Handbook of Plant Modeling IF Guidelines-Compatible Model (Electric consumption model for EV) For Vehicle Development

(ver.1.0)

Revision history

Rev.	Date	Description	Company name	Approver
1.0	Mar, 2020	New issued	AZAPA	Ichihara

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 guidelines-compatible model is expected to be used as a preemptive Guidelines checker and problem identifier when changing models.

1.2. Requirements of guidelines-compatible model

For beginners, in this handbook function and structure of vehicle are given an abstract and scope of this handbook are motion system such as rotation or translation, electric system and thermal system.

*Other physical domains are the challenges in the future.

This model assumes an electric vehicle.
It is based in Matlab® Simulink®, a programming language often used in vehicle development.

1.3. Functions of guidelines-compatible model

● Control function

・Regeneration contorol for the decelearation
・Motor torque control
・Temperature control doe air conditioner and seat heater
・Charging control and temperature control for battery
・Radiator fan control and water pump control

● Plant

・Differential gear
・Brake
・Tire
・Vehicle
・High voltage battery
・Low voltage battery
・Electric load
・Motor
・Inverter
・Charger
・DC/DC converter
・Ambient air
・Transmission
・Power train thermal
・Power electronics thermal
・Cabin thermal
・Battery thermal

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 10 64bit
PC specification	64bit Memory 8GB 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　ode3 (Bogacki-Shampine)
Sampling time	0.0025[s]
Max. step size	-
Min. step size	-
Allowable error	-

2.2. Usage environment

Simulation environment and file/folder composition of the guidelines-compatible model are shown below;

<Simulation environment of the guidelines-compatible model>

The simulation environment of the guidelines-compatible model is as shown below.

The electric 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.

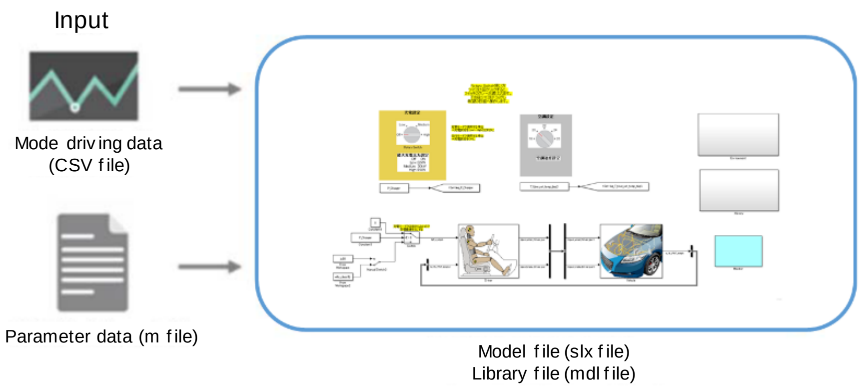


Fig.2.2.1. Simulation environment

<File composition of the guidelines-compatible model>

No	File Name	Description
1	EV_thermal_charger_2015a_20200311..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
6	(subfolder) save_param	Save folder for model environment setting

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.

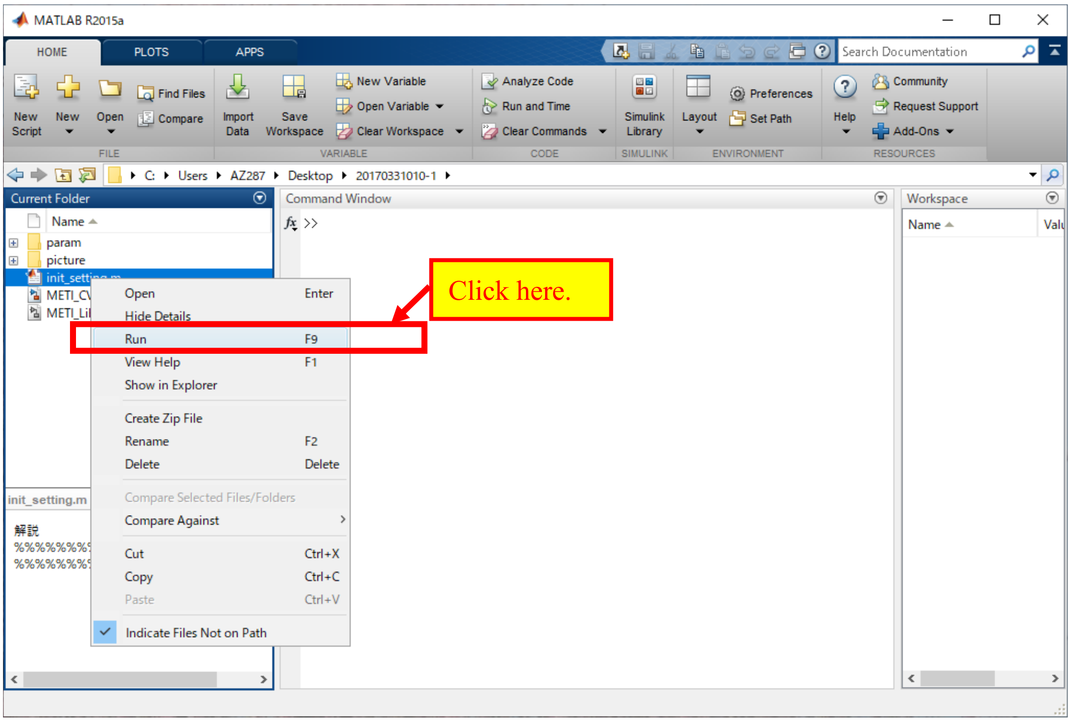
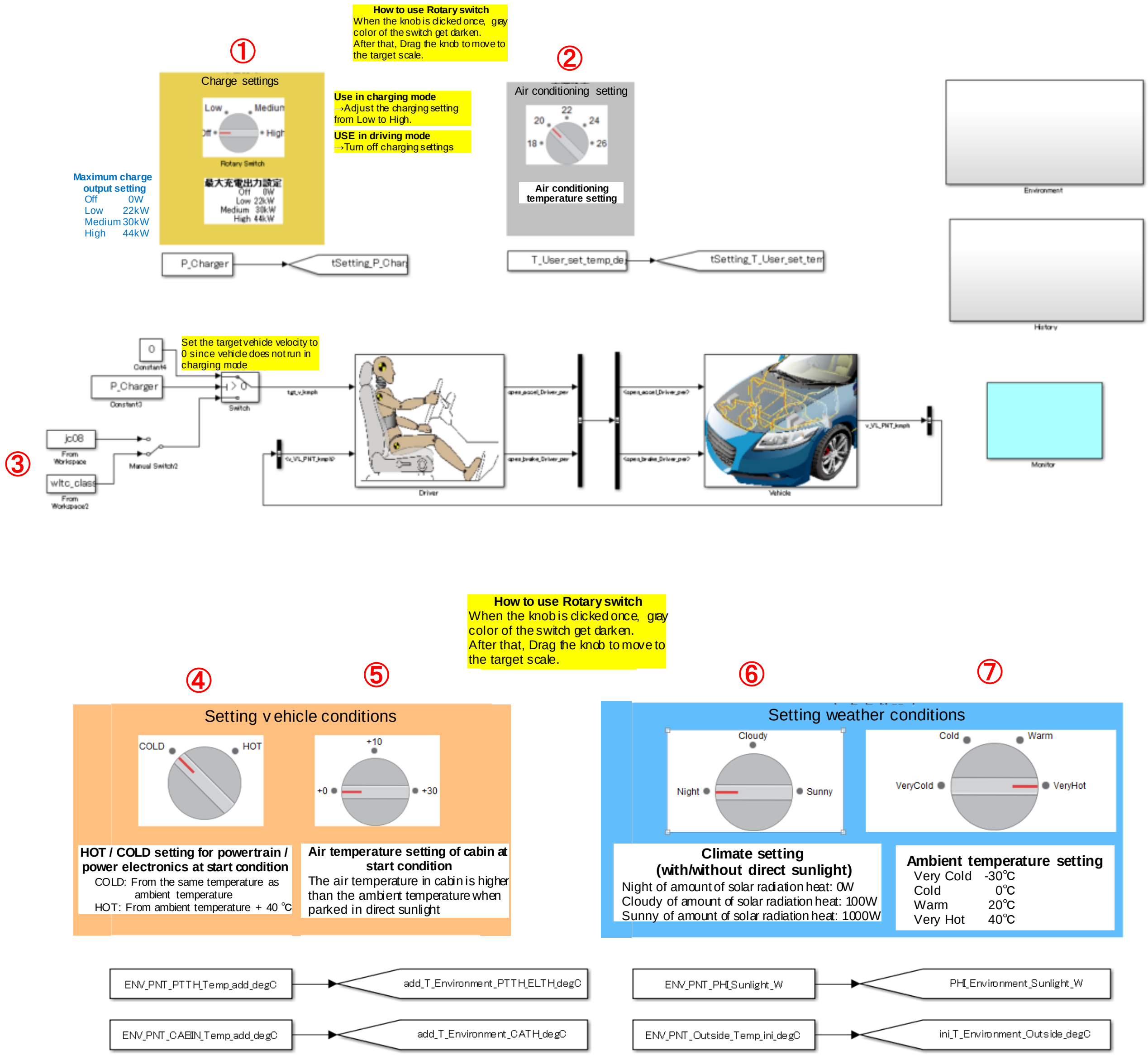


Fig. 3.1.2 Execution procedure of “init_setting.m”

3.1.3. Select the driving environment settings to use for simulation



VCU_CNT_set_params.m

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%% - set_mbd_params -
%%% Function① Read data file
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

%% ①Read data file
%HV ECU
%*****************************************************************
%Regeneration cooperative control
VCU_CNT_Cooperative_Control_Brake_flag = 0;%Regeneration cooperative control is active in 1.   ⑧

