Handbook of Plant Modeling IF Guidelines-Compatible Model for Vehicle Development

(ver.2.0)

Revision History

Rev.	Date	Revised contents	Company	Approver
--	2017/03	New issued	AZAPA	Icihara
2.0	2021/03	Modefied parameters and contents	AZAPA	Icihara

Contents

1. Preface

1.1. Purpose of guidelines-compatible model

The guidelines-compatible model is based on the Plant Modeling I/F Guidelines for Vehicle Development, which promote the distribution of models between businesses. Actual use of this model will lead to a deeper understanding of these Guidelines. In addition, by replacing and running the subsystem models with your own models, the IF guidelines-compatible model can be used as a pre-emptive guidelines checker and problem identifier when changing models.

1.2. Requirements of guidelines-compatible model

The functions and structures of a vehicle have been abstracted so that even those without basic knowledge of vehicles can easily understand the model. Physical domains include motion systems (rotation, translation) and electrical systems. *Other physical domains will be discussed in the future.

The model assumes that the vehicle has an engine displacement of 1.3 L with a continuously variable transmission (CVT) as its transmission type.
It is based in Matlab® Simulink®, a programming language often used in vehicle development.

1.3. Functions of guidelines-compatible model

●Controlling function
- Idling stop/Idling control
- Fuel cut control
- Regeneration contorol during the decelearation /Constant power generation control
- Torque converter lock-up control
- Gear shift line control

●Plant
- Engine
- Alternator
- Starter
- CVT
- Differential gear
- Brake
- Tire
- Vehicle
- Battery
- Electrical load

2. Operating/Usage environment

Operating requirement and usage environment of the guidelines-compatible model is shown below.

2.1. Operating requirement

The guideline-compatible model is proven to the operation in the following environmentand conditions.

＜OS environment＞

OS	Windows 7　64bit
PC specification	64bit Memory 6GB or more

＜Model usage environment＞

Tool name	MATLAB/Simulink
Tool ver.	2015a (64bit)
Types	.slx
Library (Except for Simulink standard library)	METI_Lib_vehicle_model.slx

＜Caluculating condition of model＞

Type of solver	Fixed step ode8 (Dormand-Prince)
Sampling time	0.0025[s]
Max. step size	-
Min. step size	-
Allowable error	-

2.2. Usage environment

The simulation environment, file structure, and folder structure of the guidelines-compatible model is as follows.

＜Simulation environment of the guidelines-compatible model＞

The simulation environment of the guidelines-compatible model is as shown below.
The CVT fuel consumption simulator is made up of a model file and a library file.
Mode-driving data, parameter data, and other data are read as inputs for settings, and the simulation is run.

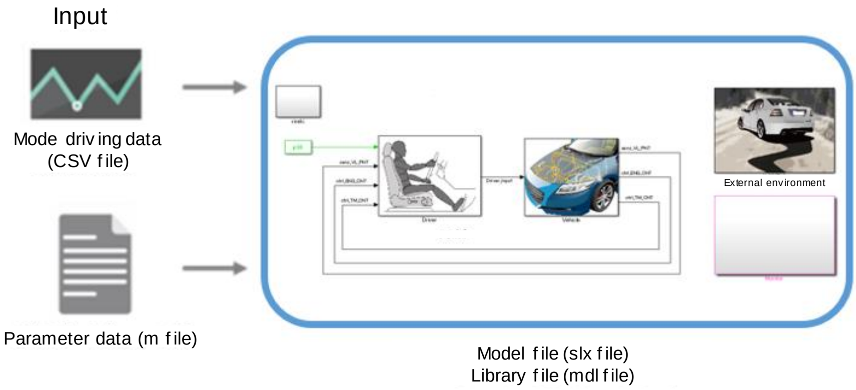


Fig. 2.2.1. Simulation environment

＜File composition of the guidelines-compatible model＞

No	File Name	Description
1	METI_CVT_vehicle_ver00_2015a.slx	Simulator
2	METI_Lib_vehicle_model.slx	METI Library
3	init_setting.m	Script for initial setting/setting parameter data/setting pass
4	(subfolder)params	Parameter data folder
5	(subfolder)pictures	Block image data folder

3. Usage

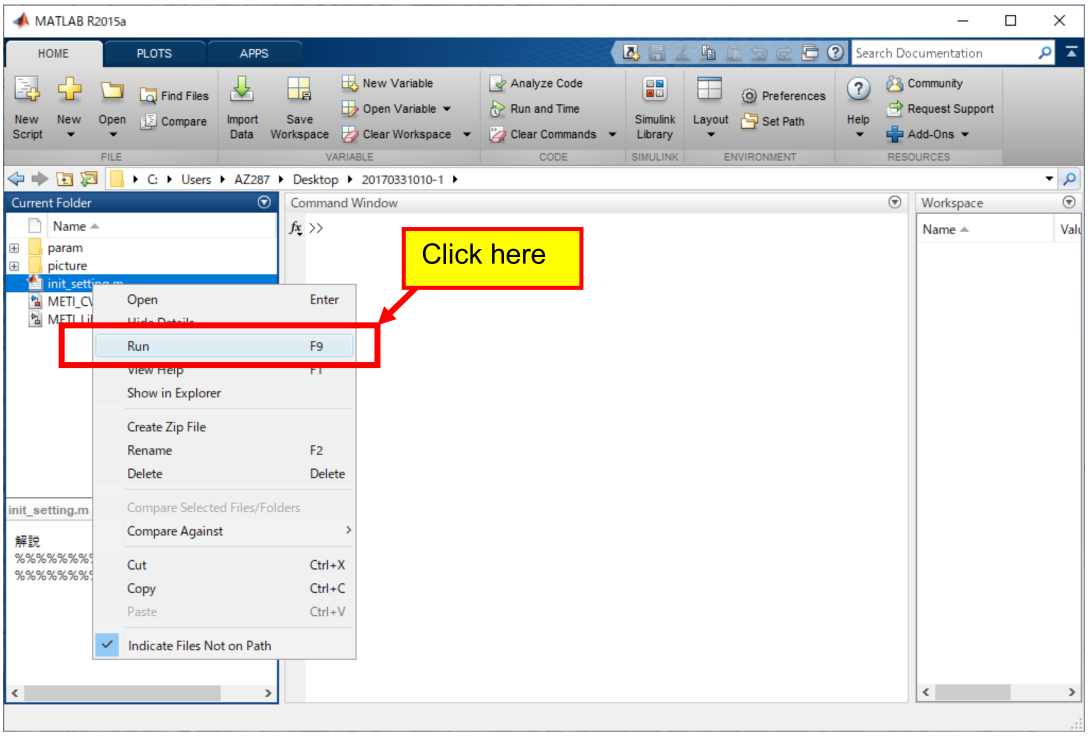
3.1. Execution of simulation

3.1.1. Launch MATLAB

Launch MATLAB 2015a.

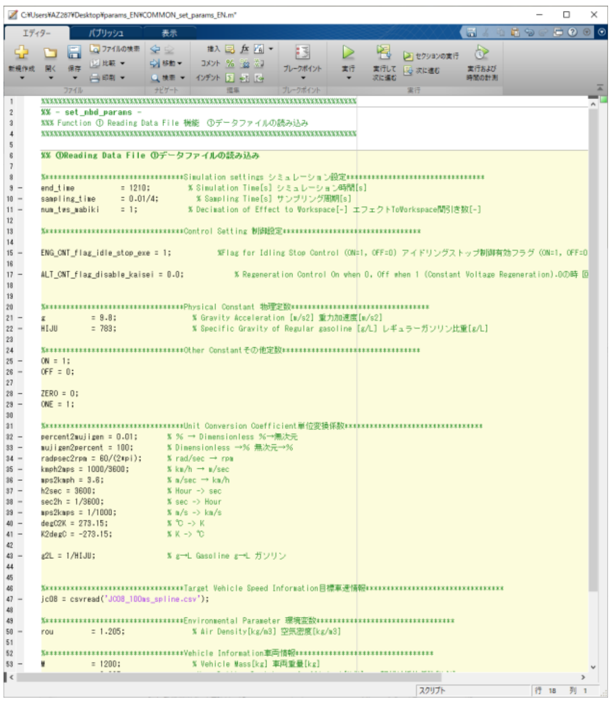
3.1.2. Initial setting

Run "init_setting.m", then set a path, a parameter, and set up the simulation model.



3.1.3. Select control to use

Controls can be chosen by setting in COMMON_set_params.m inside the params folder.



①Idling-stop

flag_idle_stop_exe = 1.0;

1 : Idling-stop

0 : Idle Speed Control (ISC)

②Regeneration control (Increase voltage when decelerating and using F/C)

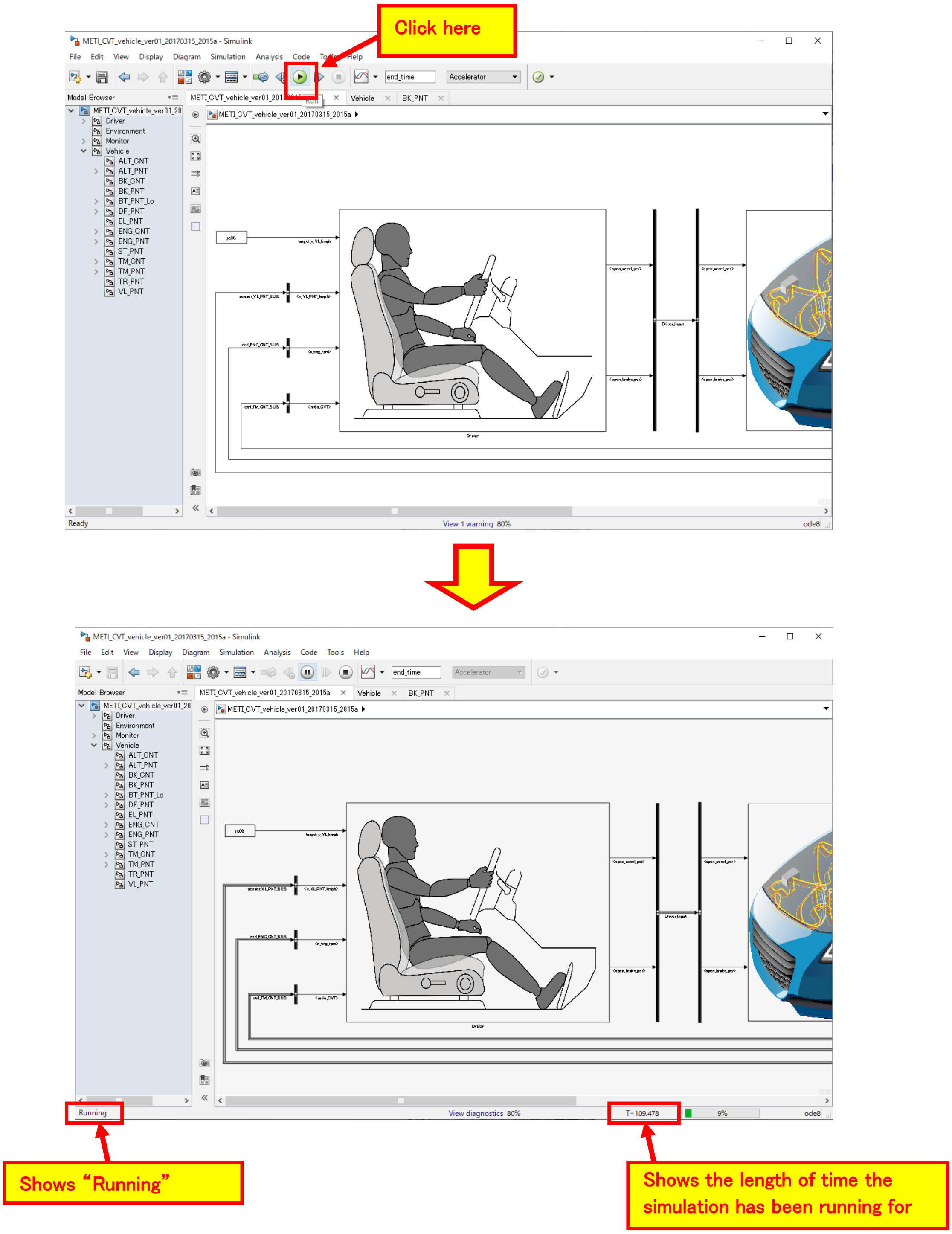
flag_disable_kaisei = 0;

0 : Regeneration cotrol is active

1 : Regeneration control is deactive (constant power generation)

3.1.4. Start simulation

Click the Start Simulation button on Simulink to begin the simulation.



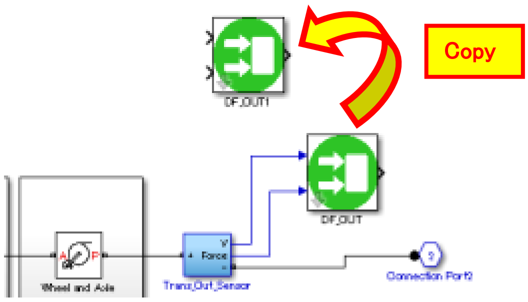
The simulation is finished when it stops showing "Running".

3.2. New energy block setup

This chapter contains the steps to modify the model to add an energy block are described. In addition, refer to the energy blocks in the library.

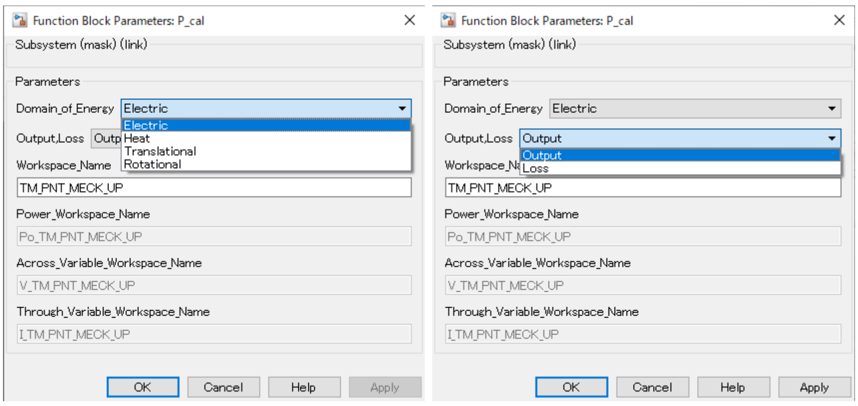
3.2.1. Copy energy block

Copy an existing energy block. Any energy block can be copied.

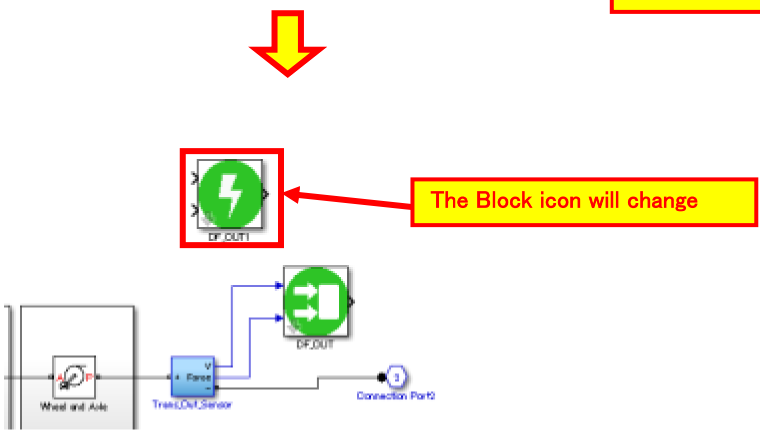


3.2.2. Set appropriate physical quantity

Select the type of energy and output / loss from the drop-down menu.
Electric and Output selected.

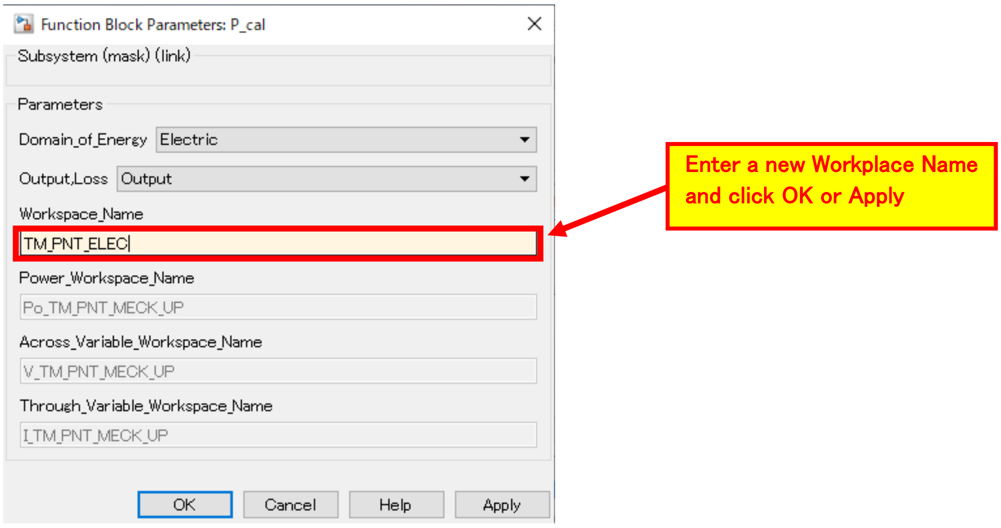


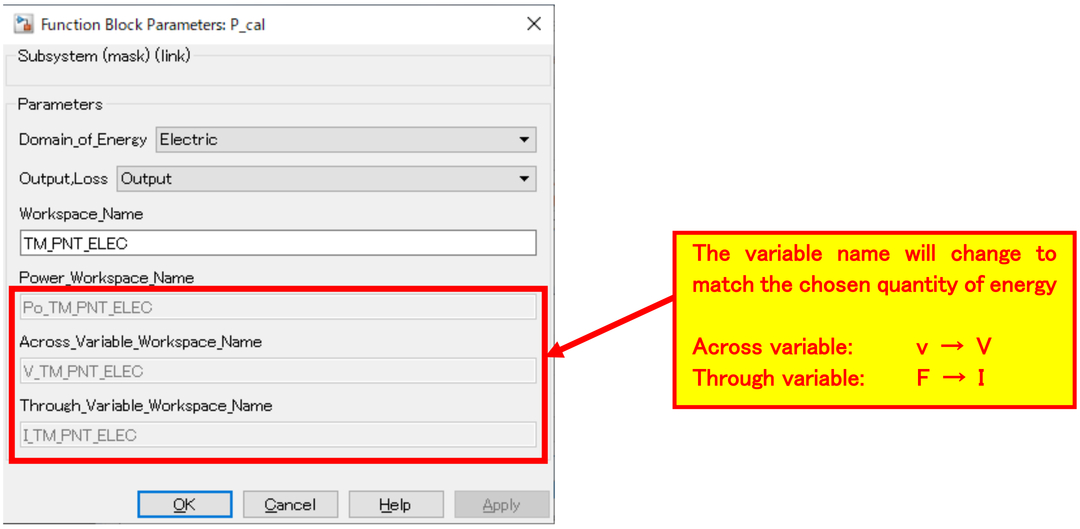
Press OK or Apply after selecting the parameters



3.2.3. Set energy name

The power, across variable, and through variable are automatically set when a Workspace_Name is entered and OK or Apply is clicked. Measurement results will also be left in the workspace.





4. Basic structure of guidelines-compatible model

The structures and system of the guidelines-compatible model's first –layer (top) and secnd-layer are described below (those separated by Simulink's subsystem into each function).

4.1. Structure of first-layer

The structure of the first-layer (entire model) of the guidelines-compatible model is shown below.

