ASM Turbocharger Light

Reference

For ASM Turbocharger Light Blockset 3.2.8 and ASM Turbocharger Operator Light Blockset 3.2.8

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dSPACE

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Important Notice

Contents

About This Reference

Content

This reference introduces you to the features provided by the map-based turbocharger block of the engine model. It describes the structure and parts of the block, 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.

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

Overview of the Turbocharger Light Library

Where to go from here

Information in this section

Turbocharger Light Library

Introduction

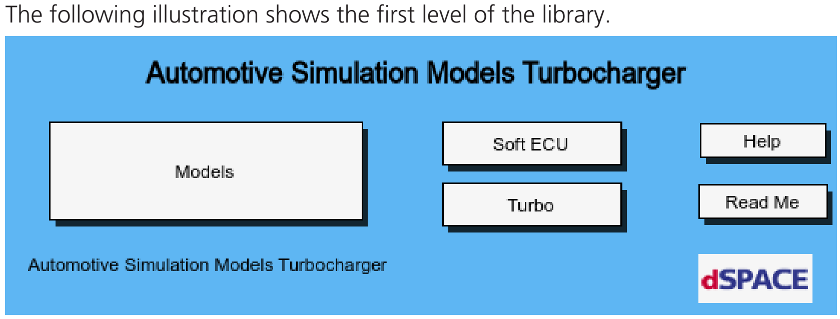
This topic gives you an overview of the ASM Turbocharger Light Library.

Opening the library

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

Models The Models subsystem contains different turbocharger models that you can use to start modelling. Refer to Models on page 23.

Soft ECU The Soft ECU subsystem contains all the subsystems that allows you to use the model offline or if a real ECU is not available. Refer to Soft ECU on page 9.

Turbo The Turbo subsystem contains all the Simulink blocks necessary to model a turbocharger. Refer to Turbo on page 15.

Light Version

Introduction

The currently installed version of ASM Turbocharger Library only offers a limited functionality. The following blocks are only empty frames without functionality.

- COMPRESSOR
- SHAFT_TC
- TURBINE
- TURBINE_SAEJ922
- WASTEGATE_VALVE
- COMPRESSOR_HP
- SHAFT_TC_HP
- TURBINE_HP
- WASTEGATE_VALVE_HP
- POSTTURBHPMAN
- POS_DISPL_COMPRESSOR

Soft ECU

Where to go from here

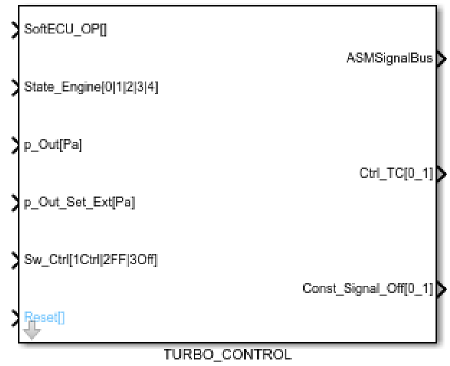
Information in this section

Turbo Control

Description

The **TURBO_CONTROL** block controls the turbocharger with the **Ctrl_TC** signal. The pressure setpoint depends on the soft ECU operating point which is set by the induced engine torque and the engine speed in the demo model. For testing a constant, an external setpoint can be used.

The controller itself is a PI controller with anti wind-up. It can be set to pass through a feed forward signal from the measurement data or to deactivate the control. This can be used to cover conditions with full actuation.



Inports

The following table shows the inports:

Name	Unit	Description
p_TurboCtrl_Meas	[Pa]	Actual value of the pressure signal
p_TurboCtrl_Set_Ext	[Pa]	External pressure set
SoftECU_OP	[]	Soft ECU operating point (n_Engine, Trq_Ind)
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_Ctrl	[1|2|3]	Switch for the control state: ▪ 1: Control with PI controller ▪ 2: FeedForward control signal from map ▪ 3: Deactivated control signal set to off position

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_TC	[0_1]	Turbocharger control signal
Ctrl_TC_Off	[0|1]	Value of deactivated signal

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_I	[]	I-Gain for pressure controller
Const_P	[]	P-Gain for pressure controller

Name	Unit	Description
Const_PI_LowLim	[]	Lower Limit of the PI Controller Output
Const_PI_UpLim	[]	Upper Limit of the PI Controller Output
Const_p_TurboCtrl_Set	[Pa]	Pressure setpoint constant
Map_Ctrl_FF	[]	Pressure control feed forward map Ctrl_FF = f(n_Engine, Trq_Ind)
Map_p_TurboCtrl_Set	[Pa]	Pressure setpoint map = f(n_Engine, Trq_Ind)
StepSize	[s]	Sample time
Sw_Invert_Control	[1|2]	Switch to invert pressure control: ▪ 1: Normal ▪ 2: Inverted
Sw_p_TurboCtrl	[1|2|3]	Switch to select pressure setpoint: ▪ 1: Map ▪ 2: Constant ▪ 3: External

Related topics

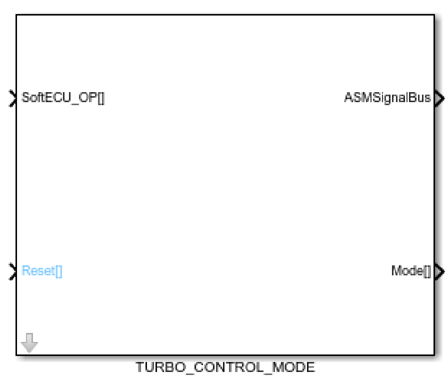
References

History of the TURBO_CONTROL Block........41
Turbo Control (ModelDesk Parameterizing 📖)

Turbo Control Mode

Description

The TURBO_CONTROL_MODE block sets the control state of the TURBO_CONTROL block. It decides whether to use the PI controller to pass through the Feed Forward Control Signal from the Measurement Data or to deactivate the controller.



Inports

The following table shows the inports:

Name	Unit	Description
Reset	[]	Reset all integrators to their initial conditions
SoftECU_OP	[]	Soft ECU operating point

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 📖).
Mode	[]	Mode of turbo control

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_Mode_TC_Thres	[]	Turbo control mode switch threshold
Map_Mode_TC_Set	[]	Turbo control mode set map = f(SoftECU_OP)
StepSize	[s]	Sample time

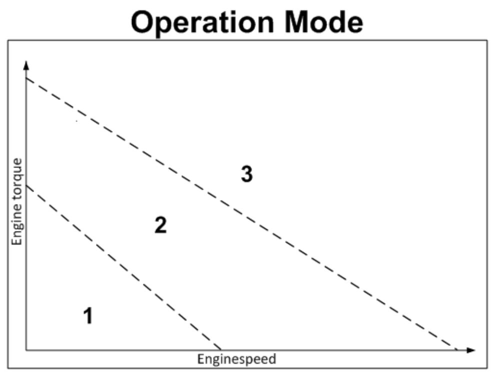
Turbo control modes

If you want to use more than one controlled component in your turbocharger system (e.g., VTG and wastegate control) you can use multiple instances of TURBO_CONTROL and TURBO_CONTROL_MODE.

