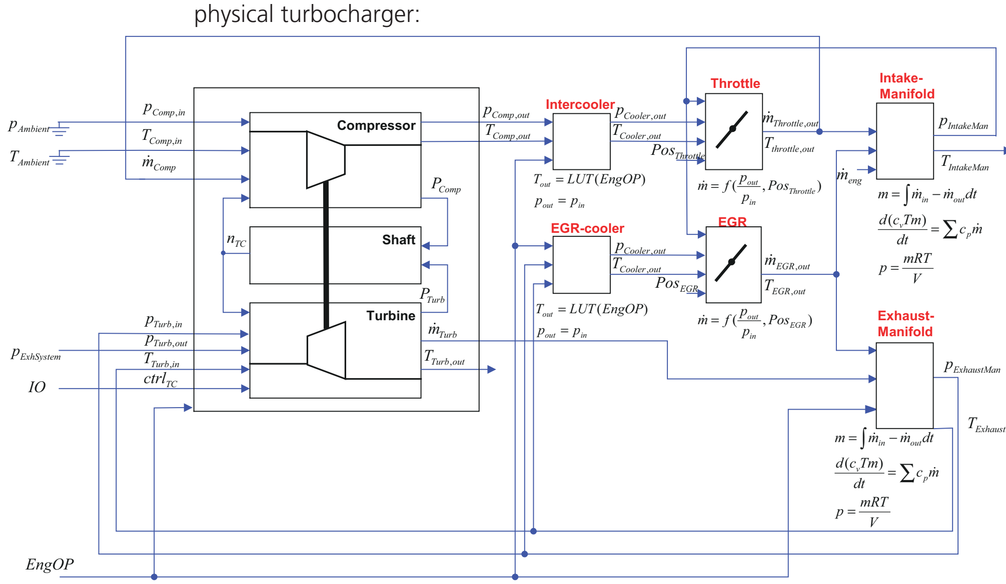
The intercooler cools the air flow from the compressor according to the efficiency and temperature difference between the input and coolant temperature. The throttle is modeled as an orifice with a variable cross-section which limits the fresh air flow into the intake manifold.

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 a variable cross-section. The EGR position can increase the air flow into the intake manifold.

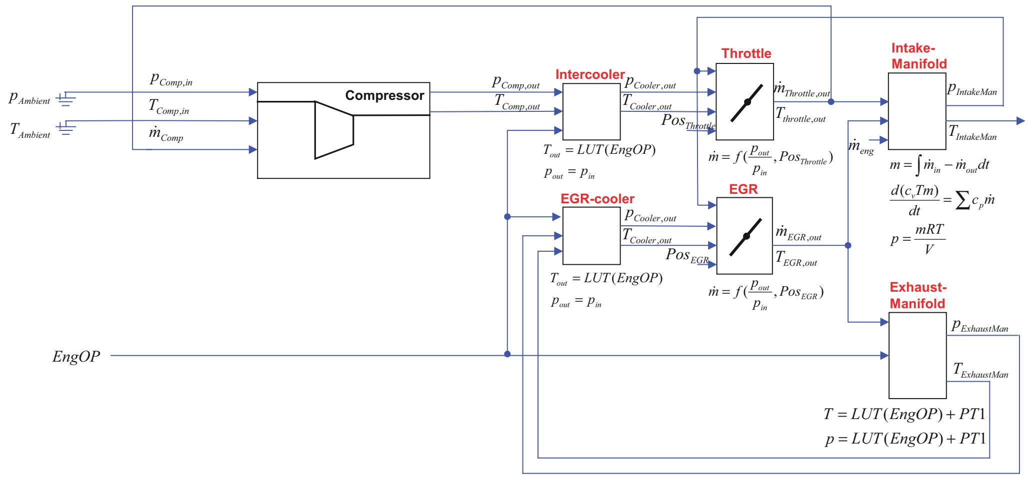
The next illustration is a schematic of the air path simulation approach with physical turbocharger:



> **Tip**
>
> A state space representation with the algebraic equations used for this approach can be found in the Equations of Air Path with Physical Turbocharger on page 254.

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 253.

The low-pressure EGR functionality can be optionally integrated into the model. For information on how to connect the **LP-EGR** subsystem to the model, refer to How to Integrate the Low-Pressure EGR Demo Model (ASM Diesel Engine Model Description).

Inports

The following table shows the inports:

Name	Unit	Description
Ctrl_EGR	[0_1]	Control signal (PWM) of electrical EGR valve
Ctrl_TC	[0_1]	Control signal (PWM) of electrical VGT or wastegate valve
Ctrl_Throttle	[0_1]	Control signal (PWM) of electrical throttle valve
EngOP	[rpm][mm^3/cyc]	Engine operating point: n_Engine[rpm],q_Inj_1cyl[mm^3/cyc]
lambda	[]	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_Out_Engine	[kg/h]	Mass flow out of the piston engine (exhaust gas)
p_Ambient	[Pa]	Ambient pressure
p_ExhSystem	[Pa]	Exhaust system back pressure (pressure after turbine)
p_Out_ExhThrottle	[Pa]	Pressure downstream of the exhaust throttle
Pos_EGR_Meas	[%]	Measured throttle position at real EGR valve
Pos_Throttle_Meas	[%]	Measured throttle position at real throttle valve

Name	Unit	Description
Sw_MainRelay	[0_1]	Activates main relay from ECU
T_Ambient	[°C]	Ambient temperature
T_Out_DPF	[K]	Temperature of the DPF
T_Out_Engine	[°C]	Engine output temperature

Outports

The following table shows the outports:

Name	Unit	Description
p_IntakeManifold	[Pa]	Intake manifold pressure (pressure before piston engine)
p_Out_DPF	[Pa]	Pressure downstream of DPF
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
T_IntakeManifold	[°C]	Intake manifold temperature

Blocks

- Air Filter on page 15
- EGR Cooler on page 16
- EGR Valve on page 18
- Exhaust Manifold on page 22
- Exhaust Throttle on page 25
- Intake Manifold on page 26
- Intercooler on page 30
- Low-Pressure EGR Cooler on page 32
- Low-Pressure EGR Valve on page 33
- Low-Pressure Exhaust Manifold on page 37
- Low-Pressure Intake Manifold on page 39
- EGR Valve (Mechanical) on page 46
- Mechanical Exhaust Throttle on page 45
- Mechanical Low-Pressure EGR Valve on page 44
- Mechanical Throttle on page 47
- Throttle Valve on page 49
- Turbocharger on page 51

Related topics

HowTos

How to Integrate the Low-Pressure EGR Demo Model (ASM Diesel Engine Model Description 📖)

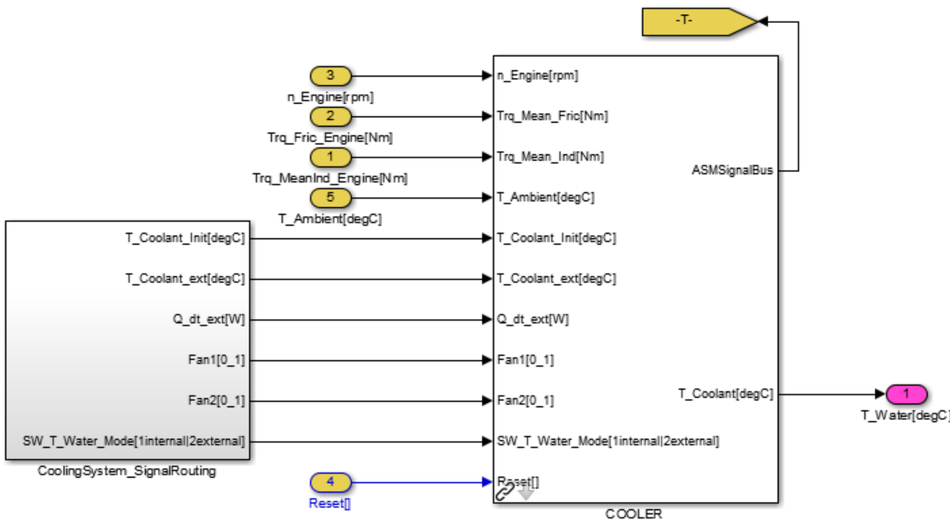
References

Basic Turbocharger (ASM Turbocharger Reference 📖)
Turbocharger 51

Cooling System Subsystem

Description

This COOLER block describes the engine cooling system. The current model version contains a basic cooler model.



Inports

The following table shows the inports:

Name	Unit	Description
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

Outports

The following table shows the outports:

Name	Unit	Description
T_Water	[°C]	Coolant temperature

Blocks

- Cooler on page 61

Exhaust Subsystem

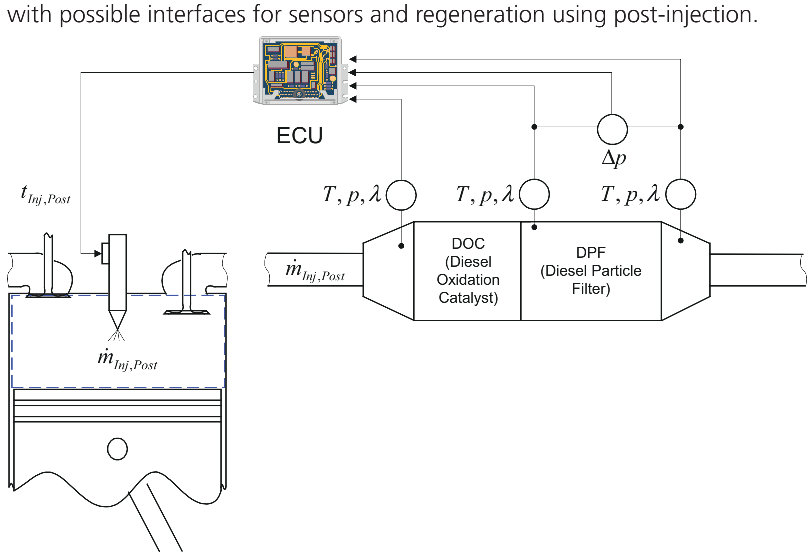
Description

This model describes the engine exhaust system. It contains models for a diesel oxidation catalyst (DOC) and diesel particulate filter (DPF).