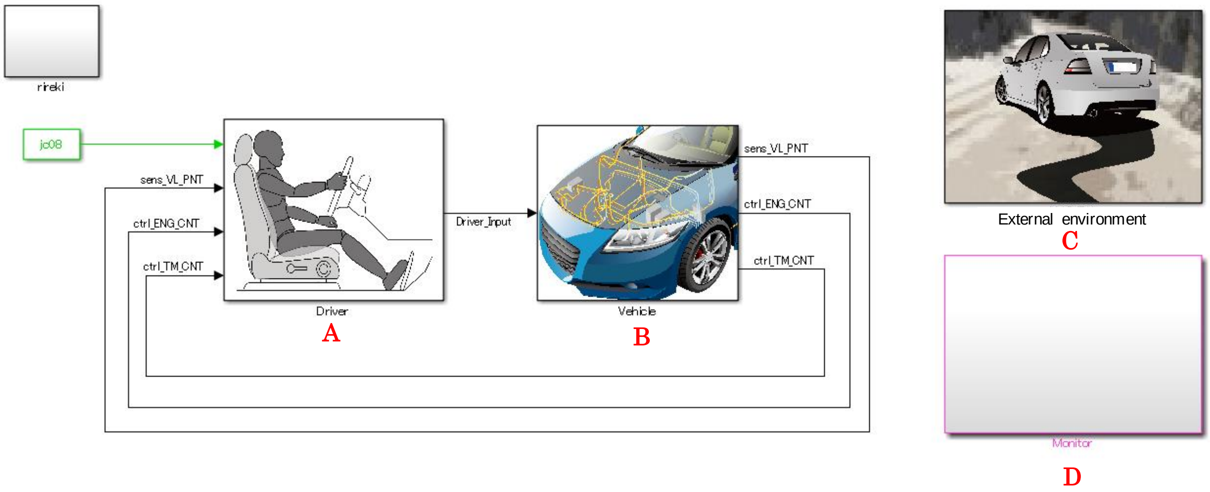


Fig. 4.1. Structure of the guidelines-compatible model’s first-layer

The function overview of first-layer system in the guidelines-compatible model is described.
A, B, C, D of the No. column on the table refer to the systems in Fig. 4.1.

Table 4.1. Each system and function overview of the guidelines-compatible model’s first-layer (entire model)

No.	System Name	Function Overview
A	Driver	Read the mode-driving pattern (JC08) and operate the accelerator and brake.
B	Vehicle	Read the accelerator and brake operations, and calculate the vehicle velocity by controlling the engine output and transmission ratio.
C	External environment	＜Implementation T.B.D.＞
D	Monitor	Monitor each variables in the vehicle system.
Other	rireki	Describes the model change history.

4.2. Structure of second-layer

The structure of each system of the second-layer in the guidelines-compatible model is shown below.

4.2.1. Structure of [A: Driver] system

The structure of the second-layer driver system in the guidelines-compatible model is shown below.

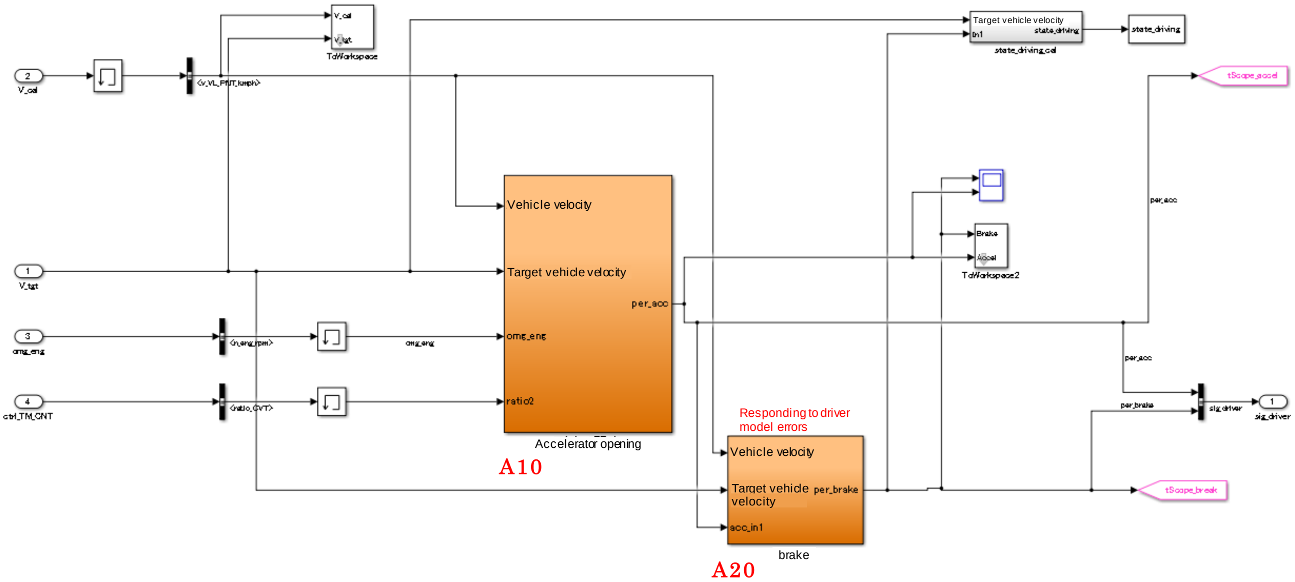


Fig. 4.2.1. Structure of second-layer driver system

The structure and the functional specification of second-layer driver system in the guidelines-compatible model is described.

The numbered elements (A10, A20) in the figure represent the system shown in Fig 4.2.1.

Table 4.2.1. Each system name and function overview of second-layer driver system

No.	System Name	Function Overview
A10	Accelerator opening	The accelerator opening is calculated based on the sum of FF control and FB control. The FF control calculates the required driving force based on the target vehicle velocity, and calculates the accelerator opening from the gear ratio and the engine rpm.FB control calculates the accelerator opening based on the difference between the target vehicle velocity and the actual vehicle velocity.
A20	Brake (opening)	The brake pedal stroke is derived from the difference between the target vehicle velocity and the actual vehicle velocity. Pedal misapplication prevention control that prevents the brake from being applied while accelerating.

4.2.2. Structure of [B: Vehicle] system

The structure of the second-layer vehicle system in the guidelines-compatible model is shown below.

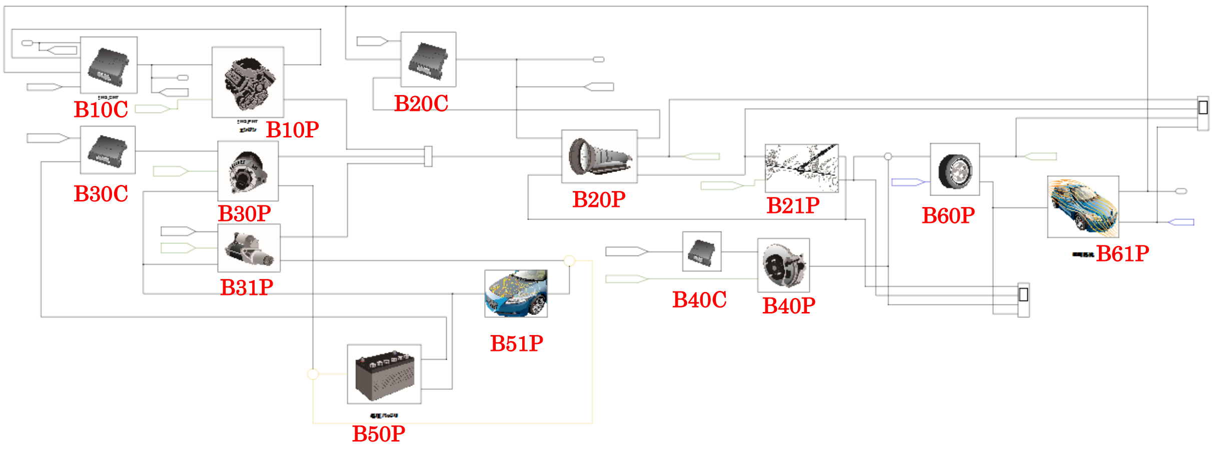


Fig. 4.2.2. Structure of second-layer vehicle system

The functional specifications of second-layer vehicle system in the guidelines-compatible model are described.

The numbered elements in the figure represent the system shown in Fig 4.2.2. The C at the end of B10C stands for Controller, and the P at the end of B10P stands for Plant.

Table 4.2.2. Each system name and function overview of second-layer vehicle system

No.	System Name	Function Overview
B10C	ENG_CNT	Controlling engine and starter.
B20C	TM_CNT	Controlling CVT and lock-up clutch.
B30C	ALT_CNT	Controlling alternator.
B40C	BK_CNT	Controlling brake.
B10P	ENG_PNT	Generate engine shaft torque and calculate fuel consumption.
B20P	TM_PNT	Shift gears toward engine rpm and torque.
B21P	DF_PNT	Decelerate from transmission output to drive shaft.
B30P	ALT_PNT	Generate electricity, and output negative torque to the engine shaft.
B31P	ST_PNT	Generate current consumption during the engine starting process.
B40P	BK_PNT	Generate brake torque on the drive shaft.
B50P	BT_PNT	Supply voltage according to SOC.
B51P	EL_PNT	Generate current consumption of low voltage electrical loads.
B60P	TR_PNT	Convert rotational motion into linear motion of drive shaft.
B61P	VL_PNT	Calculate running resistance and vehicle velocity.

4.2.3. Structure of [C: External environment] system

The structure of the second-layer external environment system in the guidelines-compatible model is shown below.

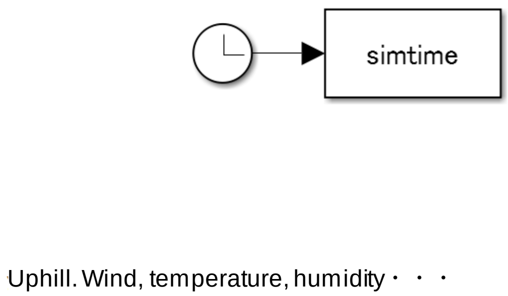


Fig. 4.2.3. Structure of second-layer external environment system

*This system will continue to have systems and functions added to it in the future.

4.2.4. Structure of [D: Monitor] system

The structure of the second-layer monitor system in the guidelines-compatible model is shown below.

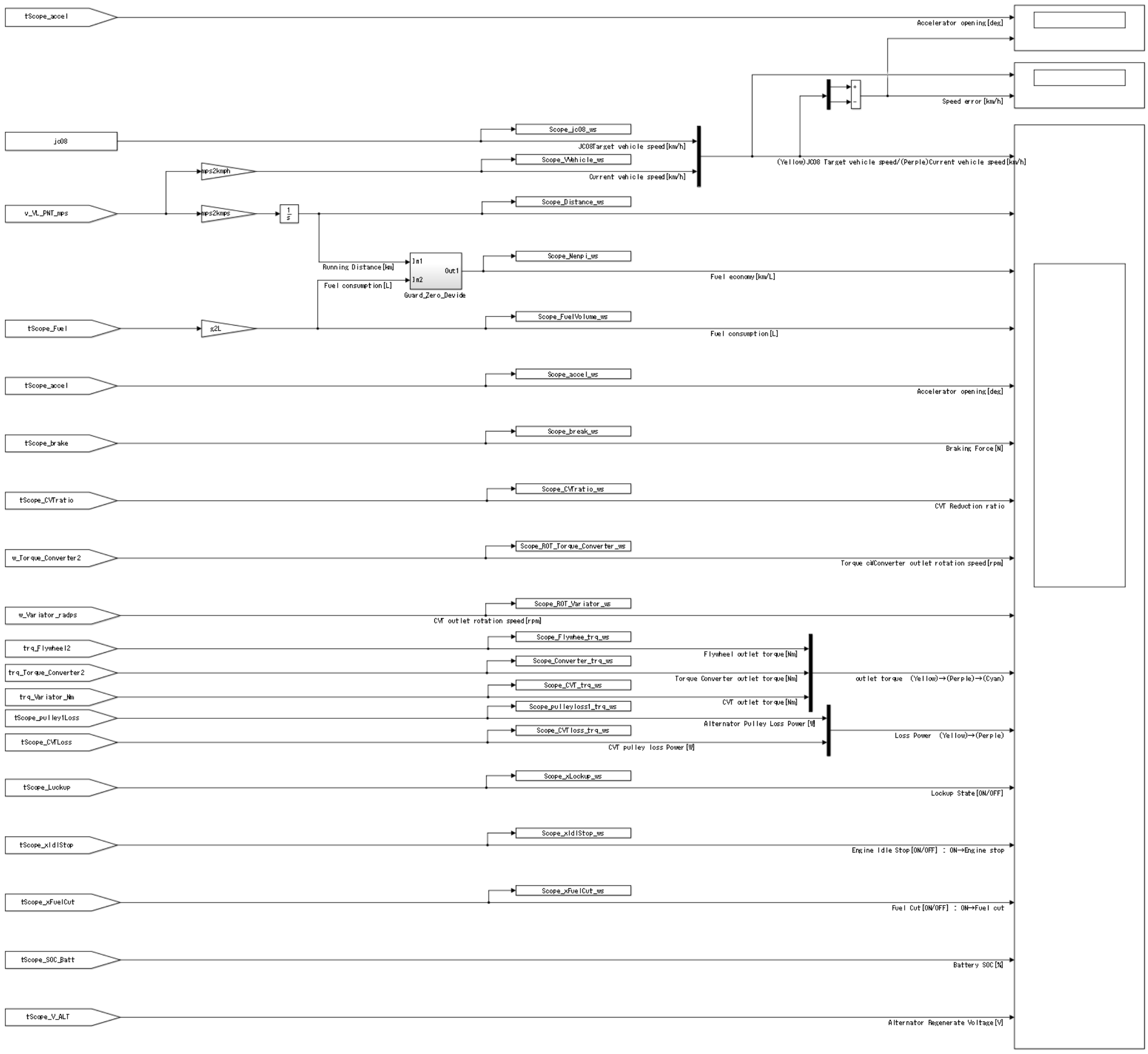


Fig. 4.2.4. Structure of second-layer monitor system

This system monitors the signals calculated from the driver, vehicle and (external environment) systems.
It does not have any deeper system layers.

5. Functional Specifications of guidelines-compatible model

5.1. Functional specification of first-layer

The functional specifications of the first-layer (entire model) in the guidelines-compatible model are described.

5.1.1. Abstract

The operating amount of the accelerator and brake is calculated by the driver model in accordance with the mode-driving pattern (JC08). The vehicle model receives these operation and calculates behaviors such as acceleration and deceleration. Information such as the vehicle velocity is sent to the driver model and used in calculations for operating the accelerator and brake.

External environment block is used to set driving environment in which the vehicle is running.

Monitor block is used to monitor the various variables in the driver model and vehicle model.

5.1.2. Data flow diagram

The data flow diagram of the entire the guidelines-compatible model is shown below.

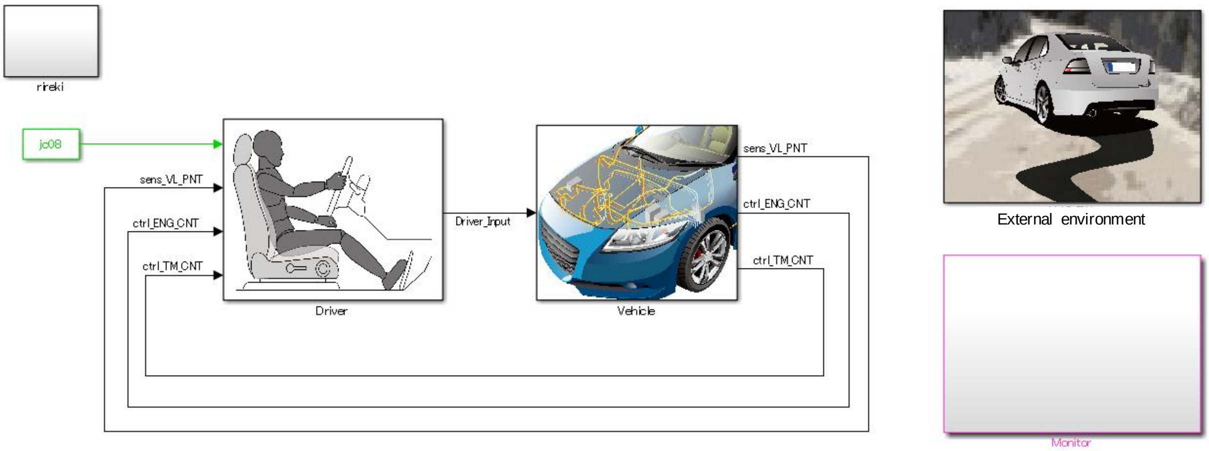


Fig. 5.1.2. Data flow diagram : first-layer (entire the guidelines-compatible model)

5.1.3. Input/output specification

The input/output specification of the entire the guidelines-compatible model is shown below.

Input			
Name	Unit	Area	Description
V_tgt	km/h	[0 200]	Target of vehicle velocity (JC08)
v_VL_PNT_kmph	km/h	[0 200]	Vehicle velocity
n_eng_rpm	rpm	0 or more	Engine rpm
ratio_CVT	-	TBD	CVT pulley ratio
Output			
Name	Unit	Area	Description
v_VL_PNT_kmph	km/h	[0 200]	Vehicle velocity
per_throttle	%	[0 100]	Throttle opening
flag_IdleStop	-	[0 1]	Idling stop flag
flag_fuelcut	-	[0 1]	Fuel cut flag
fuel_ratio	g/s	0 or more	Fuel consumption rate
timing_ignition	CA	[0 360]	Ignition timing from MBT (BTDC)
n_eng_rpm	rpm	0 or more	Engine rpm
flag_ON_Starter	-	[0 1]	Starter active flag
flag_Lockup	-	[0 1]	Lock-up instruction of torque converter
omg_Slip_rpm	-	TBD	Target rpm of lock-up slip
ratio_CVT	-	TBD	CVT pulley ratio

5.1.4. Parameter specification

The parameter specification of the entire the guidelines-compatible model is shown below.