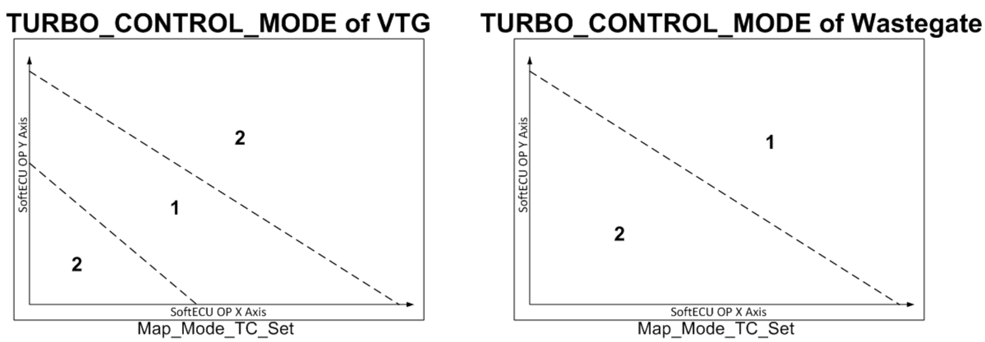
The Mode outport of TURBO_CONTROL_MODE has to be connected to the Sw_Ctrl inport of TURBO_CONTROL. It defines the operation state in which the TURBO_CONTROL is operating. The Mode outport of TURBO_CONTROL_MODE gives discrete values which are taken from Map_Mode_TC_Set, whereas Const_Mode_TC_Thres serves as a threshold for a hysteresis.

For example, if you control a turbocharger with controlled VTG turbine and a wastegate, you need to have two instances of the TURBO_CONTROL and TURBO_CONTROL_MODE blocks: one pair for the wastegate and one pair for the VTG turbine.

The following table and illustrations describe how to define the Map_Mode_TC_Set parameter in the TURBO_CONTROL_MODE block. The border conditions, such as fully open or closed, can be defined with the Map_Ctrl_FF parameter in the TURBO_CONTROL block. Set the Sw_Ctrl inport of TURBO_CONTROL to `2 (FF)` to directly pass through the signal from Map_Ctrl_FF. For an example, refer to the demo system and the Map_Ctrl_FF.m function.



Operation Mode	VTG Control Mode	Wastegate Control Mode
1	Closed: Map_Mode_TC_Set = 2 (FF)	Closed: Map_Mode_TC_Set = 2 (FF)
2	Controlled: Map_Mode_TC_Set = 1 (Ctrl)	Closed: Map_Mode_TC_Set = 2 (FF)
3	Open: Map_Mode_TC_Set = 2 (FF)	Controlled: Map_Mode_TC_Set = 1 (Ctrl)



Related topics

References

History of the TURBO_CONTROL_MODE Block.. 42
Turbo Control Mode (ModelDesk Parameterizing 📖)

Turbo

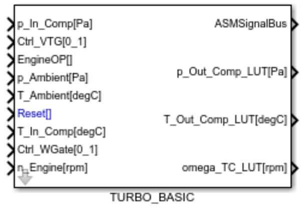
Where to go from here

Information in this section

Basic Turbocharger

Description

The basic turbocharger is an alternative to a physical-based turbocharger. It calculates the pressure and the temperature after the compressor from the engine operating point.



The **TURBO_BASIC** block can be parameterized with normal engine measurement data. No additional data sets are required.

Note

The basic turbocharger can be used instead of the physical-based turbocharger if the physical-based turbocharger is not part of the ASM installation or no accurate data for a physical-based turbocharger model is available.

Inports

The following table shows the inports:

Name	Unit	Description
Ctrl_VTG	[0_1]	Control signal of VGT
Ctrl_WGate	[0_1]	Control signal of wastegate valve
EngineOP	[]	Engine operating point
n_Engine	[rpm]	Engine speed
p_Ambient	[Pa]	Ambient pressure
p_In_Comp	[Pa]	Compressor input pressure
Reset	[]	Resets all integrators in the block to their initial conditions
T_Ambient	[°C]	Ambient temperature
T_In_Comp	[°C]	Compressor inlet 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 📖).
omega_TC_LUT	[rpm]	Turbine speed
p_Out_Comp_LUT	[Pa]	Compressor output pressure from map-based turbocharger model
Sw_Ctrl_TC_Influence	[0|1]	Switch if absolute or relative pressure is modified by control: ▪ 0: Relative ▪ 1: Absolute
Sw_State_TC	[0|1]	Switch to activate the component: ▪ 0: Off ▪ 1: On
T_Out_Comp_LUT	[°C]	Compressor output temperature from map-based turbocharger model

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_Idx_EngOP	[]	Indices to select EngOP for maps
Const_n_Engine_LowLim	[rpm]	Lower engine speed limit for Ctrl_TC influence
Const_TC_Filtertime	[s]	The dynamics of the turbocharger are modeled with a PT1 block in the signal path
Map_Ctrl_TC_Influence	[%]	Effect of turbocharger control signal map, deviations from measured control signal result in a different compressor output pressure = f(Ctrl_TC)
Map_Ctrl_TC_meas	[0_1]	Map of measured turbocharger control signal = f(Engine_OP)
Map_omega_TC_LUT	[rpm]	Turbine speed measured = f(Engine_OP)
Map_p_Out_Comp_Diff	[Pa]	Compressor output pressure difference (compared to inlet pressure) map for measured turbocharger control signal = f(Engine_OP)
Map_T_Out_Comp_Diff	[°C]	Compressor output temperature difference (compared to inlet temperature) map for measured turbocharger control signal = f(Engine_OP)
Sat_p_Out_Comp_Diff_LowLim	[Pa]	Lower limit for compressor output pressure difference
Sat_p_Out_Comp_Diff_UpLim	[Pa]	Upper limit for compressor output pressure difference
Sw_Ctrl_TC	[1|2|3]	Selector for control signal of Maps_TC: ▪ 1: Wastegate ▪ 2: VTG ▪ 3: Off

Related topics

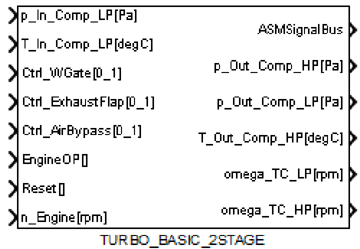
References

History of the TURBO_BASIC Block.. 39
Turbo Basic (ModelDesk Parameterizing 🕮)
Turbo Basic (ModelDesk Parameterizing 🕮)
Turbo Basic (ModelDesk Parameterizing 🕮)
Turbo Basic V8 (ModelDesk Parameterizing 🕮)
Turbo Basic V8 (ModelDesk Parameterizing 🕮)
Turbo Basic V8 (ModelDesk Parameterizing 🕮)
Turbo Charger Basic Diesel V6 (ModelDesk Parameterizing 🕮)
Turbocharger Basic Gasoline V6 (ModelDesk Parameterizing 🕮)

Basic Two-Stage Turbocharger

Description

The TURBO_BASIC_2STAGE block is a map-based model of a two-stage turbocharger. It is an alternative to a turbocharger model based on manufacturer data. It calculates the pressure and the temperature after the compressor from the engine operating point and the valve actuations.



This map-based turbocharger can be parameterized with normal engine measurement data from a test bench. No additional data sets are required.

Note

The map-based turbocharger can be used instead of the physical-based turbocharger if the physical-based turbocharger is not part of the ASM installation or no accurate data for a physical-based turbocharger model is available.