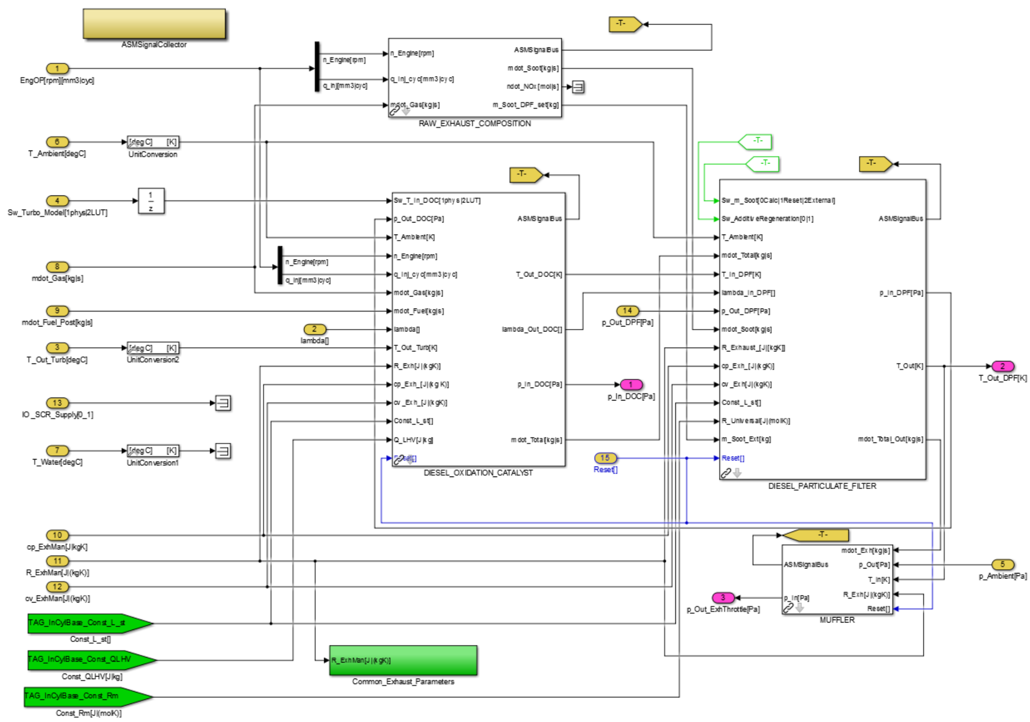
Exhaust systems containing DOCs and DPFs are very popular forms of aftertreatment in diesel engines. DOCs reduce CO and unburned HC, and DPFs reduce particulates (soot). The simulated DPF is what is called a wall-flow filter, also known as a closed system.

A wall-flow filter needs the burning of the soot (regeneration) to reduce exhaust back pressure and maintain correct DPF function. The regeneration of the DPF depends on the temperature in it. Good soot oxidation takes place at temperatures higher than 650 °C. Diesel engines usually have low exhaust temperatures, so regeneration has to be forced. One way of doing this is of course to increase the temperature, and another is to reduce the optimum temperature for regeneration. This can be done by using a chemical catalyst in the DPF or by introducing an additive that is fed into the diesel fuel from a separate tank. To increase the temperature, post-injection fuel is usually burnt in the DOC, which also increases the temperature in the DPF.

The following illustration shows the structure of the simulated exhaust system with possible interfaces for sensors and regeneration using post-injection.



The following illustration shows the Simulink model of the exhaust system:



Inports

The following table shows the inports:

Name	Unit	Description
cp_ExhMan	[J/kgK]	Isobaric heat capacity of exhaust gas
cv_ExhMan	[J/(kgK)]	Isochoric heat capacity of exhaust gas
EngOP	[rpm][mm^3/cyc]	Engine operating point
IO_SCR_Supply	[0_1]	Control signal for SCR supply system
lambda	[]	Lambda value after combustion process
mdot_Fuel_Post	[kg/s]	Mass flow of fuel injected into exhaust system to increase its temperature
mdot_Gas	[kg/s]	Mass flow of exhaust gas trough exhaust system
p_Ambient	[Pa]	Ambient pressure
p_Out_DPF	[Pa]	Pressure downstream DPF
R_ExhMan	[J/(kg K)]	Specific gas constant in the exhaust manifold
Reset	[]	Integrator's reset
T_Ambient	[°C]	Ambient temperature
T_Out_Turb	[°C]	Temperature at turbine output
T_Water	[°C]	Engine coolant temperature

Outports

The following table shows the outports:

Name	Unit	Description
p_In_DOC	[Pa]	Pressure at the DOC input side
T_Out_DPF	[K]	Temperature downstream of DPF
p_Out_ExhThrottle	[Pa]	Pressure downstream of exhaust throttle (located downstream of DPF)

Blocks

- Mass flow
- Common exhaust parameters
- Diesel oxidation catalyst
- Raw exhaust composition
- Diesel particulate filter
- Muffler

Mass flow

The mass flow has to be calculated in different ways depending on the exhaust manifold model used. If the physical model is used (together with the physical turbocharger), the mass flow can be calculated from the mass flows of the turbine and the waste gate. If the simple exhaust manifold or the LUT-based exhaust manifold is used, the mass flow has to be calculated from the mass flow over the exhaust valves and the EGR valve.

Common exhaust parameters

Parameters that are used several times in the exhaust model are collected in the COMMON_EXHAUST_PARAMETERS subsystem. This provides central online access to all the parameters. If one of these parameters is modified, this affects all the parts of the model that use it online and offline. For information on the common exhaust parameters, refer to Common Exhaust Parameters (ASM Diesel Exhaust Reference 📖).

Diesel oxidation catalyst

The diesel oxidation catalyst is used to oxidize carbon monoxide and hydrocarbon. In combination with a DPF, the oxidation of hydrocarbon is used to increase the exhaust gas temperature burning post-injected fuel (DPF regeneration). Several sensors measure the lambda values, pressures, and temperatures before and after the DOC for exhaust gas treatment. For information on the diesel oxidation catalyst, refer to Diesel Oxidation Catalyst (ASM Diesel Exhaust Reference 📖).

Raw exhaust composition

The raw exhaust gas composition model delivers the NOx molar flow and soot mass flow as functions of the engine operating point. These values are then used by the DPF and SCR. For information on the raw exhaust gas composition, refer to Exhaust Composition (ASM Diesel Exhaust Reference 📖).

Diesel particulate filter

The simulated DPF is a wall-flow filter, also called a closed system. The soot in the exhaust is trapped in the DPF by filtering. To reduce exhaust back pressure and to maintain correct DPF operation, the soot has to be burned (regeneration). The regeneration of the DPF depends on the temperature in the DPF. Basically, good oxidation of soot takes place at temperatures higher than 650 °C, but there are several ways to reduce this temperature, such as incorporating a catalyst material directly into the filter system or adding a fuel-borne catalyst to the fuel. Because diesel engine exhaust temperatures are usually low, the temperature sometimes has to be increased to activate regeneration. This is usually done by burning post-injected fuel in the DOC, which increases the temperature in the DPF, too. For information on the diesel particulate filter, refer to Diesel Particulate Filter (ASM Diesel Exhaust Reference 🕮).

Muffler

The MUFFLER block calculates the pressure upstream of the muffler as a function of the pressure downstream (usually the ambient pressure) and the exhaust mass flow. For information on the muffler, refer to Muffler (ASM Diesel Exhaust Reference 🕮).

Related topics

Basics

Diesel Exhaust Library (ASM Diesel Exhaust Reference 🕮)

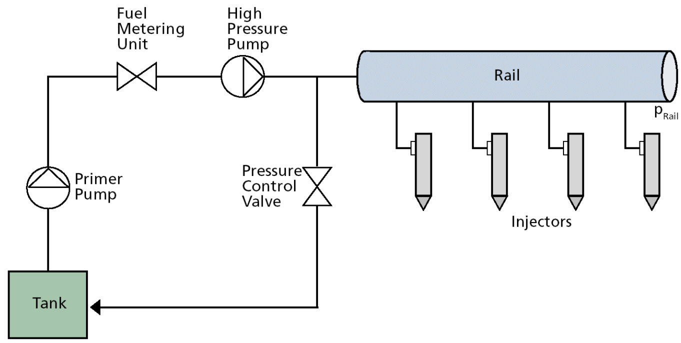
Fuel System Subsystem

Overview

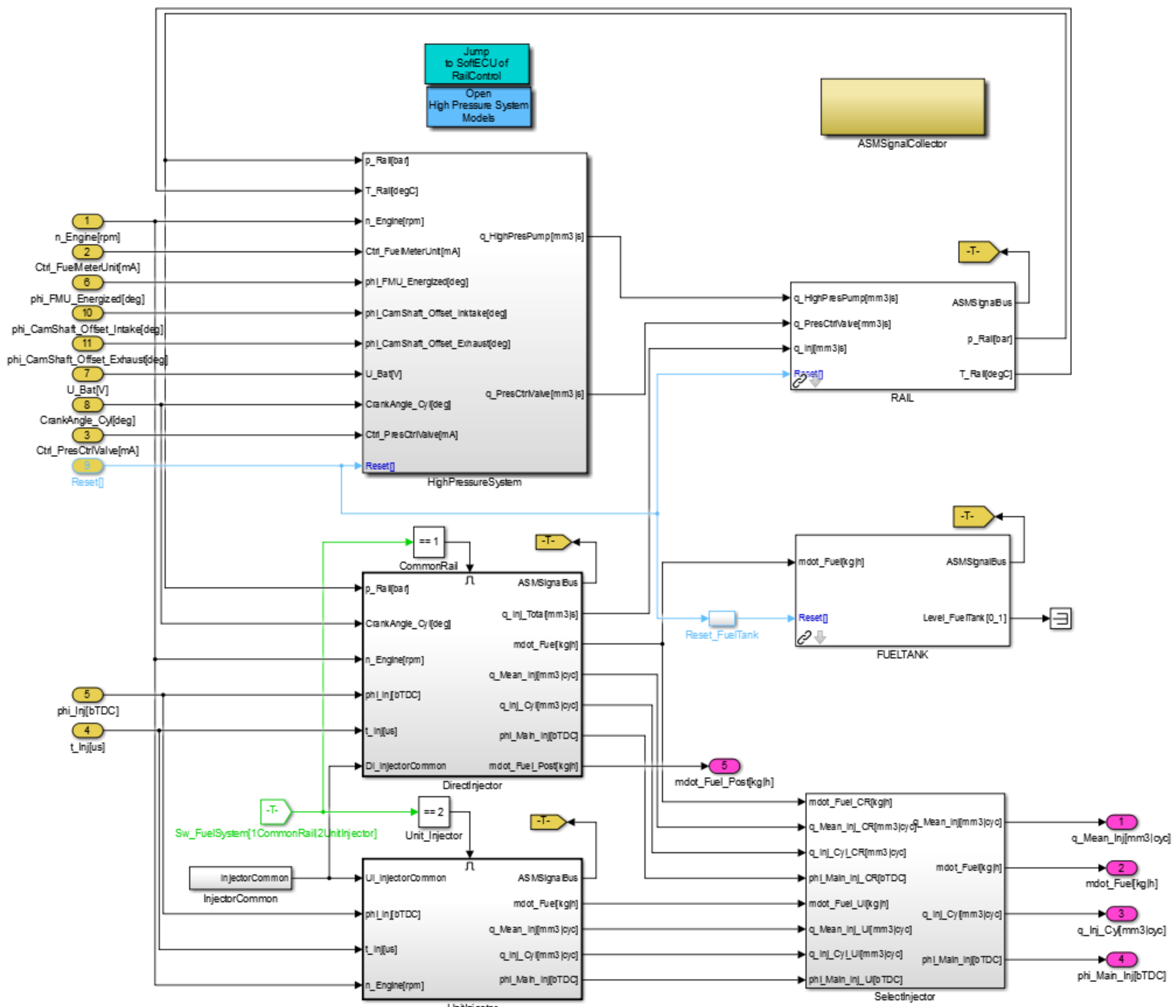
ASM provides models for a common-rail system and a unit injector. Here, the common-rail system is described. For detailed information about the model of unit injector, refer to Unit Injector on page 84.

The common rail fuel system provides fuel for injection that is 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 following illustration shows a scheme of a common-rail fuel system.



The following illustration shows the Simulink fuel system model.



The common-rail system consists of:

- High-pressure system
- Rail
- Direct injector

The high-pressure system regulates the pressure in the rail. There are two models of the high-pressure system:

- Current-based
- Crank-based

For an explanation on how to exchange the models, refer to How to Integrate the High-Pressure Pump Model (ASM Diesel Engine Model Description 📖).