Variable name	Setting value	Unit	Description
ALT_CNT_Alter_V_Kaisei_V	14	V	Target regenerative voltage
ALT_CNT_Alter_V_BASE_V	13.5	V	Standard target alternator voltage value
ALT_CNT_V_Battely_Kudo_V	12	V	Alternator lower limit voltage value
ALT_CNT_ALT_ON_RPM_HYS_rpm	1000	rpm	Engine rpm threshold that Alternator power generation start(Hysteresis processing)
ALT_CNT_ALT_OFF_RPM_HYS_rpm	600	rpm	Engine rpm threshold that Alternator power generation is turned OFF(Hysteresis processing)
ALT_PNT_Gain_Alt_v_del	100	-	P gain for calculating alternator target current value
ALT_PNT_eta_pulley_alt	0.97	-	Alternator pulley efficiency
ALT_PNT_ratio_pulley_alt	1.12	-	Pulley ratio
ALT_PNT_ALT_GDCurrent_A	0.7	A	Current for calculating alternator required torque guard value
ALT_PNT_ALT_GDVolt_V	12.5	V	Voltage for calculating alternator required torque guard value
ALT_PNT_Tau_Alternator_V_tgt_s	0.05	sec	Time constant for Alternator target voltage delay
ALT_PNT_Tau_Alternator_trq_Nm	0.01	sec	Time constant for Alternator torque delay
ALT_PNT_trq_alter_output_LL_Nm	0	Nm	Alternator torque lower limit value
ALT_PNT_Alter_trq_Nm_map_x_rpm	<1x18>	rpm	Alternator shaft torque MAP Alternator rpm
ALT_PNT_Alter_trq_Nm_map_y_Current_A	<1x12>	A	Alternator shaft torque MAP Alternator current
ALT_PNT_Alter_trq_Nm_map_z_Volt_tgt_V	<1x3>	V	Alternator shaft torque MAP Alternator target voltage
ALT_PNT_Alter_trq_Nm_map	<18x12x3>	Nm	Alternator shaft torque MAP Alternator torque
ALT_PNT_Alter_limit_Current_V_table_x_rpm	<1x14>	rpm	Alternator current limit MAP Alternator rpm
ALT_PNT_Alter_limit_Current_V_table	<1x14>	A	Alternator current limit MAP Alternator current

Variable name	Setting value	Unit	Description
BK_PNT_Tau_brake	0.85	-	Brake plant model Time constant for braking force
BK_PNT_Pow_UL	5000	N	Braking force upper limit value
BK_PNT_Pow_LL	0	N	Braking force lower limit value Also used in driver models
BT_PNT_Lo_Capa_lo_batt_F	52	Ah	Battery capacity Equivalent to 55D
BT_PNT_Lo_SOC_START_lo_batt	100	%	Battery SOC_initial value
BT_PNT_Lo_SOC_MAX_lo_batt	100	%	Battery SOC_maximum value Also used in ALT
BT_PNT_Lo_SOC_MIN_lo_batt	0	%	Battery SOC_minimum value
BT_PNT_Lo_ocv_SOC_lo_batt_OCV_V_table_x_SOC	[0,100]	%	Battery OCV calculation TABLE x － SOC term
BT_PNT_Lo_ocv_SOC_lo_batt_OCV_V_table	[10.5,12.3]	V	Battery OCV calculation TABLE
BT_PNT_Lo_R_lo_batt_ohm	0.0425	Ω	Battery internal resistance Also used in ALT_PNT
BT_PNT_Lo_V_start_ocv	12.5	V	Battery initial voltage
DF_PNT_DF_gear	5.3	-	Reduction gear ratio of differential gear
DF_PNT_eta_DF	0.98	-	Differential gear efficiency
DF_PNT_Driveshaft_Inertia	0.1	kgm^2	Drive shaft inertia
DF_PNT_Driveshaft_spring	10000	-	Drive shaft Spring coefficient
DF_PNT_Driveshaft_zeta	10	-	Damping coefficient for secondary lag system
DF_PNT_Driveshaft_damper	[*1]	-	Drive shaft Damper coefficient
DF_PNT_Driveshaft_delta_radps_UL	0.1	rpm	Drive shaft rotational deviation Upper limit value
DF_PNT_Driveshaft_delta_radps_LL	-0.1	rpm	Drive shaft rotational deviation Lower limit value
ACC_P_Gain	15	-	Feedback control P gain value
ACC_I_Gain	0	-	Feedback control I gain value
ACC_D_Gain	0	-	Feedback control D gain value
ENG_rpm	<1x8>	rpm	Back calculation map of throttle position x - engine rpm
ENG_trq_rev	<1x49>	Nm	Back calculation map of throttle position y - engine shaft torque
ENG_throttle_rev	<8x49>	%	Back calculation map of throttle position
Brk_PGain	-2500	-	Brake force Gain
Driver_Brake_Const1	-1	-	Stepping quantity of brake pedal while stopping (The target vehicle velocity is 0km/h)
Driver_Brake_Const3	0	-	Brake stepping position during the acceleration
Driver_Brake_Switch_Const2	0.1	km/h	Stopping detection during driver brake model
Driver_Brk_sh	0.01	km/h/sec	Acceleration detection
Thresh_Stop_vCar	0.1	km/h	Vehicle stop condition
drivmode_STOP	1	-	Driver condition 1: Stop
drivmode_ACC	2	-	Driver condition 2: Acceleration
drivemode_Deceleration_Acc	3	-	Driver condition 3: decelerating (power running)
drivemode_Deceleration_Brk	4	-	Driver condition 4: decelerating (regenerating)
drivmode_CONST	5	-	Driver condition 5: Steady driving
fuel_0guard	0.002	L	Blocking Fuel consumption under 0%
fuelcomsnp_0	0	km/L	Fuel consumption under the condition of ≦0%
Brk_UL	5000	N	Braking force upper limit value value
Brk_LL	0	N	Braking force lower limit value value
EL_PNT_R_bodyelec_lo_ohm	0.72	Ω	Electrical load resistance at low voltage side
ENG_CNT_IdleSpeed_Const	550	rpm	Target engine idling rpm
ENG_CNT_per_isc_max	20	%	ISC MAX opening
ENG_CNT_per_isc_min	0	%	ISC Min opening
ENG_CNT_gain_p_per_isc	0.1	-	Operation value for ISC rpm control (P gain value)
ENG_CNT_per_throttle_isc_fb	0.1	%	Throttle upper limit for ISC rpm F/B
ENG_CNT_V_car_idlestop_kmph	0.1	km/h	Vehicle velocity condition that idling stop is turned ON
ENG_CNT_brak_idlestop	0.01	%	Brake condition that idling stop is turned ON
ENG_CNT_V_vhicle_fuelcut_kmph	1	km/h	Vehicle velocity threshold that turn fuel cut ON(more than)
ENG_CNT_omg_eng_fuelcut_rpm	750	rpm	Engine rpm threshold that turn fuel cut ON(more than)
ENG_CNT_per_throttle_fuelcut	0	%	Based throttle position that turn fuel cut ON(less than)

Variable name	Setting value	Unit	Description
ENG_CNT_Accel_UL	100	%	Accelerator opening upper limit value
ENG_CNT_Accel_LL	0	%	Accelerator opening lower limit value
ENG_CNT_Throttle_UL	100	%	Throttle opening upper limit value
ENG_CNT_Throttle_LL	0	%	Throttle opening lower limit value
ENG_CNT_Starter_timer_Const_s	0.8	sec	Starter operation time after idling
ENG_PNT_FuelCon_gps_map_x_pri_rpm	<1x13>	rpm	Fuel consumption rate map x- engine rpm
ENG_PNT_FuelCon_gps_map_y_trq_Nm	<1x8>	Nm	Fuel consumption rate map y- engine shaft torque
ENG_PNT_FuelCon_gps_map	<8x13>	g/sec	Fuel consumption rate map
ENG_PNT_trq_Nm_map_x_rpm	<1x8>	rpm	Engine shaft torque map x- engine rpm
ENG_PNT_trq_Nm_map_y_throttle	<1x8>	%	Engine shaft torque map y- throttle opening
ENG_PNT_trq_Nm_map	<8x8>	Nm	Engine shaft torque map z- torque
ENG_PLT_trq_fluc_Nm_table_x_spk_tim	<1x11>	BTDC	Torque fluctuation table x- ignition timing
ENG_PLT_trq_fluc_Nm_table	<1x11>	Nm	Torque fluctuation table
ST_PNT_Starter_Res_ohm	0.12	Ω	Starter resistance value (100A at 12V)
TM_PNT_Flywheel_Inertia_kgm2	0.06	kgm^2	Flywheel inertia
TM_PNT_Flywheel_Init_radps	0	radps	Initial angular velocity value for Flywheel
TM_PNT_n_TC_min_rpm	3	rpm	Torque converter minimum rpm
TM_PNT_w_ROT_T_C_UL	10000	rpm	rpm upper limit guard
TM_PNT_w_ROT_T_C_LL	1	rpm	rpm lower limit guard of rpm (preventing from becoming ≦0%)
TM_PNT_ratio_w_ROT_T_C_UL	1	-	Rotation ratio upper limit
TM_PNT_ratio_w_ROT_T_C_LL	0	-	Rotation ratio lower limit
TM_PNT_torque_ratio_table_x_speed_ratio	<1x11>	-	Torque amplification ratio table x- velocity ratio
TM_PNT_torque_ratio_table	<1x11>	-	Torque amplification ratio table
TM_PNT_torque_capacity_Nmprpm2_table_x_speed_ratio	<1x11>	-	Capacity coefficient table x- velocity ratio
TM_PNT_torque_capacity_Nmprpm2_table	<1x11>	-	Capacity coefficient table
TM_PNT_ConvUnit	1.00E-06	-	Unit conversion ×10^-6
TM_PNT_Tau_CVT_ratio_s	0.3	sec	CVT pulley ratio delay time constant
TM_PNT_tau_LU_Clutch_s	1	s	Lock-up delay time constant
TM_PNT_Gain_LU_spring_Nmprad	200	Nm/rad	Spring coefficient at lock-up
TM_PNT_Gain_LU_zeta	2	s	Damping coefficient for secondary lag system
TM_PNT_Gain_LU_damper_Nmsprad	[*2]	-	Damper coefficient at lock-up
TM_PNT_Driveshaft_Inertia_kgm2	0.1	kgm^2	Drive shaft inertia
TM_PNT_Driveshaft_Init_radps	0	radps	Drive shaft angular velocity initial value
TM_PNT_eta_CVT	0.82	-	CVT loss
TM_CNT_Gain_CVT_ECU	0.01	-	P gain value for calculating CVT rotation ratio
TM_CNT_LU_Clutch_RelayON_rpm	500	rpm	Instruction rpm when lock-up is ON
TM_CNT_LU_Clutch_RelayOFF_rpm	150	rpm	Instruction rpm when lock-up is released
TM_CNT_LU_slip_rpm_map_x_speed_kmph	<1x8>	km/h	Target slip rpm MAP -x Vehicle velocity
TM_CNT_LU_slip_rpm_map_y_TVO	<1x8>	deg	Target slip rpm MAP -y Throttle valve opening
TM_CNT_LU_slip_rpm_map	<8x8>	rpm	Target slip rpm MAP
TM_CNT_CVTpritgt_rpm_table_x_TVO	<1x9>	deg	Primary target rpm table –x Throttle valve opening
TM_CNT_CVTpritgt_rpm_table	<1x9>	rpm	Primary target rpm table
TM_CNT_CVT_radpmin_min_rpm	[*3]	rpm	CVT input lower limit rpm
TM_CNT_CVT_ratio_LL	0.43	-	Pulley lower limit guard value There is a variable with the same name in the accelerator opening FF term on the driver side.
TM_CNT_CVT_ratio_UL	2.38	-	Pulley upper limit guard value
TM_CNT_delta_CVT_ratio_LL	-0.001	-	Pulley displacement lower limit guard value
TM_CNT_delta_CVT_ratio_UL	0.002	-	Pulley displacement upper limit guard value
VL_PNT_Vehicle_Const	0	-	Hill climb coefficient
VL_PNT_V_wind	0	m/s	Wind velocity
end_time	1210	s	Simulation time
sampling_time	0.0025	s	Sampling period

Variable name	Setting value	Unit	Description
num_tws_mabiki	1	-	Effect ToWorkspace thinning number
ENG_CNT_flag_idle_stop_exe	1	-	Idling stop operation active flag (ON=1，OFF=0)
ALT_CNT_flag_disable_kaisei	0	-	0 : Regeneration cotrol is active　1 : Regeneration control is deactive (constant power generation)
g	9.8	m/s2	Gravity acceleration
Fuel_dencity	733	g/L	Specific gravity of regular gasoline (from JARI document [*4])
ON	1	-	ON
OFF	0	-	OFF
ZERO	0	-	Zero value
ONE	1	-	1
percent2mujigen	0.01	-	% → dimensionless
mujigen2percent	100	-	dimensionless → %
radpsec2rpm	9.55	-	rad/sec → rpm
kmph2mps	0.28	-	km/h → m/sec
mps2kmph	3.6	-	m/sec → km/h
h2sec	3600	-	Hour → sec
sec2h	0.0003	-	sec → Hour
mps2kmps	0.001	-	m/s → km/s
g2L	1/Fuel_dencity	-	g → L Gasoline
jc08	<12041x2>	km/h	Target vehicle velocity table
rou	1.166	kg/m3	Air density (20℃、1013hPa)
M	1000	kg	Vehicle weight
myu	0.0075	-	μ Rolling resistance coefficient
Cd	0.29	-	Air resistance coefficient
A	2.1	m2	Frontal projected area
tire_r	0.28	m	Tire dynamic radius
vel_max	200	km/h	Maximum vehicle velocity (for divergence prevention)

Parameters in the white boxes are common to all systems.

[*1] 2*DF_PNT_Driveshaft_zeta*sqrt(DF_PNT_Driveshaft_spring*DF_PNT_Driveshaft_Inertia)

[*2] 2*TM_PNT_Gain_LU_zeta*sqrt(TM_PNT_Gain_LU_spring_Nmprad*TM_PNT_Flywheel_Inertia_kgm2)

[*3] 3*radpsec2rpm

[*4] http://www.jari.or.jp/portals/0/jhfc/data/report/2005/pdf/result_ref_1.pdf

5.1.5. Other information

None.

5.2. Functional specification of second-layer model

5.2.1. Functional specification of [A: Driver] system

The functional specification of the second-layer driver system model in the model are described.

5.2.1.1 Abstract

The abstract of this model is shown below.

① Modelized object

The driver model for fuel economy evaluation.

② Modelized level

The model to operate the accelerator and brake which need for the mode-driving pattern (JC08).

③ Modelized function

The function to calculate the operation amount of the accelerator and brake.

5.2.1.2 Data flow diagram

The diagram of this model is shown below.

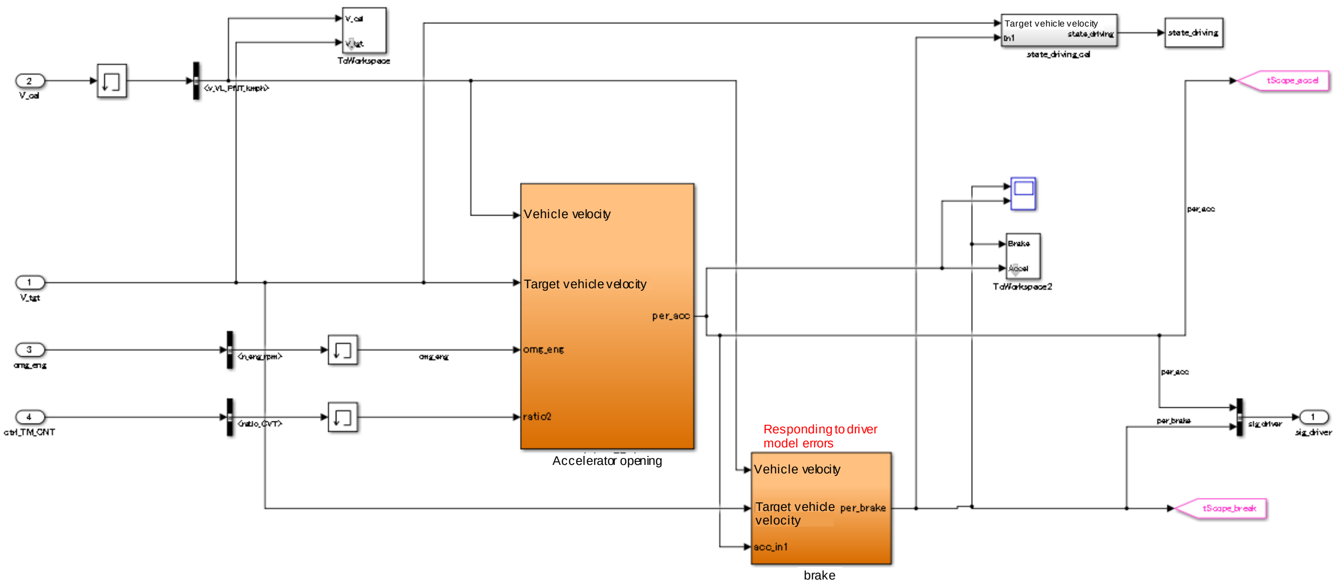


Fig. 5.2.1.2. Data flow diagram : second-layer driver system

5.2.1.3 Input/output specification

The input/output specification of this model is shown below.

Input			
Name	Unit	Area	Description
V_tgt	km/h	[0 200]	Target vehicle velocity (JC08)
v_VL_PNT_kmph	km/h	[0 200]	Vehicle velocity
n_eng_rpm	rpm	0 or more	Engine rpm
ratio_CVT	-	TBD	CVT pulley ratio
Output			
Name	Unit	Area	Description
per_acc	%	[0 100]	Accelerator opening
per_brake	%	[0 100]	Brake opening

5.2.1.4 Parameter specification

The parameter specification of this model is shown below.

Variable name	Setting value	Unit	Description
ACC_P_Gain	15	-	Feedback control P gain value
ACC_I_Gain	0	-	Feedback control I gain value
ACC_D_Gain	0	-	Feedback control D gain value
Driver_ENG_throttle_map_x_rpm	<1x8>	rpm	Back calculation map of throttle position x - engine rpm
Driver_ENG_throttle_map_y_trq_rev	<1x49>	Nm	Back calculation map of throttle position y - engine shaft torque
Driver_ENG_throttle_map	<8x49>	%	Back calculation map of throttle position
Brk_PGain	-2500	-	Brake force Gain
Driver_Brake_Const1	-1	-	Stepping quantity of brake pedal while stopping (target vehicle velocity is 0km/h)
Driver_Brake_Const3	0	-	Brake stepping position during the acceleration
Driver_Brake_Switch_Const2	0.1	km/h	Stopping detection during driver brake model
Driver_Brk_sh	0.01	km/h/sec	Acceleration detection
Thresh_Stop_vCar	0.1	km/h	Vehicle stop condition
drivmode_STOP	1	-	Driver condition 1: Stop
drivmode_ACC	2	-	Driver condition 2: Acceleration
drivemode_Deceleration_Acc	3	-	Driver condition 3: deceleration (power running)
drivemode_Deceleration_Brk	4	-	Driver condition 4: deceleration (regeneration)
drivmode_CONST	5	-	Driver condition 5: Steady driving
fuel_0guard	0.002	L	Blocking Fuel consumption under 0%
fuelcomsnp_0	0	km/L	Fuel consumption under the condition of ≦0%

5.2.1.5 Other information

None.

5.2.2. Functional specification of [B: Vehicle] system

The functional specifications of the second-layer vehicle system model in the guidelines-compatible model are described.

5.2.2.1 Abstract

The abstract of this model is shown below.

① Modelized object
The vehicle model for fuel economy evaluation.

② Modelized level
The model to calculate the fuel consumption in the mode-driving after the engine has warmed up.

③ Modelized function
The function to track the mode-driving pattern which the driver accelerates and decelerates the vehicle by operating the acceleration and brake.
The function to calculate fuel consumption in the mode-driving.

5.2.2.2 Data flow diagram

The diagram of this model is shown below.

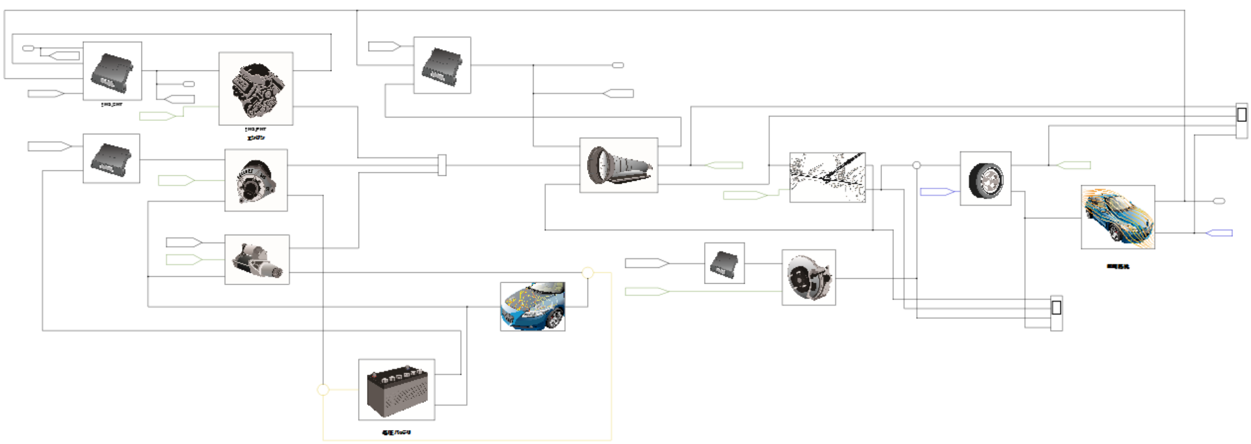


Fig. 5.2.2.2. Data flow diagram：second-layer vehicle system

5.2.2.3 Input/output specification

The input/output specification of this model is shown below.