The block works as described in the following:

Working principle The influence of a low-pressure (LP) turbine bypass valve (called the wastegate valve (WGV)) and a high-pressure (HP) turbine bypass valve (called the exhaust flap (EF)) on the HP stage is contained in the Corr_TurbBypass subsystem. If the WGV is closed/opened further than the reference data, it increases/decreases the HP compressor outlet.

The EF effect on the output pressure of the HP stage is due to the vacuum control of the valves. If the EF opens, the pressure at the inlet of the WGV increases, such that the WGV closes if the control signal for the WGV remains constant. Consequently, the output pressure of the HP stage decreases.

The EF influence on the pressure distribution between the LP and HP compressor stages is contained in the p_Distrib_HP_LP subsystem. The further the EF is opened/closed compared to the reference control signal, the higher is the influence of the LP stage on the compressor pressure fraction of the LP and HP stages, as the HP stage turbine generates less/more power.

The resulting effect on the pressure distribution is contained in the Corr_Distrib_CompBypass subsystem. The outputs of the pressure stages are filtered by means of a PT1 term. The same subsystem contains the influence of the HP compressor bypass valve (BPV). The BPV bypasses the air mass flow of the HP compressor, such that the HP stage has less influence on the charging pressure.

The output subsystem evaluates the final results for all output variables. If the Sw_Ctrl_TC_On[1Off|2On] switch is set to *1 (Off)*, the model forwards the PT1-filtered pressure and temperature values evaluated by the reference tables regardless of the control by the valves. If the switch is set to *2 (On)*, the pressure values are forwarded after evaluation by the logics described above. The speeds for both the HP and the LP shaft are based on the differential pressures. The output temperature of the HP compressor is scaled linearly according to the output pressure of the HP stage.

Inports

The following table shows the inports:

Name	Unit	Description
Ctrl_AirBypass	[0_1]	Control signal of high-pressure compressor bypass valve
Ctrl_ExhaustFlap	[0_1]	Control signal of exhaust flap/regulating valve for high-pressure stage
Ctrl_WGate	[0_1]	Control signal of wastegate valve for low-pressure stage
EngineOP	[]	Engine operating point
n_Engine	[rpm]	Engine speed
p_In_Comp_LP	[Pa]	Low-pressure compressor input pressure
Reset	[]	Resets all integrators in the block to their initial conditions
T_In_Comp_LP	[°C]	Low-pressure compressor input temperature

Outports

The following table shows the outports:

Name	Unit	Description
omega_TC_HP	[rpm]	Shaft speed (HP stage)
omega_TC_LP	[rpm]	Shaft speed (LP stage)
p_Out_Comp_HP	[Pa]	Compressor output pressure (HP stage)
p_Out_Comp_LP	[Pa]	Compressor output pressure (LP stage)
T_Out_Comp_HP	[°C]	Compressor output temperature (HP stage)

Parameters

The following table shows the parameters:

Name	Unit	Description
Const_CtrlExhFlapFullOpen	[0_1]	Exhaust flap control signal. If the exhaust flap is lower than this value, it is considered that the valve is fully opened.
Const_ExhFlapLogic	[0|1]	Exhaust flap gearshift logic ▪ 0: Closed with 0 ▪ 1: Closed with 1
Const_Idx_EngOP	[]	Indices to select EngineOP for maps
Const_nEngMinTurboActivation	[rpm]	Minimum engine speed to activate the turbocharger
Const_pCompOutRelMax	[Pa]	Maximum relative pressure at the compressor outlet
Const_pCompOutRelMin	[Pa]	Minimum relative pressure at the compressor outlet
Const_pCorr2TCorr	[°C/Pa]	Compressor outlet temperature correction factor (linear approximation to correct the temperature function of the pressure)
Const_pLowPresStageRelMax	[Pa]	Maximum relative pressure at the low-pressure stage outlet
Const_pLowPresStageRelMin	[Pa]	Minimum relative pressure at the low-pressure stage outlet
Const_pOutCompRelMinForCorrEffectivity	[Pa]	Minimum relative pressure taken as reference for the calculation of pressure corrections

Name	Unit	Description
Const_Time1stOrder_dp_HighPresStage	[s]	First-order time constant of the high-pressure stage compressor
Const_Time1stOrder_dp_LowPresStage	[s]	First-order time constant of the low-pressure stage compressor
Map_CtrlAirBypassDistribInfluence	[%]	Air bypass control signal influence on compressor outlet pressure (weighting factor between low-pressure and high-pressure stage) = f([0_1])
Map_CtrlExhFlapDistribInfluence	[%]	Exhaust flap control signal influence on differential pressure distribution between low-pressure and high-pressure stages = f([0_1])
Map_CtrlExhFlapGlobalInfluence	[%]	Exhaust flap control signal influence on compressor outlet pressure = f([0_1])
Map_CtrlExhFlapRef	[0_1]	Exhaust flap control signal as a function of the operating point (reference map) = f([rpm],[mm^3/cyc])
Map_CtrlWGInfluence	[%]	Wastegate control signal influence on compressor outlet pressure = f([0_1])
Map_CtrlWGRef	[0_1]	Wastegate control signal as a function of the operating point (reference map) = f([rpm],[mm^3/cyc])
Map_dp2omega_HighPresStage	[rpm]	High-pressure stage turbine speed as a function of the pressure difference = f([Pa])
Map_dp2omega_LowPresStage	[rpm]	Low-pressure stage turbine speed as a function of the pressure difference = f([Pa])
Map_pCompLowPresStageRelRef	[Pa]	Relative outlet pressure of the low-pressure stage compressor as a function of the operating point (reference map) = f([rpm],[mm^3/cyc])
Map_pCompOutRelRef	[Pa]	Relative outlet pressure of the compressor as a function of the operating point (reference map) = f([rpm],[mm^3/cyc])
Map_TCompOutRelRef	[°C]	Relative outlet air temperature of the compressor as a function of the operating point (reference map) = f([rpm],[mm^3/cyc])
Sw_Ctrl_TC_On	[1|2]	Selector for influence of control signal on output pressure difference: ▪ 1: Off ▪ 2: On

Related topics

References

History of the TURBO_BASIC_2STAGE Block..40
Turbo Basic 2Stage (ModelDesk Parameterizing 📖)
Turbo Basic 2Stage (ModelDesk Parameterizing 📖)
Turbo Basic 2Stage V3 (ModelDesk Parameterizing 📖)
Turbo Basic 2Stage V3 (ModelDesk Parameterizing 📖)
Turbo Basic 2Stage V3 (ModelDesk Parameterizing 📖)
Turbocharger Basic 2Stage (ModelDesk Parameterizing 📖)

Switches and Parameters

Description

The parameter subsystem contains all the variant switches and parameters for running the model in different modes. For example, you can switch between mean combustion torque and modulated combustion torque mode or set the cooling system to a fixed engine temperature. All switches are defined with MATLAB workspace variables.

The following table contains all the switches for subsystems of the air path of the diesel or gasoline engine model.