The two systems differ in terms of how 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 strength of electric current. In the crank-based approach, the fuel is delivered to the rail as needed. Here, the control signal is the crank angle degree of the fuel metering unit's energization. The model consists of one component (HPP_CRANKBASED).

Inports

The following table shows the inports:

Name	Unit	Description
CrankAngle_Cyl	[deg]	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
n_Engine	[rpm]	Engine speed
phi_CamShaft_Offset	[deg]	Camshaft offset due to variable valve train
phi_FMU_Energized	[deg]	Crank angle to energize fuel metering unit
phi_Inj	[bTDC]	Injection start angle vector (cylinder 1, pulse 1, pulse 2, ..., cylinder n, pulse m)
Reset	[]	Reset all integrator to their initial states
t_Inj	[µs]	Injection time vector (cylinder 1, pulse 1, pulse 2, ..., cylinder n, pulse m)
U_Bat	[V]	Battery voltage

Outports

The following table shows the outports:

Name	Unit	Description
EngOP	[rpm][mm^3/cyc]	Engine operating point: n_Engine[rpm], q_Inj_1cyl[mm^3/cyc]
mdot_Fuel	[kg/h]	Injection mass flow into cylinder (vector of number of cylinders)

Name	Unit	Description
mdot_Fuel_Post	[kg/h]	Fuel flow injected into exhaust system for exhaust aftertreatment
phi_Main_Inj	[bTDC]	Crank angle of main injection
q_Inj_Cyl	[mm^3/cyc]	Injection quantity per cylinder (vector of number of cylinders)

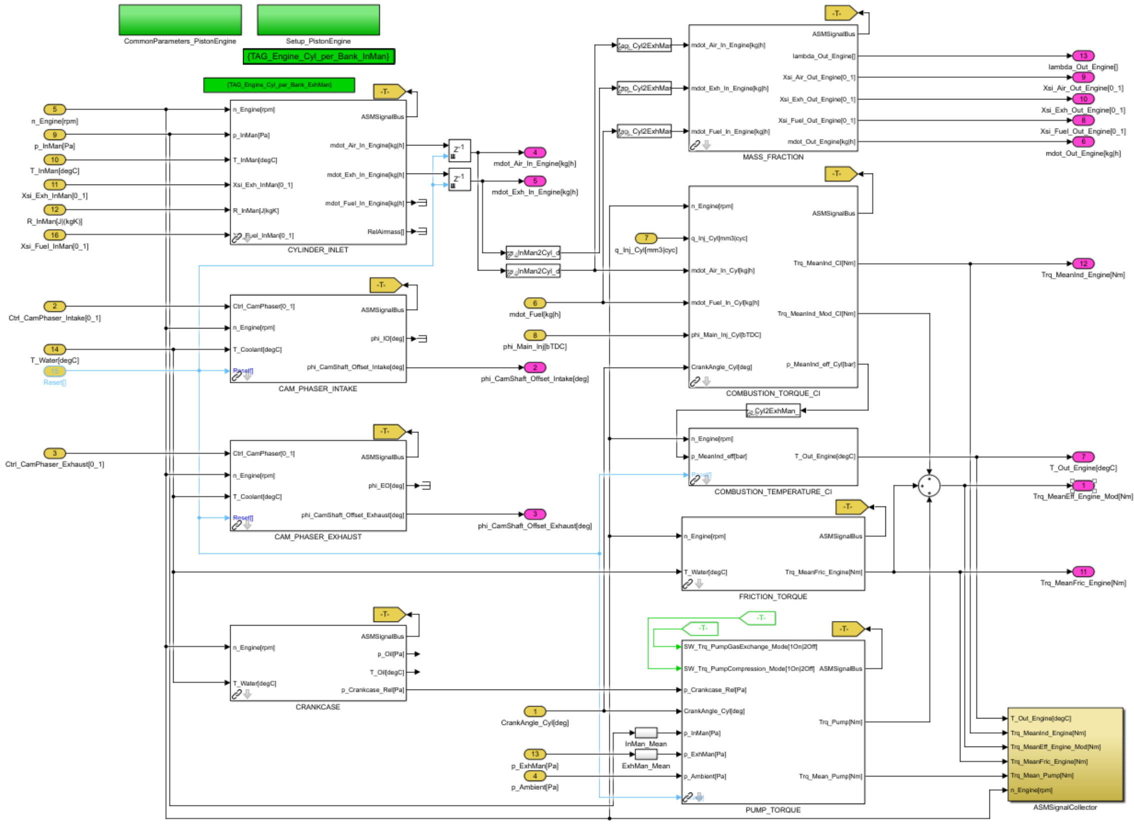
Blocks

- Direct Injector on page 76
- Fuel Tank on page 79
- High-Pressure Pump on page 80
- High-Pressure Pump (Crank-Based) on page 70
- Pressure Control Valve on page 81
- Rail on page 82
- Unit Injector on page 84

Piston Engine Subsystem

Overview

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. Both the compression and gas exchange pump torque are calculated in parallel if these effects are desired. 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	[deg]	Crank angle per cylinder, positive value is after TDC
Ctrl_CamPhaser_Exhaust	[0_1]	Control signal for the cam phaser of the exhaust cam shaft
Ctrl_CamPhaser_Intake	[0_1]	Control signal for the cam phaser of the intake cam shaft
mdot_Fuel	[kg/h]	Mass flow of fuel
n_Engine	[rpm]	Engine speed
p_Ambient	[Pa]	Ambient pressure
p_ExhMan	[Pa]	Exhaust manifold pressure
p_InMan	[Pa]	Intake manifold pressure (pressure before piston engine)
phi_Main_Inj	[bTDC]	Crank angle 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 all integrators to their initial conditions

Name	Unit	Description
T_InMan	[°C]	Intake manifold temperature
T_Water	[°C]	Coolant water temperature
Xsi_Exh_InMan	[0_1]	Mass fraction of the exhaust gas 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
lambda_Out_Engine	[]	Lambda value after the combustion process
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_Out_Engine	[kg/h]	Mass flow out of the piston engine (exhaust gas)
phi_CamShaft_Offset_Exhaust	[deg]	Offset of exhaust cam shaft by variable valve train
phi_CamShaft_Offset_Intake	[deg]	Offset of intake cam shaft by variable valve train
T_Out_Engine	[°C]	Engine output temperature
Trq_MeanFric_Engine	[Nm]	Mean friction torque
Trq_MeanEff_Engine_Mod	[Nm]	Mean effective engine torque
Trq_MeanInd_Engine	[Nm]	Mean indicated engine torque
Xsi_Air_Out_Engine	[0_1]	Mass fraction of air at the engine output side
Xsi_Exh_Out_Engine	[0_1]	Mass fraction of exhaust at the engine output side
Xsi_Fuel_Out_Engine	[0_1]	Mass fraction of fuel at the engine output side

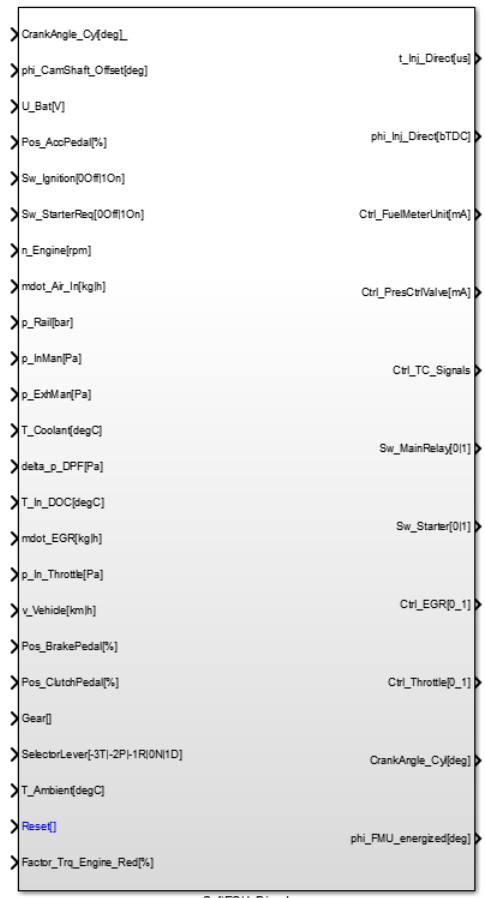
Blocks

- Camshaft Phaser Exhaust on page 88
- Camshaft Phaser Intake on page 89
- Combustion Temperature CI on page 91
- Combustion Torque on page 92
- Crankcase on page 95
- Cylinder Inlet on page 96
- Friction Torque on page 98
- Mass Fraction on page 99
- Pump Torque on page 100

Soft ECU Diesel Subsystem

Overview

The **SOFTECU_Diesel** model serves as basic diesel engine ECU controller software without any diagnostics. It 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.

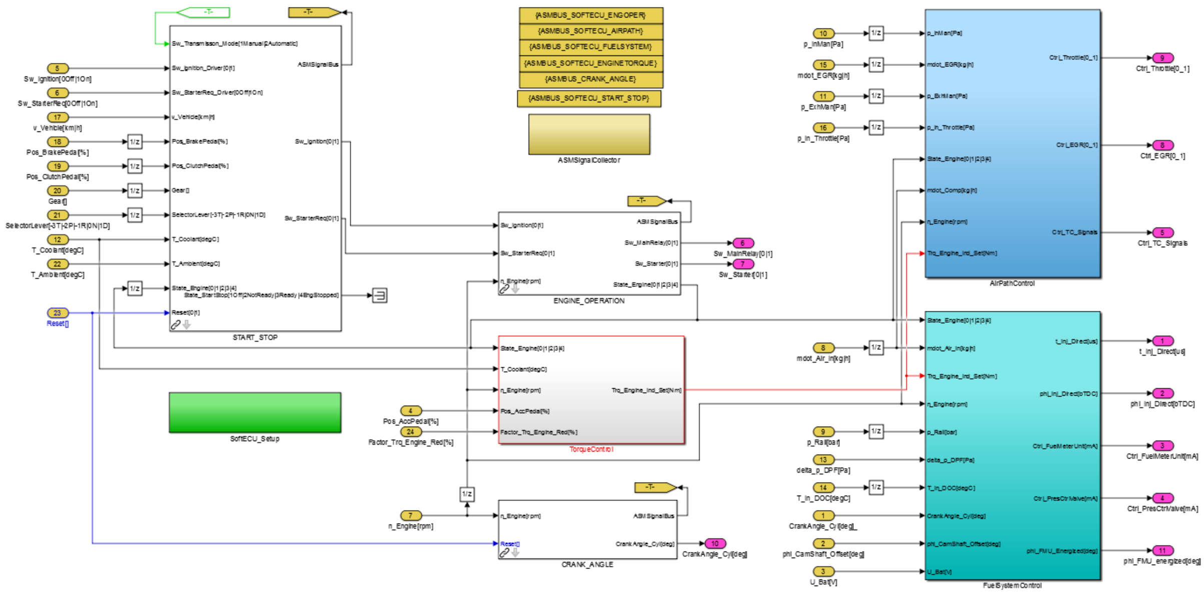


SoftECU_Diesel

The soft ECU is divided into subsystems for controlling the engine.

- Engine operation
- Crank angle calculation
- Torque control
- Setup
- Air path control
- Fuel system control
- Start-stop

The following illustration shows the described SoftECU subsystems:



In Engine Operation, 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 Torque control 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.