%! Upper limit of battery input / output
VCU_CNT_P_limit_charge     = -500*350;%Charging electric power limit value [W]-500A*350V
VCU_CNT_P_limit_discharge  =  500*350;%Discharging electric power limit value [W] -500A*350V
VCU_CNT_PSoFin_soc         = [0,95,99,100];
VCU_CNT_PSoFin_battpw      = [1, 1, 0,  0]*VCU_CNT_P_limit_charge;
VCU_CNT_PSoFout_soc        = [0, 1, 5,100];
VCU_CNT_PSoFout_battpw     = [0, 0, 1,  1]*VCU_CNT_P_limit_discharge;
```

Fig. 3.1.3 The driving environment settings to use for simulation

By using the rotary switch on the first-layer, mode switching between the driving and the charging, and parameter setting for air conditioning can be performed.
And, the driving pattern can be switched by a switch.

①Charging control setting
P_Charger
Off: 0W (Running mode)
Low: 22kW (Charging mode)
Medium: 30kW (Charging mode)
High: 44kW (Charging mode)

②Air conditioning parameter setting
T_User_set_temp_degC
18: Air conditioning temperature setting: 18 degree Celsius
20: Air conditioning temperature setting: 20 degree Celsius
22: Air conditioning temperature setting: 22 degree Celsius
24: Air conditioning temperature setting: 24 degree Celsius
26: Air conditioning temperature setting: 26 degree Celsius

③Driving pattern
jc08: JC08 mode
wltc_class3b: WLTC（Class3b）

Parameter setting of vehicle condition and climate condition can ve performed in the second-layer Environment.

④Temperature setting of power train and power electronics in starting
ENV_PNT_PTTH_Temp_add_degC
COLD: Same temperature as ambient temperature
HOT: Ambient temperature + 40degC

⑤Temperature setting of cabin in starting
(The cabin temperature will be higher than the outside temperature when a vehicle parked in direct sunlight.)
ENV_PNT_CABIN_Temp_add_degC
+0: Temperature settingof cabin + 0degC
+10: Temperature settingof cabin + 10degC
+30: Temperature settingof cabin + 30degC

⑥Climate setting (with/withoutdirect sunlight)
ENV_PNT_PHI_Sunlight_W
Night: Amount of solar raditation heat 0W
Cloudy: Amount of solar raditation heat 100W
Sunny: Amount of solar raditation heat 1000W

⑦Ambient temperature setting
ENV_PNT_Outside_Temp_ini_degC
VeryCold: -30degC
Cold: 0degC
Warm: 20degC
VeryHot: 40degC

Regenarative/Cooperative control can be selected ON/OFF by using “VCU_CNT_set_params.m” in params folder.

⑧Regenarative/Cooperative control
On: VCU_CNT_Cooperative_Control_Brake_flag = 1
Off: VCU_CNT_Cooperative_Control_Brake_flag = 0

3.1.4. Start simulation

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

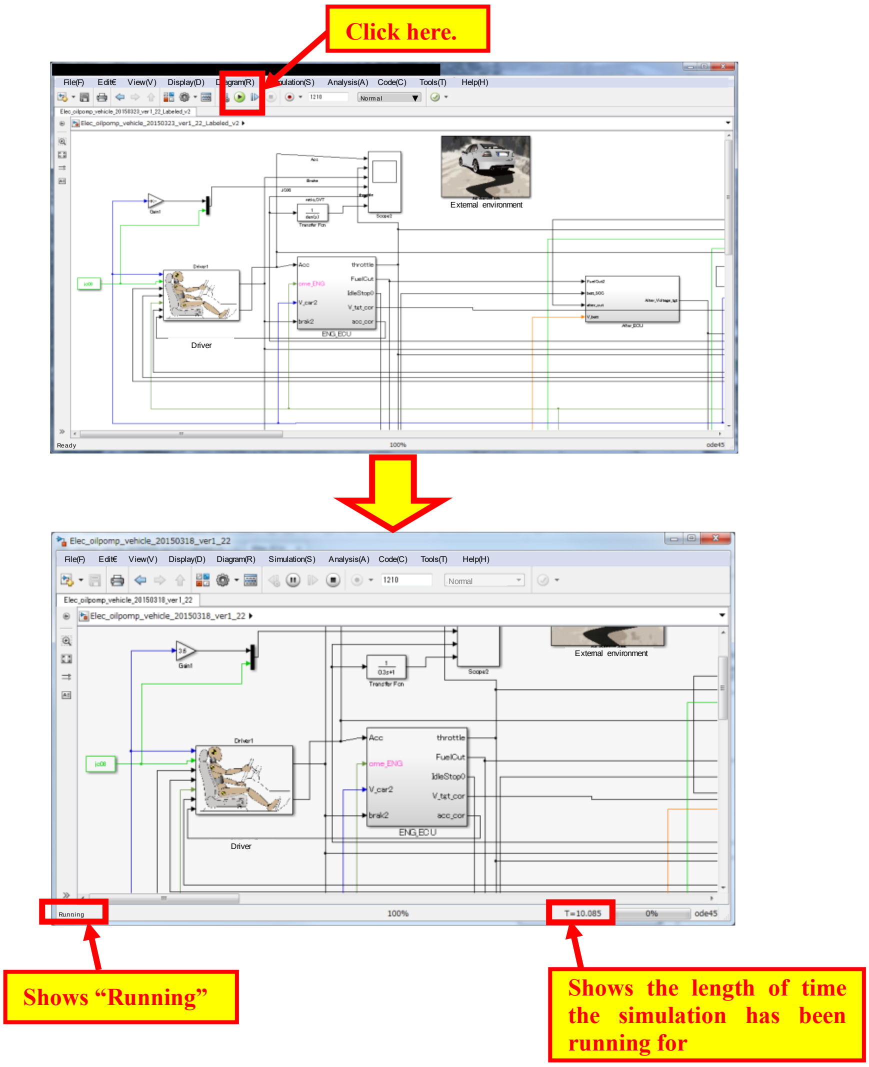


Fig. 3.1.4 Execution procedure of the simulation

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.

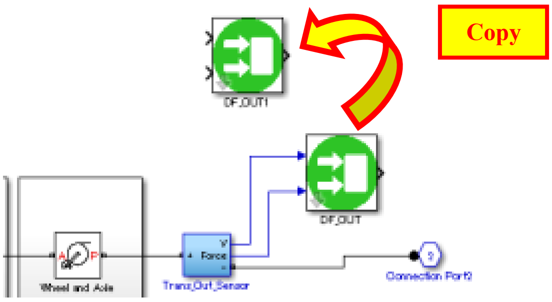


Fig. 3.2.1 How to copy block

3.2.2. Set appropriate physical quantity

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

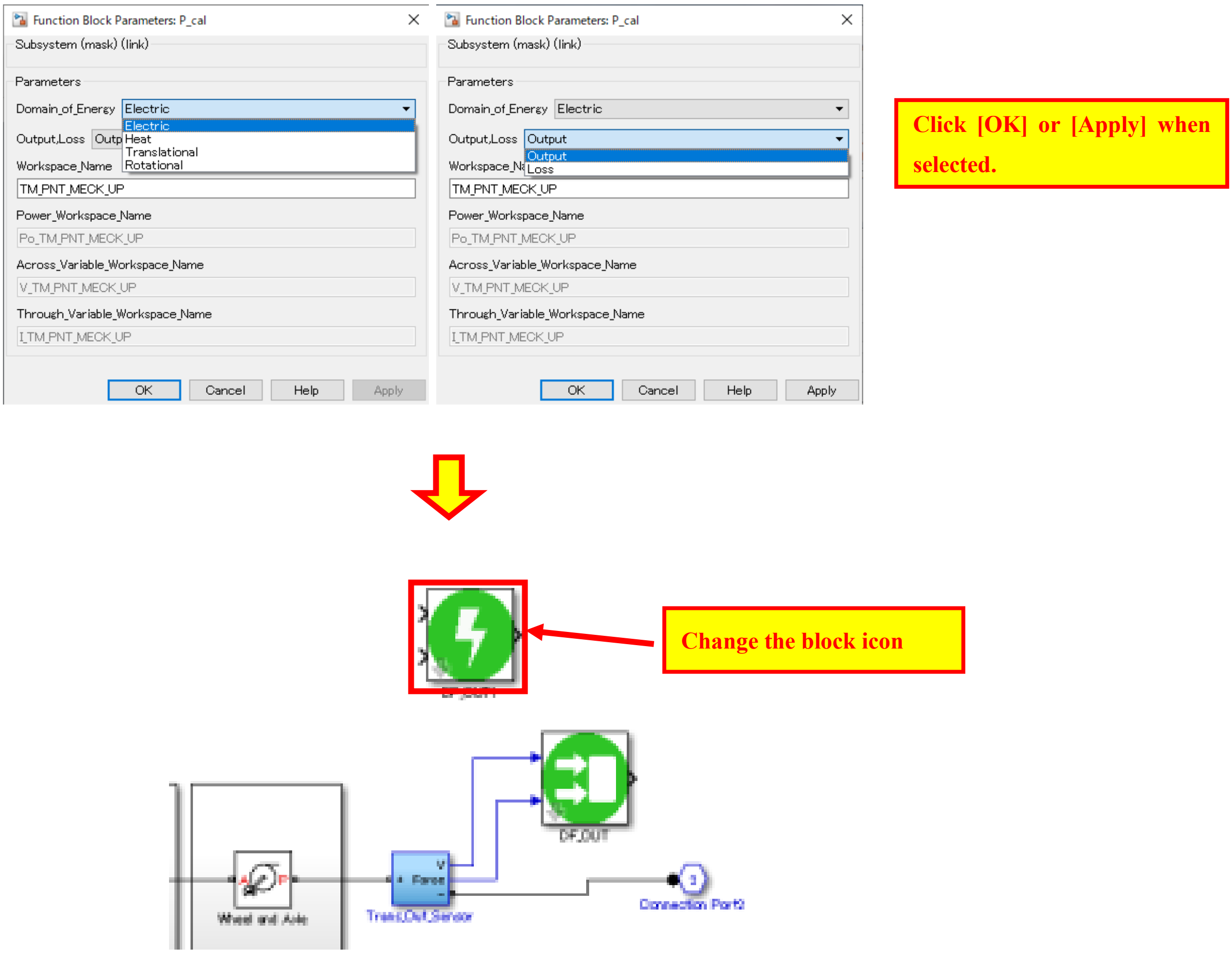


Fig. 3.2.2 How to set physical quantity

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.

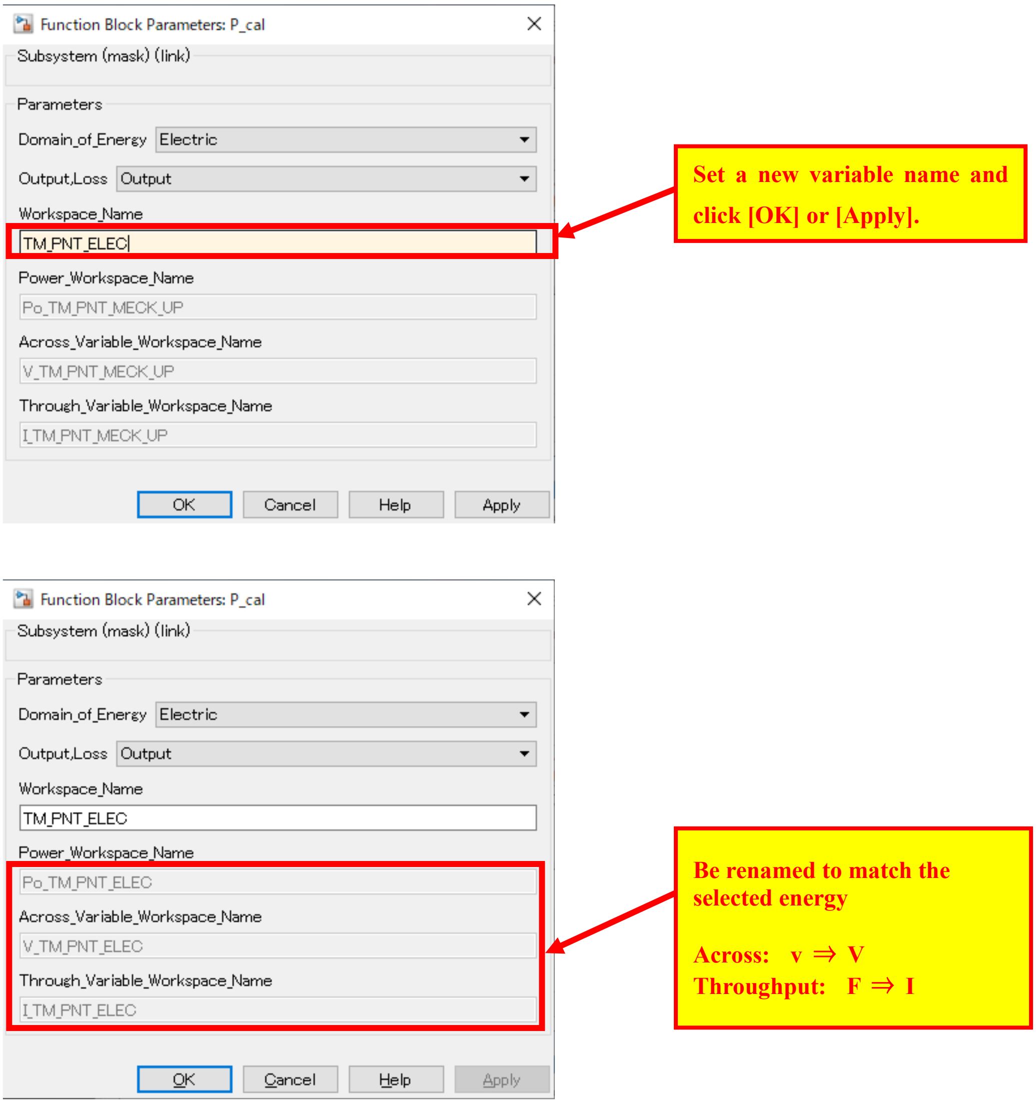


Fig. 3.2.3 How to set energy name

4. Basic structure of guideline-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. Model structure of first-layer

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

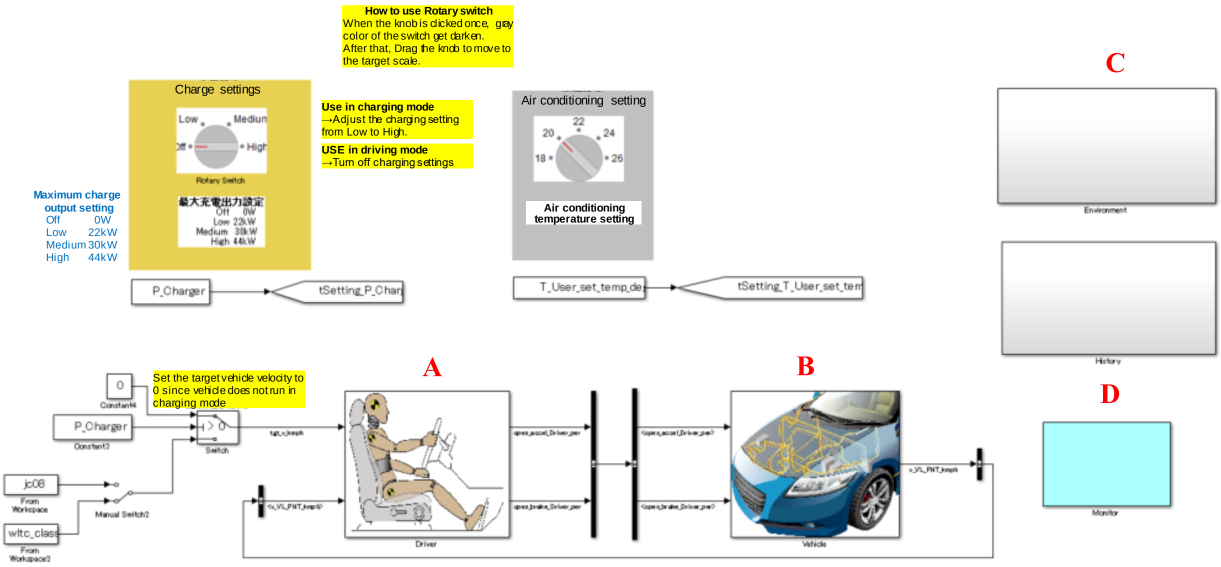


Fig. 4.1 Structure of first-layer system

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 names of first-layer system (entire model) and function overview

No.	System Name	Function Overview
A	Driver	Load the mode-driving pattern and operate the accelerator and brake after that.
B	Vehicle	Load the accelerator and brake operations, and calculate the vehicle velocity by controlling the engine output and gear ratio.
C	Environment	Set the driving environment of the vehicle.
D	Monitor	Monitor each variables in the Vehicle system
Other	Editing_History	Record model change history.

4.2. Model Structure of the second-layer

The structure of each second-layer system in the guideline-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.

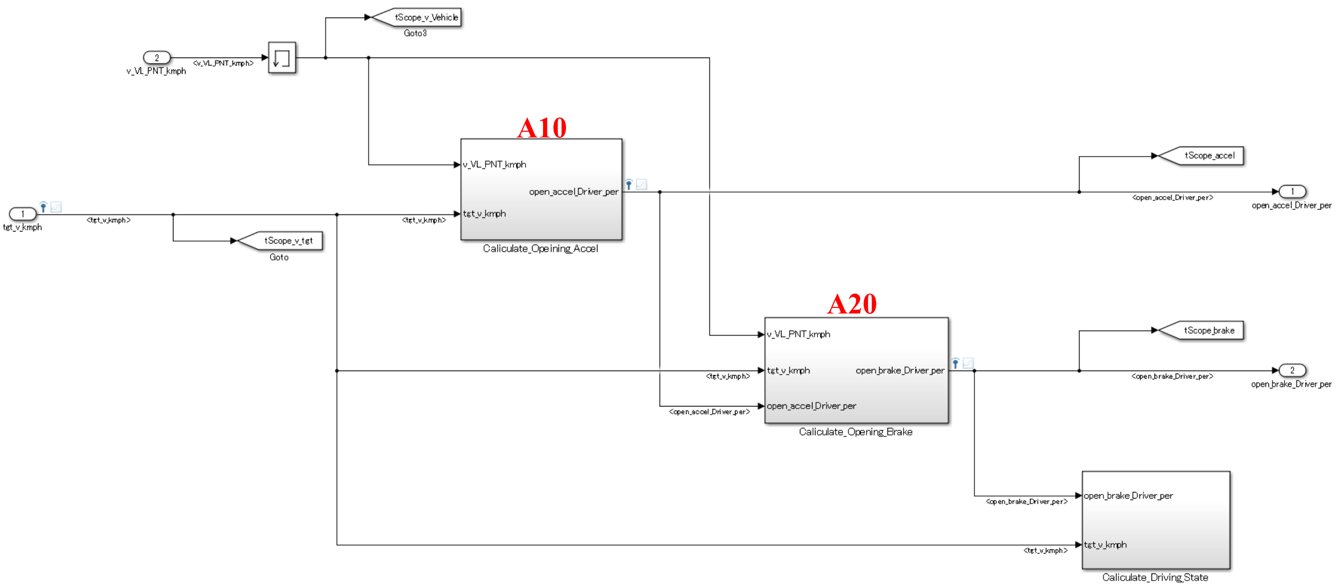


Fig. 4.2.1 Structure of second layer driver system

The function overview of second-layer driver system in the guidelines-compatible model is described. A10, A20 of the No. column on the table refer to the systems in Fig. 4.2.1.

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

No.	System name	Function Overview
A10	Accelerator opening	The accelerator position is calculated based on the sum of FF and FB control. As for FF control, the target torque is calculated based on the target vehicle velocity, and accelerator position is calculated after that. As for FB control, the accelerator opening is calculated based on the difference between the target vehicle velocity and the actual vehicle velocity.
A20	Brake opening	The brake pedal stroke is calculated from the difference between the target vehicle velocity and the actual vehicle velocity. Brake pedal cannot work to prevent simultaneous operation of both pedals while acceleration pedal is stepped on.

4.2.2. Structure of [B: Vehicle] system

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

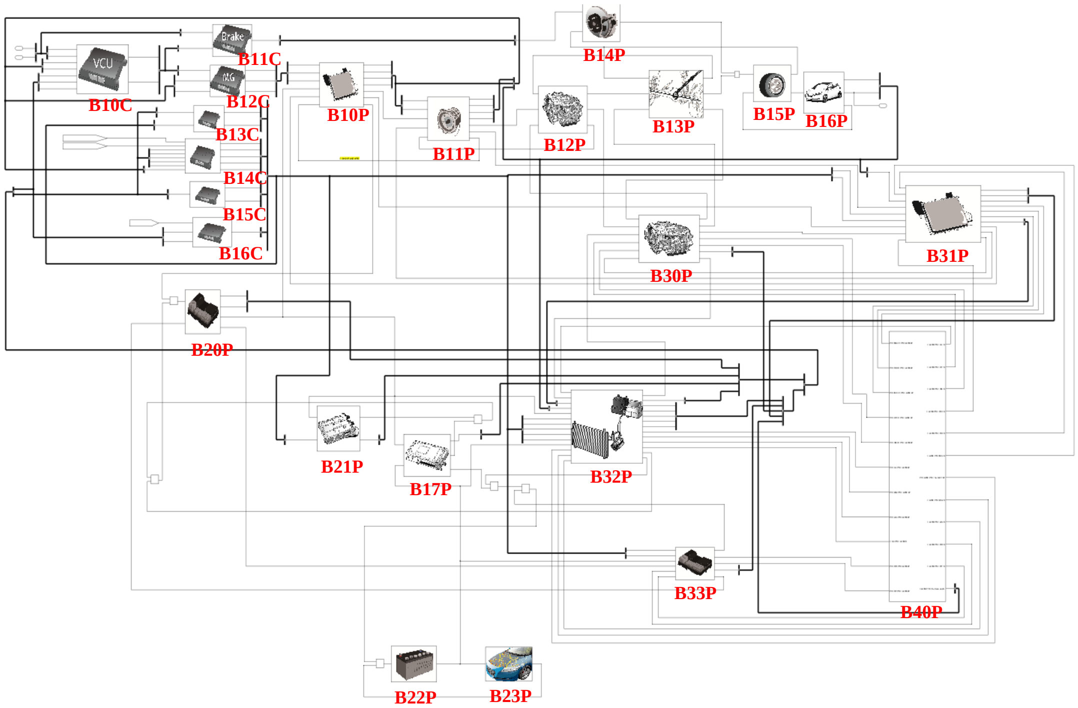


Fig. 4.2.2 Structure of second-layer vehicle system

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	VCU_CNT	Control vehicle.
B11C	BK_CNT	Control the brake.
B12C	MG_CNT	Control motor.
B13C	ELTH_CNT	Control power electronics thermal.
B14C	CATH_CNT	Control Cabin thermal.
B15C	BTTH_CNT	Control battery thermal.
B16C	CHG_CNT	Control charger.
B10P	INV_PNT	Convert direct current to alternating current and calculate amount of heat generation.
B11P	MG_PNT	Generate motor torque and calculate amount of heat generation.
B12P	TM_PNT	Change gear and calculate amount of heat generation toward motor rpm.and torque.
B13P	DF_PNT	Calculate deceleration to drive shaft and amount of heat generation from transmission output.
B14P	BK_PNT	Generate brake torque on the drive shaft.
B15P	TR_PNT	Convert rotational motion to linear motion of drive shaft.
B16P	VL_PNT	Calculate running resistance and vehicle velocity.
B20P	BT_Hi_PNT	Supply voltage and calculate amount of heat generation according to SOC.
B21P	CHG_PNT	Charge high voltage battery.
B17P	DCDC_PNT	Step down the voltage from the high voltage battery
B22P	BT_Lo_PNT	Supply voltage according to SOC.
B30P	CATH_PNT	Calculatie the temp. of HVAC, cabin, and seat heater.
B23P	EL_PNT	Generate consumption current with low voltage electrical loads.
B31P	BTTH_PNT	Calculate the temp. of motor, inverter and radiator.
P32P	PTTH_PNT	Calculate the temp. of transmission and differential gear.
B33P	ELTH_PNT	Calculate the temp. of high voltage battery.
B40P	ATM_PNT	Calculate of heat flow of direct sunlight and the ambient temp. of cabin, power train, power electronics and battery, and receive the amount of radiation from the cabin, power train, power electronics and battery.

4.2.3. Structure of [C: Environment] system

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

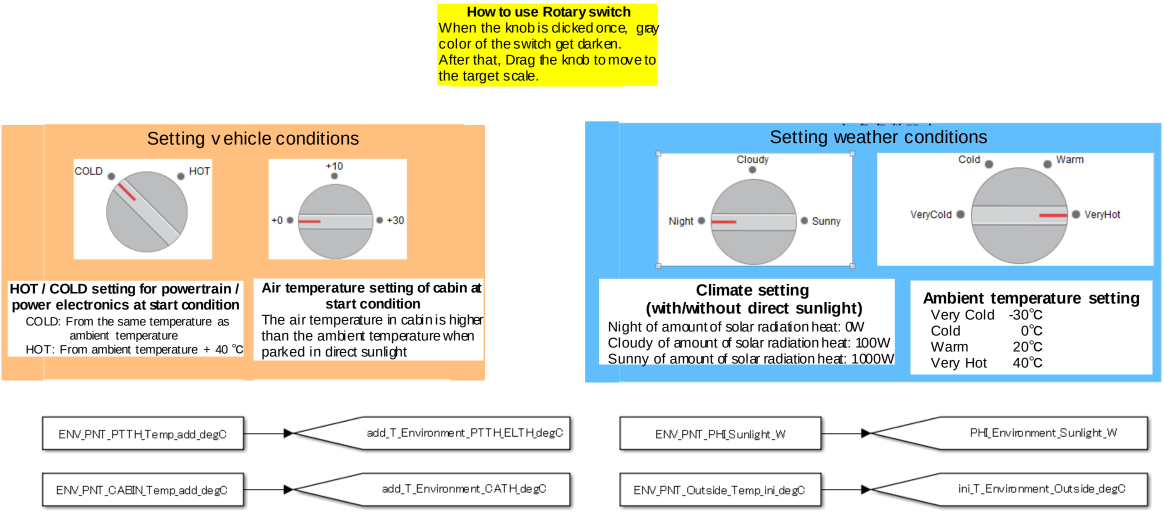


Fig. 4.2.3 Structure of second-layer environment system

External environment is set in this system.

This system has no lower system layer.

4.2.4. Structure of [D: Monitor] system

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

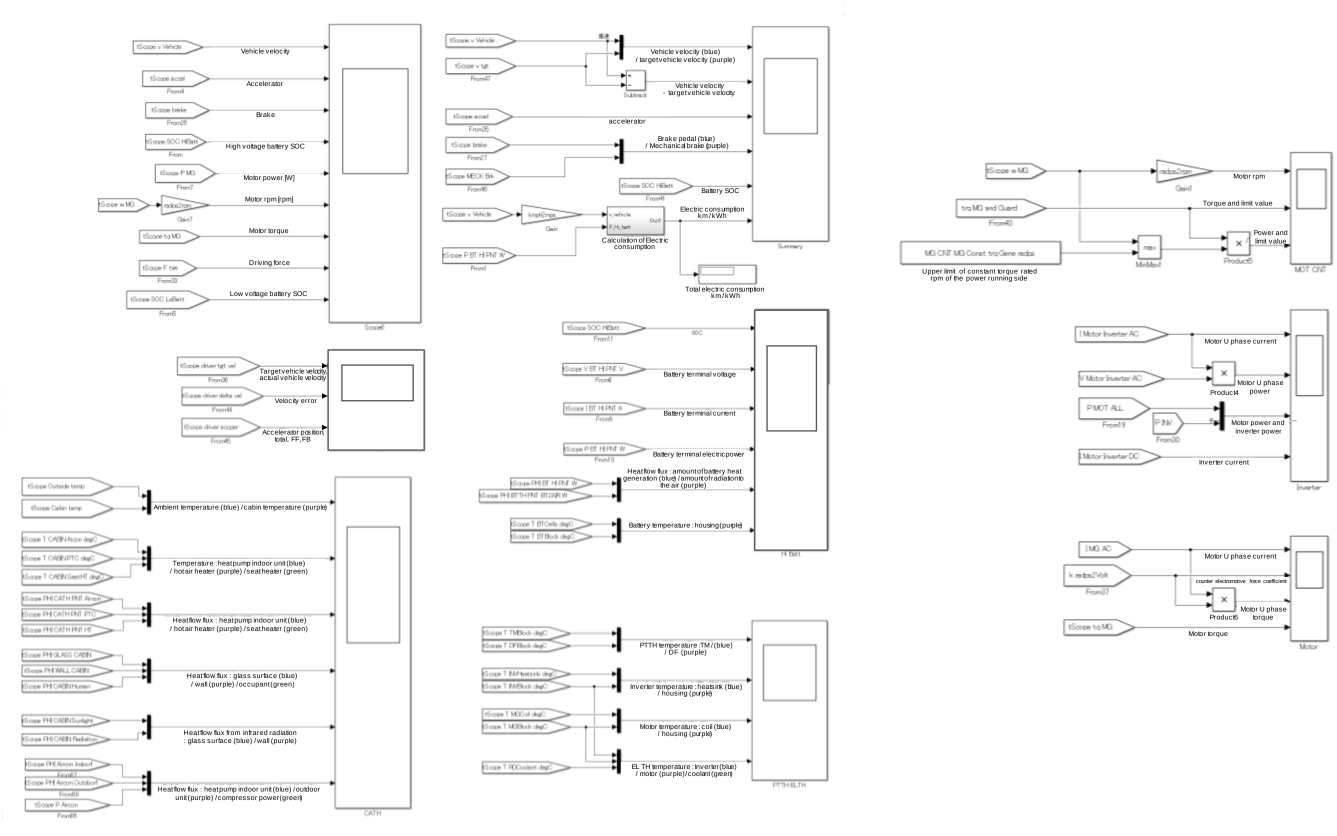


Fig. 4.2.4 Structure of second-layer monitor system

This system can monitor the signal calculated by the Driver, Vehicle and Enviroment systems.
This system has no lower system layer.

5. Functional specifications of guidelines-compatible model

5.1. Functional specification of first-layer model

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, WLTC). 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.
Set the driving environment of the vehicle for the thumb knob and the external environment.
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 guideline-compatible model is shown below.