Variable	States	Description
Sw_Ctrl_TC_On	[1|2]	Switch to activate the control signal effect when the map-based turbocharger model is used: ▪ 1: The control signal effect is ignored. ▪ 2: The control signal effect is considered.
Sw_EGR_Valve_On	[1|2|3]	Switch to select how the EGR valve is calculated: ▪ 1: EGR valve model is deactivated. ▪ 2: EGR valve model is activated. The EGR valve position is calculated from the control signal (duty cycle of a PWM). ▪ 3: EGR valve model is activated. The EGR valve position is measured at the real EGR.
Sw_EGRCooler_On	[1|2]	Switch to activate the EGR cooler: ▪ 1: EGR cooler is deactivated. ▪ 2: EGR cooler is activated.
Sw_InterCooler_On	[1|2]	Switch to decide if the intercooler is part of the engine or not: ▪ 1: The intercooler is not part of the engine. ▪ 2: The intercooler is part of the engine.
Sw_TurbineType	[1|2]	Switch to select the turbine type when the physical-based turbocharger model is used: ▪ 1: Wastegate ▪ 2: Variable turbine type (VTG)
Sw_Throttle_Valve_On	[1|2]	Switch to select how the throttle valve position is calculated: ▪ 1: The position is calculated from the control signal (duty cycle of a PWM). ▪ 2: The position is measured at a real throttle.
Sw_Turbo	[1|2]	Switch to select the turbocharger model: ▪ 1: Physical-based turbocharger ▪ 2: Map-based turbocharger

Related topics

References

Turbo Charger Basic Diesel V6 (ModelDesk Parameterizing 🕮)
Turbo Setup V2 (ModelDesk Parameterizing 🕮)
Turbocharger Basic Gasoline V6 (ModelDesk Parameterizing 🕮)

Models

Where to go from here

Information in this section

Model Overview

Turbocharger models

In combustion engines, turbochargers are used to compress the air flowing into the engine. This increases the amount of air in the cylinder per cycle. The ASM Turbocharger Model consists of two different modeling approaches:

Map-based turbocharger The map-based turbocharger model consists of maps that calculate the pressure and the temperature after the compressor. It also simulates the shaft speed and the effect of the turbocharger control signal.

You can switch the effect of the control signal on and off. The model does not simulate the turbine part, for example, the mass flow out of the exhaust manifold. You can decide whether to use the single map-based turbocharger or the two-stage map-based turbocharger system, depending on the system under investigation.

Physical-based turbocharger The physical-based turbocharger model simulates turbocharger behavior with the following three subsystems:

- A compressor subsystem which calculates the pressure and the temperature after the compressor.
- A turbine subsystem which calculates the mass flow through the turbine and the temperature after the turbine. The energy flow in the turbine can be controlled via a variable turbine geometry (VTG) or a wastegate.
- A turbocharger shaft subsystem which couples the compressor and the turbine and calculates the shaft speed.

Note

To use the physical-based turbocharger model, you must have installed the ASM Turbocharger Model.

Features

The two turbocharger modeling approaches also provide the following features:

- Switching between physical-based turbocharger model and map-based turbocharger model
- Replacing model signals by constants

Using turbocharger in engine models

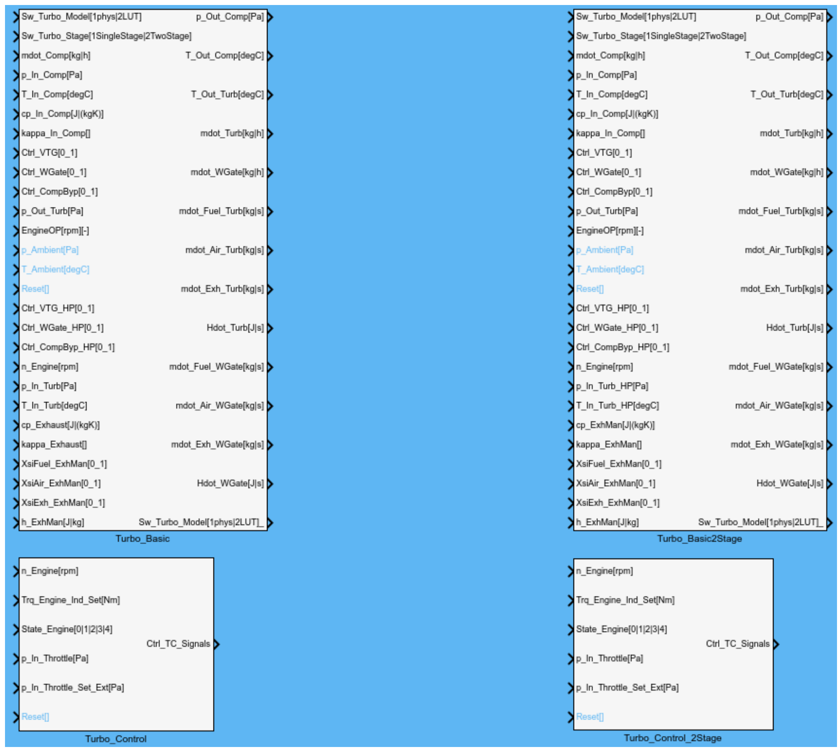
To include the turbocharger model in the diesel engine model and the gasoline engine model, several subsystems are provided. The following list gives information on the different implementations inside these subsystems:

- Turbo_Basic: The basic model includes only the map-based turbocharger model for simulating the compressor output temperature, output pressure and turbocharger shaft speed.
- Turbo_Basic2Stage: This model includes the map-based turbocharger models for simulating the compressor output temperature, output pressure, and turbocharger shaft speed of a two-stage turbocharger system.
- Turbo_Control: This model can be used in the soft ECU to control the turbocharger in the engine model. It has one controller, whose output can be used to control either the wastegate or the VTG of a turbocharger turbine.
- Turbo_Control_2Stage: This model can be used in the soft ECU to control the advanced two-stage turbocharger in the engine model. It contains five controllers, whose output is used to control the wastegate and VTG of both turbines of a two-stage turbocharger system and its HP compressor bypass valve.

These models can be used with the following ASM models:

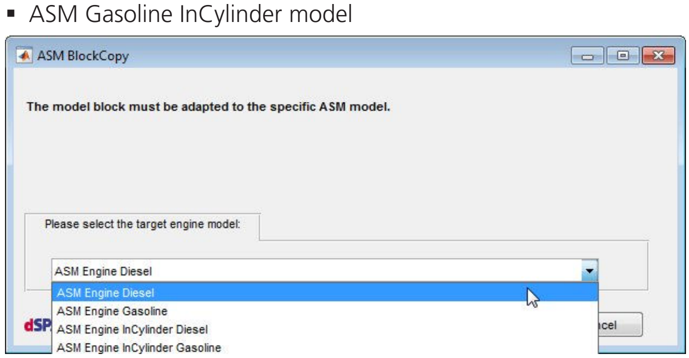
- ASM Diesel Engine
- ASM Gasoline Engine
- ASM Diesel InCylinder
- ASM Gasoline InCylinder

The following illustration shows the subsystems.



Copying a model When you copied a demo subsystem to a model, a dialog opens for you to select one of the following target models:

- ASM Diesel Engine model
- ASM Gasoline Engine model
- ASM Diesel InCylinder model
- ASM Gasoline InCylinder model



After you clicked **OK**, the mask variables and some Goto/From connections are adapted to fit the selected model type.

If you copy the Turbo_Control_2Stage demo subsystem to your model, the MDLD Multi-Instance dialog opens. Click Cancel all.

The enthalpy flow and mass flow of the components fuel, air, and exhaust are currently only required in the InCylinder models. The related ports are connected to dummy blocks in the mean value engine models.