In Fuel system control, the torque is converted to a setpoint for injection quantity. The quantity is limited by a smoke limitation map. The kind of control for the common rail pressure is set according to the actual engine operation. Two basic controllers for the pressure control valve and fuel metering unit control the rail pressure. The setpoints depend on the engine operating point. The injection timing (for all cylinders and pulses) is calculated from the resulting quantity setpoint and measured rail pressure.

Air path control serves PI-controllers for Boost pressure and EGR. The setpoints depend on the engine operating point.

Inports

The following table shows the inports:

Name	Unit	Description
CrankAngle_Cyl	[deg]	Crank angle from I/O; signal is routed to model
delta_p_DPF	[Pa]	Pressure difference over Diesel Particulate Filter (DPF)
Factor_Trq_Engine_Red	[%]	Engine torque reduction factor when shifting gears
Gear	[]	Gear
mdot_Air_In	[kg/h]	Air mass flow through compressor (HFM sensor)
mdot_EGR	[kg/h]	Mass flow through EGR valve
n_Engine	[rpm]	Engine speed
p_ExhMan	[Pa]	Pressure in exhaust manifold
p_InMan	[Pa]	Intake manifold pressure
p_In_Throttle	[Pa]	Input pressure of throttle
p_Rail	[bar]	Rail pressure (absolute)
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 all integrators to their initial conditions
SelectorLever	[-3|-2|-1|0|1]	Selector lever position: ▪ -3: TipShift ▪ -2: Park ▪ -1: Reverse ▪ 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 water temperature
T_In_DOC	[°C]	Input temperature of Diesel Oxidation Catalyst (DOC)
U_Bat	[V]	Battery voltage
v_Vehicle	[km/h]	Vehicle velocity

Outports

The following table shows the outports:

Name	Unit	Description
CrankAngle_Cyl	[deg]	Crank angle from Soft ECU
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_Signals	[0_1]	Control signal (PWM) of electrical VGT or wastegate valve
Ctrl_Throttle	[0_1]	Control signal (PWM) of electrical throttle valve
phi_FMU_energized	[deg]	Start of fuel metering unit's control
phi_Inj_Direct	[bTDC]	Injection start angle vector (cylinder 1, pulse 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	[µs]	Injection time vector (cylinder 1, pulse 1, pulse 2, ..., cylinder n, pulse m)

Blocks and subsystems

- Ambient Conditions on page 108
- Air Path Control Subsystem on page 191
- Crank Angle Calculation on page 113
- Engine Operation on page 119
- Fuel System Control Subsystem on page 193
- SoftECU Setup on page 133
- Start-Stop System on page 136
- Torque Control Subsystem on page 195

Related topics

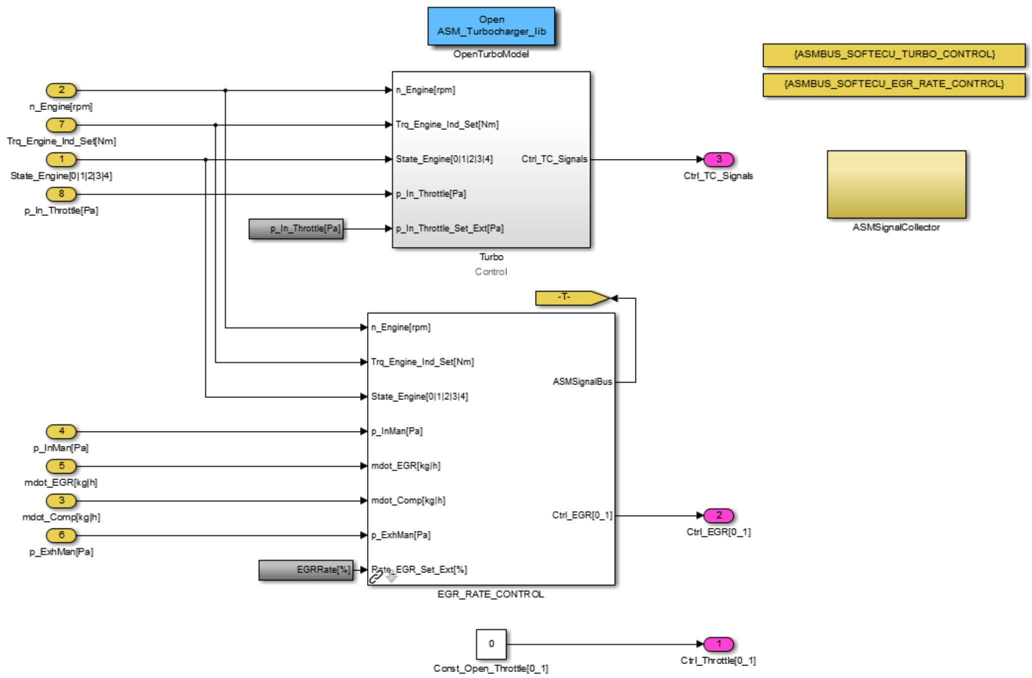
References

History of the SOFT_ECU_DIESEL Block........238

Air Path Control Subsystem

Overview

The AirPathControl block collects the controller for the air path. The external setpoints of the controller are connected to the measurement interface so that you can use measurement data as setpoint for testing purpose.



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
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 electrical LP EGR valve
Ctrl_TC_Signals	[]	Turbocharger control signal bus
Ctrl_Throttle	[0_1]	Control signal of electrical throttle valve

Ctrl_TC_Signals The turbocharger control signals are contained in a bus.

Name	Unit	Description
Ctrl_VTG	[0_1]	Control signal (PWM) of VTG
Ctrl_WGate	[0_1]	Control signal (PWM) of waste gate valve
Ctrl_VTG_HP	[0_1]	Control signal (PWM) of high pressure VTG
Ctrl_WGate_HP	[0_1]	Control signal (PWM) of high pressure waste gate valve
Ctrl_CompByp_HP	[0_1]	Control signal (PWM) of high pressure compressor bypass

Blocks

- EGR Rate Control on page 118

Fuel System Control Subsystem

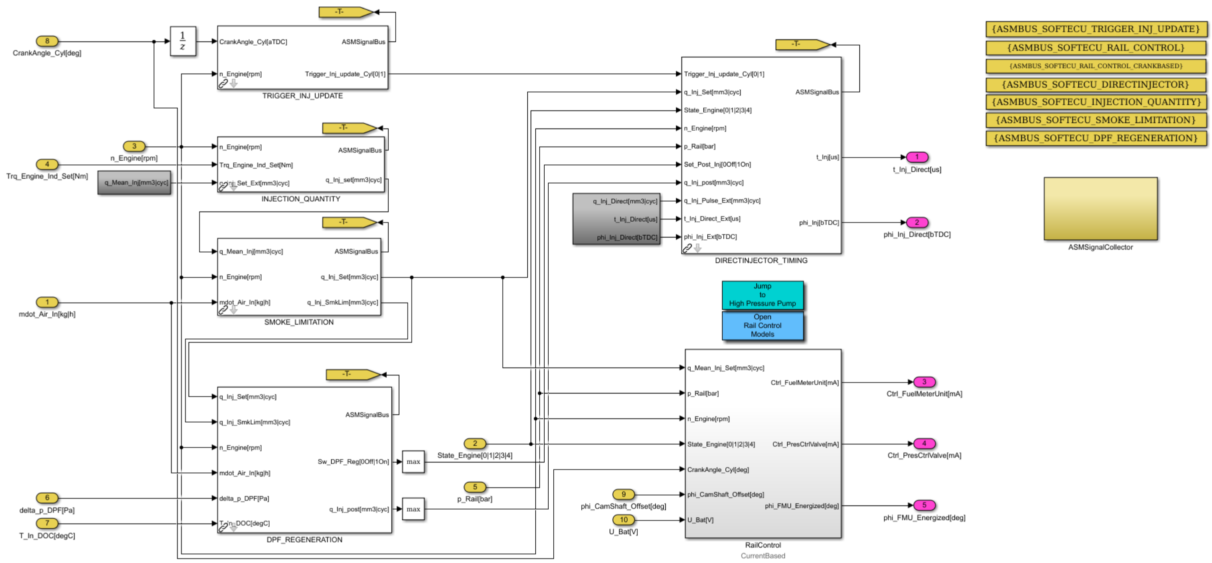
Description

The FuelSystemControl block collects the controller for the fuel system. The external setpoint of the controller are connected to the measurement interface so that you can use measurement data as setpoint for testing purpose.

In INJECTION_QUANTITY the torque is converted to a setpoint for the injection quantity.

In SMOKE_LIMITATION the quantity is limited by a smoke limitation map. In RAIL_CONTROL the kind of control for the common rail pressure is set according to actual engine operation. Two basic controllers for the pressure control valve and fuel metering unit control the rail pressure. The setpoints depend on the engine operating point. The injection timing (for all cylinders and pulses) is calculated from the resulting quantity setpoint and measured rail pressure. Up to seven injection pulses per cycle are supported. The injection signals are updated separately for every cylinder when its crank angle rises above the value of the Const_phi_Inj_Update parameter of the TRIGGER_INJ_UPDATE block.

The soft ECU supports DPF regeneration. If the differential pressure over the DPF rises above a certain limit and the input temperature of the DOC is below a certain limit, the last injection pulse is replaced with a post-injection. The injection quantity depends on the mass flow and the input temperature of the DOC. To use DPF regeneration, it is recommended to define one injection pulse (Const_num_Inj) more than the number of injection pulses in the engine measurement in the parameterization process. The injection quantity for the last pulse has to be zero and the injection angle after TDC (for example, 90 deg). With DPF regeneration, the injection quantity is replaced by the calculated quantity, but the injection angle is taken from the map.



Inports

The following table shows the inports:

Name	Unit	Description
CrankAngle_Cyl	[aTDC]	Vector with crank angles for each cylinder
delta_p_DPF	[Pa]	Pressure drop over DPF
mdot_Air_In	[kg/h]	Air mass flow into the engine
n_Engine	[rpm]	Engine speed
p_Rail	[bar]	Rail pressure
phi_CamShaft_Offset	[deg]	Camshaft offset due to variable valve train
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_In_DOC	[°C]	Temperature at DOC input side
Trq_Engine_Ind_Set	[Nm]	Induced engine torque setpoint
U_Bat	[V]	Battery voltage

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

Name	Unit	Description
phi_Inj_Direct	[bTDC]	Direct injection angle vector (cylinder 1 pulse 1, cylinder 1 pulse 2, ..., cylinder n pulse m)
phi_FMU_energized	[]	Start of fuel metering unit energizing
t_Inj_Direct	[µs]	Direct injection time vector (cylinder 1 pulse 1, cylinder 1 pulse 2, ..., cylinder n pulse m)

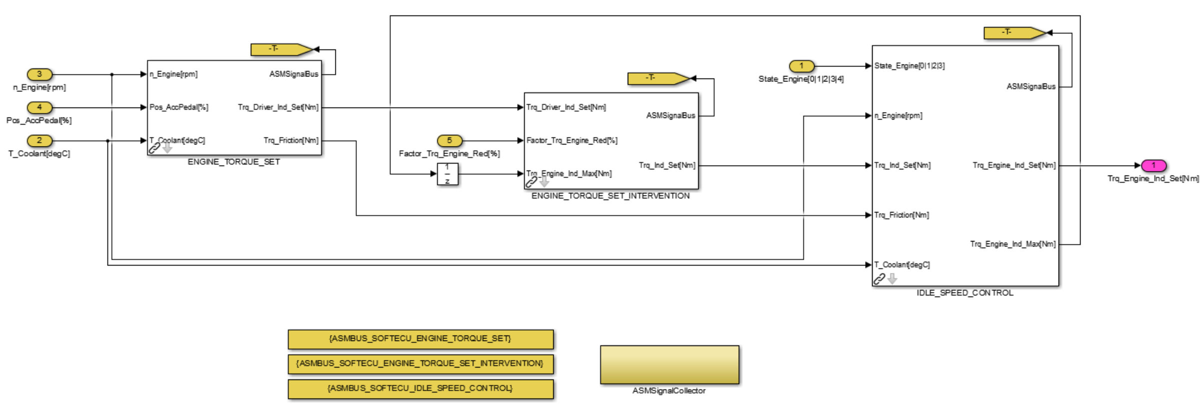
Blocks

- Direct Injector Timing on page 114
- DPF Regeneration on page 117
- Injection Quantity on page 125
- Rail Control on page 126
- Rail Control Crank-Based on page 128
- Smoke Limitation on page 132
- Trigger Injection Update on page 140

Torque Control Subsystem

Overview

In the TorqueControl block, the induced engine torque setpoint is estimated. The driver desired torque 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

Name	Unit	Description
		▪ 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 121
- Engine Torque Set Intervention on page 122
- Idle Speed Control on page 123

Soft ECU SCR Subsystem

Description

The SoftECU_SCR subsystem serves as a basic SCR controller for supply systems without any diagnostics. It is used to test the SCR model in closed-loop operation when no real ECU is connected. Its inputs are standard sensor signals and the outputs are standard actuators.