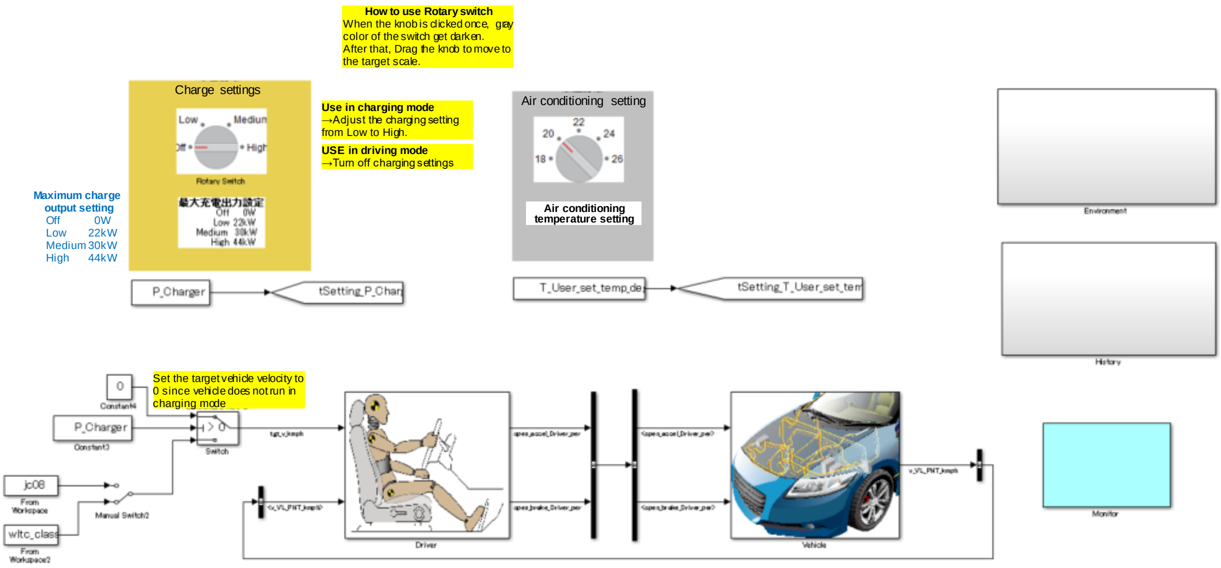


Fig. 5.1.2 Data flow diagram: first-layer (entire model)

5.1.3. Input/output specifications

The input/output specifications of the entire the guideline-compatible model is shown below.

Input			
Name	Unit	Area	Description
tgt_v_kmph	km/h	TBD	Target vehicle velocity
v_VL_PNT_kmph	km/h	TBD	Vehicle velocity(km/h)
Output			
Namea	Unit	Area	Description
v_VL_PNT_kmph	km/h	TBD	Vehicle velocity(km/h)

5.1.4. Parameter specification

Parameter specifications of the entire guideline-compatible model are shown below.

Variable name	Setting value	Unit	Description
ACC_D_Gain	0.0	-	D gain value for feedback control
ACC_I_Gain	0.0	-	I gain value for feedback control
ACC_P_Gain	10	-	P gain value for feedback control
BK_PNT_Pow_UL	20000	N	Braking force upper limit value
BK_PNT_ReGene_vel_limit_DN_kmph	0.5	km/h	Finishing velocity for stopping regenerative brake
BK_PNT_ReGene_vel_limit_UP_kmph	3	km/h	Starting velocity for stopping regenerative brake
BK_PNT_Tau_brake	0.15	s	Time constant for braking force
BT_PNT_Hi_C_pol_hi_batt	30	F	Polarization characteristics capacitor for high voltage battery
BT_PNT_Hi_Capa_hi_batt_F	115	Ah	High voltage battery capacity
BT_PNT_Hi_ocv_SOC_hi_batt_OCV_V_table	<1×10>	V	High voltage battery OCV table
BT_PNT_Hi_ocv_SOC_hi_batt_OCV_V_table_x_SOC	<1×10>	%	High voltage battery OCV table x-SOC
BT_PNT_Hi_R_hi_batt_cell	0.0096	Ω	Internal cell resistance value of high voltage battery
BT_PNT_Hi_R_pol_hi_batt	0.096	Ω	Polarization characteristics resistance for high voltage battery
BT_PNT_Hi_SOC_MAX_hi_batt	100	%	Maximum SOC value of high voltage battery
BT_PNT_Hi_SOC_MIN_hi_batt	0.0	%	Minimum SOC value of high voltage battery
BT_PNT_Hi_SOC_START_hi_batt	50	%	Initial SOC value of high voltage battery
BT_PNT_Lo_Capa_lo_batt_F	45	Ah	Low voltage battery capacity: GS YUASA 45Ah
BT_PNT_Lo_ocv_SOC_lo_batt_OCV_V_table	<1×2>	V	Low voltage battery OCV table
BT_PNT_Lo_ocv_SOC_lo_batt_OCV_V_table_x_SOC	<1×2>	%	Low voltage battery OCV table x-SOC
BT_PNT_Lo_R_lo_batt_ohm	0.01	Ω	Internal resistance value of low voltage battery
BT_PNT_Lo_SOC_MAX_lo_batt	120	%	Maximum SOC value of low voltage battery
BT_PNT_Lo_SOC_MIN_lo_batt	0.0	%	Minimum SOC value of low voltage battery
BT_PNT_Lo_SOC_START_lo_batt	95	%	Initial SOC value of low voltage battery
BTTH_CNT_P_BT_Heater_W	<1×4>	W	Target output map for battery heater
BTTH_CNT_P_BT_Heater_W_x_BTCells_degC	<1×4>	℃	Target output map for battery heater: x-battery Cell Temp
BTTH_CNT_Voltage_BTFan_V	<1×4>	V	Battery fan voltage map
BTTH_CNT_Voltage_BTFan_V_x_BTCells_degC	<1×4>	℃	Battery fan voltage map: x-Battery cell temp.
BTTH_PNT_BT_Heat_Resi_KpW	<1×3>	K/W	Thermal resistance map for battery cooling

Variable name	Setting value	Unit	Description
BTTH_PNT_BT_Heat_Resi_KpW_x_Wind_m3ps	<1×3>	m3/s	Thermal resistance map for battery cooling: x-Battery fan air flow
BTTH_PNT_BT_Heater_Heat_Capa_JpK	1060	J/K	Heat capacity of battery heater
BTTH_PNT_BT_Heater2BTCells_Heat_Resi_KpW	0.001	K/W	Thermal resistance value between battery heater and battery cell
BTTH_PNT_BTBlock_Heat_Capa_JpK	8800	J/K	Heat capacity of battery housing
BTTH_PNT_BTBlock2BTAir_Heat_Resi_KpW	0.005	K/W	Thermal resistance value between battery housing and external environment
BTTH_PNT_BTCells_Heat_Capa_JpK	300000	J/K	heat capacity of battery cell
BTTH_PNT_BTCells2BTBlock_Heat_Resi_KpW	0.02	K/W	Thermal resistance value between battery cell and battery housing
BTTH_PNT_v_BTFan_Wind_vel_mps	<1×3>	m/s	Wind velocity map of battery fan
BTTH_PNT_v_BTFan_Wind_vel_mps_x_V_BTFan	<1×3>	V	Wind velocity map of battery fan: x-Battery fan voltage
Brk_LL	0.0	N	Lower limit value of braking force
Brk_PGain	-5000	-	P gain value for braking force
Brk_UL	20000	N	Upper limit value of braking force
CATH_CNT_P_Aircon_W_LL	-3000	W	Lower compressor output limit for heat pump cooling
CATH_CNT_P_Aircon_W_UL	2000	W	Upper compressor output limit for heat pump heating
CATH_CNT_P_Gain_Aircon	200	-	P gain value from temp. difference to output for air conditioning
CATH_CNT_P_Gain_PTC_Heater	100	-	P gain value from temp. difference to output when temp over upper limit
CATH_CNT_P_Gain_SeatHT	100	-	P gain value from temp. difference to output for seat heater
CATH_CNT_P_PTC_Heater	<1×4>	W	Target output map of PTC heater for hot air blower
CATH_CNT_P_PTC_Heater_W_LL	0.0	W	Lower limit value of PTC heater output
CATH_CNT_P_PTC_Heater_W_UL	1000	W	Upper limit value of PTC heater output
CATH_CNT_P_PTC_Heater_x_T_Outside_temp_degC	<1×4>	℃	Target output map of PTC heater for hot air blower: x-ambient temp.
CATH_CNT_P_SeatHT_W_LL	0.0	W	Lower limit value of seat heater output
CATH_CNT_P_SeatHT_W_UL	500	W	Upper limit value of seat heater output
CATH_CNT_PGain_Temp_blowout	10.0	-	P gain value for blower air temp. control
CATH_CNT_T_Aircon_Indoor_degC	<1×6>	℃	Temperature control map for indoor unit of heat pump
CATH_CNT_T_Aircon_Indoor_degC_x_T_blowout_degC	<1×6>	℃	Temperature control map for indoor unit of heat pump: x-Temp.
CATH_CNT_T_PTC_Heater_degC_UL	80	℃	Upper limit value of PTC heater temp.
CATH_CNT_T_SeatHT_Temp_degC	<1×4>	℃	Target temp. map for sheet heater
CATH_CNT_T_SeatHT_Temp_degC_x_T_blowout_degC	<1×4>	℃	Target temp. map for sheet heater: x-Temperature
CATH_CNT_V_HVAC_Fan	<1×6>	m3/s	air flow map of blower fan for air conditioning
CATH_CNT_V_HVAC_Fan_x_T_blowout_degC	<1×6>	℃	Air flow map of blower fan for air conditioning: x-HVAC fan voltage
CATH_CNT_V_RDFan_V	<1×8>	V	Radiator fan voltage map
CATH_CNT_V_RDFan_x_P_Aircon_W	<1×8>	W	Radiator fan voltage map: x-heat pump power
CATH_PNT_Air_Convection_Heat_Resi_KpW	<1×13>	K/W	Thermal resistance map of thermal transfer by convection
CATH_PNT_Air_Convection_Heat_Resi_x_mps	<1×13>	m/s	Thermal resistance map of thermal transfer by convection: x- average air flow speed
CATH_PNT_Aircon_Indoor_Unit_Heat_Capa_JpK	4400	J/K	Heat capacity of indoor unit for air conditioners
CATH_PNT_Aircon_Outdoor_Unit_Heat_Capa_JpK	4400	J/K	Heat capacity of outdoor unit for air conditioners
CATH_PNT_CABIN_AIR_Heat_Capa_JpK	7037.976	J/K	Heat capacity of cabin space
CATH_PNT_CABIN_Glass_S_m2	4.0	m2	Glass area

Variable name	Setting value	Unit	Description
CATH_PNT_CABIN_SeatHT_Heat_Resi_KpW	0.01	K/W	Thermal resistance value between sheet heater and cabin space
CATH_PNT_CABIN_Wall_S_m2	10.0	m2	Opaque wall area
CATH_PNT_COP_Aircon	3.0	-	Performance coefficient of air conditioning
CATH_PNT_Glass_emissivity	0.3	-	Emissivity of glass
CATH_PNT_Glass_Heat_Capa_JpK	209.25e8	J/K	Heat capacity of window glass
CATH_PNT_Glass_Heat_Resi_m2KpW	0.005	m2K/W	Thermal resistance value of window glass area
CATH_PNT_HVAC_Heat_Resi_KpW	<1×4>	K/W	Thermal resistance map of the air conditioning heat exchanger
CATH_PNT_HVAC_Heat_Resi_KpW_x_Wind_m3ps	<1×4>	m3/s	Thermal resistance map of the air conditioning heat exchanger: x-air flow of HVAC fan
CATH_PNT_PHI_Human_body_W	140	W	Amount of heat generation from occupant (2 occupants)
CATH_PNT_PTC_Heater_Heat_Capa_JpK	1000	J/K	Heat capacity of PTC heater for air conditioner
CATH_PNT_Seat_Heater_Capa_JpK	100	J/K	Heat capacity of seat heater
CATH_PNT_v_HVAC_Fan_Wind_vel_m3ps	<1×3>	m3/s	air flow map of blower fan for air conditioning
CATH_PNT_v_HVAC_Fan_Wind_vel_m3ps_x_V_HVAC_Fan	<1×3>	V	Air flow map of blower fan for air conditioning: x-HVAC fan voltage
CATH_PNT_Wall_emissivity	0.5	-	Emissivity of the opaque wall
CATH_PNT_Wall_Heat_Capa_JpK	5231.25e7	J/K	Heat capacity of opaque wall
CATH_PNT_Wall_Heat_Resi_m2KpW	1.00	m2K/W	Thermal resistance value of window glass area
CATH_PNT_Wall_Radiation_W	0.0	W	Radiation (infrared re-radiation) heat amount from opaque wall
CHG_CNT_charge_current_rate_LL	-20	A/s	Lower limit value of charging current increase rate
CHG_CNT_charge_current_rate_UL	20	A/s	Upper limit value of charging current increase rate
CHG_CNT_charge_UL_SOC	100	%	Charging stop SOC
CHG_CNT_Initial_Charge_Current_A	0.5	A	Initial charging current
CHG_CNT_Maximum_Charge_Current_A	125	A	Upper limit value of charger current