Note

To use these subsystems, the COMMON_ENGINE_PARAMETERS block from the corresponding engine library is necessary.

Related topics

References

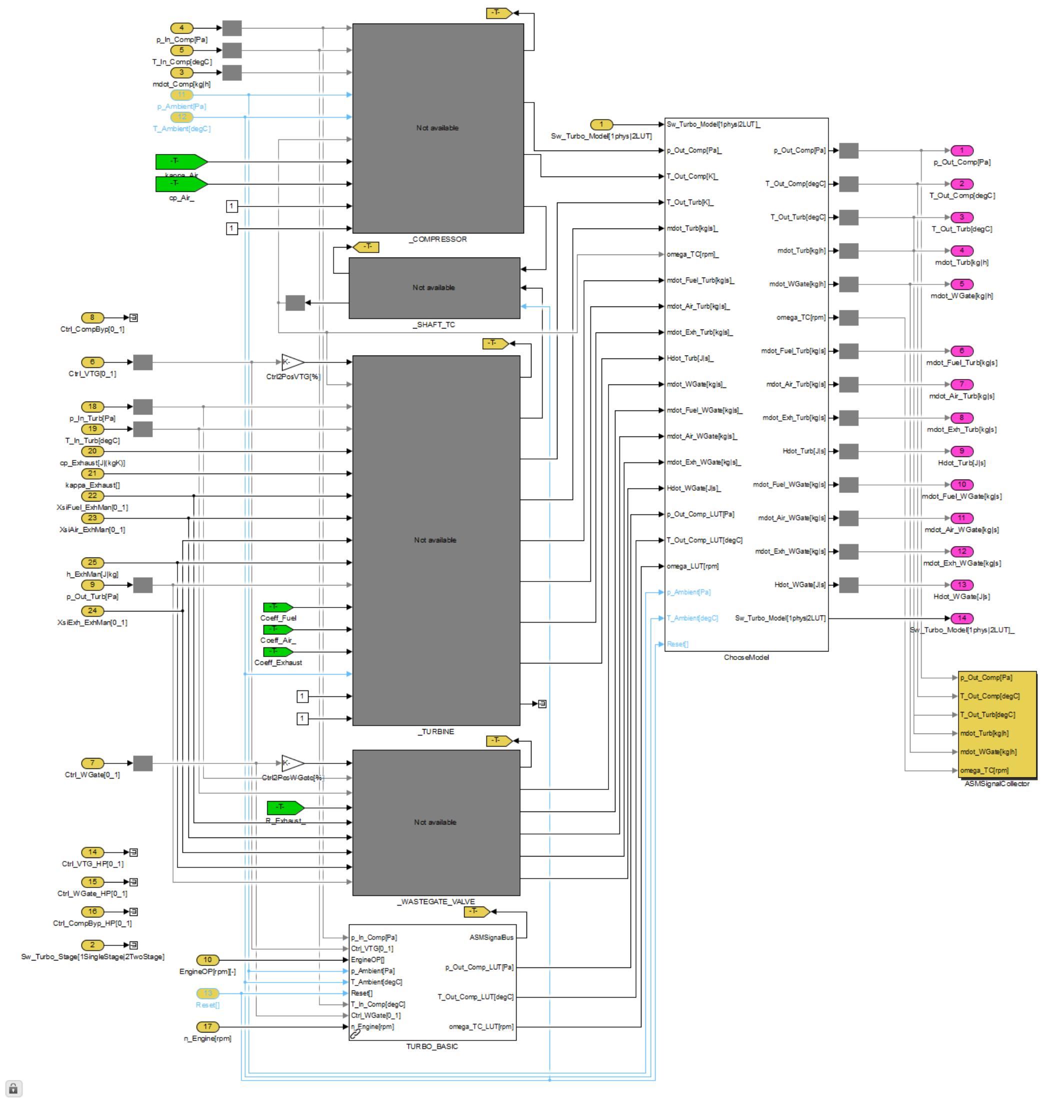
Common Engine Parameters (ASM Diesel Engine Reference 📖)
Common Engine Parameters (ASM Gasoline Engine Reference 📖)
Common Engine Parameters (ASM Diesel InCylinder Reference 📖)
Common Engine Parameters (ASM Gasoline InCylinder Reference 📖)

Basic Turbocharger

Description

The Turbo_Basic subsystem calculates the pressure and the temperature after the compressor, and the shaft speed related to the engine operating point.

The following illustration shows the Simulink basic turbocharger model.



Inports

The following table shows the inports:

Name	Unit	Description
cp_ExhMan	[J/(kgK)]	Specific heat capacity of exhaust manifold
cp_In_Comp	[J/(KgK)]	Specific heat capacity of gas entering the compressor
Ctrl_CompByp_HP	[0_1]	Control signal for high pressure stage compressor bypass
Ctrl_VTG	[0_1]	Control signal of turbine VTG
Ctrl_VTG_HP	[0_1]	Control signal of HP turbine VTG
Ctrl_WGate	[0_1]	Control signal of electrical wastegate valve
Ctrl_WGate_HP	[0_1]	Control signal of electrical HP wastegate valve

Name	Unit	Description
EngineOP	[rpm][]	Engine operating point
h_ExhMan	[J/kg]	Specific enthalpy in the exhaust manifold
kappa_ExhMan	[]	Isentropic ratio of exhaust manifold
kappa_In_Comp	[]	Isentropic ratio of gas entering the compressor
mdot_Comp	[kg/h]	Mass flow through compressor
n_Engine	[rpm]	Engine speed
p_Ambient	[Pa]	Ambient pressure
p_In_Comp	[Pa]	Compressor input pressure
p_In_Turb	[Pa]	Pressure at the turbine input
p_Out_Turb	[Pa]	Turbine output pressure
Reset	[]	Reset of states
Sw_Model	[1|2]	Switch to select the turbocharger model: ▪ 1: Physical-based turbocharger ▪ 2: Map-based turbocharger
Sw_Turbo_Model	[1|2]	Selector signal for turbo model: ▪ 1: Physical ▪ 2: Look-up table
Sw_Turbo_Stage	[1|2]	Selctor signal for turbo stages: ▪ 1: Single stage ▪ 2: Two stage
T_Ambient	[°C]	Ambient temperature
T_In_Comp	[°C]	Compressor input temperature
T_In_Turb	[°C]	Turbine input temperature
XsiAir_ExhMan	[0_1]	Mass fraction of air in the exhaust manifold
XsiExh_ExhMan	[0_1]	Mass fraction of exhaust in the exhaust manifold
XsiFuel_ExhMan	[0_1]	Mass fraction of fuel in the exhaust manifold

Outports

The following table shows the outports:

Name	Unit	Description
Hdot_Turb	[J/s]	Enthalpy flow through the turbine
Hdot_WGate	[J/s]	Enthalpy flow through the wastegate
mdot_Air_Turb	[kg/s]	Air mass flow through the turbine
mdot_Air_WGate	[kg/s]	Air mass flow through the wastegate
mdot_Exh_Turb	[kg/s]	Exhaust mass flow through the turbine
mdot_Exh_WGate	[kg/s]	Exhaust mass flow through the wastegate
mdot_Fuel_Turb	[kg/s]	Fuel mass flow through the turbine
mdot_Fuel_WGate	[kg/s]	Fuel mass flow through the wastegate
mdot_Turb	[kg/h]	Mass flow through turbine