For more information on the Soft ECU SCR, refer to SoftECU (ASM Diesel Exhaust Reference 🕮).

Blocks from Former Versions

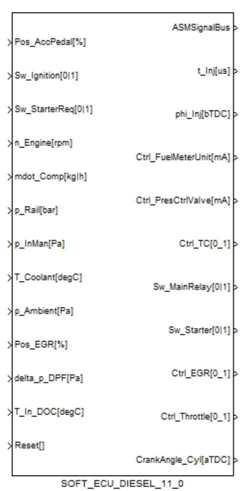
Introduction

The following topics provide information on blocks that are used in previous library versions.

Soft_ECU_Diesel_11_0

Description

The SOFT_ECU_DIESEL_11_0 block serves as basic diesel engine ECU controller software without any diagnostics. It 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 is divided into subsystems for controlling the engine.

- SoftECU_EngOperation - Engine operation detection
- SoftECU_Trq_Engine - Engine torque calculation
- SoftECU_FuelQuantity - Torque to injection quantity conversion
- SoftECU_Injection - Controllers for common-rail injection system

- SoftECU_AirPath - Controllers for air path
- SoftECU_APU - Angular processing unit

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.

In SoftECU_FuelQuantity, the torque is linearly converted to a setpoint for the injection quantity.

In SoftECU_Injection, the quantity is limited by a smoke limitation map. The kind of control for the common rail pressure is set according to the actual engine operation. Two basic controllers for the pressure control valve and fuel metering unit control the rail pressure. The setpoints depend on the engine operating point. The injection timing (for all cylinders and pulses) is calculated from the resulting quantity setpoint and measured rail pressure.

SoftECU_AirPath serves PI-controllers for Boost pressure and EGR. The setpoints depend on the engine operating point.

Inports

The following table shows the inports:

Name	Unit	Description
delta_p_DPF	[Pa]	Pressure difference over Diesel Particulate Filter (DPF)
mdot_Comp	[kg/h]	Air mass flow through compressor (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	[]	Reset all integrators 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

Name	Unit	Description
T_Coolant	[°C]	Coolant water temperature
T_In_DOC	[°C]	Input temperature of Diesel Oxidation Catalyst (DOC)

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
Ctrl_Throttle	[0_1]	Control signal (PWM) of electrical throttle valve
phi_Inj	[bTDC]	Injection start angle vector (cylinder 1, pulse 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	[µs]	Injection time vector (cylinder 1, pulse 1, pulse 2, ..., cylinder n, pulse m)

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_delta_p_DPF_RegOff	[Pa]	DPF Differential pressure limit for regeneration off
Const_delta_p_DPF_RegOn	[Pa]	DPF Differential pressure limit for regeneration on
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_FMUSet	[]	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_max_num_Cyl	[]	Maximal number of cylinders
Const_max_num_Inj	[]	Maximal number of injections per cylinder
Const_n_Engine_EngineOn	[rpm]	Minimum engine speed for engine operation mode is on
Const_P_Idle	[]	P gain for idle speed 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

Name	Unit	Description
Const_P_p_Turbo_Set	[]	P gain for turbo pressure controller
Const_phi_Inj_Cylx	[bTDC]	Start angles of injection pulses for every cylinder. Length is Const_num_Inj.
Const_Pos_AccPed_Idle	[%]	Maximum accelerator position for idle speed control
Const_P_Pos_EGR_set	[]	P gain for EGR position controller
Const_phi_Inj_PostLimit	[bTDC]	Post-injection angle limit (injections beyond this angle are activated only during DPF regeneration)
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.
Const_q_Mean_Inj_Set	[mm^3/cyc]	Set constant injection quantity
Const_T_DOC_In_RegOff	[°C]	DPF Input Temperature limit for regeneration off
Const_T_DOC_In_RegOn	[°C]	DPF Input Temperature limit for regeneration on
Map_n_EngineIdle_Set	[rpm]	Target idle speed map, n_EngineIdle = f(T_EngineCoolant)
Map_p_InMan_Set	[Pa]	Turbo pressure setpoint map
Map_p_Rail_Set	[Pa]	Static rail pressure setpoint map = f(n_Engine, q_Inj_1cyl)
Map_Pos_EGR_Set	[Pa]	Static EGR position setpoint map = f(n_Engine, q_Inj_1cyl)
Map_q_Inj_Smoke_Limit	[mm^3/cyc]	Smoke limitation map = f(n_Engine, mdot_In_Air)
Map_q_Mean_Inj_Set	[mm^3/cyc]	Fuel quantity setpoint map = f(n_Engine, Trq_MeanInd_Eng)
Map_t_Injection	[µs]	Injection timing map = f(q_Injection,p_Rail)
Map_Trq_Driver	[Nm]	Requested driver torque map = f(Pos_AccPed, n_engine)
Map_Trq_Engine_Max	[Nm]	Maximum allowed engine torque table = f(n_engine)
Map_Trq_Friction	[Nm]	Friction torque map (used for torque setpoint calculation) = f(n_engine, T_Water)
StepSize	[s]	Simulation step size
Sw_q_Mean_Inj	[1|2]	Switch for selection of injection quantity source ▪ 1 : Map ▪ 2 : Const

Related topics

References

Soft ECU Diesel V11 (ModelDesk Parameterizing 🕮)

New Features/Migration History of the ASM Engine Diesel Blockset

Introduction

The following topics provide an overview of the changes to the ASM products in the previous Releases.

For an overview of the new features and migration of the current Release, refer to Automotive Simulation Models (ASM) (New Features and Migration 📖).

Where to go from here

Information in this section

General Changes to the ASM Engine Diesel Blockset

Release 2020-A

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

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 ControlDesk.

Resettable delay The **Unit Delay Resettable** block from the sludpate 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:

- DIRECTINJECTOR_TIMING
- EGR_RATE_CONTROL
- ENGINE_OPERATION
- HPP_CRANKBASED
- IGNITION_SET
- INJECTOR_MODE
- PORTINJECTOR_TIMING
- RAIL_CONTROL
- RAIL_CONTROL_CRANKBASED
- TRIGGER_INJ_UPDATE

Release 2018-A

Variable valve train The demo models contain a blockset for simulating variable valve actuation. The camshaft phase can be adjusted by a cam phaser block. In the DieselEngine 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 operating 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, pressing the reset will now retrieve the simulation.

The Reset inport was added to the following blocks:

- IGNITION_SET
- INJECTOR_MODE
- PORTINJECTOR_TIMING
- RAIL_CONTROL
- TRIGGER_INJ_UPDATE
- ENGINE_OPERATION
- DIRECTINJECTOR_TIMING
- EGR_RATE_CONTROL
- RAIL_CONTROL_CRANKBASED

Release 2017-B

EGR_VALVE_MECHANICAL 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.

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

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

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
- CATALYST
- COMBUSTION_TORQUE_CI
- COOLER
- CRANKCASE
- CYLINDER_INLET
- DIESEL_OXIDATION_CATALYST_1_0, DIESEL_OXIDATION_CATALYST
- DIESEL_PARTICULATE_FILTER, DIESEL_PARTICULATE_FILTER_1_0, DIESEL_PARTICULATE_FILTER
- DIRECTINJECTOR_TIMING
- DPF_REGENERATION
- EGR_RATE_CONTROL
- EGR_VALVE, EGR_VALVE_1_0
- EGRCOOLER
- ENGINE_SETUP
- ENGINE_TORQUE_SET
- EXHAUST_MANIFOLD
- EXHAUSTTHROTTLE
- FRICTION_TORQUE
- HIGH_PRESSURE_PUMP
- HPP_CRANKBASED
- HPP_CRANKBASED_1_0
- INJECTION_QUANTITY
- INJECTOR, INJECTOR_1_0, INJECTOR_2_0
- INTAKE_MANIFOLD
- INTERCOOLER
- LP_EGR_VALVE
- LP_EGRCOOLER
- LP_INTAKE_MANIFOLD
- LP_INTAKE_MANIFOLD_4_0
- PRESSURE_CONTROL_VALVE
- PUMP_TORQUE
- RAIL
- RAIL_CONTROL
- RAIL_CONTROL_CRANKBASED
- SMOKE_LIMITATION
- SOFT_ECU_DIESEL_1_0, SOFT_ECU_DIESEL_11_0, SOFT_ECU_DIESEL_3_0
- THROTTLE_MECHANICAL
- THROTTLE_VALVE
- UNIT_INJECTOR, UNIT_INJECTOR_1_0, UNIT_INJECTOR_7_0

License check of ASM Utils blocks The ASM_UTILS license was discontinued. The ASM Utils blocks now check the license of the ASM blockset in which they are used.

The Utils blocks in the following blocks within this library were updated:

- EGR_VALVE, EGR_VALVE_1_0
- EXHAUST_MANIFOLD
- EXHAUSTTHROTTLE
- LP_EGR_VALVE
- LP_INTAKE_MANIFOLD, LP_INTAKE_MANIFOLD_4_0
- THROTTLE_MECHANICAL

Release 2016-A

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

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 cycles WLTC (Worldwide Harmonized Light Vehicle Test Procedure) with three classes (depending on the power-to-mass ratio) have 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 Diesel Engine Operator Blockset is the operator version of the ASM Engine Diesel 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 has been removed from the library block and placed before the mdot_AirFilter[kg|h] inport of the library block.
Release 7.2	New to integrate a low-pressure EGR in the model. This functionality is optional. It is not included in the standard demo model.
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 108

History of the CATALYST Block

Release 7.3	The block has been adapted to support engine reset functionality.

History of the COOLER Block

Release 2018-A	The continuous integrators were replaced by discrete ones.
Release 7.3	The block has been adapted to support engine reset functionality.

Now negative engine speeds are also taken into account by evaluating the absolute value of the engine speed.

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 – EngineDiesel – 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 Diesel – Cooler Diesel 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 ===%`

Release 6.4

The energy balance has been corrected.