Input			
Name	Unit	Area	Description
per_acc	%	[0 100]	Accelerator opening
per_brake	%	[0 100]	Brake opening
Output			
Name	Unit	Area	Description
v_VL_PNT_kmph	km/h	[0 200]	Vehicle velocity
per_throttle	%	[0 100]	Throttle opening
flag_IdleStop	-	[0 1]	Idling stop flag
flag_fuelcut	-	[0 1]	Fuel cut flag
fuel_ratio	g/s	0 or more	Fuel consumption rate
timing_ignition	CA	[0 360]	Ignition timing from MBT (BTDC)
n_eng_rpm	rpm	0 or more	Engine rpm
flag_ON_Starter	-	[0 1]	Starter active flag
flag_Lockup	-	[0 1]	Lock-up instruction of torque converter
omg_Slip_rpm	-	TBD	Target rpm of lock-up slip
ratio_CVT	-	TBD	CVT pulley ratio

5.2.2.4 Parameter specification

The parameter specification of this model is shown below.

Variable name	Setting value	Unit	Description
ALT_CNT_Alter_V_Kaisei_V	14	V	Target regenerative voltage
ALT_CNT_Alter_V_BASE_V	13.5	V	Standard target alternator voltage value
ALT_CNT_V_Battely_Kudo_V	12	V	Alternator lower limit voltage value
ALT_CNT_ALT_ON_RPM_HYS_rpm	1000	rpm	Engine rpm threshold that Alternator power generation start(Hysteresis processing)
ALT_CNT_ALT_OFF_RPM_HYS_rpm	600	rpm	Engine rpm threshold that Alternator power generation is turned OFF(Hysteresis processing)
ALT_PNT_Gain_Alt_v_del	100	-	P gain for calculating alternator target current value
ALT_PNT_eta_pulley_alt	0.97	-	Alternator pulley efficiency
ALT_PNT_ratio_pulley_alt	1.12	-	Pulley ratio
ALT_PNT_ALT_GDCurrent_A	0.7	A	Current for calculating alternator required torque guard value
ALT_PNT_ALT_GDVolt_V	12.5	V	Voltage for calculating alternator required torque guard value
ALT_PNT_Tau_Alternator_V_tgt_s	0.05	sec	Time constant for Alternator target voltage delay
ALT_PNT_Tau_Alternator_trq_Nm	0.01	sec	Time constant for Alternator torque delay
ALT_PNT_trq_alter_output_LL_Nm	0	Nm	Alternator torque lower limit
ALT_PNT_Alter_trq_Nm_map_x_rpm	<1x18>	rpm	Alternator shaft torque MAP Alternator rpm
ALT_PNT_Alter_trq_Nm_map_y_Current_A	<1x12>	A	Alternator shaft torque MAP Alternator current
ALT_PNT_Alter_trq_Nm_map_z_Volt_tgt_V	<1x3>	V	Alternator shaft torque MAP Alternator target voltage
ALT_PNT_Alter_trq_Nm_map	<18x12x3>	Nm	Alternator shaft torque MAP Alternator torque
ALT_PNT_Alter_limit_Current_V_table_x_rpm	<1x14>	rpm	Alternator current limit MAP Alternator rpm
ALT_PNT_Alter_limit_Current_V_table	<1x14>	A	Alternator current limit MAP Alternator current
BK_PNT_Tau_brake	0.85	-	Brake plant model Time constant for braking force
BK_PNT_Pow_UL	5000	N	Braking force upper limit value
BK_PNT_Pow_LL	0	N	Braking force lower limit value Also used in driver models
BT_PNT_Lo_Capa_lo_batt_F	52	Ah	Battery capacity Equivalent to 55D
BT_PNT_Lo_SOC_START_lo_batt	100	%	Battery SOC_initial value

Variable name	Setting value	Unit	Description
BT_PNT_Lo_SOC_MAX_lo_batt	100	%	Battery SOC_maximum value　Also used in ALT
BT_PNT_Lo_SOC_MIN_lo_batt	0	%	Battery SOC_minimum value
BT_PNT_Lo_ocv_SOC_lo_batt_OCV_V_table_x_SOC	[0,100]	%	Battery OCV calculation TABLE　x- SOC term
BT_PNT_Lo_ocv_SOC_lo_batt_OCV_V_table	[10.5,12.3]	V	Battery OCV calculation TABLE
BT_PNT_Lo_R_lo_batt_ohm	0.00425	Ω	Battery internal resistance　Also used in ALT_PNT
BT_PNT_Lo_V_start_ocv	12.5	V	Battery initial voltage
DF_PNT_DF_gear	5.3	-	Reduction gear ratio of differential gear
DF_PNT_eta_DF	0.98	-	Differential gear efficiency
DF_PNT_Driveshaft_Inertia	0.1	kgm^2	Drive shaft inertia
DF_PNT_Driveshaft_spring	10000	-	Drive shaft　Spring coefficient
DF_PNT_Driveshaft_zeta	10	-	Damping coefficient for secondary lag system
DF_PNT_Driveshaft_damper	[*1]	-	Drive shaft　Damper coefficient
DF_PNT_Driveshaft_delta_radps_UL	0.1	rpm	Drive shaft rotational deviation　Upper limit value
DF_PNT_Driveshaft_delta_radps_LL	-0.1	rpm	Drive shaft rotational deviation　Lower limit value
EL_PNT_R_bodyelec_lo_ohm	0.72	Ω	Electrical load resistance at low voltage side
ENG_CNT_IdleSpeed_Const	550	rpm	Target engine idle rpm
ENG_CNT_per_isc_max	20	%	ISC MAX opening
ENG_CNT_per_isc_min	0	%	ISC Min opening
ENG_CNT_gain_p_per_isc	0.1	-	Operation value for ISC rpm control (P gain value)
ENG_CNT_per_throttle_isc_fb	0.1	%	Throttle upper limit for ISC rpm F/B
ENG_CNT_V_car_idlestop_kmph	0.1	km/h	Vehicle velocity condition that idling stop is turned ON
ENG_CNT_brak_idlestop	0.01	%	Brake condition that idling stop is turned ON
ENG_CNT_V_vhicle_fuelcut_kmph	1	km/h	Vehicle velocity threshold that turn fuel cut ON(more than)
ENG_CNT_omg_eng_fuelcut_rpm	750	rpm	Engine rpm threshold that turn fuel cut ON(more than)
ENG_CNT_per_throttle_fuelcut	0	%	Based throttle position that turn fuel cut ON(less than)
ENG_CNT_Accel_UL	100	%	Accelerator opening upper limit value
ENG_CNT_Accel_LL	0	%	Accelerator opening lower limit value
ENG_CNT_Throttle_UL	100	%	Throttle opening upper limit value
ENG_CNT_Throttle_LL	0	%	Throttle opening lower limit value
ENG_CNT_Starter_timer_Const_s	0.8	sec	Starter operation time after idling
ENG_PNT_FuelCon_gps_map_x_pri_rpm	<1x13>	rpm	Fuel consumption rate map　x- engine rpm
ENG_PNT_FuelCon_gps_map_y_trq_Nm	<1x8>	Nm	Fuel consumption rate map　y- engine shaft torque
ENG_PNT_FuelCon_gps_map	<8x13>	g/sec	Fuel consumption rate map
ENG_PNT_trq_Nm_map_x_rpm	<1x8>	rpm	Engine shaft torque map　x - engine rpm
ENG_PNT_trq_Nm_map_y_throttle	<1x8>	%	Engine shaft torque map　y- throttle opening
ENG_PNT_trq_Nm_map	<8x8>	Nm	Engine shaft torque map　z- torque
ENG_PLT_trq_fluc_Nm_table_x_spk_tim	<1x11>	BTDC	Torque fluctuation table　x- ignition timing
ENG_PLT_trq_fluc_Nm_table	<1x11>	Nm	Torque fluctuation table
ST_PNT_Starter_Res_ohm	0.12	Ω	Starter resistance value (100A at 12V)
TM_PNT_Flywheel_Inertia_kgm2	0.06	kgm^2	Flywheel inertia
TM_PNT_Flywheel_Init_radps	0	radps	Initial angular velocity value for Flywheel
TM_PNT_n_TC_min_rpm	3	rpm	Torque converter minimum rpm
TM_PNT_w_ROT_T_C_UL	10000	rpm	rpm upper limit guard
TM_PNT_w_ROT_T_C_LL	1	rpm	rpm lower limit guard of rpm (preventing from becoming ≦0%)
TM_PNT_ratio_w_ROT_T_C_UL	1	-	Rotation ratio upper limit
TM_PNT_ratio_w_ROT_T_C_LL	0	-	Rotation ratio lower limit
TM_PNT_torque_ratio_table_x_speed_ratio	<1x11>	-	Torque amplification ratio table　x- velocity ratio
TM_PNT_torque_ratio_table	<1x11>	-	Torque amplification ratio table
TM_PNT_torque_capacity_Nmprpm2_table_x_speed_ratio	<1x11>	-	Capacity coefficient table　x- velocity ratio
TM_PNT_torque_capacity_Nmprpm2_table	<1x11>	-	Capacity coefficient table
TM_PNT_ConvUnit	1.00E-06	-	Unit conversion　×10ˆ-6
TM_PNT_Tau_CVT_ratio_s	0.3	sec	CVT pulley ratio delay time constant
TM_PNT_tau_LU_Clutch_s	1	s	Lock-up delay time constant
TM_PNT_Gain_LU_spring_Nmprad	200	Nm/rad	Spring coefficient at lock-up
TM_PNT_Gain_LU_zeta	2	s	Damping coefficient for secondary lag system
TM_PNT_Gain_LU_damper_Nmsprad	[*2]	-	Damper coefficient at lock-up
TM_PNT_Driveshaft_Inertia_kgm2	0.1	kgm^2	Drive shaft inertia
TM_PNT_Driveshaft_Init_radps	0	radps	Drive shaft angular velocity initial value
TM_PNT_eta_CVT	0.82	-	CVT loss
TM_CNT_Gain_CVT_ECU	0.01	-	CVT rotation ratio calculation　P gain value
TM_CNT_LU_Clutch_RelayON_rpm	500	rpm	Instruction rpm when lock-up is ON
TM_CNT_LU_Clutch_RelayOFF_rpm	150	rpm	Instruction rpm when lock-up is released
TM_CNT_LU_slip_rpm_map_x_speed_kmph	<1x8>	km/h	Target slip rpm MAP -x　Vehicle velocity

Variable name	Setting value	Unit	Description
TM_CNT_LU_slip_rpm_map_y_TVO	<1x8>	deg	Target slip rpm MAP -y Throttle valve opening
TM_CNT_LU_slip_rpm_map	<8x8>	rpm	Target slip rpm MAP
TM_CNT_CVTpritgt_rpm_table_x_TVO	<1x9>	deg	Primary target rpm table -x Throttle valve opening
TM_CNT_CVTpritgt_rpm_table	<1x9>	rpm	Primary target rpm table
TM_CNT_CVT_radpmin_min_rpm	[*3]	rpm	CVT input lower limit rpm
TM_CNT_CVT_ratio_LL	0.43	-	Pulley lower limit guard value There is a variable with the same name in the accelerator opening FF term on the driver side.
TM_CNT_CVT_ratio_UL	2.38	-	Pulley upper limit guard value
TM_CNT_delta_CVT_ratio_LL	-0.001	-	Pulley displacement lower limit guard value
TM_CNT_delta_CVT_ratio_UL	0.002	-	Pulley displacement upper limit guard value
VL_PNT_Vehicle_Const	0	-	Hill climb coefficient
VL_PNT_V_wind	0	m/s	Wind velocity

5.2.2.5 Other information

None.

5.2.3. Functional specification of [C: External environment] system

The functional specifications of the second-layer external environment system model in the guidelines-compatible model are described.

5.2.3.1 Abstract

The abstract of this model is shown below.

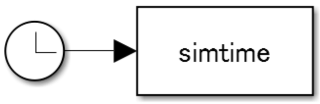
① Modelized object
TBD

② Modelized level
TBD

③ Modelized function
TBD

5.2.3.2 Data flow diagram

The diagram of this model is shown below.



Uphill. Wind, temperature, humidity・・・

Fig. 5.2.3.2. Data flow diagram : second-layer external environment system

5.2.3.3 Input/output specification

TBD ※In the current specification, input/output in this system.

5.2.3.4 Parameter specification

TBD ※In the current specification, no parameter in this system.

5.2.3.5 Other information

None.

5.2.4. Functional specification of [D: Monitor] system

The functional specifications of the second-layer monitor system model in the guidelines-compatible model are described.

5.2.4.1 Abstract

The abstract of this model is shown below.

① Modelized object
None.

② Modelized level
None.

③ Modelized function
None.

5.2.4.2 Data flow diagram

The diagram of this model is shown below.

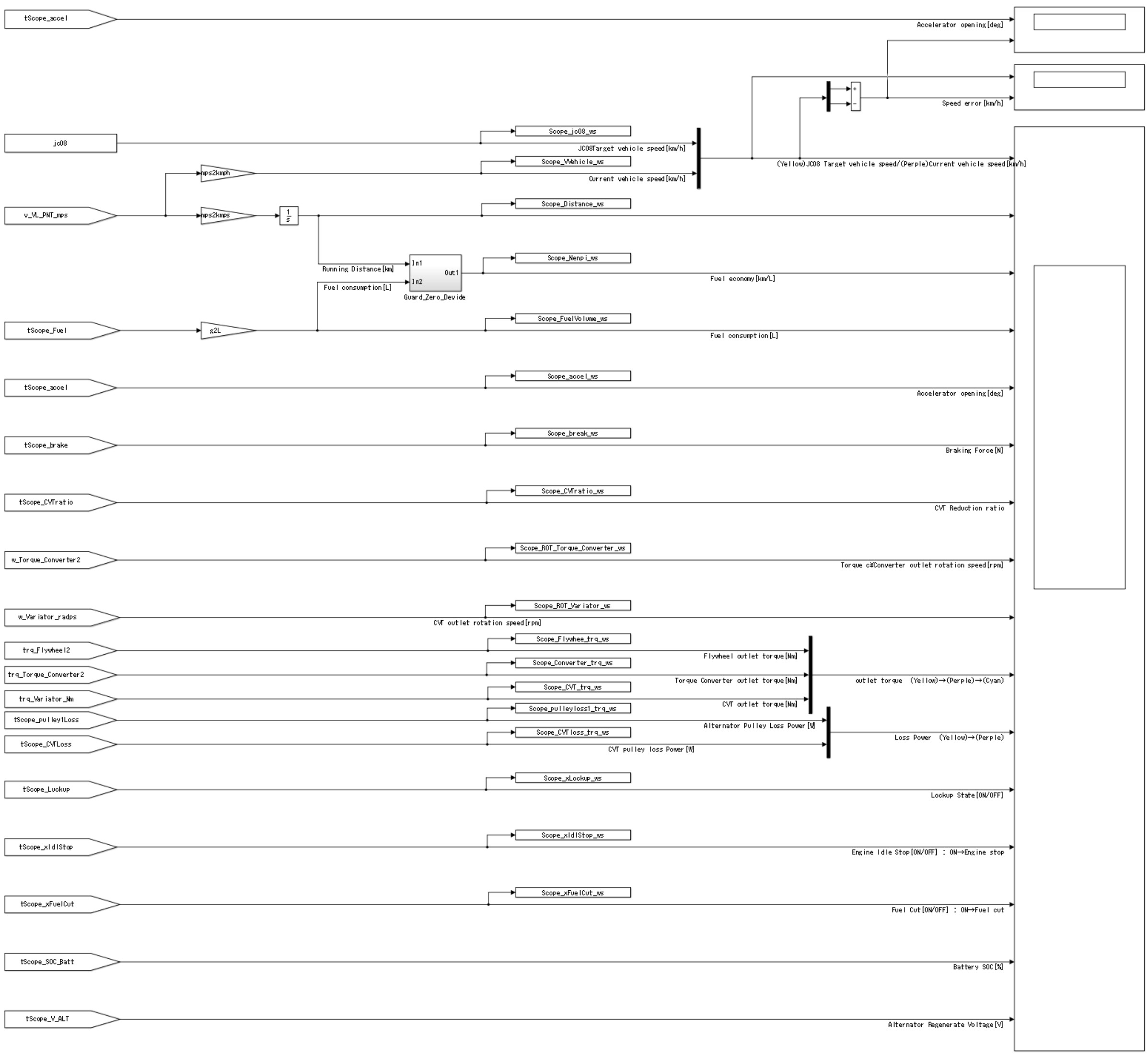


Fig. 5.2.4.2. Data flow diagram：second-layer monitor system

5.2.4.3 Input/output specification

The input/output specification of this model is shown below.

Input			
Name	Unit	Area	Description
jc08(V_tgt)	km/h	[0 200]	Target vehicle velocity (JC08)
v_VL_PNT_kmph	km/h	[0 200]	Vehicle velocity
tScope_Fuel	g/s	0 or more	Fuel consumption rate
tScope_xFuelCut	-	[0 1]	Fuel cut flag
tScope_accel	%	[0 100]	Accelerator opening
tScope_break	%	[0 100]	Brake opening
tScope_CVTratio	-	TBD	CVT pulley ratio
tScope_CVTLoss	kW	TBD	CVT mechanical loss
tScope_pulley1Loss	kW	TBD	Pulley 1 mechanical loss
tScope_Lockup	-	[0 1]	Lock-up instruction of torque converter
tScope_xIdleStop	-	[0 1]	Idling stop flag
tScope_SOC_Batt	%	[0 100]	Battery SOC
tScope_V_ALT	V	TBD	Alternator voltage
w_Torque_Coverter2	rpm	TBD	Torque converter outlet rpm
w_Variator_radps	rpm	TBD	CVT outlet rpm
trq_Flywheel2	Nm	TBD	Flywheel outlet torque
Output			
Name	Unit	Area	Description
None	None	None	None

5.2.4.4 Parameter specification

No parameter in this system.

5.2.4.5 Other information

None.

5.3. Functional specification of third-layer

5.3.1. Functional specification of [A10: Accelerator opening] system

The functional specifications of the third-layer accelerator opening system model in the guidelines-compatible model are described.

5.3.1.1 Abstract

The abstract of this model is shown below.

① Modelized object

The model for evaluating the operating amount of the accelator by the driver.

② Modelized level

The model to calculate the accelerator position which needed to track the target vehicle velocity of the mode-driving pattern (JC08).

③ Modelized function

The FF control that calculates an accelerator position to output an engine torque snitable for vehicle inertia and running resistance, and FB control that adjusts the accerator opening based on the difference between the actual vehicle velocity and target vehicle velocity.

5.3.1.2 Data flow diagram

The diagram of this model is shown below.