Name	Unit	Description
mdot_WGate	[kg/h]	Mass flow through wastegate
p_Out_Comp	[Pa]	Compressor output pressure
Sw_Turbo_Model	[1|2]	Switch for turbo model: ▪ 1: Physical ▪ 2: Look-up table
T_Out_Comp	[°C]	Compressor output temperature
T_Out_Turb	[°C]	Turbine output temperature

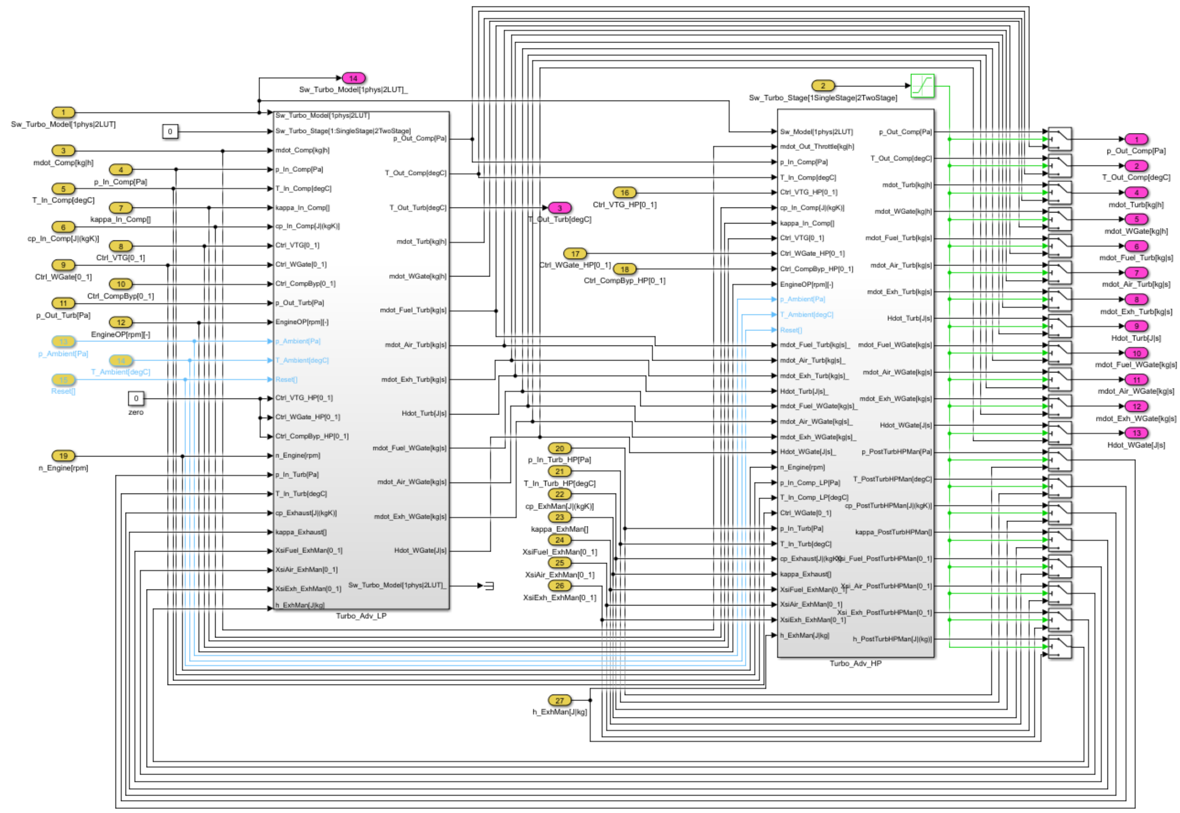
Subsystems

- Basic Turbocharger on page 15

Two-Stage Basic Turbocharger

Description

The **Turbo_Basic2Stage** subsystem calculates the pressure output and the shaft speed related to the engine operating point of the high and the low pressure compressor stage. It also calculates the temperature after the high pressure compressor stage. The two stage basic turbocharger contains the basic turbocharger model and a similar model with the map based two stage turbocharger which is arranged as a sequential system serving as the high pressure stage. The following illustration shows the Simulink two stage basic turbocharger model.



Inports The following table shows the inports:

Name	Unit	Description
cp_ExhMan	[J/(kgK)]	Specific heat capacity of exhaust manifold
cp_In_Comp	[J/(KgK)]	Specific heat capacity of gas entering the compressor
Ctrl_CompByp_HP	[0_1]	Control signal for high pressure stage compressor bypass
Ctrl_VTG	[0_1]	Control signal of turbine VTG
Ctrl_VTG_HP	[0_1]	Control signal of HP turbine VTG
Ctrl_WGate	[0_1]	Control signal of electrical wastegate valve
Ctrl_WGate_HP	[0_1]	Control signal of electrical HP wastegate valve
EngineOP	[rpm][]	Engine operating point
h_ExhMan	[J/kg]	Specific enthalpy in the exhaust manifold
kappa_ExhMan	[]	Isentropic ratio of exhaust manifold
kappa_In_Comp	[]	Isentropic ratio of gas entering the compressor
mdot_Comp	[kg/h]	Mass flow through compressor
n_Engine	[rpm]	Engine speed
p_Ambient	[Pa]	Ambient pressure
p_In_Comp	[Pa]	Compressor input pressure

Name	Unit	Description
p_In_Turb	[Pa]	Pressure at the turbine input
p_Out_Turb	[Pa]	Turbine output pressure
Reset	[]	Reset of states
Sw_Model	[1|2]	Switch to select the turbocharger model: ▪ 1: Physical-based turbocharger ▪ 2: Map-based turbocharger
Sw_Turbo_Model	[1|2]	Selector signal for turbo model: ▪ 1: Physical ▪ 2: Look-up table
Sw_Turbo_Stage	[1|2]	Selctor signal for turbo stages: ▪ 1: Single stage ▪ 2: Two stage
T_Ambient	[°C]	Ambient temperature
T_In_Comp	[°C]	Compressor input temperature
T_In_Turb	[°C]	Turbine input temperature
XsiAir_ExhMan	[0_1]	Mass fraction of air in the exhaust manifold
XsiExh_ExhMan	[0_1]	Mass fraction of exhaust in the exhaust manifold
XsiFuel_ExhMan	[0_1]	Mass fraction of fuel in the exhaust manifold

Outports

The following table shows the outports:

Name	Unit	Description
Hdot_Turb	[J/s]	Enthalpy flow through the turbine
Hdot_WGate	[J/s]	Enthalpy flow through the wastegate
mdot_Air_Turb	[kg/s]	Air mass flow through the turbine
mdot_Air_WGate	[kg/s]	Air mass flow through the wastegate
mdot_Exh_Turb	[kg/s]	Exhaust mass flow through the turbine
mdot_Exh_WGate	[kg/s]	Exhaust mass flow through the wastegate
mdot_Fuel_Turb	[kg/s]	Fuel mass flow through the turbine
mdot_Fuel_WGate	[kg/s]	Fuel mass flow through the wastegate
mdot_Turb	[kg/h]	Mass flow through turbine
mdot_WGate	[kg/h]	Mass flow through wastegate
p_Out_Comp	[Pa]	Compressor output pressure
Sw_Turbo_Model	[1|2]	Switch for turbo model: ▪ 1: Physical ▪ 2: Look-up table
T_Out_Comp	[°C]	Compressor output temperature
T_Out_Turb	[°C]	Turbine output temperature