Release 6.2	The unit of cooler parameters in the mask of the block was changed from "degC" to "K".
Related topics	References Cooler....61

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	Basics Combustion Temperature CI....91

History of the COMBUSTION_TORQUE_CI Block

Release 2020-A	The calculations of combustion temperature and overall lambda values were moved to other blocks. V engine support is now taken into account for all equations.
Release 2018-B	The continuous integrator of the PT1 block in the Engine Out Temperature block inside the COMBUSTION_TORQUE_CI block was replaced by a discrete integrator.
Release 2017-A	The size of the Map_eta_lambda parameter increased from [12,1] to [13,1].
Release 2013-A	Calculation of a modulated cylinder pressure (p_MeanInd_Cyl_Mod[bar]) has been introduced and included in the ASM signal bus.
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 7.2

The Xsi_i_ExhMan output is added to provide a sufficient interface for the physical turbocharger.

Release 7.1

The replacement value for zero injection mass was changed from 0 to 99. 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 6.6

The block was updated to correct the lambda value calculation. The lambda_CyL signal is added to the ASMSignalbus.

Related topics

References

Combustion Torque.. 92

History of the COMMON_DIESEL_PARAMETERS Block

Release 2014-B

The COMMON_DIESEL_PARAMETERS block no longer exists. It is replaced by two new blocks: COMMON_ENGINE_PARAMETERS and ENGINE_SETUP.

Its original parameters are assigned to the new blocks. The COMMON_DIESEL_PARAMETERS block is converted to a regular Common_Diesel_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 2013-B

The units of Lower_Heat_Value and R_Universal have been changed to SI units. The unit of Lower_Heat_Value is [J/kg] and the unit of R_Universal is [J/(molK)]. Directly after the COMMON_DIESEL_PARAMETERS block, there is a Gain block to convert the unit of Lower_Heat_Value from [J/kg] to [kJ/kg]. After migration, R_Universal is used in [J/(molK)].

Release 7.3	The Goto/From tags have been moved out of the library block. Parameters for pump torque support have been inserted. Injection matrix definitions have 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 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_DIESEL_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 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]] The parameters will be initialized with dummy values. The new outports will be terminated.
Release 2014-B	This block is new. It contains the physical constants of air, exhaust, and fuel. The COMMON_DIESEL_PARAMETERS block is discontinued. It is split up into the COMMON_ENGINE_PARAMETERS and ENGINE_SETUP blocks.
Related topics	References Common Engine Parameters.. 53

History of the CRANKCASE Block

Release 7.3	In order to simulate the pump torque effect, a CRANKCASE block has been integrated to simulate the crankcase pressure of the engine.
Related topics	References Crankcase.. 95

History of the CYLINDER_INLET Block

Release 2020-A	The memory blocks for loop prevention were moved to the demo model. Relative air mass and fuel mass flow calculations were introduced to the block. 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

History of the DIESEL_OXIDATION_CATALYST Block

Release 7.3	The block has been adapted to support engine reset functionality.
Release 6.2	The Const_lambda_UpLim parameter was deleted, because it is not used inside the block.

History of the DIESEL_PARTICULATE_FILTER Block

Release 7.3	The block has been adapted to support engine reset functionality.

History of the DIRECTINJECTOR Block

Release 2020-A	The description of the Sw_InjMode parameter was changed from [1Mean|2Pulse] to [1Pulse|2Mean]. The functionality of the block was not modified. You have to modify the parameter comment and the real-time path in your ControlDesk experiment.
Release 2018-A	A new outport was added: q_Inj_Post[mm3|s]. The sum of q_Inj[mm3|s] and q_Inj_Post[mm3|s] is the total fuel mass taken from the rail.
Release 2016-B	The block is the advancement of the INJECTOR block. 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.

Related topics

References

History of the DPF_REGENERATION Block

Release 2015-B

A data type conversion block has been inserted in order to account for data type consistency checks in MATLAB/Simulink. The change has no functional effect and just prevents warnings in MATLAB during **Update diagram**.

Related topics

References

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_EGRCooler 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**) has been created.

The library link of the block was changed to**FormerVersion/EGRCOOLER_4_0**.

Release 7.2

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 mass flow 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.. 118

History of the EGR_VALVE Block

Release 2017-B

The former EGR_VALVE block was 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_6_0) was created.

	The library link of the block was changed toFormerVersion/EGR_VALVE_6_0.
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 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 EGR Valve........................ 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 has been 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.

The block's parameters will be initialized with dummy values. The new outports will be terminated.

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\engdiesel\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 EngineDiesel model.

The Const_max_num_Inj_Direct, Const_max_num_Inj_Port, and Const_m_Air_ref parameters are added in the pre-migrate variant.

The value of the MDL.EngineDiesel.Const.Const_max_num_Inj parameter is assigned to the MDL.EngineDiesel.Setup.Const_max_num_Inj_Direct parameter.

The value of the MDL.EngineDiesel.Const.Const_max_num_Cyl parameter is assigned to the MDL.EngineDiesel.Setup.Const_max_num_Cyl parameter during postmigration.

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 diesel page in ModelDesk. Model structure:

MDL.EngineDiesel.Setup.Const_max_num_Cyl

MDL.EngineDiesel.Setup.Const_max_num_Inj_Port

MDL.EngineDiesel.Setup.Const_max_num_Inj_Direct

Related topics

References

Engine Setup.. 55

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

History of the EXHAUSTTHROTTLE Block

Release 2017-B	The former EXHAUSTTHROTTLE block was split into a physical model (EXHAUSTTHROTTLE in dSPACE Release 2017-B) and a mechanical model (EXHAUSTTHROTTLE_MECHANICAL). A former version block (EXHAUSTTHROTTLE_5_0) was created. The library link of the block was changed toFormerVersion/EXHAUSTTHROTTLE_5_0.
Release 2017-A	The modeling of the block was changed. It is implemented as a standard ASM throttle that calculates the mass flow rate. A former version of the block was created: EXHAUSTTHROTTLE_4_0. During migration, the library link of the block changes to its former version: EXHAUSTTHROTTLE_4_0. For the new features, use the new version of the EXHAUSTTHROTTLE block together with the LP_EXHAUST_MANIFOLD block.
Release 2014-B	The mdot_Exh and Pos_ExhThrottle inports of the look-up table parameter Map_p_diff_ExhThrottle have been replaced by T_Out_DPF and Vdot_In_ExhThrottle, because the original inports did not fit the axes of the parameter.
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	New to integrate a low-pressure EGR in the model. This functionality is optional. It is not included in the standard demo model.

Related topics

References

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 mulitple branches 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_10_0) has been created.

The library link of the block was changed toFormerVersion/EXHAUST_MANIFOLD_10_0.

Release 7.4

A reset condition has been inserted to switch between 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 mass flow inputs.

Release 6.6

The block is internally restructured without influencing its functionality.

Release 6.3	Because the ForwardEuler S-function can now be used for V-engines, too, problems can occur with the signal width when calling the `Update Diagram` command (Ctrl+D) for models generated in Release 5.4 or earlier. To avoid these problems, a fixed width for the EngOP[rpm][mm3|cyc] input has been specified. A SignalSpecification block has been added.
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

Exhaust Manifold.. 22

History of the FRICTION_TORQUE Block

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.. 98

History of the FUELTANK Block

Release 2018-A	The continuous integrators were replaced by discrete ones. A new outport was added: Level_FuelTank[0_1].
Related topics	References

Fuel Tank.. 79

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.. 80

History of the HPP_CRANKBASED Block

Releae 2019-B

The 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 has been 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 has been 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 has been 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.

The 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 has been 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 model approaches:

- A mean value model
- A pulsed model

Both approaches use the fuel delivery time as the source of volume calculation. The control signal of this pump is the start of the energizing (closing) of the fuel metering unit in degrees of the crank angle.

Related topics

References

High-Pressure Pump (Crank-Based).. 70

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.. 123

History of the INJECTOR Block

Release 2016-B	The block was discontinued and changed to the INJECTOR_9_0 block. During migration, the library link of the INJECTOR block is changed to the INJECTOR_9_0. For the new features of the block, use the DIRECT_INJECTOR block together with the ENGINE_SETUP block.
Release 2015-B	The block has been fixed for use with 20 cylinders. There was a bug assigning the injection to cylinder 19 instead of to cylinder 20, where it was supposed to be. The injection that is supposed to be in cylinder 20 will now be correctly assigned to cylinder 20.
Release 7.3	To define the injection matrix uniquely in the model, the parameter has been moved to the COMMON_PARAMETERS block. Now negative engine speeds are also taken into account.

Release 7.0	The calculation of the post-injection quantity is now cumulated for all cylinders, instead of representing the mean injection quantity for only one cylinder.
Release 6.5	The pulsed injection mode has been updated, such that the enable flag will be 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 for 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 maximum number of cylinders has been increased to 34 (from 20). The Const_phi_Inj_TrqEffLimit[bTDC] constant block was moved one level up to avoid the parameter is being used twice in the block. This was necessary so that the parameter can be changed via ControlDesk or ModelDesk.

History of the INTAKE_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 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_8_0) was created. The library link of the block was changed toFormerVersion/INTAKE_MANIFOLD_8_0.
Release 7.3	The block has been adapted to support engine reset functionality.
Release 7.2	The new mdot_Out_Throttle_Exh[kg|h] inport takes into account the exhaust mass flow through the throttle valve, which exists if a low-pressure EGR is used.
Release 7.0	The integrator lower limits have been set to zero. Summation blocks have been inserted to allow vector-based mass flow inputs.

Release 6.6	The block is internally restructured without influencing its functionality.
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

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 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 (**INTERCOOLER_5_0**) was created.

The library link of the block was changed to**FormerVersion/INTERCOOLER_5_0**.

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 mass flow calculations are now possible.

Related topics

References

Intercooler.. 30

History of the LP_EGRCOOLER Block

Release 2017-B

The Map_eta_Cooler_phy parameter was renamed to Map_eta_Cooler.

The new Sw_State_Cooler parameter was introduced to switch off the intercooler.

The Sw_LP_EGRCooler_On parameter was removed.

The unit of the mass flow entering the block was changed from [kg/s] to [kg/h].

A former version block (LP_EGRCOOLER_4_0) was created.

The library link of the block was changed toFormerVersion/LP_EGRCOOLER_4_0.

Release 2013-A

The efficiency mask description has been corrected.

The unit of the input port for the cooler mass flow has been corrected.

Release 7.2

This block is new to integrate a low-pressure EGR in the model. This functionality is optional. It is not included in the standard demo model.

Related topics

References

Low-Pressure EGR Cooler... 32

History of the LP_EGR_VALVE Block

Release 2017-B	The former LP_EGR_VALVE block was split into a physical model (LP_EGR_VALVE in dSPACE Release 2017-B) and a mechanical model (LP_EGR_VALVE_MECHANICAL). The new LP_EGR_VALVE block is vectorial, i.e., the block 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_LPEGR[degC] outport was removed, because the process in the model is isothermal. A former version block (LP_EGR_VALVE_6_0) was created. The library link of the block was changed toFormerVersion/LP_EGR_VALVE_6_0.
Release 2017-A	The implementation (revert direction) of the return[0|1] signal has been modified. It is 1 (reverse flow direction) if p_Out_LPEGR[Pa] is greater than p_In_LPEGR[Pa]. Before the modification, the logic was converse. The logic of the return[0|1] outport is inverted by means of the NOT block.
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	This block is new to integrate a low-pressure EGR in the model. This functionality is optional. It is not included in the standard demo model.