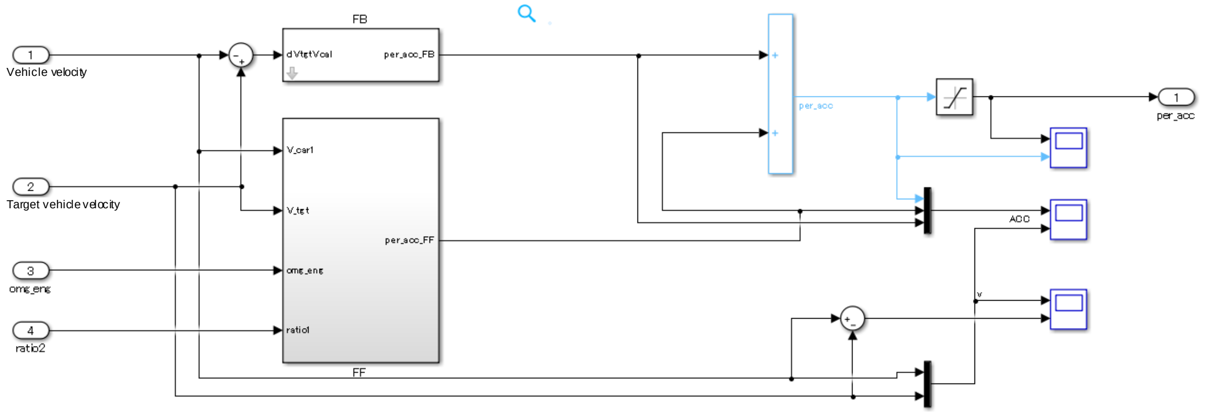


Fig. 5.3.1.2. Data flow diagram : third-layer accelerator opening system

5.3.1.3 Input/output specification

The input/output specification of this model is shown below.

Input			
Name	Unit	Area	Description
V_tgt	km/h	[0 200]	Target vehicle velocity (JC08)
v_VL_PNT_kmph	km/h	[0 200]	Vehicle velocity
n_eng_rpm	rpm	0 or more	Engine rpm
ratio_CVT	-	TBD	CVT pulley ratio
Output			
Name	Unit	Area	Description
per_acc	%	[0 100]	Accelerator opening

5.3.1.4 Parameter specification

The parameter specification of this model is shown below.

Variable name	Setting value	Unit	Description
ACC_P_Gain	15	-	Feedback control P gain value
ACC_I_Gain	0	-	Feedback control I gain value
ACC_D_Gain	0	-	Feedback control D gain value
ENG_rpm	<1x8>	rpm	Back calculation map of throttle position x- engine rpm
ENG_trq_rev	<1x49>	Nm	Back calculation map of throttle position y- engine shaft torque
ENG_throttle_rev	<8x49>	%	Back calculation map of throttle position
Brk_PGain	-2500	-	Brake force Gain
Driver_Brake_Const1	-1	-	Stepping quantity of brake pedal while stopping (target vehicle velocity is 0km/h)
Driver_Brake_Const3	0	-	Brake stepping position during the acceleration
Driver_Brake_Switch_Const2	0.1	km/h	Stopping detection during driver brake model
Driver_Brk_sh	0.01	km/h/sec	Acceleration detection
Thresh_Stop_vCar	0.1	km/h	Vehicle stop condition
drivmode_STOP	1	-	Driver condition 1: Stop
drivmode_ACC	2	-	Driver condition 2: Acceleration
drivemode_Deceleration_Acc	3	-	Driver condition 3: deceleration (power running)
drivemode_Deceleration_Brk	4	-	Driver condition 4: deceleration (regeneration)
drivmode_CONST	5	-	Driver condition 5: Steady driving
fuel_0guard	0.002	L	Blocking Fuel consumption under 0%
fuelcomsnp_0	0	km/L	Fuel consumption under the condition of ≦0%
Brk_UL	5000	N	Braking force upper limit value
Brk_LL	0	N	Braking force lower limit value

5.3.1.5 Other information

None.

5.3.2. Functional specification of [A20: Brake (opening)] system

The functional specifications of the third-layer brake (opening) system model in the guidelines-compatible model are described.

5.3.2.1 Abstract

The abstract of this model is shown below.

① Modelized object
The model for evaluating the operating amount of the brake by the driver.

② Modelized level
The model to calculate the brake pedal position which needed to track the target vehicle velocity of the mode-driving pattern (JC08).

③ Modelized function
The ratio control to calculate the brake pedal position based on the difference between the actual vehicle velocity and target vehicle velocity.
The pedal misapplication prevention control not to step the brake pedal during acceleration simultaneons pedal stepping.

5.3.2.2 Data flow diagram

The diagram of this model is shown below.

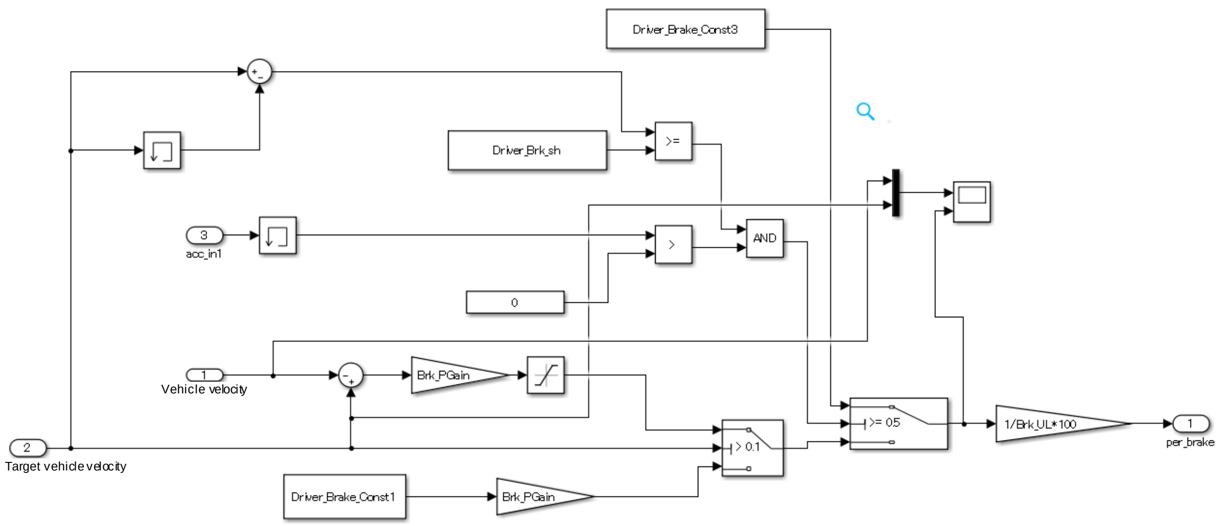


Fig. 5.3.2.2. Data flow diagram：third-layer brake opening system

5.3.2.3 Input/output specification

The input/output specification of this model is shown below.

Input			
Name	Unit	Area	Description
V_tgt	km/h	[0 200]	Target vehicle velocity (JC08)
v_VL_PNT_kmph	km/h	[0 200]	Vehicle velocity
per_acc	%	[0 100]	Accelerator opening
Output			
Name	Unit	Area	Description
per_brake	%	[0 100]	Brake opening

5.3.2.4 Parameter specification

The parameter specification of this model is shown below.

Variable name	Setting value	Unit	Description
ACC_P_Gain	15	-	Feedback control P gain value
ACC_I_Gain	0	-	Feedback control I gain value
ACC_D_Gain	0	-	Feedback control D gain value
ENG_rpm	<1x8>	rpm	Back calculation map of throttle position x- engine rpm
ENG_trq_rev	<1x49>	Nm	Back calculation map of throttle position y- engine shaft torque
ENG_throttle_rev	<8x49>	%	Back calculation map of throttle position
Brk_PGain	-2500	-	Brake force Gain
Driver_Brake_Const1	-1	-	Stepping quantity of brake pedal while stopping (target vehicle velocity is 0km/h)
Driver_Brake_Const3	0	-	Brake stepping position during the acceleration
Driver_Brake_Switch_Const2	0.1	km/h	Stopping detection during driver brake model
Driver_Brk_sh	0.01	km/h/sec	Acceleration detection
Thresh_Stop_vCar	0.1	km/h	Vehicle stop condition
drivmode_STOP	1	-	Driver condition 1: Stop
drivmode_ACC	2	-	Driver condition 2: Acceleration
drivemode_Deceleration_Acc	3	-	Driver condition 3: deceleration (power running)
drivemode_Deceleration_Brk	4	-	Driver condition 4: deceleration (regeneration)
drivmode_CONST	5	-	Driver condition 5: Steady driving
fuel_0guard	0.002	L	Blocking Fuel consumption under 0%
fuelcomsnp_0	0	km/L	Fuel consumption under the condition of ≦0%
Brk_UL	5000	N	Braking force upper limit value
Brk_LL	0	N	Braking force lower limit value

5.3.2.5 Other information

None.

5.3.3. Functional specification of [B10C: ENG_CNT] system

The functional specifications of the third-layer ENG_CNT system model in the guidelines-compatible model are described.

5.3.3.1 Abstract

The abstract of this model is shown below.

① Modelized object

The engine controlling ECU model for fuel economy evaluation.

② Modelized level

The control model that contributes to the fuel consumption in the mode-driving after the engine has warmed up.

③ Modelized function

The engine rpm control during idling.

The fuel cut (FC) control during deceleration.

The idling-stop system instruction control.

5.3.3.2 Data flow diagram

The diagram of this model is shown below.

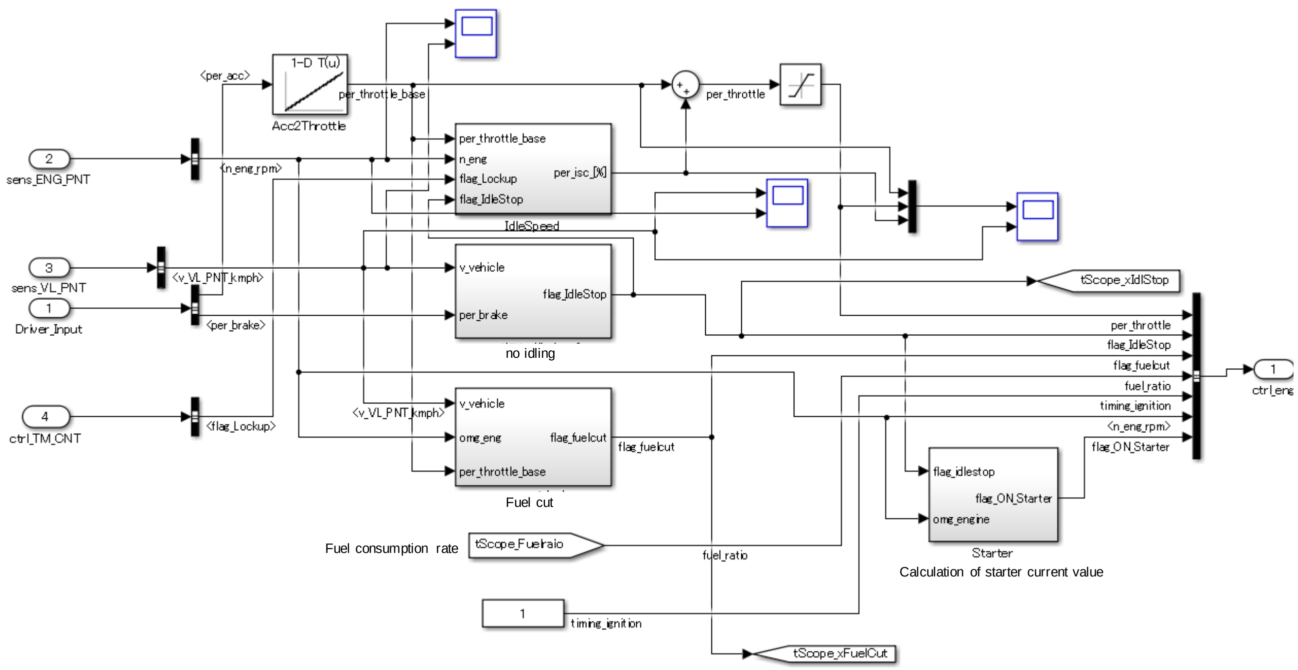


Fig. 5.3.3.2. Data flow diagram：third-layer ENG_CNT system

5.3.3.3 Input/output specification

The input/output specification of this model is shown below.

Input			
Name	Unit	Area	Description
per_acc	%	[0 100]	Accelerator opening
per_brake	%	[0 100]	Brake opening
n_eng_rpm	rpm	0 or more	Engine rpm
v_VL_PNT_kmph	km/h	[0 200]	Vehicle velocity
flag_Lockup	-	[0 1]	Lock-up instruction of torque converter
Output			
Name	Unit	Area	Description
per_throttle	%	[0 100]	Throttle opening
flag_IdleStop	-	[0 1]	Idling stop flag
flag_fuelcut	-	[0 1]	Fuel cut flag
fuel_ratio	g/s	0 or more	Fuel consumption rate
timing_ignition	CA	[0 360]	Ignition timing from MBT (BTDC)
n_eng_rpm	rpm	0 or more	Engine rpm
flag_ON_Starter	-	[0 1]	Starter active flag

5.3.3.4 Parameter specification

The parameter specification of this model is shown below.

Variable name	Setting value	Unit	Description
ENG_CNT_IdleSpeed_Const	550	rpm	Target engine idling rpm
ENG_CNT_per_isc_max	20	%	ISC MAX opening
ENG_CNT_per_isc_min	0	%	ISC Min opening
ENG_CNT_gain_p_per_isc	0.1	-	Operation value for ISC rpm control (P gain value)
ENG_CNT_per_throttle_isc_fb	0.1	%	Throttle upper limit for ISC rpm F/B
ENG_CNT_V_car_idlestop_kmph	10	km/h	ON Vehicle velocity condition that idling stop is turned ON
ENG_CNT_brak_idlestop	0.01	%	Brake condition that idling stop is turned ON
ENG_CNT_V_vhicle_fuelcut_kmph	1	km/h	Vehicle velocity threshold that turn fuel cut ON(more than)
ENG_CNT_omg_eng_fuelcut_rpm	750	rpm	Engine rpm threshold that turn fuel cut ON(more than)
ENG_CNT_per_throttle_fuelcut	0	%	Based throttle position that turn fuel cut ON(less than)
ENG_CNT_Accel_UL	100	%	Accelerator opening upper limit value
ENG_CNT_Accel_LL	0	%	Accelerator opening lower limit value
ENG_CNT_Throttle_UL	100	%	Throttle opening upper limit value
ENG_CNT_Throttle_LL	0	%	Throttle opening lower limit value
ENG_CNT_Starter_timer_Const_s	0.8	sec	Starter operation time after idling

5.3.3.5 Other information

None.

5.3.4. Functional specification of [B20C: TM_CNT] system

The functional specifications of the third-layer TM_CNT system model in the guidelines-compatible model are described.

5.3.4.1 Abstract

The abstract of this model is shown below.

① Modelized object
The transmission controlling ECU model for fuel economy evaluation.

② Modelized level
The transmission control model that contributes to the fuel consumption in the mode-driving.

③ Modelized function
The lock-up clutch control
The CVT transmission ratio control

5.3.4.2 Data flow diagram

The diagram of this model is shown below.

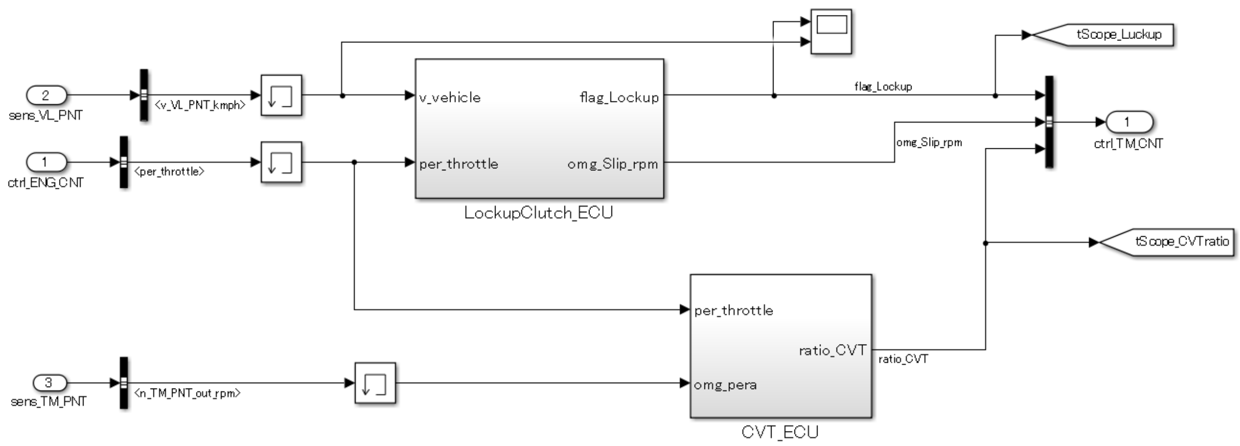


Fig. 5.3.4.2. Data flow diagram：third-layer TM_CNT system

5.3.4.3 Input/output specification

The input/output specification of this model is shown below.

Input			
Name	Unit	Area	Description
per_throttle	%	[0 100]	Throttle opening
v_VL_PNT_kmph	km/h	[0 200]	Vehicle velocity
n_TM_PNT_out_rpm	rpm	TBD	Torque converter outlet rpm
Output			
Name	Unit	Area	Description
flag_Lockup	-	[0 1]	Lock-up instruction of torque converter
omg_Slip_rpm	-	TBD	Target rpm of lock-up slip
ratio_CVT	-	TBD	CVT pulley ratio

5.3.4.4 Parameter specification

The parameter specification of this model is shown below.

Variable name	Setting value	Unit	Description
TM_CNT_Gain_CVT_ECU	0.01	-	CVT rotation ratio calculation P gain value
TM_CNT_LU_Clutch_RelayON_rpm	500	rpm	Instruction rpm when lock-up is ON
TM_CNT_LU_Clutch_RelayOFF_rpm	150	rpm	Instruction rpm when lock-up is released
TM_CNT_LU_slip_rpm_map_x_speed_kmph	<1x8>	km/h	Target slip rpm MAP -x Vehicle velocity
TM_CNT_LU_slip_rpm_map_y_TVO	<1x8>	deg	Target slip rpm MAP -y Throttle valve opening
TM_CNT_LU_slip_rpm_map	<8x8>	rpm	Target slip rpm MAP
TM_CNT_CVTpritgt_rpm_table_x_TVO	<1x9>	deg	Primary target rpm table -x Throttle valve opening
TM_CNT_CVTpritgt_rpm_table	<1x9>	rpm	Primary target rpm table
TM_CNT_CVT_radpmin_min_rpm	[*3]	rpm	CVT input lower limit rpm
TM_CNT_CVT_ratio_LL	0.43	-	Pulley lower limit guard value There is a variable with the same name in the accelerator opening FF term on the driver side.
TM_CNT_CVT_ratio_UL	2.38	-	Pulley upper limit guard value
TM_CNT_delta_CVT_ratio_LL	-0.001	-	Pulley displacement lower limit guard value
TM_CNT_delta_CVT_ratio_UL	0.002	-	Pulley displacement upper limit guard value

5.3.4.5 Other information

None.

5.3.5. Functional specification of [B30C: ALT_CNT] system

The functional specifications of the third-layer ALT_CNT system model in the guidelines-compatible model are described.

5.3.5.1 Abstract

The abstract of this model is shown below.

① Modelized object

The alternator controlling ECU model for fuel economy evaluation.

② Modelized level

The alternator control model that contributes to the fuel consumption in the mode-driving.

③ Modelized function

The normal power generation control

The forced regeneration control

The power generation prohibitive control

5.3.5.2 Data flow diagram

The diagram of this model is shown below.