Subsystems

- Basic Turbocharger on page 15
- Basic Two-Stage Turbocharger on page 17

Turbo Control

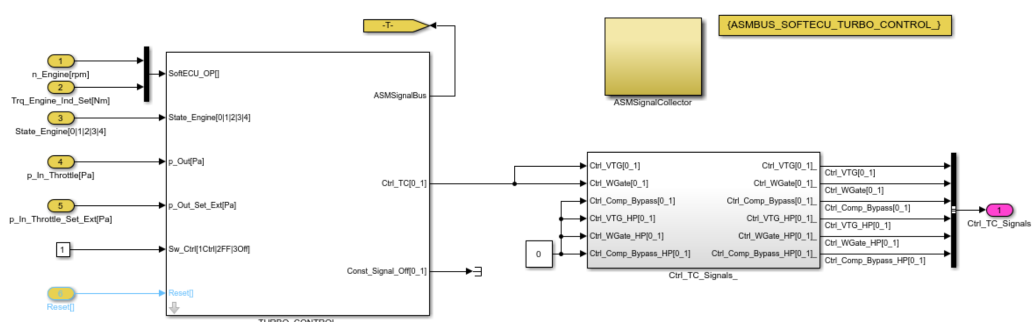
Description

The ASM Turbocharger Library provides a model for the soft ECU for validating the behavior of the turbocharger models. It is assumed that the pressure in front of the throttle valve is the output pressure of the turbocharger configuration, independently of the compressor stages.

The Turbo_Control model controls the turbocharger output pressure with the following subsystems:

- The TURBO_CONTROL subsystem is a PI controller that can also be used to feed forward a signal from the engine measurement.
- The CTRL_TC_Signals serves as a hub so that the actuation system can easily be adjusted to control different configurations of the turbocharger without changing the rest of the soft ECU model.

The following illustration shows the Simulink Turbo_Control model:



Inports

The following table shows the inports:

Name	Unit	Description
n_Engine	[rpm]	Engine speed
p_In_Throttle	[Pa]	Pressure at the throttle input side
p_In_Throttle_Set_Ext	[Pa]	External input for throttle input pressure setpoint
Reset	[]	Reset all integrators to their initial conditions
State_Engine	[0|1|2|3|4]	Engine state: ▪ 0: Engine off ▪ 1: Ignition on

Name	Unit	Description
		▪ 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_TC_Signals	[]	Signal bus with the following signals: ▪ Ctrl_VTG[0_1] ▪ Ctrl_WGate[0_1] ▪ Ctrl_VTG_HP[0_1] ▪ Ctrl_WGate_HP[0_1] ▪ Ctrl_Comp_Bypass_HP[0_1]

Subsystems

- Turbo Control on page 9

Two-Stage Turbo Control

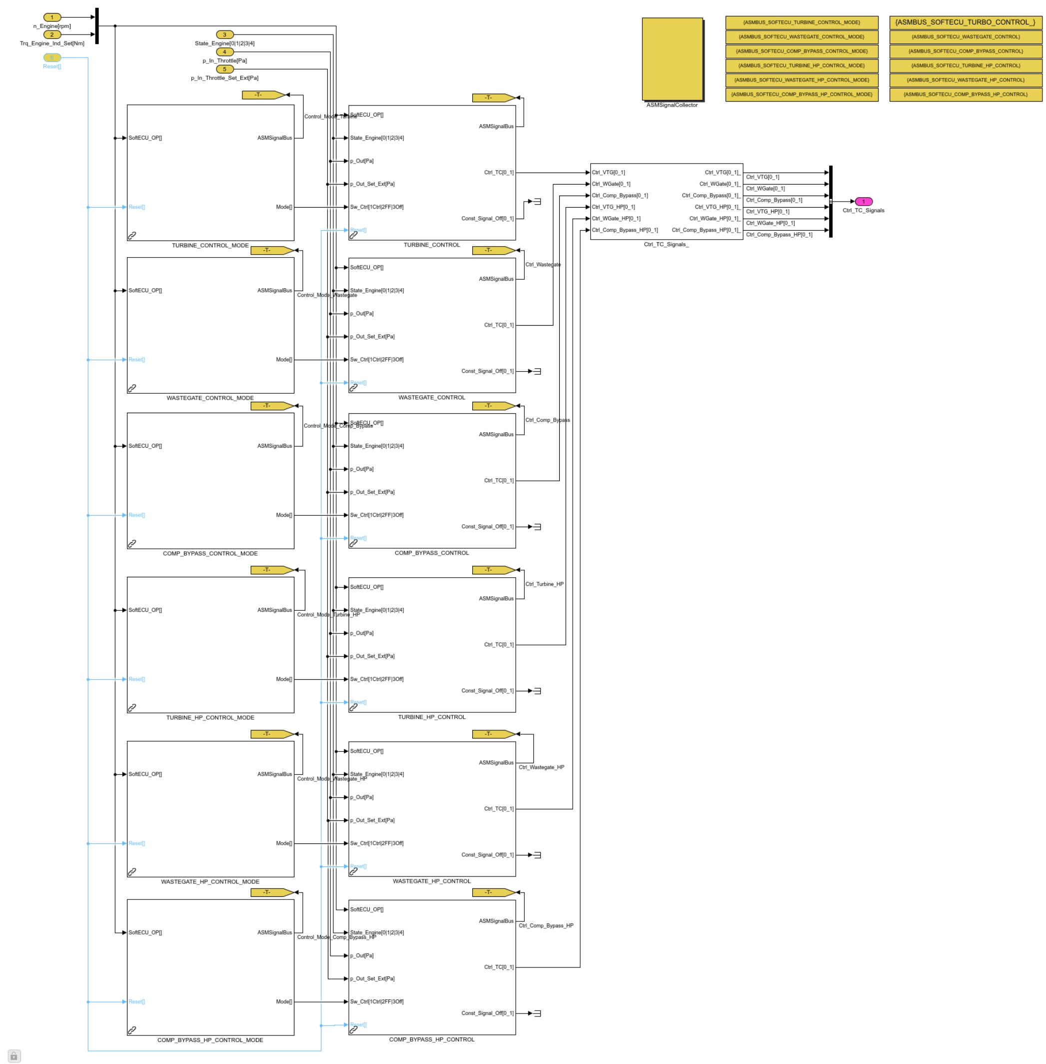
Description

The ASM Turbocharger Library provides an advanced model for the soft ECU for validating the behavior of the turbocharger models. It is assumed that the pressure in front of the throttle valve is the output pressure of the turbocharger configuration. This model has separate controllers for the turbine wastegate, the turbine VTG, the high-pressure turbine wastegate, the high-pressure turbine VTG, and the high-pressure compressor bypass valve.

The Turbo_Control_2Stage model controls the turbocharger output pressure with multiple instances of the following subsystems:

- The TURBO_CONTROL subsystem is a PI controller that can also be used to feed forward a signal from the engine measurement. The instances are renamed TURBINE_CONTROL, WASTEGATE_CONTROL, TURBINE_HP_CONTROL, WASTEGATE_HP_CONTROL, and COMP_BYPASS_HP_CONTROL. This is essential for the parameterization function to select the corresponding signal from the engine measurement.
- The TURBO_CONTROL_MODE subsystem can be configured to define if the TURBO_CONTROL calculates the *ctrl_signal* with the PI controller or uses the feed forward mode. The instances are also renamed.
- The CTRL_TC_Signals serves as a hub so that the actuation system can easily be adjusted to control different configurations of the turbocharger without changing the rest of the soft ECU model.