Related topics

References

History of the LP_EXHAUST_MANIFOLD Block

Release 2017-B

The LP_EXHAUST_MANIFOLD block differentiates between the air and the exhaust gas in the calculation of the temperature and the pressure.

The block has a new outport for the gas constant (R_LPExhMan[J|(kgK)]) as well as the mass fractions of the air (Xsi_Air_LPExhMan[0_1]) and the exhaust gas (Xsi_Exh_LPExhMan[0_1]) of the manifold.

The unit of the mass flows entering the block was changed from [kg/h] to [kg/s].

The unit for the temperature entering or leaving the block was changed from [Kelvin] to [°C].

A former version block (LP_EXHAUST_MANIFOLD_1_0) was created.

The library link of the block was changed toFormerVersion/LP_EXHAUST_MANIFOLD_1_0.

Release 2017-A

This is a new component in the low-pressure EGR demo model. The block is modeled as a container to calculate the temperature and pressure before the low-pressure EGR system. For detailed information on the demo model of the low-pressure EGR, refer to How to Integrate the Low-Pressure EGR Demo Model (ASM Diesel Engine Model Description 📖).

Related topics

References

History of the LP_INTAKE_MANIFOLD Block

Release 2017-B

In this version, the sum blocks of the enthalpy flows inside the energy balance are vectorial, i.e., the LP_INTAKE_MANIFOLD block can simulate multiple branches of the air path simultaneously.

There is a new outport for the gas constant of the manifold (R_LPMan[J|(kgK)]).

The T_In_Comp[degC] inport was renamed to T_Out_LPInMan[degC], which is the temperature downstream of the low-pressure intake manifold. The signal is used to simulate the back flow.

A former version block (LP_INTAKE_MANIFOLD_6_0) was created.

The library link of the block was changed toFormerVersion/LP_INTAKE_MANIFOLD_6_0.

Release 2016-A

The block has been revised. The behavior of the block has been changed. The LP_INTAKE_MANIFOLD block of the former release was renamed to the LP_INTAKE_MANIFOLD_4_0 block. During migration to dSPACE Release 2016-A, the former block is moved to the FormerVersions sublibrary.

During migration, the LP_INTAKE_MANIFOLD block is redirected to the former version LP_INTAKE_MANIFOLD_4_0 block in the ASM Diesel Engine Library.

Release 2014-B

The implementation now considers the backflow through the air path.

Release 2013-A

The conversion factor from degrees Celsius to Kelvin has been corrected to 273.15.

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

This block is new to integrate a low-pressure EGR in the model. This functionality is optional. It is not included in the standard demo model.

Related topics

References

Low-Pressure Intake Manifold.. 39

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

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 the previous versions, the parameter was located in an external SWITCHES_PRES_CTRL_VALVE block, which does not exist anymore. There is a former version of the PRESSURE_CONTROL_VALVE block. During migration, the library link of the PRESSURE_CONTROL_VALVE block was changed to the PRESSURE_CONTROL_VALVE_3_0 block.
Related topics	References

History of the PUMP_TORQUE Block

Releae 2020-A	The torque calculation now supports two stroke engines.
Release 2017-A	There is a new Trq_Mean_Pump[Nm] outport for the simulation of the mean pump torque of the engine, which is basically the torque of the gas exchange. The outport is used to calculate the mean effective engine torque. To avoid the oscillations in the calculation of the cylinder pressure during the compression/expansion, the pressure of the intake manifold (p_InMan[Pa] inport) is held constant during the compression/expansion.

	The original labels (Trq_MeanPump_Engine[Nm], Trq_MeanPump_Cyl[Nm]) in the ASMSignalBus were restored and the new Trq_Mean_PumpTorque[Nm] was terminated.
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 appropriate switches.
Related topics	References Pump Torque........ 100

History of the RAIL Block

Release 2018-A	The continuous integrators were replaced by discrete ones.
Release 2014-B	The block has a new parameter: Const_T_Rail. The Const_T_Rail parameter is added in the pre-migrate variant.
Release 7.3	The block has been adapted to support engine reset functionality.
Related topics	References Rail........ 82

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

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

A new inport was added: phi_CamShaft_Offset_Exhaust[deg].

The phi_CamShaft_Offset[deg] inport was 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 has been 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.. 128

History of the SOFT_ECU_DIESEL 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 the 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. In the migrated model, the library link has been moved to the former version of this block.
Release 2013-B	The SOFT_ECU subsystem Trq2quantity has been modified and renamed to SoftECU_FuelQuantity, so the Map_Trq2Quant parameter has been renamed to Map_q_Mean_Inj_Set. The injection quantity is now calculated as the function of the indicated torque and engine speed instead of the torque only. Two new parameters have been introduced: ▪ Const_q_Mean_Inj_Set[mm3|cyc] ▪ Sw_q_Mean_Inj[1Map|2Const]
Release 2013-A	The crank angle bus signal has been renamed from Crank_Angle_Cyl[bTDC] to Crank_Angle_Cyl[aTDC].
Release 7.4	The extrapolation method for injection timing and smoke limitation map has been changed to interpolation-extrapolation (for homogenous and stratified mode) due to ModelDesk conformity. The crank angle bus signal has been renamed to correct the angle unit.
Release 7.3	The block has been adapted to support engine reset functionality. The Map_Trq_Friction parameter has 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 is corrected.

Release 7.1

The ground block with constant zero was replaced to avoid problems with signal dimensions which cannot be evaluated by Simulink.

Release 6.6

The anti-windup implementation has been improved for the idle speed controller. The lookup method for maximum torque map for interpolation/extrapolation was changed for consistency. The parameterization is adapted so that T_max(n_engine=0)>0 and T_max(n_engine>n_max)<<0.

Release 6.4

The post-injection management for DPF regeneration has been modified so that the injection quantity distribution is set to zero for injections beginning after a given post-injection limit angle if the DPF regeneration is deactivated.

The maximum torque characteristic uses end values instead of being extrapolated when the input engine speed is out of range.

The parameters for the number of cylinders and the number of injections have been replaced by the maximal number of cylinders and the maximal number of injections.

A new parameter has been added to specify the post-injection limit angle.

Release 6.3

The parameter which describes the relative portions of the injections (Const_inj_rel) is not accepted as a colum (original) and as a row vector (new). This adaptation is required due to adaptations in ASM Parameterization.

Release 6.2

The maximum number of cylinders has been increased to 34 (from 20).

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.

The MDL.SoftECU.SoftECUDiesel.Map_q_Inj_Smoke_Limit mask parameter is only used once in the model. This is necessary so that the parameter can be changed via ControlDesk or ModelDesk. If the number of injection pulses was set to one, the soft ECU calculated a wrong value for the injection quantity setpoint. This has been fixed in this version. Now the friction torque is included in the calculation of the drivers's torque setpoint. An additional parameter containing the friction torque map has been added to the block mask for this.

Related topics

References

Soft ECU Diesel Subsystem.. 187

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

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

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_DPF Block

Release 7.3	The switch from SWITCHES_EXHAUSTSYSTEM has been moved to support the multi-instance feature.

History of the SWITCHES_EGR_COOLER Block

Release 2017-B	The block has been discontinued.The library link of the block was changed toFormerVersion/SWITCHES_EGR_COOLER_2_0.
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 2017-B	The block has been discontinued.The library link of the block was changed toFormerVersion/SWITCHES_EGR_VALVE_2_0.
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 7.3	The switch from SWITCHES_FUELSYSTEM has been moved to support the multi-instance feature.

History of the SWITVHES_FUEL_METER_UNIT_1_0 Block

Release 2014-B	The block has been discontinued. The block's parameter has been moved to the HIGH_PRESSURE_PUMP block.

History of the SWITCHES_FUEL_SYSTEM 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 is discontinued. 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.
Release 7.3	The switch from SWITCHES_FUELSYSTEM has been moved to support the multi-instance feature.

History of the SWITCHES_INTERCOOLER Block

Release 2017-B	The block has been discontinued.The library link of the block was changed toFormerVersion/SWITCHES_INTERCOOLER_2_0.
Release 7.3	The switch from SWITCHES_AIRPATH has been moved to support the multi-instance feature.

History of the SWITCHES_PRESS_CTRL_VALVE Block

Release 2018-A	The block was discontinued. There is a former version of the block. During migration, the library link of the SWITCHES_PRES_CTRL_VALVE block was changed to the SWITCHES_PRES_CTRL_VALVE _3_0 block.
Release 7.3	The switch from SWITCHES_FUELSYSTEM has been moved to support the multi-instance feature.

History of the SWITCHES_SCR_ADBLUE_TANK_MODE Block

Release 7.3	The switch from SWITCHES_EXHAUSTSYSTEM has been moved to support the multi-instance feature.

History of the SWITCHES_SCR_AIR_TANK_MODE Block

Release 7.3	The switch from SWITCHES_EXHAUSTSYSTEM has been moved to support the multi-instance feature.

History of the SWITCHES_THROTTLE Block

Release 7.3	The switch from SWITCHES_AIRPATH has been moved to support the multi-instance feature.

History of the SWITCHES_THROTTLE_1_0 Block

Release 2014-B	The block has been discontinued.

History of the SWITCHES_TRQ_COMB_MODE Block

Release 7.3	The switch from SWITCHES_COMBUSTION has been moved to support the multi-instance feature.

History of the SWITCHES_TURBO Block

Release 7.4	The link to former version has been moved due to ModelDesk conformity by using the MAPS_TC parameter page.

Release 7.3	The switch from SWITCHES_AIRPATH has been moved to support the multi-instance feature.

History of the SWITCHES_WALL_FILM_MODE Block

Release 7.3	The switch from SWITCHES_COMBUSTION has been moved to support the multi-instance feature.

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.

The value of the new Sw_State_ValveMechanical parameter (mask value Sw_State_Throttle) is set to 1, i.e., the valve is open.

The name of the bus of the THROTTLE_MECHANICAL component in the ASMSignalBus has been renamed from Throttle_Mechanical to ThrottleMechanical. During the migration, the original name is restored.

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.. 47

History of the THROTTLE_VALVE Block

Release 2017-B	Signals in the ASMSignalBus was renamed from mdot_Out_Throttle[kg|h] to mdot_Throttle[kg|h] and T_Out_Throttle[degC] to T_Throttle[degC]. During the migration, the signal names are changed to the original names.
Release 2014-B	The former THROTTLE_VALVE block no longer exists. It is replaced by two new blocks: THROTTLE_MECHANICAL and THROTTLE_VALVE. Its original parameters are assigned to the new blocks. The THROTTLE_VALVE block is converted to a regular Simulink subsystem containing the new blocks. The calculation of the throttle position has been removed. The calculation is performed in the new THROTTLE_MECHANICAL block.
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 Throttle Valve.. 49

History of the TURBO_CONTROL Block

Release 2015-A	The block has been expanded and moved to the ASM Turbocharger Library

History of the UNIT_INJECTOR Block

Release 2016-B	There is a new version of the block and the former version is changed to the UNIT_INJECTOR_7_0 block. During migration, the library link of the UNIT_INJECTOR block is changed to UNIT_INJECTOR_7_0. For the new features of the block, use the UNIT_INJECTOR block together with the ENGINE_SETUP block.

To improve the turnaround time of the simulation model, the Const_Inj_Matrix parameter (routed by the GoToFrom connection from the ENGINE_SETUP block) has been deleted. The block requires the ENGINE_SETUP of the current release (Version 5.0).