CHG_CNT_Maximum_Charge_Power_W	44000	W	Upper limit value of charger output
CHG_CNT_Maximum_Charge_Voltage_V	500	V	Upper limit value of charger voltage
CHG_CNT_SOC_Adapt_Charge_Current_A	<1×14>	A	Charging map current
CHG_CNT_SOC_Adapt_Charge_Current_x_SOC	<1×14>	%	Charging map: x-SOC
CHG_PNT_Charger_cable_R	0.0046	Ω	Resistance value of charging cable
CHG_PNT_Charger_internal_R	0.005	Ω	Internal resistance value of the charger
DCDC_PNT_eta_conv_lo	0.95	-	Buck converter efficiency
DCDC_PNT_R_conv_lo	0.02	Ω	Resistance value of buck converter
DCDC_PNT_Vtgt_conv_lo	14.0	V	Target voltage for buck converter
DF_PNT_DF_gear	3.25	-	Reduction gear ratio of differential gear
DF_PNT_Driveshaft_damper	252.982	Nm/(rad/s)	Damping coefficient for drive shaft
DF_PNT_Driveshaft_spring	10000	Nm/rad	Drive shaft spring coefficient
DF_PNT_eta_DF	0.96	-	Differential gear efficiency
Driver_Brake_Const1	5	%	Brake stopping position during the acceleration (when the target vehicle velocity is positive)
Driver_Brake_Const3	0.0	%	Brake stepping position during the acceleration (when the target vehicle velocity is positive)
Driver_Brake_Switch_Const2	0.1	km/h	Stopping detection during driver brake model
Driver_Brk_offset	0.5	km/h	Offset value of velocity error without braking
Driver_Brk_sh	0.01	km/h/s	Acceleration detection value
EL_PNT_R_bodyelec_lo	14/30	V/A	Electrical load resistance at low voltage side
ELTH_CNT_V_RDFan_V	<1×6>	V	Radiator fan voltage map

Variable name	Setting value	Unit	Description
ELTH_CNT_V_RDFan_x_T_Coolant	<1×6>	℃	Radiator fan voltage map: x-coolant temp.
ELTH_CNT_V_Water_Pump_V	<1×6>	V	Water pump voltage map
ELTH_CNT_V_Water_Pump_x_T_Coolant	<1×6>	℃	Water pump voltage map: x-temp. of coolant
ELTH_PNT_INV2Coolant_Heat_Resi_KpW	<1×4>	K/W	Thermal resistance map between inverter heat sink and coolant
ELTH_PNT_INV2Coolant_Heat_Resi_x_qv_Coolant	<1×4>	m3/s	Thermal resistance map between inverter heat sink and coolant: x-coolant flow
ELTH_PNT_INVBlock_Heat_Capa_JpK	1000	J/K	Heat capacity of inverter housing
ELTH_PNT_INVBlock2DFAir_Heat_Resi_KpW	10.0	K/W	Thermal resistance value between inverter housing and external environment
ELTH_PNT_INVHeatsink_Heat_Capa_JpK	1000	J/K	Heat capacity of inverter heat sink
ELTH_PNT_INVHeatsink2INVBlock_Heat_Resi_KpW	1.0	K/W	Thermal resistance value between inverter heat sink and DF block
ELTH_PNT_MG2Coolant_Heat_Resi_KpW	<1×4>	K/W	Thermal resistance map between motor housing and coolant
ELTH_PNT_MG2Coolant_Heat_Resi_x_qv_Coolant	<1×4>	m3/s	Thermal resistance map between motor housing and coolant: x-coolant flow
ELTH_PNT_MG2INVBlock_Heat_Resi_KpW	1.0	K/W	Thermal resistance value between motor housing and inverter housing
ELTH_PNT_MGCoil_Heat_Capa_JpK	10600	J/K	Heat capacity of MG coil
ELTH_PNT_MGCoil2MGHousing_Heat_Resi_KpW	0.001	K/W	Thermal resistance value between MG coil to MG housing
ELTH_PNT_MGHousing_Heat_Capa_JpK	10000	J/K	Heat capacity of T/M block
ELTH_PNT_MGHousing2TMAir_Heat_Resi_KpW	1.0	K/W	Thermal resistance value between T/M block and external environment
ELTH_PNT_PTTH2MGHousing_Heat_Resi_KpW	1.0	K/W	Thermal resistance value between PTTH and MG housings
ELTH_PNT_Qv_Water_Pump_m3ps	<1×5>	m3/s	Coolant flow map for water pump
ELTH_PNT_Qv_Water_Pump_x_V_WP	<1×5>	V	Coolant flow map for water pump: x-voltage
ELTH_PNT_RDCoolant_Heat_Capa_JpK	54000	J/K	Heat capacity of coolant in radiator
ELTH_PNT_RDCore_Heat_Resi_KpW	<1×6>	K/W	Thermal resistance map between the radiator and the external environment
ELTH_PNT_RDCore_Heat_Resi_KpW_x_Wind_m3ps	<1×6>	m3/s	Thermal resistance map between the radiator and the external environment: x- radiator air flow
ELTH_PNT_RDFan_area_m2	0.25	m2	Radiator fan area
ELTH_PNT_RDGrill_area_m2	0.20	m2	Radiator grill area
ELTH_PNT_v_RDFan_Wind_vel_mps	<1×2>	m/s	Voltage - air flow characteristics map of radiator fan
ELTH_PNT_v_RDFan_Wind_vel_mps_x_V_RDFan	<1×2>	V	Voltage - air flow characteristics map of radiator fan: x-radiator fan voltage
ENV_PNT_PTTH_Temp_add_degC	0.0	℃	Initial temp. difference between power sysytem and outside ambient temp.
ENV_PNT_CABIN_Temp_add_degC	0.0	℃	Initial temp. difference between cabin and outside ambient temp.
ENV_PNT_PHI_Sunlight_W	0.0	W	Heat flow from direct sunlight
ENV_PNT_Outside_Temp_ini_degC	40.0	℃	Initial ambient temp.
I_Gain_CV_Charge	0.0	-	I gain value of charging current
MG_CNT_MG_Const_trq_Gene_radps	343.75	rad/s	Constant torque rpm on power running side
MG_CNT_MG_Const_trq_ReGene_radps	262.295	rad/s	Rated rpm at regenerative side
MG_CNT_Pmax_MG_Gene_W	110e3	W	Rated output at power running side
MG_CNT_Pmin_MG_ReGene_W	-80e3	W	Rated output of regenerative side
MG_PNT_eta_MG	0.92	-	Motor efficiency
MG_PNT_eta_MG_Inv	0.97	-	Inverter efficiency
MG_PNT_MG_mod_factor	0.707	-	Inverter modulation rate
MG_PNT_MG_Power_factor	0.85	-	Motor power factor

Variable name	Setting value	Unit	Description
MG_PNT_MG_WeakField_LL	0.05	-	Lower limit value of the field weakening ratio
MG_PNT_MG_WeakField_UL	1.0	-	Upper limit value of the field weakening ratio
MG_PNT_V_MG_Rated	351	Ω	Line resistance U-phase of motor
MG_PNT_w_ROT_MG_Rated	343.75	rad/s	Rated rpm. of motor
P_Gain_CV_Charge	5.0	-	P gain value for charge output
PTTH_PNT_DFBlock_Heat_Capa_JpK	10000	J/K	Heat capacity of DF block
PTTH_PNT_DFBlock2DFAir_Heat_Resi_KpW	0.3	K/W	Thermal resistance value between DF block and external environment
PTTH_PNT_DFOil_Heat_Capa_JpK	10000	J/K	Heat capacity of DF oil
PTTH_PNT_DFOil2DFBlock_Heat_Resi_KpW	0.01	K/W	Thermal resistance value between DF oil and DF block
PTTH_PNT_TF_Heat_Capa_JpK	10600	J/K	Heat capacity of TF
PTTH_PNT_TF2TMBlock_Heat_Resi_KpW	0.001	K/W	Thermal resistance value between TF and T/M block
PTTH_PNT_TMBlock_Heat_Capa_JpK	10000	J/K	Heat capacity of T/M block
PTTH_PNT_TMBlock2DFBlock_Heat_Resi_KpW	0.03	K/W	Thermal resistance value between TM block and DF block
PTTH_PNT_TMBlock2TMAir_Heat_Resi_KpW	0.3	K/W	Thermal resistance value between T/M block and external environment
sigma_Stefan_Boltzmann	5.67e-8	W/m2K4	Stefan-Boltzmann constant
TM_PNT_eta_MG2_gear	0.97	-	Primary deceleration efficiency of generator
TM_PNT_ratio_MG2_gear	2.52	-	Transmission gear ratio
TM_PNT_TM_Inertia	0.3	kgm2	Transmission inertia
VCU_CNT_Cooperative_Control_Brake_flag	0	W	Regeneration cooperative contoroｌ is active in 1.
VCU_CNT_PSoFin_battpw	<1×4>	W	Charging power map
VCU_CNT_PSoFin_soc	<1×4>	%	Charging power map: x-SOC
VCU_CNT_PSoFout_battpw	<1×4>	W	Discharging power map
VCU_CNT_PSoFout_soc	<1×4>	%	Discharging power map: x-SOC
VCU_CNT_trq_req_brak_th	0.0001	N	Brake threshold for vehicle stopping detection
VCU_CNT_trq_req_delaytime	0.2	s	time constants of 1st order lag for Gain value
VCU_CNT_trq_req_Gain_OFF	0.001	-	Required driving torque gain value for vehicle stopping detection
VCU_CNT_trq_req_Gain_ON	1	-	Required drivie torque gain value for driving ditection
VCU_CNT_trq_req_v_vehicle_th	1	km/h	Vehicle velocity threshold for vehicle stopping detection
VCU_CNT_trq_require_accper	<1×8>	%	Required driving force estimation map: x-accelerator position
VCU_CNT_trq_require_Nm	<8×21>	Nm	Required driving force estimation map
VCU_CNT_trq_require_v_kmph	<21×1>	km/h	Required driving force estimation map: y-vehicle velocity
VCU_CNT_w_mot_limit_gain	200000	-	Torque limit gain value when the motor rpm reach upper limit
VCU_CNT_w_mot_limit_rpm	10000	rpm	Upper limit value of motor rpm
VEHICLE_CNT_ACCper_LL	0.0	%	Lower limit value of accelerator position
VEHICLE_CNT_ACCper_UL	100	%	Upper limit value of accelerator position
A	2.2	m2	Frontal projected area
Cd	0.27	-	Air resistance coefficient
deg2rad	pi/180	-	Degree→rad
degC2K	273.15	-	℃→K
g	9.8	m/s2	gravity acceleration
h2sec	3600	-	Hour -> sec
jc08	<12041×2>	km/h	Target vehicle velocity（JC08）
K2degC	-273.15	-	K→℃
kmph2mps	1000/3600	-	Km/h → m/s

Variable name	Setting value	Unit	Description
M	1630	kg	Weight of vehicle: weight of vehicle + weight of occupant
mps2kmph	3.6	-	m/s → km/h