The following illustration shows the Simulink Turbo_Control_2Stage model:



Inports

The following table shows the inports:

Name	Unit	Description
n_Engine	[rpm]	Engine speed
p_In_Throttle	[Pa]	Pressure at the throttle input side
p_In_Throttle_Set_Ext	[Pa]	External input for throttle input pressure setpoint
Reset	[]	Reset all integrators to their initial conditions
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
Trq_Engine_Ind_Set	[Nm]	Induced engine torque setpoint

Outports

The following table shows the outports:

Name	Unit	Description
Ctrl_TC_Signals	[]	Signal bus with the following signals: ▪ Ctrl_VTG[0_1] ▪ Ctrl_WGate[0_1] ▪ Ctrl_VTG_HP[0_1] ▪ Ctrl_WGate_HP[0_1] ▪ Ctrl_Comp_Bypass_HP[0_1]

Subsystems

- Turbo Control on page 9
- Turbo Control Mode on page 11

New Features/Migration History of the ASMTurbocharger Light 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

History of the MAPS_TC Block

Release 2015-B	The MAPS_TC block has been renamed to TURBO_BASIC. The Sw_Ctrl_TC inport has been removed and added as the Sw_Ctrl_TC parameter to decide whether to use the wastegate, VTG, or no actuation signal.
Release 2015-A	The block has been extended with a new inport. Now it is not mandatory to define the engine speed as the first element of the engine operating point. This is a requirement for in-cylinder models. The Ctrl_TC[0_1] inport has been renamed to Ctrl_VTG[0_1]. A new Ctrl_WGate[0_1] inport has been added. A Sw_Ctrl_TC parameter has been added to decide whether to use Ctrl_VTG or Ctrl_WGate as input of the internal map. The migration has no functional effect.
Release 7.4	A link to the MAPS_TC block is changed to the former version MAPS_TC_6_0 block during migration to guarantee the same block behavior after migration. The new MAPS_TC block contains several changes: ▪ The turbo control influence on efficiency has been modified from additive to multiplicative. ▪ The temperatures are evaluated relatively instead of absolutely to account for changes in the ambient conditions. ▪ The variable naming for compressor output pressure limits has been corrected.
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 7.0	The map-based turbocharger block now uses the model ambient conditions as initialization values. The compressor output pressure is not influenced below a parameterized engine speed.
Release 6.3	The control signal for the turbocharger (Ctrl_TC[0_1]) has been added to the ASMSignalBus block.

History of the MAPS_TC_2STAGE Block

Release 2015-B	The MAPS_TC_2STAGE block has been renamed to TURBO_BASIC_2STAGE. The Sw_Ctrl_TC inport has been removed and added as the Sw_Ctrl_TC parameter to decide if the system uses the incoming actuation signal.
Release 2015-A	The block has been extended with a new inport. Now it is not mandatory to define the engine speed as the first element of the engine operating point. This is a requirement for in-cylinder models. No functional change has been performed.
Release 7.3	The block has been adapted to support engine reset functionality. Internal subsystems have been restructured without any functional change. Some trace paths of internal block variables have therefore changed. If those variables are connected in a ControlDesk layout, the connections must be updated.
Release 7.2	The ASM Turbocharger blockset offers the option to simulate a two-stage turbocharger system. The system can be modeled by using a map-based approach to simulate the engine test bench data or by implementing the turbocharger components separately and parameterizing them with the turbocharger test bench data. This block has been added to support the two-stage turbocharger functionality.

History of the TURBO_BASIC Block

Release 2019-A	A switch parameter to decide if the control signal influence is multiplied with the relative or absolute pressure was added to the block.
Release 2015-B	The MAPS_TC block has been renamed to TURBO_BASIC. The Sw_Ctrl_TC inport has been removed and added as the Sw_Ctrl_TC parameter to decide whether to use the wastegate, VTG, or no actuation signal.
Release 2015-A	The block has been extended with a new inport. Now it is not mandatory to define the engine speed as the first element of the engine operating point. This is a requirement for in-cylinder models. The Ctrl_TC[0_1] inport has been renamed to Ctrl_VTG[0_1].

A new Ctrl_WGate[0_1] inport has been added.

A Sw_Ctrl_TC parameter has been added to decide whether to use Ctrl_VTG or Ctrl_WGate as input of the internal map. The migration has no functional effect.

Release 7.4

A link to the MAPS_TC block is changed to the former version MAPS_TC_6_0 block during migration to guarantee the same block behavior after migration.

The new MAPS_TC block contains several changes:

- The turbo control influence on efficiency has been modified from additive to multiplicative.
- The temperatures are evaluated relatively instead of absolutely to account for changes in the ambient conditions.
- The variable naming for compressor output pressure limits has been corrected.

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 7.0

The map-based turbocharger block now uses the model ambient conditions as initialization values. The compressor output pressure is not influenced below a parameterized engine speed.

Release 6.3

The control signal for the turbocharger (Ctrl_TC[0_1]) has been added to the ASMSignalBus block.

Related topics

References

Basic Turbocharger.. 15

History of the TURBO_BASIC_2STAGE Block

Release 2015-B

The MAPS_TC_2STAGE block has been renamed to TURBO_BASIC_2STAGE.

The Sw_Ctrl_TC inport has been removed and added as the Sw_Ctrl_TC parameter to decide if the system uses the incoming actuation signal.

Release 2015-A

The block has been extended with a new inport. Now it is not mandatory to define the engine speed as the first element of the engine operating point. This is a requirement for in-cylinder models. No functional change has been performed.

Release 7.3

The block has been adapted to support engine reset functionality.

Internal subsystems have been restructured without any functional change. Some trace paths of internal block variables have therefore changed. If those variables are connected in a ControlDesk layout, the connections must be updated.

Release 7.2

The ASM **Turbocharger** blockset offers the option to simulate a two-stage turbocharger system. The system can be modeled by using a map-based approach to simulate the engine test bench data or by implementing the turbocharger components separately and parameterizing them with the turbocharger test bench data. This block has been added to support the two-stage turbocharger functionality.

Related topics

References

Basic Two-Stage Turbocharger.. 17

History of the TURBO_CONTROL Block

Release 2015-A

The block has been enhanced and moved to the ASM Turbocharger Library. A new inport was added so that the block now can switch between calculating the control signal and feeding it forward from an internal map. The names of the parameters have been changed. An outport was added to output the signal for minimum actuation. When migrating, a subsystem is used as a shell to transfer the parameters to the new names and to replicate the exact old behavior with the new library block.

Related topics

References

Turbo Control... 9

History of the TURBO_CONTROL_MODE Block

Release 2015-A

The **TURBO_CONTROL_MODE** block sets the control state of the **TURBO_CONTROL** block. It decides whether to use the PI controller to pass through the Feed Forward Control Signal from the Measurement Data or to deactivate the controller.

Related topics

References

Turbo Control Mode........ 11

Appendix

Bibliography

List of literature

The following literature provides more details:

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