Release 2015-B

The block has been fixed for use with 20 cylinders. There was a bug assigning the injection to cylinder 19 instead of to cylinder 20, where it was supposed to be.

The injection that is supposed to be in cylinder 20 will now be correctly assigned to cylinder 20.

Release 7.3

To define the injection matrix uniquely in the model, the parameter has been moved to the COMMON_PARAMETERS block.

Now negative engine speeds are also taken into account.

Release 7.2

MDL.Const.rho_Fuel in ASMSignalCollector is replaced by a corresponding Goto-From connection for the fuel density.

Release 6.4

The parameters for 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 maximum number of cylinders has been increased to 34 (from 20).

The Const_phi_Inj_TrqEffLimit[bTDC] constant block was moved one level up to avoid the parameter being used twice in the block. This is necessary so that the parameter can be changed via ControlDesk or ModelDesk.

Related topics

References

Unit Injector.. 84

History of the Engine Diesel 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 have been introduced to combine, split, or route vector signals through the model.

Unburned fuel mass flow Unburned fuel during combustion can now be simulated and is routed back into the combustion chamber through exhaust gas recirculation and intake manifold.

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.

SoftECU_SCR block The inports of the system were changed:

- T_Out_DPF[degC] (temperature downstream of the DPF) was changed to T_Exh[degC] (temperature after urea decomposition).
- Xsi_Air_PumpHose[] (mass fraction of air in the pump hose) was replaced by r_Volume_Air_PumpHose[] (volumetric fraction of air in the pump hose).

No changes are made to the system as a result of the migration process. To use the new features of the block, manually copy the new block from the library to the simulation model.

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.

Fuel tank The post-injection of the direct injector is also considered in the mass balance of the fuel tank (mdot_Fuel[kg|h] inport of the FUELTANK block).

Rail The post-injection of the direct injector is also considered in the mass balance of the rail (q_Inj[mm3|s] inport of the RAIL 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.

Release 2017-B

AirPath The tags of the Goto/From blocks in the AirPath are not specific to a certain engine type anymore. The tags are renamed from TAG_EngineDiesel_* to TAG_Engine_*.

The GotoTagVisibility blocks have to be used.

Engine The EngineOperationPoint system was 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 were added to the ASMSignalBus.

FuelConsumption The FuelConsumption system (ASM_EngineDiesel / MDLUserInterface / EngineDiesel / MDL_DISP / FuelConsumption) has been 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

Mean effective engine torque The mean pump torque of the engine (Trq_Mean_Pump[Nm] outport) of the PUMP_TORQUE block is used to calculate the mean effective engine torque. In previous Releases, the current, i.e., the time-dependent pump torque was used to calculate the mean effective engine torque.

Truck variant The truck variant of the Engine Diesel demo model, including the SAE turbo model, has been parameterized with the new measurements.

Low-pressure EGR The demo model of the low-pressure EGR has new inports and outports:

- Inports: p_Ambient[Pa], Ctrl_ExhThrottle[0_1] and mdot_Out_DPF[kg|s]
- Outports: mdot_ExhThrottle[kg|s], T_LPExhMan[K] and T_LPExhMan[K]

The mdot_HPEGR[kg|h] and mdot_Out_Engine[kg|h] inports have been removed.

Start-stop system soft ECU The engine soft ECU has been extended with a start-stop system. 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 has been extended to show the start-stop system status.

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.

MDL_DISP of engine In the demo model, just a few basic signals of the exhaust system are prepared for the visualization on the scope. Further signals can be found in the ASM Diesel Exhaust Library. The MDL_DISP of the Engine model contains a link to the location of the signals in the ASM Diesel Exhaust library.

Injectors The injector (Unit or Direct) that is not used is disabled. This modification improves the turnaround time of the model.

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 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.

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**).

Low-pressure EGR The AirPath model has a new interface to easily replace the low-pressure EGR model. The new OpenLowPressureEGRModel button lets you add a prepared low-pressure EGR demo to your model. Then, use drag & drop to add the demo model from the library to the AirPath model and replace the existing low-pressure EGR.

Release 2014-B

FuelSystem The FuelSystem model now contains two high-pressure pump models, one current-based and one crank angle-based model.

The High-Pressure Pump library can be opened by clicking Open High Pressure Pump Models next to the HighPressurePump subsystem in the model. The HighPressurePump model can be replaced 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_MECHANICAL block calculates the throttle position.
- 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.

LP_EGR The calculation of the mass flow through the exhaust throttle has been changed. In the current version, the mass flow is calculated as the mass flow of the exhaust gas leaving the engine minus the mass flow of the high-pressure EGR and the mass flow through the low-pressure EGR cooler.

Release 2013-B

Engine subsystem The Engine subsystem of ASM_EngineDiesel has been revised.

There is a new Exhaust subsystem, which contains further subsystems:

- ExhaustSystem_SignalRouting
- ExhaustSystem

ExhaustSystem contains the aftertreatment models and can be replaced by a desired exhaust system. To replace the exhaust system, drag and drop the ExhaustSystem from the exhaust library to the Exhaust subsystem.

The MVEM_Setup_Integrator subsystem with corresponding visibility tags has been moved from the ExhaustSystem subsystem one level up.

Release 7.4

MDLUserInterface/Engine Diesel/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 respectively.

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

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:

$$\begin{bmatrix} \dot{m}_{InMan} \\ \dot{T}_{InMan} \end{bmatrix} =$$

$$\begin{bmatrix} \dot{m}_{Out,Throttle} + \dot{m}_{Out,EGR} - \dot{m}_{In,Engine} \\ \frac{c_p}{c_v m_{InMan}} \left(\dot{m}_{Out,Throttle} T_{Out,Throttle} + \dot{m}_{Out,EGR} T_{Out,EGR} - \dot{m}_{In,Engine} T_{InMan} \right) \\ -c_v \left(T_{InMan} \left(\dot{m}_{Out,Throttle} + \dot{m}_{Out,EGR} - \dot{m}_{In,Engine} \right) \right) - \frac{1}{c_v m_{InMan}} \left(T_{InMan} - T_{Ambient} \right) k_{InMan} A_{InMan} \end{bmatrix}$$

with the equation for pressure in the intake manifold (ideal gas law):

$$p_{InMan} = \frac{R}{V_{InMan}} m_{InMan} T_{InMan}$$

Algebraic equations:

$$\dot{m}_{In,\,Engine} = \lambda_A\left(p_{InMan}, n_{Engine}\right)\frac{p_{InMan}}{RT_{InMan}} V_d i n_{Engine}$$

$$\dot{m}_{Out,\,EGR} = A_{EGR,\,max} g\left(Pos_{EGR}\right)\Psi\left(\frac{p_{InMan}}{p_{ExMan}}\right)$$

$$T_{Out,\,EGR} = T_{In,\,EGR} = T_{ExMan} - \eta_{EGRcooler}\left(n_{Engine}, q_{Inj,\,Engine}\right)\left(T_{ExMan} - T_{Ambient}\right)$$

$$\dot{m}_{Out,\,Throttle} = A_{Throttle,\,max} f\left(Pos_{Throttle}\right)\Psi\left(\frac{p_{InMan}}{p_{Out,\,Comp}}\right)$$

$$T_{Out,\,Throttle} = T_{In,\,Throttle} = T_{Out,\,Comp} - \eta_{Intercooler}\left(n_{Engine}, q_{Inj,\,Engine}\right)\left(T_{Out,\,Comp} - T_{Ambient}\right)$$

$$p_{ExMan} = p_{ExMan}\left(n_{Engine}, q_{Inj,\,Engine}\right)$$

$$p_{Out,\,Comp} = p_{Out,\,Comp}\left(n_{Engine}, q_{Inj,\,Engine}\right)$$

$$T_{Out,\,Comp} = T_{Out,\,Comp}\left(n_{Engine}, q_{Inj,\,Engine}\right)$$

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:

$$\dot{m}_{In,Engine} = \lambda_A\left(p_{InMan}, n_{Engine}\right)\frac{p_{InMan}}{RT_{InMan}} V_d in_{Engine}$$

$$\dot{m}_{In,EGR} = \dot{m}_{Out,EGR} = A_{EGR,max} g(Pos_{EGR}) p_{in}\sqrt{\frac{2}{RT_{in}}}\Psi\left(\frac{p_{InMan}}{p_{Out,Comp}}\right)$$

$$T_{Out,EGR} = T_{In,EGR} = T_{ExMan} - \eta_{EGRcooler}\left(n_{Engine}, q_{Inj,Engine}\right)\left(T_{ExMan} - T_{Ambient}\right)$$

$$\dot{m}_{Comp} = \dot{m}_{Out,Throttle} = A_{Throttle,max} f(Pos_{Throttle}) p_{in}\sqrt{\frac{2}{RT_{in}}}\Psi\left(\frac{p_{InMan}}{p_{Out,Comp}}\right)$$

$$T_{Out,Throttle} = T_{In,Throttle} = T_{Out,Comp} - \eta_{Intercooler}\left(n_{Engine}, q_{Inj,Engine}\right)\left(T_{Out,Comp} - T_{Ambient}\right)$$

$$Pow_{Comp} = \dot{m}_{Comp} \cdot c_{p,air} \cdot \frac{1}{\eta_{Comp,is}\left(\dot{m}_{Comp,red}, \eta_{TC,red}\right)} \cdot T_{In,Comp} \cdot \left(\Pi_{Comp}\left(\dot{m}_{Comp,red}, \eta_{TC,red}\right)^{\frac{K-1}{K}} - 1\right)$$

$$T_{Out,Comp} = T_{In,Comp} \cdot \left(1 + \frac{1}{\eta_{Comp,is}\left(\dot{m}_{Comp,red}, \eta_{TC,red}\right)} \cdot \left(\Pi_{Comp}\left(\dot{m}_{Comp,red}, \eta_{TC,red}\right)^{\frac{K-1}{K}} - 1\right)\right)$$

$$p_{Out,Comp} = p_{Ambient}\Pi_{Comp}\left(\dot{m}_{Comp,red}, \eta_{TC,red}\right)$$

$$\dot{m}_{Turb} = \dot{m}_{Turb,red}(\Pi_{Turb}, Ctrl_{TC})\frac{\frac{p_{In,Turb}}{p_{Turb,ref}}}{\sqrt{\frac{T_{In,Turb}}{T_{Turb,ref}}}}$$

$$Pow_{Turb} = \dot{m}_{Turb} \cdot c_{p,air} \cdot \eta_{Turb,is}\left(\dot{m}_{Turb,red}, \eta_{TC,red}\right) \cdot T_{In,Turb} \cdot \left(1 - \left(\frac{1}{\Pi_{Turb}}\right)^{\frac{K-1}{K}}\right)$$

$$T_{Out,Turp} = T_{In,Turb} \cdot \left(1 + \eta_{Turb,is}\left(\dot{m}_{Turb,red}, \eta_{TC,red}\right) \cdot \left(\left(\frac{1}{\Pi_{Turb}}\right)^{\frac{K-1}{K}} - 1\right)\right),$$

$$T_{In,Turb} = T_{ExMan}$$

$$\dot{m}_{Out,Engine} = \dot{m}_{In,Engine} + \dot{m}_{In,Fuel}\left(t_{In,Fuel}, p_{Rail}\right)$$

$$T_{Out,Engine} = T_{Out,Engine}\left(p_{MainInd}\left(n_{Engine}, q_{Inj,Engine}\right), n_{Engine}\right)$$

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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