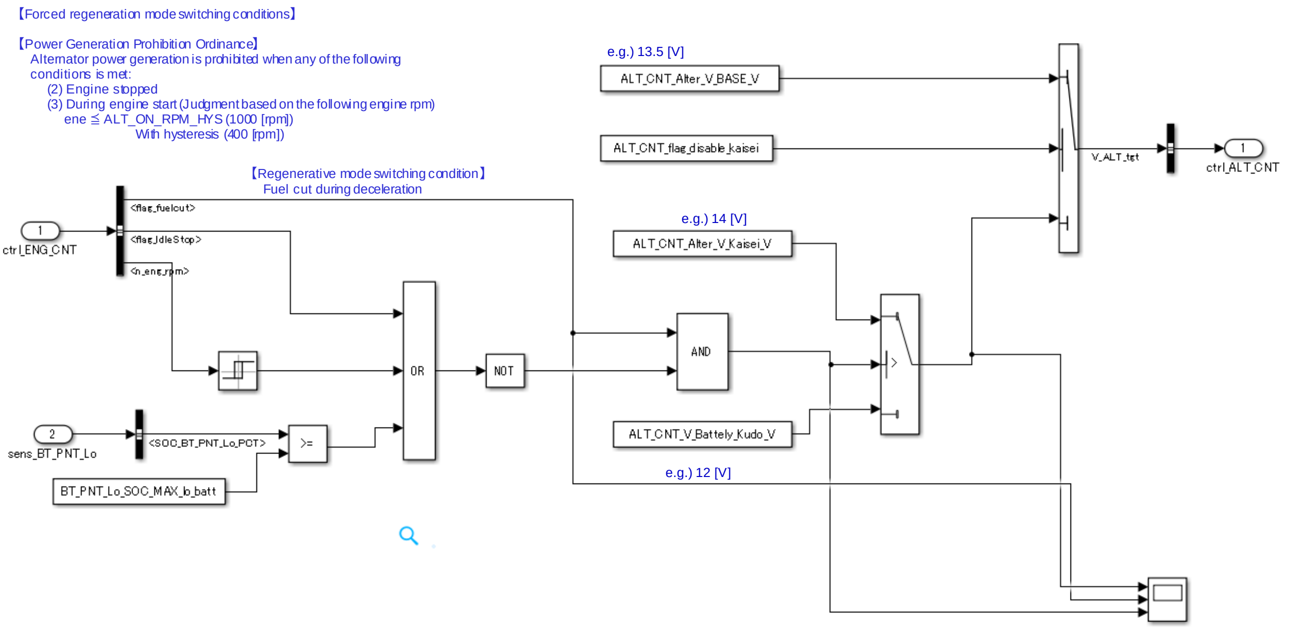


Fig. 5.3.5.2. Data flow diagram : third-layer ALT_CNT system

5.3.5.3 Input/output specification

The input/output specification of this model is shown below.

Input			
Name	Unit	Area	Description
flag_fuelcut	-	[0 1]	Fuel cut flag
flag_IdleStop	-	[0 1]	Idling stop flag
fuel_ratio	g/s	0 or more	Fuel consumption rate
SOC_BT_PNT_Lo_PCT	%	[0 100]	Battery SOC
Output			
Name	Unit	Area	Description
V_ALT_tgt	V	TBD	Alternator target voltage

5.3.5.4 Parameter specification

The parameter specification of this model is shown below.

Variable name	Setting value	Unit	Description
ALT_CNT_Alter_V_Kaisei_V	14	V	Target regenerative voltage
ALT_CNT_Alter_V_BASE_V	13.5	V	Standard target alternator voltage value
ALT_CNT_V_Battely_Kudo_V	12	V	Alternator lower limit voltage value
ALT_CNT_ALT_ON_RPM_HYS_rpm	1000	rpm	Engine rpm threshold that Alternator power generation start(Hysteresis processing)
ALT_CNT_ALT_OFF_RPM_HYS_rpm	600	rpm	Engine rpm threshold that Alternator power generation is turned OFF(Hysteresis processing)

5.3.5.5 Other information

None.

5.3.6. Functional specification of [B40C: BK_CNT] system

The functional specifications of the third-layer BK_CNT system model in the guidelines-compatible model are described.

5.3.6.1 Abstract

The abstract of this model is shown below.

① Modelized object
The brake controlling ECU model for fuel economy evaluation.

② Modelized level
The control model that contributes to the braking in the mode-driving.

③ Modelized function
The braking function

5.3.6.2 Data flow diagram

The diagram of this model is shown below.

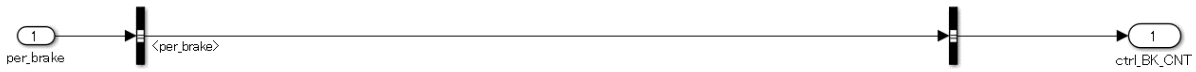


Fig. 5.3.6.2. Data flow diagram : third-layer BK_CNT system

5.3.6.3 Input/output specification

The input/output specification of this model is shown below.

Input			
Name	Unit	Area	Description
per_brake	%	[0 100]	Brake opening
Output			
Name	Unit	Area	Description
per_brake	%	[0 100]	Brake opening

5.3.6.4 Parameter specification

No parameter in this system.

5.3.6.5 Other information

None.

5.3.7. Functional specification of [B10P: ENG_PNT] system

The functional specifications of the third-layer ENG_PNT system model in the guidelines-compatible model are described.

5.3.7.1 Abstract

The abstract of this model is shown below.

① Modelized object

The engine model for fuel economy evaluation.

② Modelized level

The model to calculate the output torque and fuel consumption after the engine has warmed up.

③ Modelized function

The output of the engine shaft torque

The calculation of the fuel consumption

5.3.7.2 Data flow diagram

The diagram of this model is shown below.

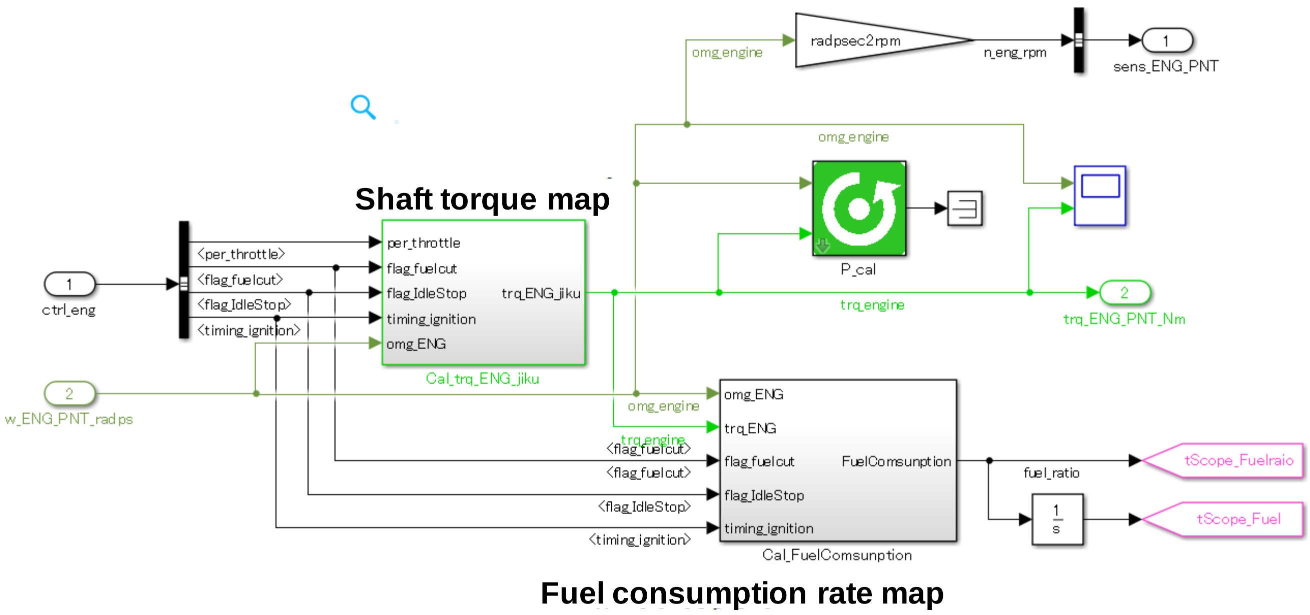


Fig. 5.3.7.2. Data flow diagram : third-layer ENG_PNT system

5.3.7.3 Input/output specification

The input/output specification of this model is shown below.

Input			
Name	Unit	Area	Description
per_throttle	%	[0 100]	Throttle opening
flag_fuelcut	-	[0 1]	Fuel cut flag
flag_IdleStop	-	[0 1]	Idling stop flag
timing_ignition	CA	[0 360]	Ignition timing from MBT (BTDC)
w_ENG_PNT_radps	rad/s	TBD	Engine rpm (based on rad)
Output			
Name	Unit	Area	Description
n_eng_rpm	rpm	0 or more	Engine rpm
trq_ENG_PNT_Nm	Nm	TBD	Engine shaft torque

5.3.7.4 Parameter specification

The parameter specification of this model is shown below.

Variable name	Setting value	Unit	Description
ENG_PNT_FuelCon_gps_map_x_pri_rpm	<1x13>	rpm	Fuel consumption rate map x- engine rpm
ENG_PNT_FuelCon_gps_map_y_trq_Nm	<1x8>	Nm	Fuel consumption rate map y- engine shaft torque
ENG_PNT_FuelCon_gps_map	<8x13>	g/sec	Fuel consumption rate map
ENG_PNT_trq_Nm_map_x_rpm	<1x8>	rpm	Engine shaft torque map x- engine rpm
ENG_PNT_trq_Nm_map_y_throttle	<1x8>	%	Engine shaft torque map y- throttle opening
ENG_PNT_trq_Nm_map	<8x8>	Nm	Engine shaft torque map z- torque
ENG_PLT_trq_fluc_Nm_table_x_spk_tim	<1x11>	BTDC	Torque fluctuation table x- ignition timing
ENG_PLT_trq_fluc_Nm_table	<1x11>	Nm	Torque fluctuation table

5.3.7.5 Other information

None.

5.3.8. Functional specification of [B20P: TM_PNT] system

The functional specifications of the third-layer TM_PNT system model in the guidelines-compatible model are described.

5.3.8.1 Abstract

The abstract of this model is shown below.

① Modelized object
The transmission model for fuel economy evaluation.

② Modelized level
The inertia and the gear changing fuction after the engine has warmed up.

③ Modelized function
The engine-side inertia and the differential-side inertia of the transmission
The gear changing fuction from the torque converter
The gear changing fuction of CVT
The loss of torque due to CVT efficiency
The lock-up function of torque converter by the lock-up clutch

5.3.8.2 Data flow diagram

The diagram of this model is shown below.

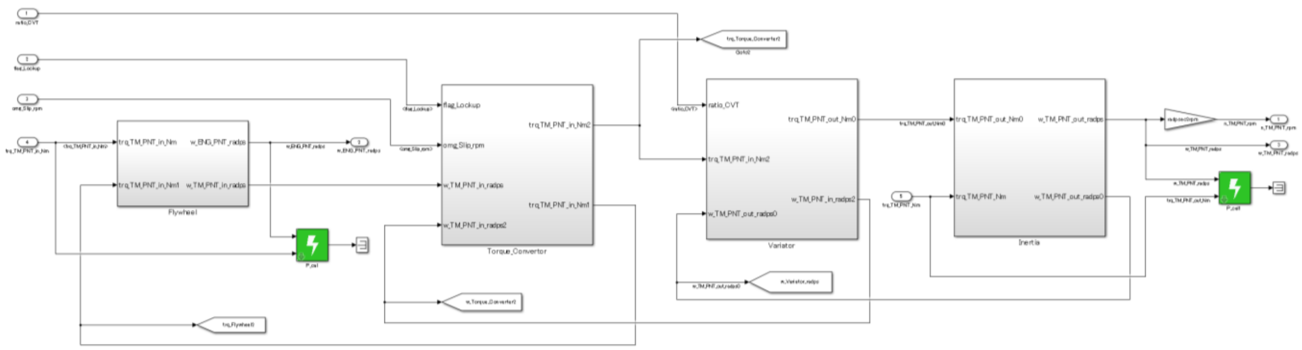


Fig. 5.3.8.2. Data flow diagram : third-layer TM_PNT system

5.3.8.3 Input/output specification

The input/output specification of this model is shown below.

Input			
Name	Unit	Area	Description
flag_Lockup	-	[0 1]	Lock-up instruction of torque converter
omg_Slip_rpm	-	TBD	Target rpm of lock-up slip
ratio_CVT	-	TBD	CVT pulley ratio
trq_TM_PNT_in_Nm	Nm	TBD	Torque converter inlet torque
trq_TM_PNT_out_Nm	Nm	TBD	Differential gear inlet torque
Output			
Name	Unit	Area	Description
w_ENG_PNT_radps	rad/s	TBD	Engine rpm (based on rad)
n_TM_PNT_out_rpm	rpm	TBD	Torque converter outlet rpm
w_TM_PNT_out_radps	rad/s	TBD	Torque converter outlet rpm (based on rad)

5.3.8.4 Parameter specification

The parameter specification of this model is shown below.

Variable name	Setting value	Unit	Description
TM_PNT_Flywheel_Inertia_kgm2	0.06	kgm^2	Flywheel inertia
TM_PNT_Flywheel_Init_radps	0	radps	Initial angular velocity value for Flywheel
TM_PNT_n_TC_min_rpm	3	rpm	Torque converter minimum rpm
TM_PNT_w_ROT_T_C_UL	10000	rpm	rpm upper limit guard
TM_PNT_w_ROT_T_C_LL	1	rpm	rpm lower limit guard (preventing from becoming ≦0 %)
TM_PNT_ratio_w_ROT_T_C_UL	1	-	rpm ratio upper limit
TM_PNT_ratio_w_ROT_T_C_LL	0	-	rpm ratio lower limit
TM_PNT_torque_ratio_table_x_speed_ratio	<1x11>	-	Torque amplification ratio table x- velocity ratio
TM_PNT_torque_ratio_table	<1x11>	-	Torque amplification ratio table
TM_PNT_torque_capacity_Nmprpm2_table_x_speed_ratio	<1x11>	-	Capacity coefficient table x-velocity ratio
TM_PNT_torque_capacity_Nmprpm2_table	<1x11>	-	Capacity coefficient table
TM_PNT_ConvUnit	1.00E-06	-	Unit conversion ×10^-6
TM_PNT_Tau_CVT_ratio_s	0.3	sec	CVT pulley ratio delay time constant
TM_PNT_tau_LU_Clutch_s	1	s	Lock-up delay time constant
TM_PNT_Gain_LU_spring_Nmprad	200	Nm/rad	Spring coefficient at lock-up
TM_PNT_Gain_LU_zeta	2	s	Damping coefficient for secondary lag system
TM_PNT_Gain_LU_damper_Nmsprad	[*2]	-	Damper coefficient at lock-up
TM_PNT_Driveshaft_Inertia_kgm2	0.1	kgm^2	Drive shaft inertia
TM_PNT_Driveshaft_Init_radps	0	radps	Drive shaft angular velocity initial value
TM_PNT_eta_CVT	0.82	-	CVT loss

5.3.8.5 Other information

None.

5.3.9. Functional specification of [B21P: DF_PNT] system

The functional specifications of the third-layer DF_PNT system model in the guidelines-compatible model are described.

5.3.9.1 Abstract

The abstract of this model is shown below.

① Modelized object

The differential gear model for fuel economy evaluation.

② Modelized level

The transmission mechanism that reflects the transmission efficiency in the mode-driving.

③ Modelized function

The gear changing fuction of the differential gear ratio.

The torqueloss from the differential gear efficiency.

5.3.9.2 Data flow diagram

The diagram of this model is shown below.

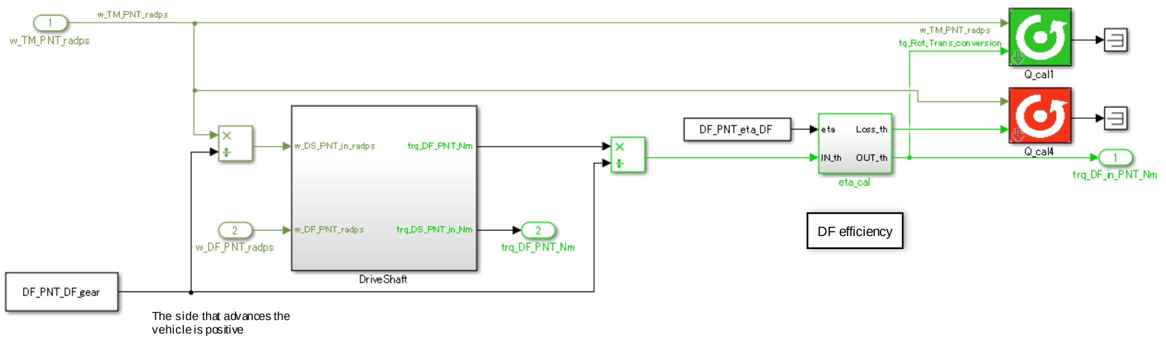


Fig. 5.3.9.2. Data flow diagram : third-layer DF_PNT system

5.3.9.3 Input/output specification

The input/output specification of this model is shown below.

Input			
Name	Unit	Area	Description
w_ENG_PNT_radps	rad/s	TBD	Engine rpm (based on rad)
w_DF_PNT_radps	rad/s	TBD	Differential gear rpm (based on rad)
Output			
Name	Unit	Area	Description
trq_DF_in_PNT_Nm	Nm	TBD	Differential gear inlet torque
trq_DF_PNT_Nm	Nm	TBD	Differential gear outlet torque

5.3.9.4 Parameter specification

The parameter specification of this model is shown below.

Variable name	Setting value	Unit	Description
DF_PNT_DF_gear	5.3	-	Reduction gear ratio of differential gear
DF_PNT_eta_DF	0.98	-	Differential gear efficiency
DF_PNT_Driveshaft_Inertia	0.1	kgm^2	Drive shaft inertia
DF_PNT_Driveshaft_spring	10000	-	Drive shaft Spring coefficient
DF_PNT_Driveshaft_zeta	10	-	Damping coefficient for secondary lag system
DF_PNT_Driveshaft_damper	[*1]	-	Drive shaft Damper coefficient
DF_PNT_Driveshaft_delta_radps_UL	0.1	rpm	Drive shaft rotational deviation Upper limit value
DF_PNT_Driveshaft_delta_radps_LL	-0.1	rpm	Drive shaft rotational deviation Lower limit value

5.3.9.5 Other information

None.

5.3.10. Functional specification of [B30P: ALT_PNT] system

The functional specifications of the third-layer ALT_PNT system model in the guidelines-compatible model are described.

5.3.10.1 Abstract

The abstract of this model is shown below.

① Modelized object

The alternator model for fuel economy evaluation.

② Modelized level

The model to calculate the generated current and the anti-torque on the engine shaft.

③ Modelized function

The function to shift from the engine shaft rpm to the alternator shaft rpm, by a belt drive.

The function to calculate the generated current from the target voltage, alternator terminal voltage and alternator shaft rpm.

The function to calculate the anti-torque on the alternator shaft from the generated current, alternator terminal voltage and alternator shaft rpm.

5.3.10.2 Data flow diagram

The diagram of this model is shown below.