mps2kmps	1/1000	-	m/s -> km/s
mujigen2percent	100	-	non-dimension →%
myu	7.161e-3	-	Rolling resistance coefficient A rank: 7.8≦RRC ≦9.0
num_tws_mabiki	10	-	Thinning number from effect toWorkspace
P_Charger	0.0	W	Maximum charging power of the charger
percent2mujigen	0.01	-	%→non-dimensionless
radps2rpm	60/(2*pi)	-	Rad/sec → rpm
rou	1.205	kg/m3	Air density
sampling_time	2.5e-3	s	Sampling period
T_User_set_temp_degC	20	℃	Air-conditioning temp.
tire_r	0.3162	m	Tire radius [m] 205/55R16
wltc_class3b	<18001×2>	km/h	Target vehicle velocity（WLTC）

※ Colored parameters are common to all systems.

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 specifications of the second-layer driver system in the guidelines-compatible model are described.

5.2.1.1 Abstract

The abstract of this system is shown below.

① Modelized object
Driver model

② Modelized level
Accelerator and brake operations required for mode-driving patterns (JC08, WLTC)

③ Modelized function
The function to calculate the amount of accelerator operation
The function to calculate the amount of brake operation

5.2.1.2 Data flow diagram

The data flow diagram of this system is shown below.

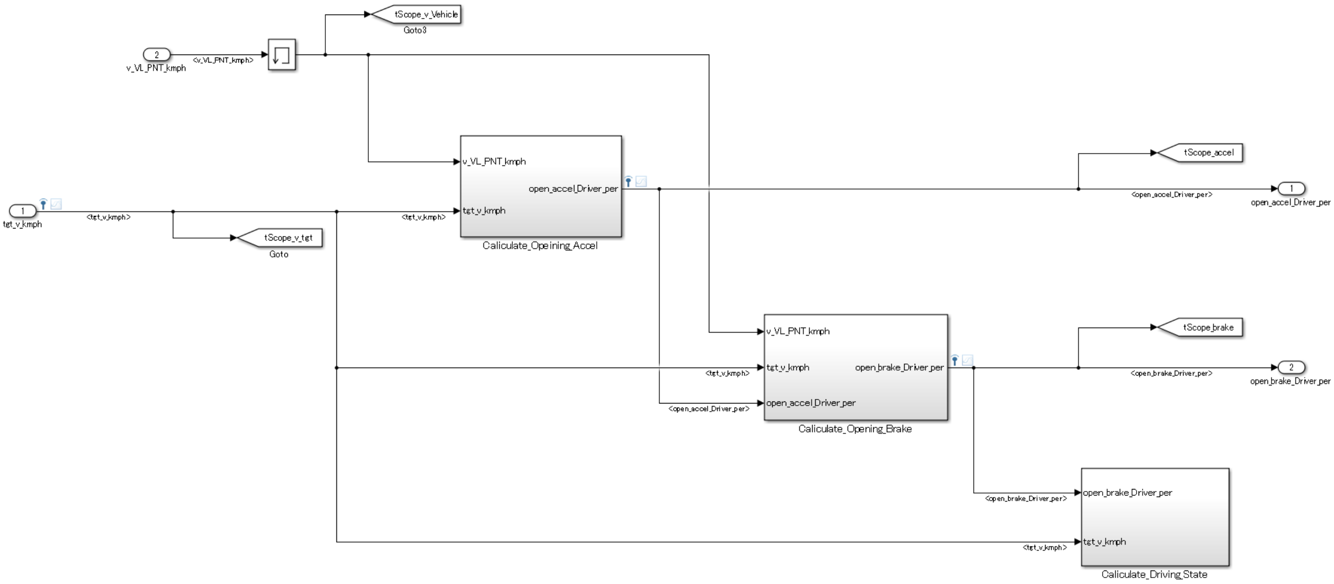


Fig. 5.2.1.2 Data flow diagram: second-layer driver system

5.2.1.3 Input/output specification

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

Input			
Name	Unit	Area	Description
tgt_v_kmph	km/h	TBD	Target vehicle velocity
v_VL_PNT_kmph	km/h	TBD	Vehicle velocity(km/h)
Output			
Name	Unit	Area	Description
open_accel_Driver_per	%	[0 100]	Accelerator position(input)
open_brake_Driver_per	%	[0 100]	Brake opening ratio

5.2.1.4 Parameter specification

The parameter specification of this system is shown below.

Variable name	Setting value	Unit	Description
ACC_D_Gain	0.0	-	D gain value for feedback control
ACC_I_Gain	0.0	-	I gain value for feedback control
ACC_P_Gain	10	-	P gain value for feedback control
Brk_LL	0.0	N	Lower limit value of braking force
Brk_PGain	-5000	-	P gain value for braking force
Brk_UL	20000	N	Upper limit value of braking force
DF_PNT_DF_gear	3.25	-	Reduction gear ratio of differential gear
DF_PNT_eta_DF	0.96	-	Differential gear efficiency
Driver_Brake_Const1	5	%	Brake stopping position during the acceleration (when the target vehicle velocity is positive)
Driver_Brake_Const3	0.0	%	Brake stepping position during the acceleration (when the target vehicle velocity is positive)
Driver_Brake_Switch_Const2	0.1	km/h	Stopping detection during driver brake model
Driver_Brk_offset	0.5	km/h	Offset value of velocity error without braking
Driver_Brk_sh	0.01	km/h/s	Acceleration detection value
TM_PNT_eta_MG2_gear	0.97	-	Primary deceleration efficiency of generator
TM_PNT_ratio_MG2_gear	2.52	-	Transmission gear ratio
VCU_CNT_trq_require_accper	<1×8>	%	Required driving force estimation map: x-accelerator position
VCU_CNT_trq_require_Nm	<8×21>	Nm	Required driving force estimation map
VCU_CNT_trq_require_v_kmph	<1×21>	km/h	Required driving force estimation map: y-vehicle velocity
VEHICLE_CNT_ACCper_LL	0.0	%	Lower limit value of accelerator position
VEHICLE_CNT_ACCper_UL	100	%	Upper limit value of accelerator position

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 in the guidelines-compatible model are described.

5.2.2.1 Abstract

The abstract of this system is shown below.

① Modelized object
Vehicle model

② Modelized level
Calculate power consumption by acceleration / deceleration when driving in mode
Temperature control by air conditioning and Calculate power consumption
Calculate the amount of heat generation and temperature of power train
Calculate the amount of heat generation and temperature of power electronics

③ Modelized function
The function to accelerate and decelerate by driver's accelerator and brake operation
The function to calculate the temperature in mode driving
The function to calculate the amount of heat generation in mode driving
The function to calculate current consumption in mode running

5.2.2.2 Data flow diagram

The data flow diagram of this system is shown below.

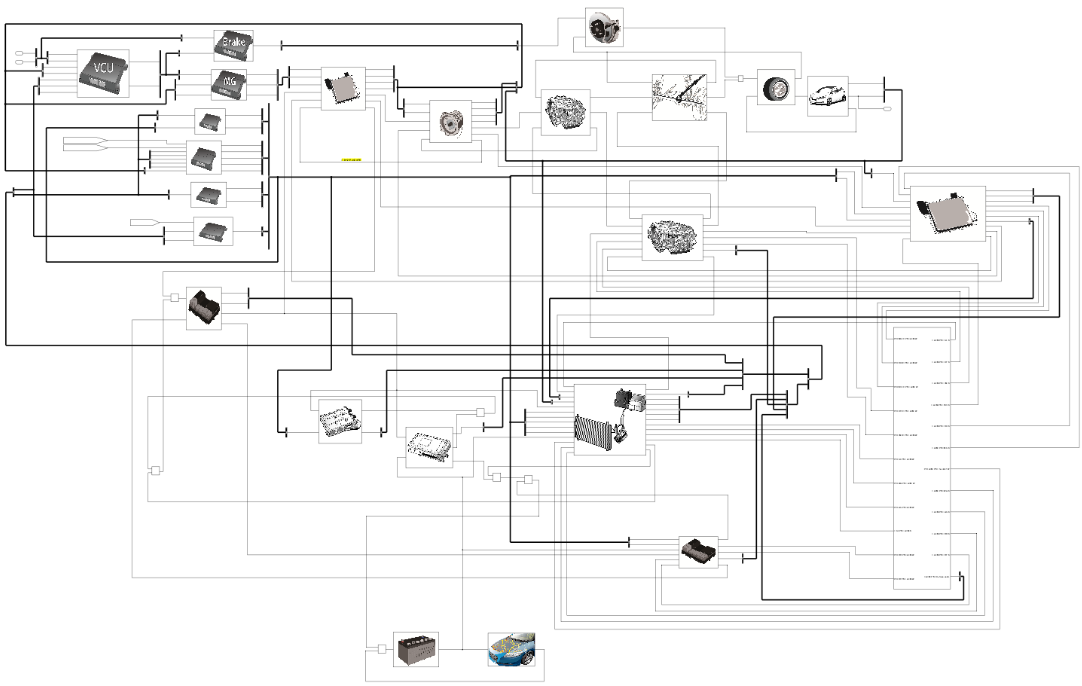


Fig. 5.2.2.2 Data flow diagram: second-layer vehicle system

5.2.2.3 Input/output specification

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

Input			
Name	Unit	Area	Description
Open_accel_Driver_per	%	[0 100]	Accelerator position(input)
Open_brake_Driver_per	%	[0 100]	Brake opening ratio
Output			
Name	Unit	Area	Description
v_VL_PNT_kmph	Km/h	TBD	Vehicle velocity(km/h

5.2.2.4 Parameter specification

The parameter specification of this system is shown belo

Variable name	Setting value	Unit	Description
BK_PNT_Pow_UL	20000	N	Braking force upper limit value
BK_PNT_ReGene_vel_limit_DN_kmph	0.5	km/h	Finishing velocity for stopping regenerative brake
BK_PNT_ReGene_vel_limit_UP_kmph	3	km/h	Starting velocity for stopping regenerative brake
BK_PNT_Tau_brake	0.15	s	Time constant for braking force
BT_PNT_Hi_C_pol_hi_batt	30	F	Polarization characteristics capacitor for high voltage battery
BT_PNT_Hi_Capa_hi_batt_F	115	Ah	High voltage battery capacity
BT_PNT_Hi_ocv_SOC_hi_batt_OCV_V_table	<1×10>	V	High voltage battery OCV table
BT_PNT_Hi_ocv_SOC_hi_batt_OCV_V_table_x_SOC	<1×10>	-	High voltage battery OCV table x-SOC
BT_PNT_Hi_R_hi_batt_cell	0.0096	Ω	Internal cell resistance value of high voltage battery
BT_PNT_Hi_R_pol_hi_batt	0.096	Ω	Polarization characteristics resistance for high voltage battery
BT_PNT_Hi_SOC_MAX_hi_batt	100	%	Maximum SOC value of high voltage battery
BT_PNT_Hi_SOC_MIN_hi_batt	0.0	%	Minimum SOC value of high voltage battery
BT_PNT_Hi_SOC_START_hi_batt	50	%	Initial SOC value of high voltage battery
BT_PNT_Lo_Capa_lo_batt_F	45	Ah	Low voltage battery capacity: GS YUASA 45Ah
BT_PNT_Lo_ocv_SOC_lo_batt_OCV_V_table	<1×2>	V	Low voltage battery OCV table
BT_PNT_Lo_ocv_SOC_lo_batt_OCV_V_table_x_SOC	<1×2>	%	Low voltage battery OCV table x-SOC
BT_PNT_Lo_R_lo_batt_ohm	0.01	Ω	Internal resistance value of low voltage battery
BT_PNT_Lo_SOC_MAX_lo_batt	120	%	Maximum SOC value of low voltage battery
BT_PNT_Lo_SOC_MIN_lo_batt	0.0	%	Minimum SOC value of low voltage battery
BT_PNT_Lo_SOC_START_lo_batt	95	%	Initial SOC value of low voltage battery
BTTH_CNT_P_BT_Heater_W	<1×4>	W	Target output map for battery heater
BTTH_CNT_P_BT_Heater_W_x_BTCells_degC	<1×4>	℃	Target output map for battery heater: x-battery Cell Temp
BTTH_CNT_Voltage_BTFan_V	<1×4>	V	Battery fan voltage map
BTTH_CNT_Voltage_BTFan_V_x_BTCells_degC	<1×4>	℃	Battery fan voltage map: x-Battery cell temp.
BTTH_PNT_BT_Heat_Resi_KpW	<1×3>	K/W	Thermal resistance map for battery cooling
BTTH_PNT_BT_Heat_Resi_KpW_x_Wind_m3ps	<1×3>	m3/s	Thermal resistance map for battery cooling: x-Battery fan air flow
BTTH_PNT_BT_Heater_Heat_Capa_JpK	1060	J/K	Heat capacity of battery heater
BTTH_PNT_BTBlock_Heat_Capa_JpK	8800	J/K	Heat capacity of battery housing
BTTH_PNT_BTBlock2BTAir_Heat_Resi_KpW	0.005	K/W	Thermal resistance value between battery housing and external environment
BTTH_PNT_BTCells_Heat_Capa_JpK	300000	J/K	heat capacity of battery cell
BTTH_PNT_BTCells2BTBlock_Heat_Resi_KpW	0.02	K/W	Thermal resistance value between battery cell and battery housing
BTTH_PNT_v_BTFan_Wind_vel_mps	<1×3>	m/s	Wind velocity map of battery fan
BTTH_PNT_v_BTFan_Wind_vel_mps_x_V_BTFan	<1×3>	V	Wind velocity map of battery fan: x-Battery fan voltage
CATH_CNT_P_Aircon_W_LL	-3000	W	Lower compressor output limit for heat pump cooling
CATH_CNT_P_Aircon_W_UL	2000	W	Upper compressor output limit for heat pump heating
CATH_CNT_P_Gain_Aircon	200	-	P gain value from temp. difference to output for air conditioning

Variable name	Setting value	Unit	Description
CATH_CNT_P_Gain_PTC_Heater	100	-	P gain value from temp. difference to output when temp over upper limit
CATH_CNT_P_Gain_SeatHT	100	-	P gain value from temp. difference to output for seat heater
CATH_CNT_P_PTC_Heater	<1×4>	W	Target output map of PTC heater for hot air blower