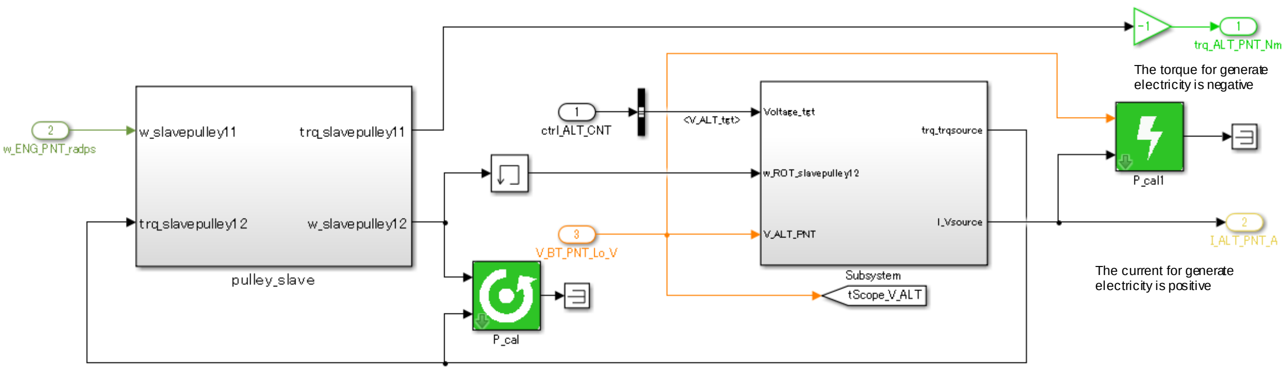


Fig. 5.3.10.2. Data flow diagram : third-layer ALT_PNT system

5.3.10.3 Input/output specification

The input/output specification of this model is shown below.

Input			
Name	Unit	Area	Description
w_ENG_PNT_radps	rad/s	TBD	Engine rpm (based on rad)
Output			
Name	Unit	Area	Description
trq_ALT_PNT_Nm	Nm	TBD	Torque for alternator power generation
I_ALT_PNT_A	A	TBD	Alternator current

5.3.10.4 Parameter specification

The parameter specification of this model is shown below.

Variable name	Setting value	Unit	Description
ALT_PNT_Gain_Alt_v_del	100	-	P gain for calculating alternator target current value
ALT_PNT_eta_pulley_alt	0.97	-	Alternator pulley efficiency
ALT_PNT_ratio_pulley_alt	1.12	-	Pulley ratio
ALT_PNT_ALT_GDCurrent_A	0.7	A	Current for calculating alternator required torque guard value
ALT_PNT_ALT_GDVolt_V	12.5	V	Voltage for calculating alternator required torque guard value
ALT_PNT_Tau_Alternator_V_tgt_s	0.05	sec	Time constant for Alternator target voltage delay
ALT_PNT_Tau_Alternator_trq_Nm	0.01	sec	Time constant for Alternator torque delay
ALT_PNT_trq_alter_output_LL_Nm	0	Nm	Alternator torque lower limit value
ALT_PNT_Alter_trq_Nm_map_x_rpm	<1x18>	rpm	Alternator shaft torque MAP Alternator rpm
ALT_PNT_Alter_trq_Nm_map_y_Current_A	<1x12>	A	Alternator shaft torque MAP Alternator current
ALT_PNT_Alter_trq_Nm_map_z_Volt_tgt_V	<1x3>	V	Alternator shaft torque MAP Alternator target voltage
ALT_PNT_Alter_trq_Nm_map	<18x12x3>	Nm	Alternator shaft torque MAP Alternator torque
ALT_PNT_Alter_limit_Current_V_table_x_rpm	<1x14>	rpm	Alternator current limit MAP Alternator rpm
ALT_PNT_Alter_limit_Current_V_table	<1x14>	A	Alternator current limit MAP Alternator current

5.3.10.5 Other information

None.

5.3.11. Functional specification of [B31P: ST_PNT] system

The functional specifications of the third-layer ST_PNT system model in the guidelines-compatible model are described.

5.3.11.1 Abstract

The abstract of this model is shown below.

① Modelized object
The starter model for fuel economy evaluation.

② Modelized level
The model to calcurate the current consumption when the starter is working.

③ Modelized function
The function to calculate the current consumption when the starter is working according to the starter terminal voltage.

5.3.11.2 Data flow diagram

The diagram of this model is shown below.

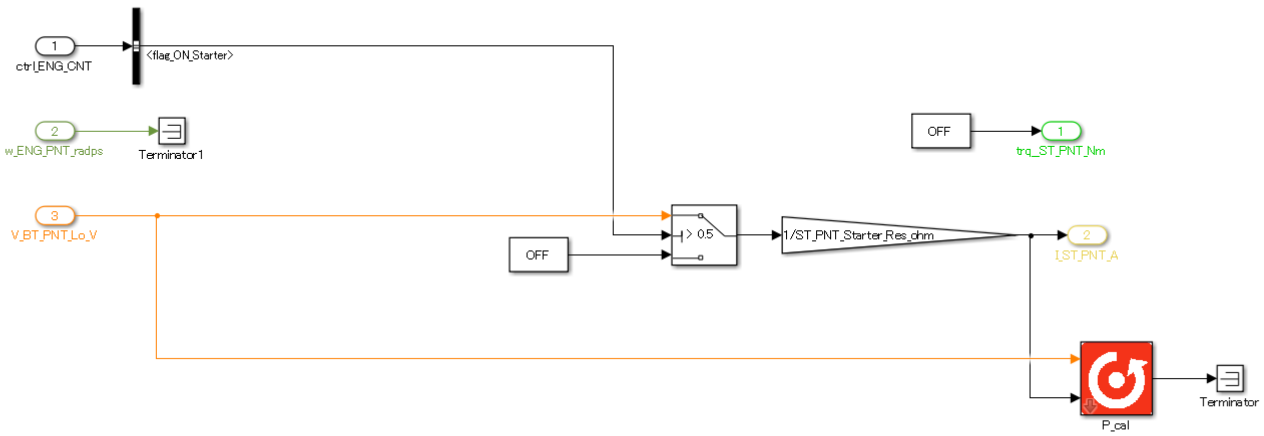


Fig. 5.3.11.2. Data flow diagram : third-layer ST_PNT system

5.3.11.3 Input/output specification

The input/output specification of this model is shown below.

Input			
Name	Unit	Area	Description
flag_ON_Starter	-	[0 1]	Starter active flag
w_ENG_PNT_radps	rad/s	TBD	Engine rpm (based on rad)
V_BT_PNT_Lo_V	V	TBD	Battery voltage
Output			
Name	Unit	Area	Description
trq_ST_PNT_Nm	Nm	TBD	Starter operation torque
I_ST_PNT_A	A	TBD	Starter current

5.3.11.4 Parameter specification

The parameter specification of this model is shown below.

Variable name	Setting value	Unit	Description
ST_PNT_Starter_Res_ohm	0.12	Ω	Starter resistance value (100A at 12V)

5.3.11.5 Other information

None.

5.3.12. Functional specification of [B40P: BK_PNT] system

The functional specifications of the third-layer BK_PNT system model in the guidelines-compatible model are described.

5.3.12.1 Abstract

The abstract of this model is shown below.

① Modelized object
The brake model for fuel economy evaluation.

② Modelized level
The model to generate a braking force in the mode-driving.

③ Modelized function
The function to apply the braking force as the drive shaft torque.

5.3.12.2 Data flow diagram

The diagram of this model is shown below.

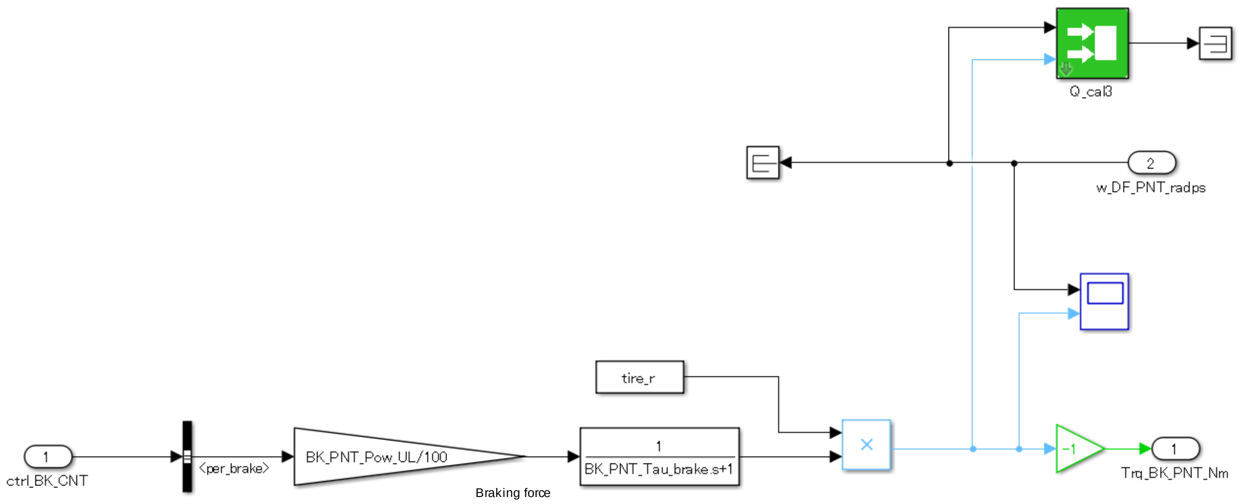


Fig. 5.3.12.2. Data flow diagram : third-layer BK_PNT system

5.3.12.3 Input/output specification

The input/output specification of this model is shown below.

Input			
Name	Unit	Area	Description
per_brake	%	[0 100]	Brake opening
Output			
Name	Unit	Area	Description
Trq_BK_PNT_Nm	Nm	TBD	Braking force

5.3.12.4 Parameter specification

The parameter specification of this model is shown below.

Variable name	Setting value	Unit	Description
BK_PNT_Tau_brake	0.85	-	Brake plant model Time constant for braking force
BK_PNT_Pow_UL	5000	N	Braking force upper limit value
BK_PNT_Pow_LL	0	N	Braking force lower limit value Also used in driver models

5.3.12.5 Other information

None.

5.3.13. Functional specification of [B50P: BT_PNT_Lo] system

The functional specifications of the third-layer BT_PNT_Lo system model in the guidelines-compatible model are described.

5.3.13.1 Abstract

The abstract of this model is shown below.

① Modelized object
The battery model for fuel economy evaluation.

② Modelized level
The model that the OCV is determined by the SOC, and the terminal voltage is determined by the addition of the voltage drop from the charge/discharge current and internal resistance.

③ Modelized function
The function to calculate the SOC from the charge/discharge current.
The function to determine the OCV voltage depending on the SOC.
The function to calculate the voltage drop from the charge/discharge current and internal resistance.

5.3.13.2 Data flow diagram

The diagram of this model is shown below.

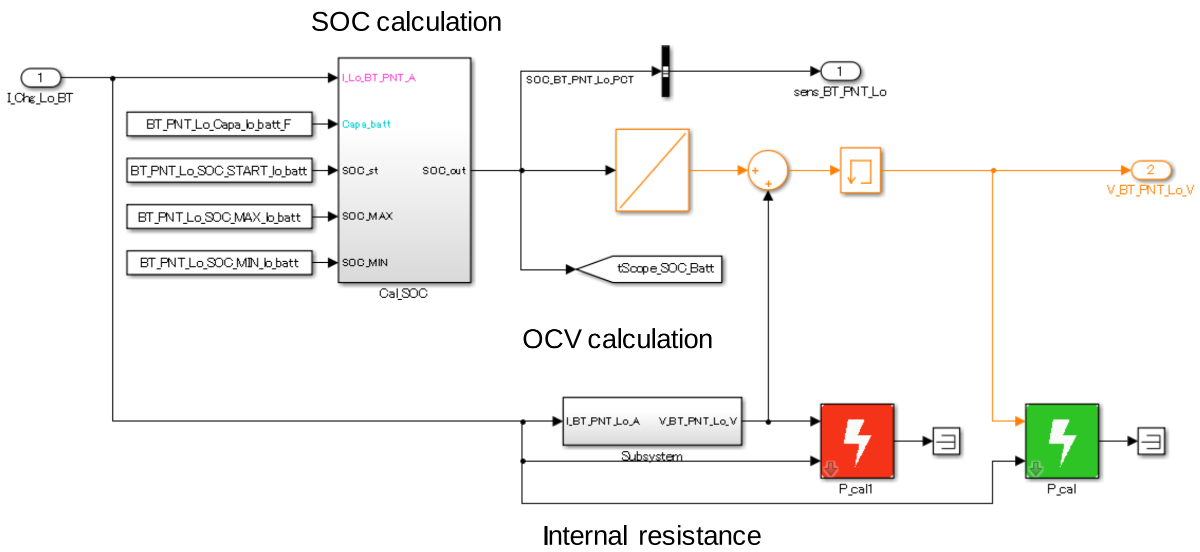


Fig. 5.3.13.2. Data flow diagram：third-layer BT_PNT_Lo system

5.3.13.3 Input/output specification

The input/output specification of this model is shown below.

Input			
Name	Unit	Area	Description
I_Chg_Lo_BT	A	TBD	Battery input current
Output			
Name	Unit	Area	Description
SOC_BT_PNT_Lo_PCT	%	[0 100]	Battery SOC
V_BT_PNT_Lo_V	V	TBD	Battery voltage

5.3.13.4 Parameter specification

The parameter specification of this model is shown below.

Variable name	Setting value	Unit	Description
BT_PNT_Lo_Capa_lo_batt_F	52	Ah	Battery capacity　Equivalent to 55D
BT_PNT_Lo_SOC_START_lo_batt	100	%	Battery SOC initial value
BT_PNT_Lo_SOC_MAX_lo_batt	100	%	Battery SOC maximum value　Also used in ALT
BT_PNT_Lo_SOC_MIN_lo_batt	0	%	Battery SOC minimum value
BT_PNT_Lo_ocv_SOC_lo_batt_OCV_V_table_x_SOC	[0,100]	%	Battery OCV calculation TABLE x- SOC term
BT_PNT_Lo_ocv_SOC_lo_batt_OCV_V_table	[10.5,12.3]	V	Battery OCV calculation TABLE
BT_PNT_Lo_R_lo_batt_ohm	0.0425	Ω	Battery internal resistance　Also used in ALT_PNT
BT_PNT_Lo_V_start_ocv	12.5	V	Battery initial voltage

5.3.13.5 Other information

None.

5.3.14. Functional specification of [B51P: EL_PNT] system

The functional specifications of the third-layer EL_PNT system model in the guidelines-compatible model are described.

5.3.14.1 Abstract

The abstract of this model is shown below.

① Modelized object

The low voltage electrical load model for fuel economy evaluation.

② Modelized level

The model to calculate the current consumption at the low-voltage side in the mode-driving.

③ Modelized function

The function to calculate the current consumption at depending on the terminal voltage of the low-voltage load.

5.3.14.2 Data flow diagram

The diagram of this model is shown below.

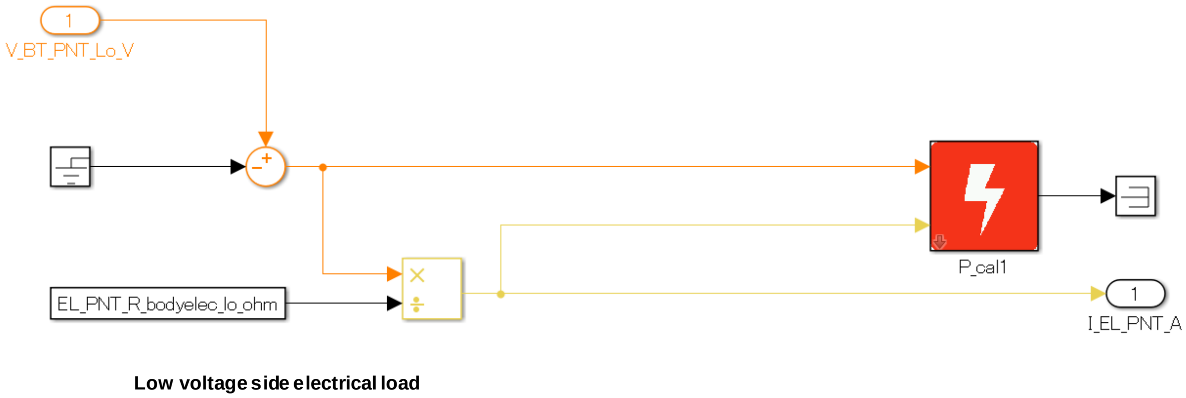


Fig. 5.3.14.2. Data flow diagram : third-layer EL_PNT system

5.3.14.3 Input/output specification

The input/output specification of this model is shown below.

Input			
Name	Unit	Area	Description
V_BT_PNT_Lo_V	V	TBD	Battery voltage
Output			
Name	Unit	Area	Description
I_EL_PNT_A	A	TBD	Current at low voltage side

5.3.14.4 Parameter specification

The parameter specification of this model is shown below.

Variable name	Setting value	Unit	Description
EL_PNT_R_bodyelec_lo_ohm	0.72	Ω	Electrical load resistance at low voltage side

5.3.14.5 Other information

None.

5.3.15. Functional specification of [B60P: TR_PNT] system

The functional specifications of the third-layer TR_PNT system model in the guidelines-compatible model are described.

5.3.15.1 Abstract

The abstract of this model is shown below.

① Modelized object

The tire model for fuel economy evaluation.

② Modelized level

The model to convert the rotational movement of the drive shaft to the translational movement of the vehicle.

Add the rolling resistance in the mode-driving.

③ Modelized function

The function to convert the rotational movement to the translational movement.

The function to add the rolling resistance of the tires to the accelerating force of the translational movement.

5.3.15.2 Data flow diagram

The diagram of this model is shown below.

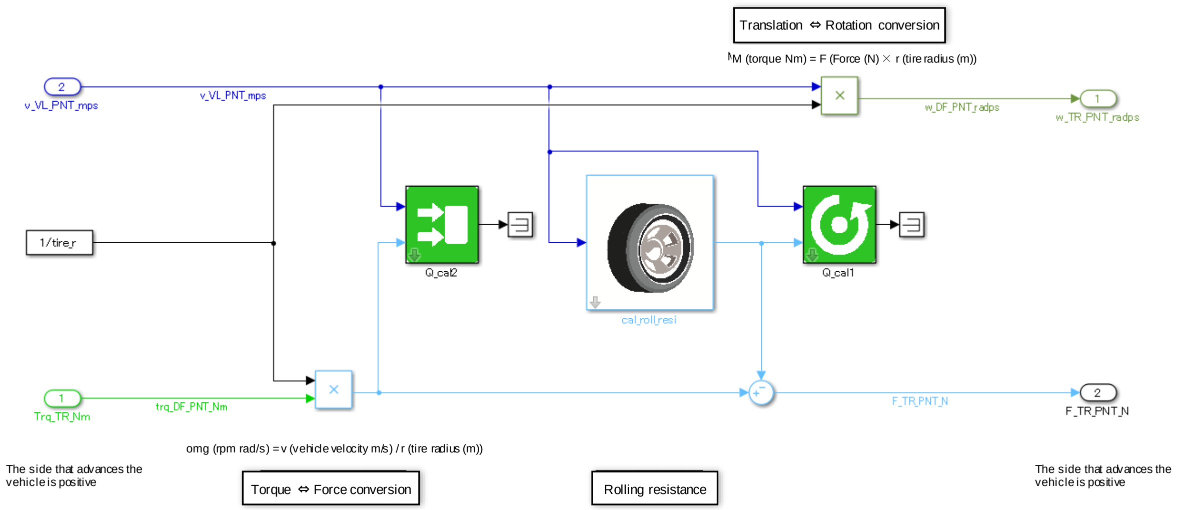


Fig. 5.3.15.2. Data flow diagram : third-layer TR_PNT system

5.3.15.3 Input/output specification

The input/output specification of this model is shown below.

Input			
Name	Unit	Area	Description
Trq_TR_Nm	Nm	TBD	Differential gear outlet torque - braking force
v_VL_PNT_mps	m/s	TBD	Vehicle velocity (m/s unit)
Output			
Name	Unit	Area	Description
w_TR_PNT_radps	rad/s	TBD	Rotational velocity of tire
F_TR_PNT_N	N	TBD	Tire propulsion force (side that advances vehicle is positive)

5.3.15.4 Parameter specification

Only the common parameters are used in this system.