CATH_CNT_P_PTC_Heater_W_LL	0.0	W	Lower limit value of PTC heater output
CATH_CNT_P_PTC_Heater_W_UL	1000	W	Upper limit value of PTC heater output
CATH_CNT_P_PTC_Heater_x_T_Outside_temp_degC	<1×4>	℃	Target output map of PTC heater for hot air blower: x-ambient temp.
CATH_CNT_P_SeatHT_W_LL	0.0	W	Lower limit value of seat heater output
CATH_CNT_P_SeatHT_W_UL	500	W	Upper limit value of seat heater output
CATH_CNT_PGain_Temp_blowout	10.0	-	P gain value for blower air temp. control
CATH_CNT_T_Aircon_Indoor_degC	<1×6>	℃	Temperature control map for indoor unit of heat pump
CATH_CNT_T_Aircon_Indoor_degC_x_T_blowout_degC	<1×6>	℃	Temperature control map for indoor unit of heat pump: x-Temp.
CATH_CNT_T_PTC_Heater_degC_UL	80	℃	Upper limit value of PTC heater temp.
CATH_CNT_T_SeatHT_Temp_degC	<1×4>	℃	Target temp. map for sheet heater
CATH_CNT_T_SeatHT_Temp_degC_x_T_blowout_degC	<1×4>	℃	Target temp. map for sheet heater: x-Temperature
CATH_CNT_V_HVAC_Fan	<1×6>	m3/s	air flow map of blower fan for air conditioning
CATH_CNT_V_HVAC_Fan_x_T_blowout_degC	<1×6>	℃	Air flow map of blower fan for air conditioning: x-Temp.
CATH_CNT_V_RDFan_V	<1×8>	V	Radiator fan voltage map
CATH_CNT_V_RDFan_x_P_Aircon_W	<1×8>	W	Radiator fan voltage map: x-heat pump power
CATH_PNT_Air_Convection_Heat_Resi_KpW	<1×13>	K/W	Thermal resistance map of thermal transfer by convection
CATH_PNT_Air_Convection_Heat_Resi_x_mps	<1×13>	m/s	Thermal resistance map of thermal transfer by convection: x- average air flow speed
CATH_PNT_Aircon_Indoor_Unit_Heat_Capa_JpK	4400	J/K	Heat capacity of indoor unit for air conditioners
CATH_PNT_Aircon_Outdoor_Unit_Heat_Capa_JpK	4400	J/K	Heat capacity of outdoor unit for air conditioners
CATH_PNT_CABIN_AIR_Heat_Capa_JpK	7037.976	J/K	Heat capacity of cabin space
CATH_PNT_CABIN_Glass_S_m2	4.0	m2	Glass area
CATH_PNT_CABIN_SeatHT_Heat_Resi_KpW	0.01	K/W	Thermal resistance value between sheet heater and cabin space
CATH_PNT_CABIN_Wall_S_m2	10.0	m2	Opaque wall area
CATH_PNT_COP_Aircon	3.0	-	Performance coefficient of air conditioning
CATH_PNT_Glass_emissivity	0.3	-	Emissivity of glass
CATH_PNT_Glass_Heat_Capa_JpK	209.25e8	J/K	Heat capacity of window glass
CATH_PNT_Glass_Heat_Resi_m2KpW	0.005	m2K/W	Thermal resistance value of window glass area
CATH_PNT_HVAC_Heat_Resi_KpW	<1×4>	K/W	Thermal resistance map of the air conditioning heat exchanger
CATH_PNT_HVAC_Heat_Resi_KpW_x_Wind_m3ps	<1×4>	m3/s	Thermal resistance map of the air conditioning heat exchanger: x-air flow of HVAC fan
CATH_PNT_PHI_Human_body_W	140	W	Amount of heat generation from occupant (2 occupants)
CATH_PNT_PTC_Heater_Heat_Capa_JpK	1000	J/K	Heat capacity of PTC heater for air conditioner
CATH_PNT_Seat_Heater_Capa_JpK	100	J/K	Heat capacity of seat heater
CATH_PNT_v_HVAC_Fan_Wind_vel_m3ps	<1×3>	m3/s	air flow map of blower fan for air conditioning
CATH_PNT_v_HVAC_Fan_Wind_vel_m3ps_x_V_HVAC_Fan	<1×3>	V	Air flow map of blower fan for air conditioning: x-HVAC fan voltage
CATH_PNT_Wall_emissivity	0.5	-	Emissivity of the opaque wall
CATH_PNT_Wall_Heat_Capa_JpK	5231.25e7	J/K	Heat capacity of opaque wall
CATH_PNT_Wall_Heat_Resi_m2KpW	1	m2K/W	Thermal resistance value of window glass area
CATH_PNT_Wall_Radiation_W	0.0	W	Radiation (infrared re-radiation) heat amount from opaque wall
CHG_CNT_charge_current_rate_LL	-20	A/s	Lower limit value of charging current increase rate
CHG_CNT_charge_current_rate_UL	20	A/s	Upper limit value of charging current increase rate
CHG_CNT_charge_UL_SOC	100	%	Charging stop SOC
CHG_CNT_Initial_Charge_Current_A	0.5	A	Initial charging current
CHG_CNT_Maximum_Charge_Current_A	125	A	Upper limit value of charger current
CHG_CNT_Maximum_Charge_Power_W	44000	W	Upper limit value of charger output

Variable name	Setting value	Unit	Description
CHG_CNT_Maximum_Charge_Voltage_V	500	V	Upper limit value of charger voltage
CHG_CNT_SOC_Adapt_Charge_Current_A	<1×14>	A	Charging map current
CHG_CNT_SOC_Adapt_Charge_Current_x_SOC	<1×14>	%	Charging map: x-SOC
CHG_PNT_Charger_cable_R	0.0046	Ω	Resistance value of charging cable
CHG_PNT_Charger_internal_R	0.0050	Ω	Internal resistance value of the charger
DCDC_PNT_eta_conv_lo	0.95	-	Buck converter efficiency
DCDC_PNT_R_conv_lo	0.02	Ω	Resistance value of buck converter
DCDC_PNT_Vtgt_conv_lo	14.0	V	Target voltage for buck converter
DF_PNT_DF_gear	3.25	-	Reduction gear ratio of differential gear
DF_PNT_Driveshaft_damper	252.982	Nm/(rad/s)	Damping coefficient for drive shaft
DF_PNT_Driveshaft_spring	10000	Nm/rad	Drive shaft spring coefficient
DF_PNT_eta_DF	0.96	-	Differential gear efficiency
EL_PNT_R_bodyelec_lo	14/30	V/A	Electrical load resistance at low voltage side
ELTH_CNT_V_RDFan_V	<1×6>	V	Radiator fan voltage map
ELTH_CNT_V_RDFan_x_T_Coolant	<1×6>	℃	Radiator fan voltage map: x-coolant temp.
ELTH_CNT_V_Water_Pump_V	<1×6>	V	Water pump voltage map
ELTH_CNT_V_Water_Pump_x_T_Coolant	<1×6>	℃	Water pump voltage map: x-temp. of coolant
ELTH_PNT_INV2Coolant_Heat_Resi_KpW	<1×4>	K/W	Thermal resistance map between inverter heat sink and coolant
ELTH_PNT_INV2Coolant_Heat_Resi_x_qv_Coolant	<1×4>	m3/s	Thermal resistance map between inverter heat sink and coolant: x-coolant flow
ELTH_PNT_INVBlock_Heat_Capa_JpK	1000	J/K	Heat capacity of inverter housing
ELTH_PNT_INVBlock2DFAir_Heat_Resi_KpW	10.0	K/W	Thermal resistance value between inverter housing and external environment
ELTH_PNT_INVHeatsink_Heat_Capa_JpK	1000	J/K	Heat capacity of inverter heat sink
ELTH_PNT_INVHeatsink2INVBlock_Heat_Resi_KpW	1.0	K/W	Thermal resistance value between inverter heat sink and DF block
ELTH_PNT_MG2Coolant_Heat_Resi_KpW	<1×4>	K/W	Thermal resistance map between motor housing and coolant
ELTH_PNT_MG2Coolant_Heat_Resi_x_qv_Coolant	<1×4>	m3/s	Thermal resistance map between motor housing and coolant: x-coolant flow
ELTH_PNT_MG2INVBlock_Heat_Resi_KpW	1.0	K/W	Thermal resistance value between motor housing and inverter housing
ELTH_PNT_MGCoil_Heat_Capa_JpK	10600	J/K	Heat capacity of MG coil
ELTH_PNT_MGCoil2MGHousing_Heat_Resi_KpW	0.001	K/W	Thermal resistance value between MG coil to MG housing
ELTH_PNT_MGHousing_Heat_Capa_JpK	10000	J/K	Heat capacity of T/M block
ELTH_PNT_MGHousing2TMAir_Heat_Resi_KpW	1.0	K/W	Thermal resistance value between T/M block and external environment
ELTH_PNT_PTTH2MGHousing_Heat_Resi_KpW	1.0	K/W	Thermal resistance value between PTTH and MG housings
ELTH_PNT_Qv_Water_Pump_m3ps	<1×5>	m3/s	Coolant flow map for water pump
ELTH_PNT_Qv_Water_Pump_x_V_WP	<1×5>	V	Coolant flow map for water pump: x-voltage
ELTH_PNT_RDCoolant_Heat_Capa_JpK	54000	J/K	Heat capacity of coolant in radiator
ELTH_PNT_RDCore_Heat_Resi_KpW	<1×6>	K/W	Thermal resistance map between the radiator and the external environment
ELTH_PNT_RDCore_Heat_Resi_KpW_x_Wind_m3ps	<1×6>	m3/s	Thermal resistance map between the radiator and the external environment: x- radiator air flow
ELTH_PNT_RDFan_area_m2	0.25	m2	Radiator fan area
ELTH_PNT_RDGrill_area_m2	0.20	m2	Radiator grill area
ELTH_PNT_v_RDFan_Wind_vel_mps	<1×2>	m/s	Voltage - air flow characteristics map of radiator fan
ELTH_PNT_v_RDFan_Wind_vel_mps_x_V_RDFan	<1×2>	V	Voltage - air flow characteristics map of radiator fan: x-radiator fan voltage
I_Gain_CV_Charge	0.0	-	I gain value of charging current
MG_CNT_MG_Const_trq_Gene_radps	343.75	rad/s	Constant torque rpm on power running side
MG_CNT_MG_Const_trq_ReGene_radps	262.295	rad/s	Rated rpm at regenerative side
MG_CNT_Pmax_MG_Gene_W	110000	W	Rated output at power running side
MG_CNT_Pmin_MG_ReGene_W	-80000	W	Rated output of regenerative side
MG_PNT_eta_MG	0.92	-	Motor efficiency
MG_PNT_eta_MG_Inv	0.97	-	Inverter efficiency
MG_PNT_MG_mod_factor	0.707	-	Inverter modulation rate
MG_PNT_MG_Power_factor	0.85	-	Motor power factor
MG_PNT_MG_WeakField_LL	0.05	-	Lower limit value of the field weakening ratio
MG_PNT_MG_WeakField_UL	1.0	-	Upper limit value of the field weakening ratio

Variable name	Setting value	Unit	Description
MG_PNT_V_MG_Rated	351	Ω	Line resistance U-phase of motor
MG_PNT_w_ROT_MG_Rated	343.75	rad/s	Rated rpm. of motor
P_Gain_CV_Charge	5.0	-	P gain value for charge output
PTTH_PNT_DFBlock_Heat_Capa_JpK	10000	J/K	Heat capacity of DF block
PTTH_PNT_DFBlock2DFAir_Heat_Resi_KpW	0.3	K/W	Thermal resistance value between DF block and external environment
PTTH_PNT_DFOil_Heat_Capa_JpK	10000	J/K	Heat capacity of DF oil
PTTH_PNT_DFOil2DFBlock_Heat_Resi_KpW	0.01	K/W	Thermal resistance value between DF oil and DF block
PTTH_PNT_TF_Heat_Capa_JpK	10600	J/K	Heat capacity of TF
PTTH_PNT_TF2TMBlock_Heat_Resi_KpW	0.001	K/W	Thermal resistance value between TF and T/M block
PTTH_PNT_TMBlock_Heat_Capa_JpK	10000	J/K	Heat capacity of T/M block
PTTH_PNT_TMBlock2DFBlock_Heat_Resi_KpW	0.03	K/W	Thermal resistance value between TM block and DF block
PTTH_PNT_TMBlock2TMAir_Heat_Resi_KpW	0.3	K/W	Thermal resistance value between T/M block and external environment
sigma_Stefan_Boltzmann	5.67e-8	W/m2K4	Stefan-Boltzmann constant
TM_PNT_eta_MG2_gear	0.97	-	Primary deceleration efficiency of generator
TM_PNT_ratio_MG2_gear	2.52	-	Transmission gear ratio
TM_PNT_TM_Inertia	0.3	kgm2	Transmission inertia
VCU_CNT_Cooperative_Control_Brake_flag	0	W	Regeneration cooperative contoroｌ is active in 1.
VCU_CNT_PSoFin_battpw	<1×4>	W	Charging power map
VCU_CNT_PSoFin_soc	<1×4>	%	Charging power map: x-SOC
VCU_CNT_PSoFout_battpw	<1×4>	W	Discharging power map
VCU_CNT_PSoFout_soc	<1×4>	%	Discharging power map: x-SOC
VCU_CNT_trq_req_brak_th	0.0001	N	Brake threshold for vehicle stopping detection
VCU_CNT_trq_req_delaytime	0.2	s	time constants of 1st order lag for Gain value
VCU_CNT_trq_req_Gain_OFF	0.001	-	Required driving torque gain value for vehicle stopping detection
VCU_CNT_trq_req_Gain_ON	1	-	Required drivie torque gain value for driving ditection
VCU_CNT_trq_req_v_vehicle_th	1	km/h	Vehicle velocity threshold for vehicle stopping detection
VCU_CNT_trq_require_accper	<1×8>	%	Required driving force estimation map: x-accelerator position
VCU_CNT_trq_require_Nm	<8×21>	Nm	Required driving force estimation map
VCU_CNT_trq_require_v_kmph	<21×1>	km/h	Required driving force estimation map: y-vehicle velocity
VCU_CNT_w_mot_limit_gain	200000	-	Torque limit gain value when the motor rpm reach upper limit
VCU_CNT_w_mot_limit_rpm	10000	rpm	Upper limit value of motor rpm

5.2.2.5 Other information

None.

5.2.3. Functional specification of [C: Environment] system

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

5.2.3.1 Abstract

The abstract of this system is shown below.

① Modelized object
External environmental model

② Modelized level
Model for setting vehicle conditions and weather conditions during mode driving

③ Modelized function
Function to set the vehicle conditions
Function to set weather conditions

5.2.3.2 Data flow diagram

The data flow diagram of this system is shown below.

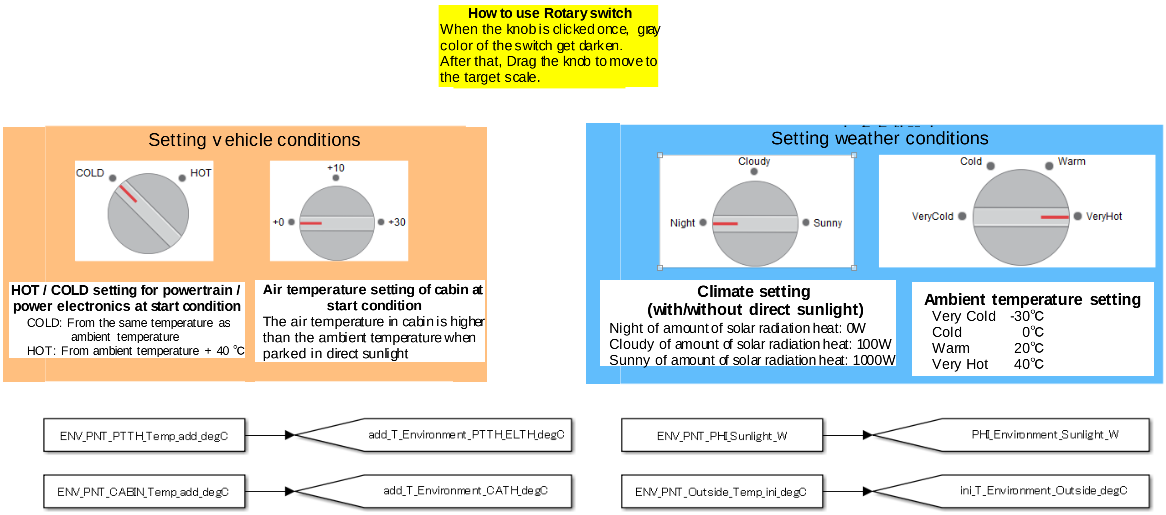


Fig. 5.2.3.2 Data flow diagram: second-layer environment system

5.2.3.3 Input/output specification

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

Input			
Name	Unit	Area	Description
None	None	None	None
Output			
Name	Unit	Area	Description
add_T_Environment_PTTH_ELTH_degC	℃	[0 40]	Initial temp. difference between power sysytem and outside ambient temp.
add_T_Environment_CATH_degC	℃	[0 30]	Initial temp. difference between cabin and outside ambient temp.
PHI_Environment_Sunlight_W	W	[0 1000]	Heat flow of solar radiation
ini_T_Environment_Outside_degC	℃	[-30 40]	Initial outside ambient temp.

5.2.3.4 Parameter specification

The parameter specification of this system is shown below.

Variable name	Setting value	Unit	Description
ENV_PNT_PTTH_Temp_add_degC	0.0	℃	Initial temp. difference between power sysytem and outside ambient temp.
ENV_PNT_CABIN_Temp_add_degC	0.0	℃	Initial temp. difference between cabin and outside ambient temp.
ENV_PNT_PHI_Sunlight_W	0.0	W	Heat flow from direct sunlight
ENV_PNT_Outside_Temp_ini_degC	40.0	℃	Initial ambient temp.

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 in the guidelines-compatible model are described.

5.2.4.1 Abstract

The abstract of this system is shown below.

① Modelized object
None

② Modelized level
None

③ Modelized function
None

5.2.4.2 Data flow diagram

The data flow diagram of this system is shown below.

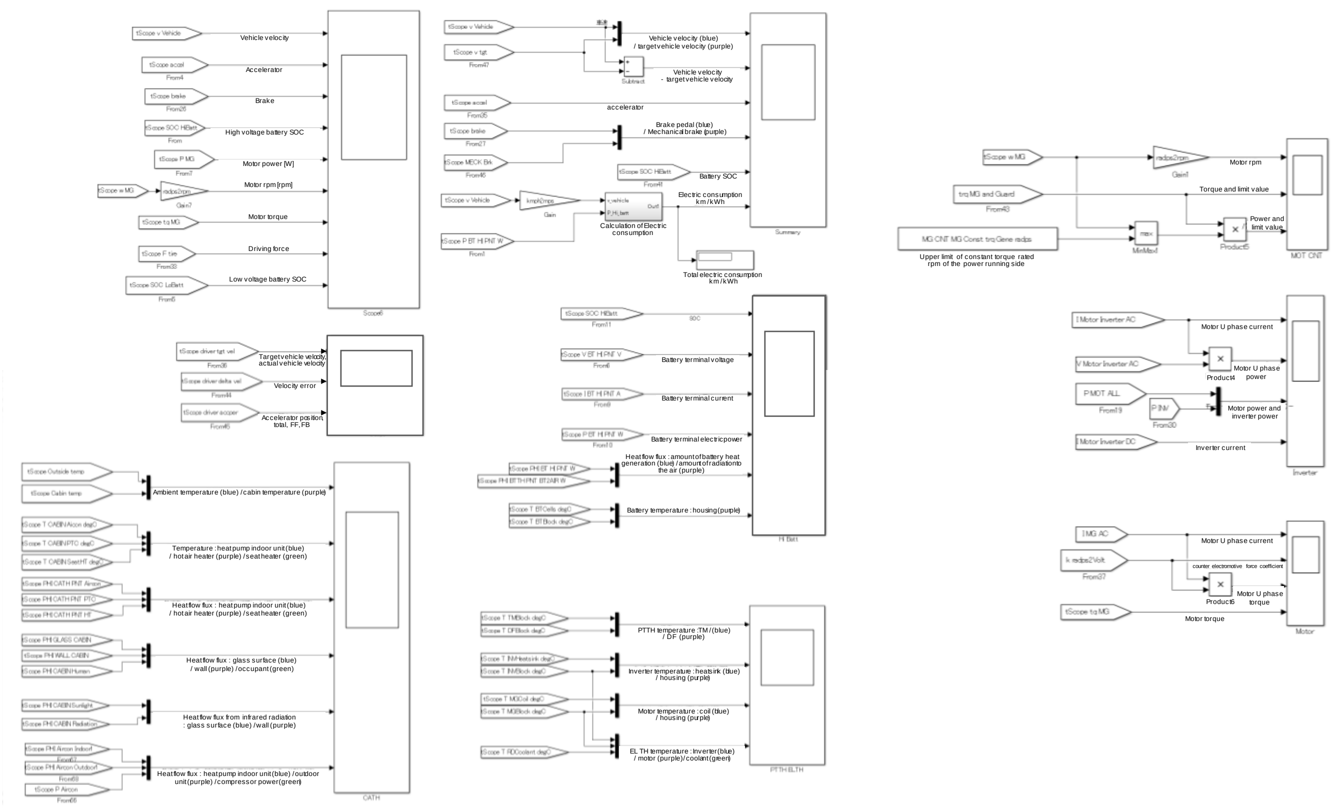


Fig. 5.2.4.2 Data flow diagram: second-layer monitor system

5.2.4.3 Input/output specification

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

Input			
Name	Name	Name	Name
tScope_v_Vehicle	km/h	TBD	Vehicle velocity
tScope_accel	%	[0 100]	Accelerator position
tScope_brake	%	[0 100]	Brake opening ratio
tScope_SOC_HiBatt	%	TBD	SOC of high voltage battery
tScope_P_MG	W	TBD	Motor power
tScope_w_MG	rad/s	TBD	Motor rpm
tScope_tq_MG	Nm	TBD	Motor torque
tScope_F_tire	N	TBD	Driving force
tScope_SOC_LoBatt	%	[0 100]	SOC of low voltage battery
tScope_driver_tgt_vel	km/h	TBD	Target vehicle velocity
tScope_driver_delta_vel	km/h	TBD	velocity error
tScope_driver_accper	%	[0 100]	Accelerator position: Total of FF and FB
tScope_Outside_temp	℃	TBD	Outside ambient temp.
tScope_Cabin_temp	℃	TBD	Cabin temp.
tScope_T_CABIN_Aicon_degC	℃	TBD	Temp. of heat pump indoor unit
tScope_T_CABIN_PTC_degC	℃	TBD	PTC heater temp.
tScope_T_CABIN_SeatHT_degC	℃	TBD	Temp. of seat heater
tScope_PHI_CATH_PNT_Aircon	W	TBD	Heat flow of heat pump indoor unit
tScope_PHI_CATH_PNT_PTC	W	TBD	Heat flow of hot air heater
tScope_PHI_CATH_PNT_HT	W	TBD	Heat flow of seat heater
tScope_PHI_GLASS_CABIN	W	TBD	Heat flow of glass surface
tScope_PHI_WALL_CABIN	W	TBD	Heat flow of wall surface
tScope_PHI_CABIN_Human	W	TBD	Heat flow from occupant
tScope_PHI_CABIN_Sunlight	W	TBD	Heat flow of glass surface by infrared radiation
tScope_PHI_CABIN_Radiation	W	TBD	Heat flow of wall by infrared radiation
tScope_PHI_Aircon_Indoor1	W	TBD	Heat flow of heat pump indoor unit
tScope_PHI_Aircon_Outdoor1	W	TBD	heat flow of outdoor unit
tScope_P_Aircon	W	TBD	Compressor power
tScope_v_tgt	km/h	TBD	Target vehicle velocity
tScope_MECK_Brk	%	[0 100]	Mechanical brake
tScope_P_BT_HI_PNT_W	W	TBD	Terminal electric power of high voltage battery
tScope_V_BT_HI_PNT_V	V	TBD	terminal voltage of high voltage battery
tScope_I_BT_HI_PNT_A	A	TBD	Terminal current of high voltage battery
tScope_PHI_BT_HI_PNT_W	W	TBD	Amount of heat generation from high voltage battery
tScope_PHI_BTTH_PNT_BT2AIR_W	W	TBD	Amount of radiation to the atmosphere
tScope_T_BTCells_degC	℃	TBD	Cell temp. of high voltage battery
tScope_T_BTBlock_degC	℃	TBD	Temp. of high voltage battery housing
tScope_T_TMBlock_degC	℃	TBD	Transmission temp.
tScope_T_DFBlock_degC	℃	TBD	Temp. of differential gear
tScope_T_INVHeatsink_degC	℃	TBD	Inverter heat sink temp.
tScope_T_INVBlock_degC	℃	TBD	Temp.of inverter housing
tScope_T_MGCoil_degC	℃	TBD	motor coil temp.
tScope_T_MGBlock_degC	℃	TBD	Motor housing temp.
tScope_T_RDCoolant_degC	℃	TBD	Coolant temp.
trq_MG_and_Guard	Nm	TBD	Motor torque and torque limit value
I_Motor_Inverter_AC	A	TBD	Motor U-phase current
V_Motor_Inverter_AC	V	TBD	Voltage of motor U-phase
P_MOT_ALL	W	TBD	Motor power
P_INV	W	TBD	Inverter power
I_Motor_Inverter_DC	A	TBD	Inverter DC current
I_MG_AC	A	TBD	Motor U-phase current
k_radps2Volt	V/rad/s	-	Counter electromotive force coefficient
Output			
Name	Name	Name	Name
None	None	None	None

5.2.4.4 Parameter specification

The parameter specification of this system is shown below.

Variable name	Setting value	Unit	Description
MG_CNT_MG_Const_trq_Gene_radps	343.75	rad/s	Constant torque rpm on power running side

5.2.4.5 Other information

None.

5.3. Functional specification of third-layer model

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

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

5.3.1.1 Abstract

The abstract of this system is shown below.

① Modelized object
Model to calculate the amount of acceleration operated by the driver

② Modelized level
Model to calculate the accelerator position required to follow the target of vehicle speed in the mode driving pattern (JC08, wltc)