5.3.15.5 Other information

None.

5.3.16. Functional specification of [B61P: VL_PNT] system

The functional specifications of the third-layer VL_PNT system model in the guidelines-compatible model are described.

5.3.16.1 Abstract

The abstract of this model is shown below.

① Modelized object

The vehicle dynamics model for fuel economy evaluation.

② Modelized level

Calcuate the translational speed of the vehicle.

Add the air resistance and climbing resistance to the translational accelerating force of the vehicle.

③ Modelized function

The function to calculate the vehicle velocity from its translational accelerating force.

The function to calculate the air resistance from the translational velocity of the vehicle and add this air resistance to the translational accelerating force.

The function to calculate the climbing resistance on the vehicle and add this climbing resistance to the translational accelerating force.

5.3.16.2 Data flow diagram

The diagram of this model is shown below.

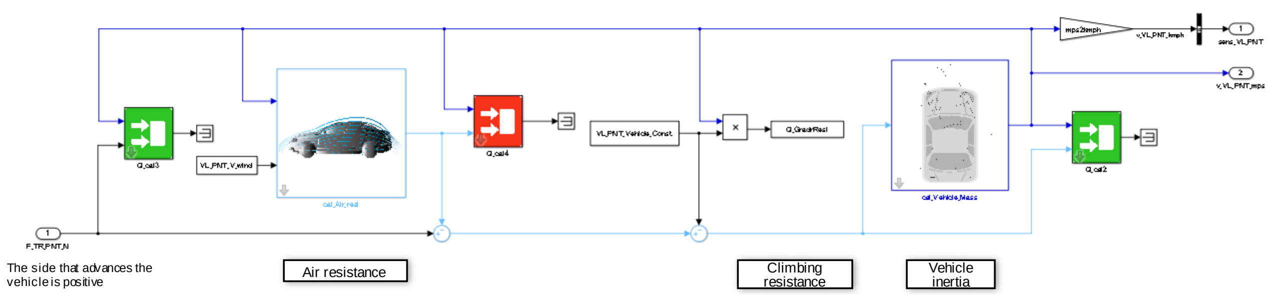


Fig. 5.3.16.2. Data flow diagram：third-layer VL_PNT system

5.3.16.3 Input/output specification

The input/output specification of this model is shown below.

Input			
Name	Unit	Area	Description
F_TR_PNT_N	N	TBD	Tire propulsion force (side that advances vehicle is positive)
Output			
Name	Unit	Area	Description
v_VL_PNT_kmph	km/h	[0 200]	Vehicle velocity
v_VL_PNT_mps	m/s	TBD	Vehicle velocity (m/s unit)

5.3.16.4 Parameter specification

The parameter specification of this model is shown below.

Variable name	Setting value	Unit	Description
VL_PNT_Vehicle_Const	0	-	Hill climb coefficient
VL_PNT_V_wind	0	m/s	Wind velocity

5.3.16.5 Other information

None.

6. Description in this model

6.1. Purpose

Model description method to understand this model is as shown below.
The content written here does not regulate the usage of Matlab® Simulink®.

6.2. Precondition

The PLANT MODELING GUIDELINES USING MATLAB® and Simulink® Version 2.1, issued by the Japan MATLAB Automotive Advisory Board (JMAAB) on December 2, 2008 [1], was used as reference to create the guidelines-compatible model. This document will be referred to hereinafter as the Plant Modeling Guidelines.

The methods used to describe the model here do not necessarily follow the Plant Modeling Guidelines, and are defined to help in understanding this model.

6.3. Diagnostic parameter setting

6.3.1. Solver setting

No provision.

6.3.2. Diagnostic parameter setting

This setting is based on JP2103 "Diagnostic parameter setting" of the Plant Modeling Guidelines.

6.4. Naming

6.4.1. Available character

The characters used in the label names of subsystems and signal lines are based on the usable characters for names in JP2503 "Subsystem".

6.4.2. Subsystem name

The list of the subsystem names is shown below.

Table 6.4.2. List of subsystem names

Part	Notation	abbreviation	Part	Notation	abbreviation	Part	Notation	abbreviation	Part	Notation	abbreviation
Driver	Driver										
Vehicle	Vehicle		Vehicle Control	Vehicle Control	VC	Engine Control	EngineControl	ENG_CNT			
						Transmission Control	TransmissionControl	TM_CNT			
						Brake control	BrakeControl	BK_CNT			
						Alternater Control	AlternaterControl	ALT_CNT ACG_CNT			
			Vehicle Plant	Vehicle Body	VB	Engine	Engine	ENG_PNT			
						Transmission	Transmission	TM_PNT	Torque Converter	TorqueConverter	TC
									Gear	Gear	GR
									Oil Pump	OilPump	OP
						Differential gear	DifferentialGear	DF_PNT			
						Tire	Tire	TR_PNT			
						Brake	Brake	BK_PNT			
						Vehicle	VehicleLoad	VL_PNT			
						Battery	Battery	BT_PNT			
						Alternater	Alternater	ALT_ PLNT ,ACG			
						Starter	Starter	ST			
						Electriical Load	ElectriicalLoad	EL			
Environmental Monitor	Environment Monitor										

6.4.3. Signal name

Name the signals based on the energy flow, as shown below.

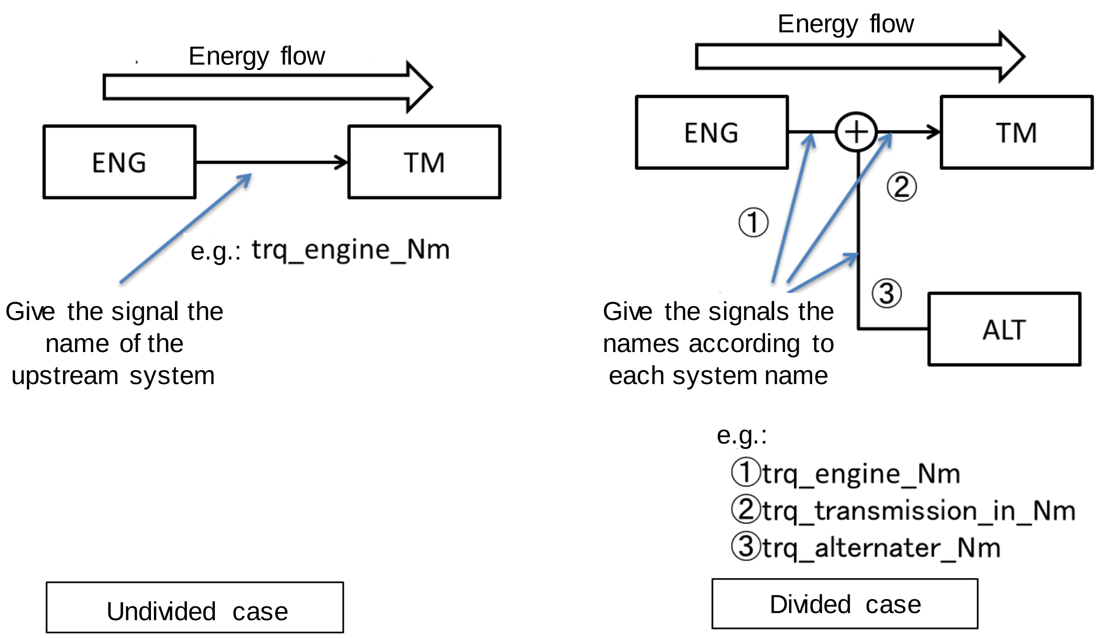


Fig. 6.4.3. How to name the signals

6.4.4. Input/output terminal name

Separate plants and controls when naming them, as shown below.

Plant I/F: amount_system name (_definition_unit)

Control I/F: definition_system name_[unit]

e.g. Plant

Physical symbol: omega: rpm

System name: Option 1 What is making the output? Option 2 Give it the name of the upstream energy system: name it "engine". omg_engine(_radps)

e.g. Control
Engine rpm (rpm)
n_engine_rpm

6.4.5. Parameter name

Put the subsystem name at the beginning of the parameter name
System name_definition_[unit]
e.g. engine_nEngine_rpm

6.5. System model structure

The structure of the plant model have below three proposal, and the IF guidelines-compatible model is based on Option 3.

＜Option 1＞

Use JP3001 "Plant model structure (Model architecture)" of the Plant Modeling Guidelines as reference.
In the current Simulink Model, the control model is separated from plant model.
Because control model and plant model should be integrated originally but some suppliers have only either control model or plant model and this guideline need to deal with that. This is a method that takes maintenance into account.

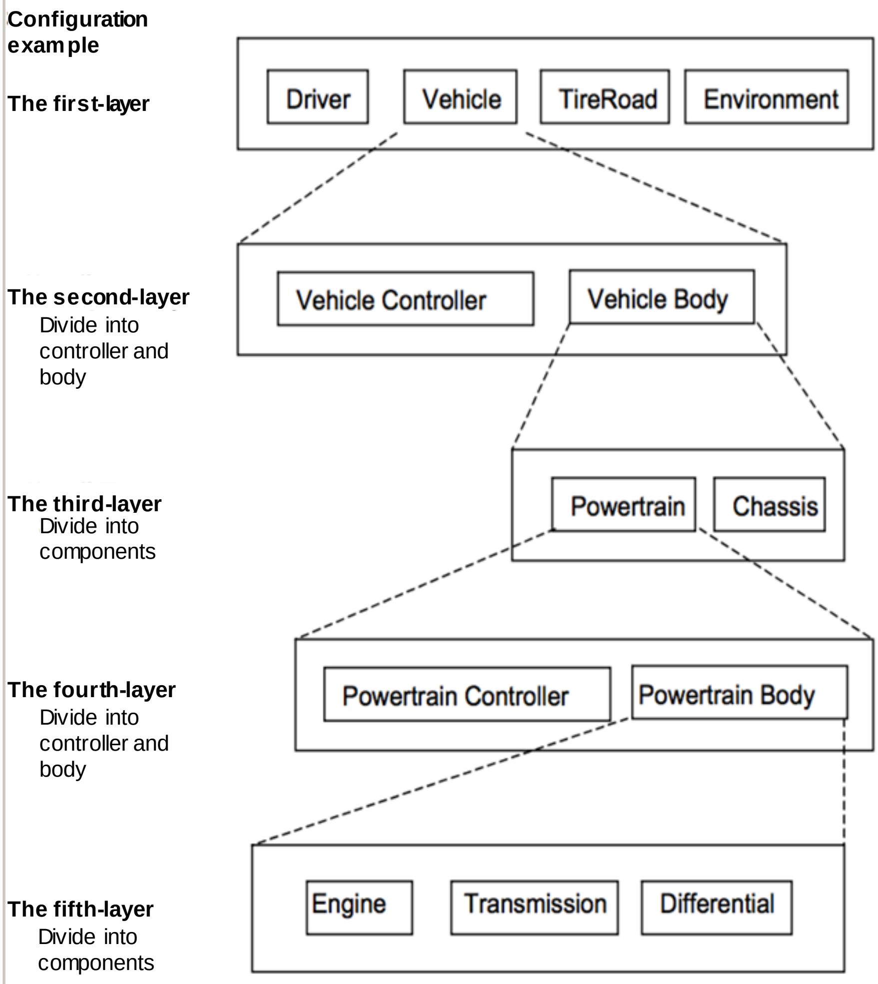
Description	The plant model architecture is described as the layer structure, as shown below. The layers that separates the structural components and the layers that shows the plant and controller in a 1 to 1 comparison are alternately placed. The placement of each part model should be same as the placement of the part in a actual vehicle, as much as possible. 

Fig. 6.5.1. JP3001 “Plant model structure”

＜Option 2＞

The plant and control model are on the same layer.
This is based on the idea that it is better to make ECU and mechanics of system into subsystem in order to distribute this model as a base.(suppliers are concerned that their know-how might could leak outside the company if ECU command values can be monitored).

<Option 3>

Broadly divide plants and controls.

This architecture makes it easy to understand the relationships between plant models. This is to clarify as a model that complies with the I / F guidelines between plant models.

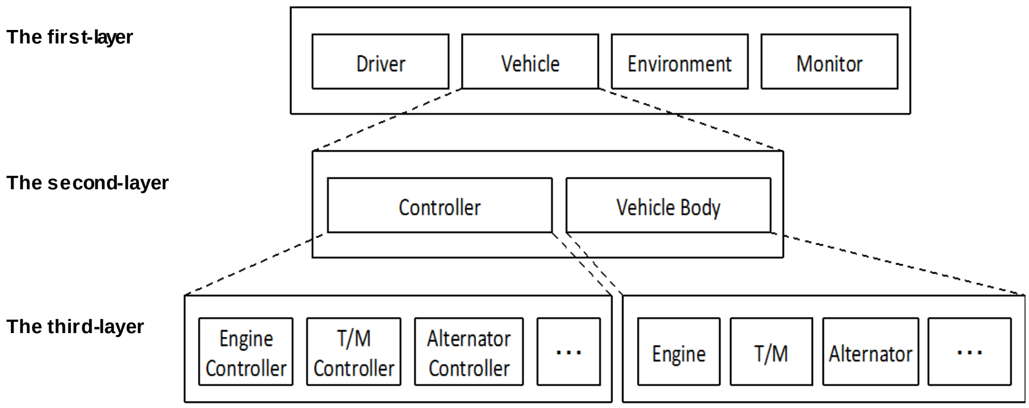


Fig. 6.5.2. The structure broadly divides controls and plants in the same layer

6.6. Interface

6.6.1. Type

The interface is separated into ①physical I/F, ②sensor, ③actuator and ④CAN and defined as the I/F. Follow the method detailed below.

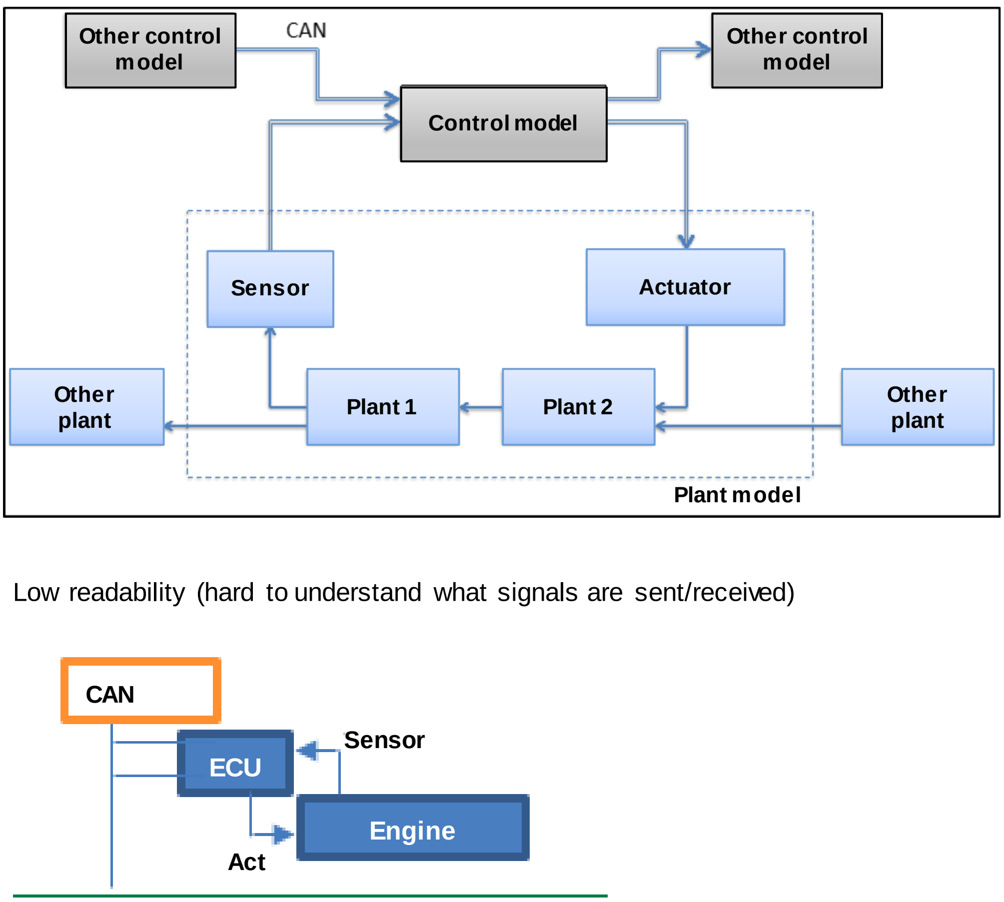


Fig. 6.6.1. I/F type and drawing method

6.6.2. Bus

Buses are generally used for control, sensor, and actuator signals because input/output is too much and looks like spaghetti structure. However, there is a demerit that the detail of inputs and outputs cannot be seen from a higher level.

6.7. Unit

The units of variables and variates used in the model will follow the rules below..

①Plant model
The plant model follows the unit systems of the Plant Model I/F Guidelines
However, the monitors for rpm and velocity will be output as rpm and km/h, respectively.

②Control model
Each control model will follow the I/F specifications.

Below is a list of unit systems.

Table 6.7. List of unit systems used in the model

SI Basic unit

Base quantity	Name	Symbol	Alphabetical character proposal in model
Length	Meter	m	m
Mass	Kilogram	kg	kg
Time	Second	s	s
Current	Ampere	A	A
Thermodynamic temperature	Kelvin	K	K
Amount of substance	Mole	mol	mol
Luminous intensity	Candela	cd	cd

SI units with specific names, SI derived units

Quantity	Unit	Unit symbol	Alphabetical character proposal in model
Plane angle	Radian	rad	rad
Frequency	Hertz	Hz	Hz
Force	Newton	N	N
Pressure, stress	Pascal	Pa	Pa
Energy Amount of work, amount of heat	Joule	J	J
Power, electric power	Watt	W	W
Charge	coulomb	C	C
Electric potential of difference, electric potential	Volt	V	V
Electrostatic capacitance	Farad	F	F
Electrical resistance	Ohm	Ω	ohm

Celsius' temperature	Degree Celsius	℃	dC(＝degree Celsius)
Inductance	Henry	H	H

6.8. Parameter operation

Each system parameter should have “m” file, and load each “m” file as the run file.
All of the points below should be covered:

- Overall parameter management
- General physical values
- Overall shared parameters (changes in units, etc.)
- All system parameters

It is generally not allowed to directly input parameters into the model.
Parameters should also be managed by each system.

6.9. Type

Types should follow JP5001 "Data type" of the Plant Modeling Guidelines.
Default values should be used in most cases. Do not use logical values in calculations.
State all exceptions in the model specifications.

Although not required, the points below should be kept in mind:

- 64/32bit for double-precision floating-point values
- The need for counters, etc. in non-linear models
- Floating point errors when the double type is used
- Values such as the gear stage signal are sometimes stored as int. Therefore, there is a need to assume that "this applies to physical values that interact between model components".

6.10. Others

The following opinions and issues need to be considered with regard to model creation rules:

- No library other than the standard Simulink library should be used.
- Stateflow should generally not be used.
  (As some people might not have the Stateflow library)

7. Reference document

[1] “非因果モデリングツールを用いたFMIモデル接続ガイドライン Ver.1.0”(Society of Automotive Engineers of Japan) *Japanese only
https://www.jsae.or.jp/tops/topics/1241/1241-1A.pdf
[2] “PLANT MODELING GUIDELINES USING MATLAB® and Simulink® Version 2.1” (Japan MATLAB Automotive Board, JMAAB 2nd Dec. 2008)
http://jmaab.mathworks.jp/doc/plantmodeling_sg/PMSG_english_v2.1.pdf