③ Modelized function
FF control to calculate the accelerator position required to output the motor torque corresponding to the vehicle inertia and running resistance
FB control to correct accelerator position based on the difference between the target vehicle speed and the vehicle speed

5.3.1.2 Data flow diagram

The data flow diagram of this system is shown below.

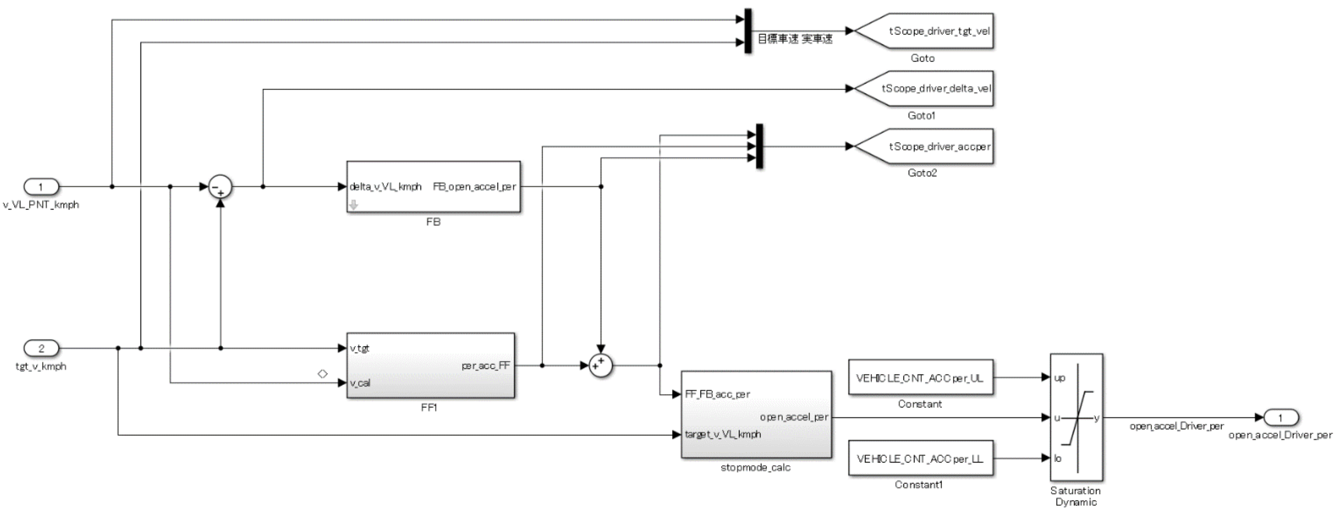


Fig. 5.3.1.2 Data flow diagram: third-layer acceleration system

5.3.1.3 Input/output specification

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

Input			
Name	Unit	Area	Description
v_VL_PNT_kmph	km/h	TBD	Vehicle velocity(km/h)
tgt_v_kmph	km/h	TBD	Target vehicle velocity
Output			
Name	Unit	Area	Description
open_accel_Driver_per	%	[0 100]	Accelerator position(input)

5.3.1.4 Parameter specification

The parameter specification of this system is shown below.

Variable name	Setting value	Unit	Description
ACC_D_Gain	0.0	-	D gain value for feedback control
ACC_I_Gain	0.0	-	I gain value for feedback control
ACC_P_Gain	10	-	P gain value for feedback control
DF_PNT_DF_gear	3.25	-	Reduction gear ratio of differential gear
DF_PNT_eta_DF	0.96	-	Differential gear efficiency
Driver_Brake_Switch_Const2	0.1	km/h	Stopping detection during driver brake model
TM_PNT_eta_MG2_gear	0.97	-	Primary deceleration efficiency of generator
TM_PNT_ratio_MG2_gear	2.52	-	Transmission gear ratio
VCU_CNT_trq_require_Nm	<8×21>	Nm	Required driving force estimation map
VCU_CNT_trq_require_accper	<1×8>	%	Required driving force estimation map: x-accelerator position
VCU_CNT_trq_require_v_kmph	<1×21>	km/h	Required driving force estimation map: y-vehicle velocity
VEHICLE_CNT_ACCper_LL	0.0	%	Lower limit value of accelerator position
VEHICLE_CNT_ACCper_UL	100	%	Upper limit value of accelerator position

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 in the guidelines-compatible model are described.

5.3.2.1 Abstract

The abstract of this system is shown below.

① Modelized object
A model to calculate the brake operation of a driver

② Modelized level
Calculate the brake stepping position required to follow the target vehicle speed in the mode driving pattern

③ Modelized function
Proportional control to calculate the brake speed based on the difference between the target vehicle speed and the vehicle speed
Bipedal simultaneous operation that prevented brake pedal operation while acceleration pedal is stepped on

5.3.2.2 Data flow diagram

The data flow diagram of this system is shown below.

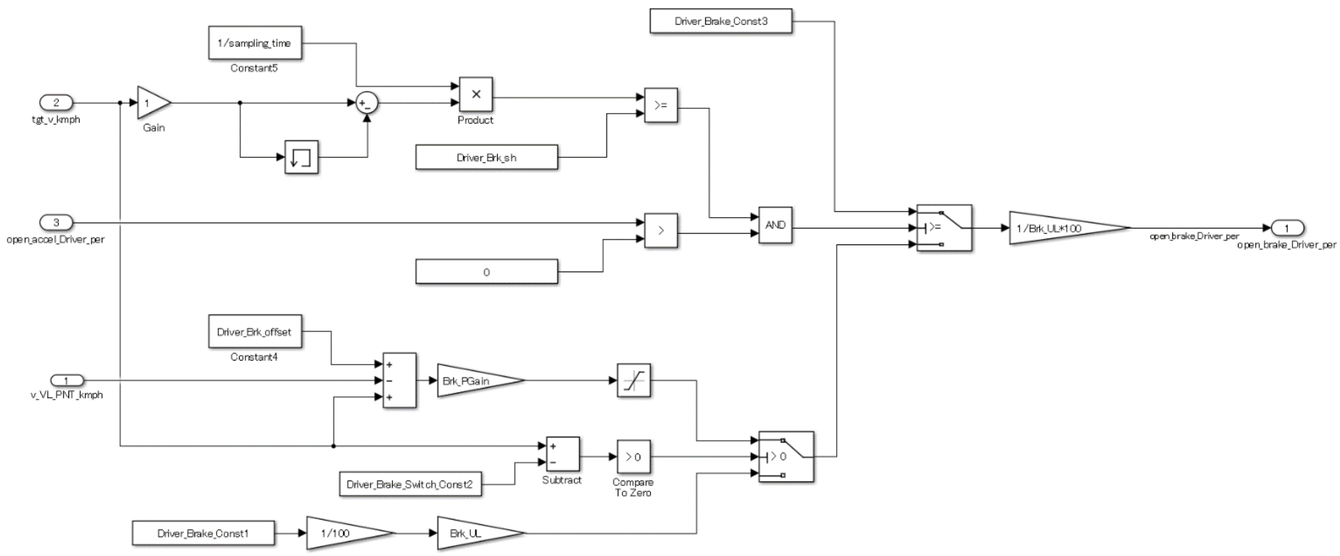


Fig. 5.3.2.2 Data flow diagram: third-layer brake opening (input) system

5.3.2.3 Input/output specification

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

Input			
Name	Unit	Area	Description
tgt_v_kmph	km/h	TBD	Target vehicle velocity
open_accel_Driver_per	%	[0 100]	Accelerator position(input)
v_VL_PNT_kmph	km/h	TBD	Vehicle velocity(km/h)
Output			
Name	Unit	Area	Description
open_brake_Driver_per	%	[0 100]	Brake opening ratio

5.3.2.4 Parameter specification

The parameter specification of this system is shown below.

Variable name	Setting value	Unit	Description
Brk_LL	0.0	N	Lower limit value of braking force
Brk_PGain	-5000	-	P gain value for braking force
Brk_UL	20000	N	Upper limit value of braking force
Driver_Brake_Const1	5	%	Brake stopping position during the acceleration (when the target vehicle velocity is positive)
Driver_Brake_Const3	0.0	%	Brake stepping position during the acceleration (when the target vehicle velocity is positive)
Driver_Brake_Switch_Const2	0.1	km/h	Stopping detection during driver brake model
Driver_Brk_offset	0.5	km/h	Offset value of velocity error without braking
Driver_Brk_sh	0.01	km/h/sec	Acceleration detection value

5.3.2.5 Other information

None.

5.3.3. Functional specification of [B10C: VCU_CNT] system

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

5.3.3.1 Abstract

The abstract of this system is shown below.

① Modelized object
Vehicle control ECU model

② Modelized level
Calculate the target torque and regenerative braking force of the motor in mode driving

③ Modelized function
Function to calculate the target motor torque from the electirc consumption on the high voltage side and the low voltage side, accelerator opening, brake opening, vehicle speed, motor speed and battery SOC
Function to calculate regenerative braking force from the electirc consumption on the high voltage side and the low voltage side, accelerator opening, brake opening, vehicle speed, motor speed and battery SOC

5.3.3.2 Data flow diagram

The data flow diagram of this system is shown below.

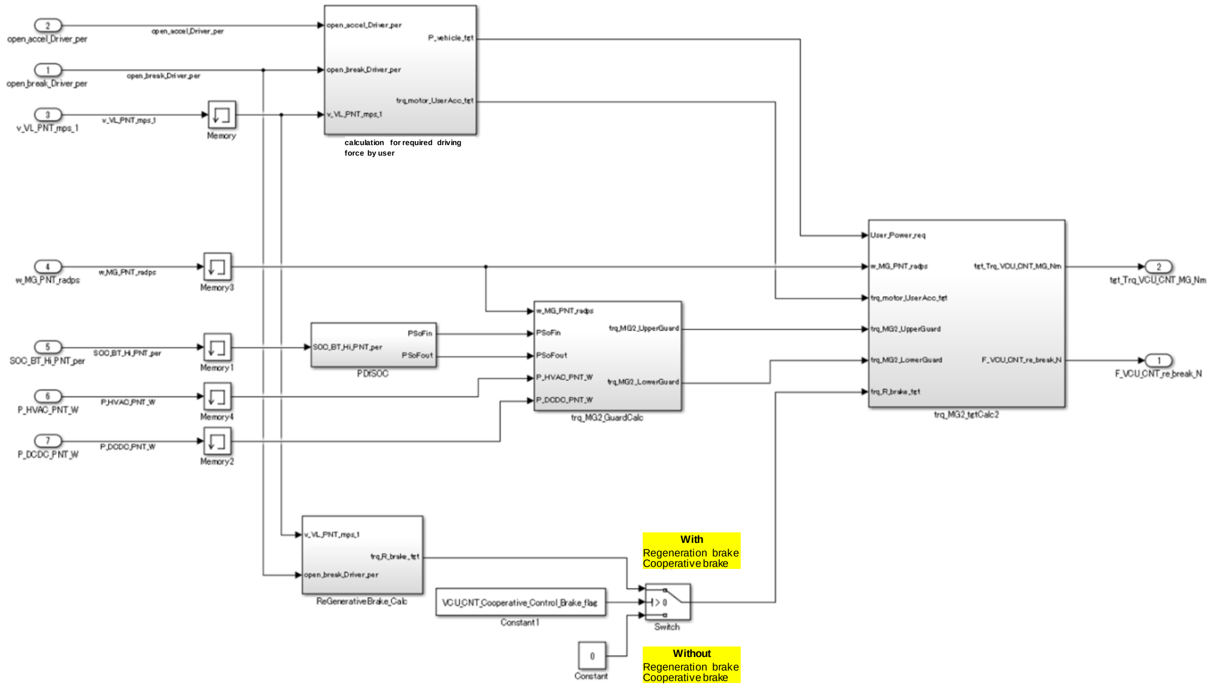


Fig. 5.3.3.2 Data flow diagram: third-layer VCU_CNT system

5.3.3.3 Input/output specification

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

Input			
Name	Unit	Area	Description
open_accel_Driver_per	%	[0 100]	Accelerator position(input)
open_brake_Driver_per	%	[0 100]	Brake opening ratio
P_HVAC_PNT_W	W	TBD	HVAC electric power
P_DCDC_PNT_W	W	TBD	Electric consumption of low voltage auxiliary unit
SOC_BT_Hi_PNT_per	%	[0 100]	High voltage battery SOC
v_VL_PNT_mps_1	m/s	TBD	Vehicle velocity(m/s)
w_MG_PNT_radps	rad/s	TBD	Motor rpm
Output			
Name	Unit	Area	Description
F_VCU_CNT_re_brake_N	N	TBD	Regenerative braking force
tgt_Trq_VCU_CNT_MG_Nm	Nm	TBD	Target motor torque

5.3.3.4 Parameter specification

The parameter specification of this system is shown below

Variable name	Setting value	Unit	Description
BK_PNT_Pow_UL	20000	N	Braking force upper limit value
BK_PNT_ReGene_vel_limit_DN_kmph	0.5	km/h	Finishing velocity for stopping regenerative brake
BK_PNT_ReGene_vel_limit_UP_kmph	3	km/h	Starting velocity for stopping regenerative brake
DF_PNT_DF_gear	3.25	-	Reduction gear ratio of differential gear
DF_PNT_eta_DF	0.96	-	Differential gear efficiency
MG_CNT_MG_Const_trq_Gene_radps	343.75	rad/s	Constant torque rpm on power running side
MG_CNT_MG_Const_trq_ReGene_radps	262.295	rad/s	Rated rpm at regenerative side
MG_CNT_Pmax_MG_Gene_W	110000	W	Rated output at power running side
MG_CNT_Pmin_MG_ReGene_W	-80000	W	Rated output of regenerative side
TM_PNT_eta_MG2_gear	0.97	-	Primary deceleration efficiency of generator
TM_PNT_ratio_MG2_gear	2.52	-	Transmission gear ratio
VCU_CNT_Cooperative_Control_Brake_flag	0	W	Regeneration cooperative contoroｌ is active in 1.
VCU_CNT_PSoFin_battpw	<1×4>	W	Charging power map
VCU_CNT_PSoFin_soc	<1×4>	%	Charging power map: x-SOC
VCU_CNT_PSoFout_battpw	<1×4>	W	Discharging power map
VCU_CNT_PSoFout_soc	<1×4>	%	Discharging power map: x-SOC
VCU_CNT_trq_req_Gain_OFF	0.001	-	Required driving torque gain value for vehicle stopping detection
VCU_CNT_trq_req_Gain_ON	1	-	Required drivie torque gain value for driving ditection
VCU_CNT_trq_req_brak_th	0.0001	N	Brake threshold for vehicle stopping detection
VCU_CNT_trq_req_delaytime	0.2	s	time constants of 1st order lag for Gain value
VCU_CNT_trq_req_v_vehicle_th	1	km/h	Vehicle velocity threshold for vehicle stopping detection
VCU_CNT_trq_require_Nm	<8×21>	Nm	Required driving force estimation map
VCU_CNT_trq_require_accper	<1×8>	%	Required driving force estimation map: x-accelerator position
VCU_CNT_trq_require_v_kmph	<21×1>	km/h	Required driving force estimation map: y-vehicle velocity
VCU_CNT_w_mot_limit_gain	200000	-	Torque limit gain value when the motor rpm reach upper limit
VCU_CNT_w_mot_limit_rpm	10000	rpm	Upper limit value of motor rpm

5.3.3.5 Other information

None.

5.3.4. Functional specification of [B11C: BK_CNT] system

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

5.3.4.1 Abstract

The abstract of this system is shown below.

① Modelized object
Vehicle control ECU model

② Modelized level
Calculate mechanical braking force

③ Modelized function
Function to calculate the braking force according to the amount of brake stroke and the regenerative braking force

5.3.4.2 Data flow diagram

The data flow diagram of this system is shown below.

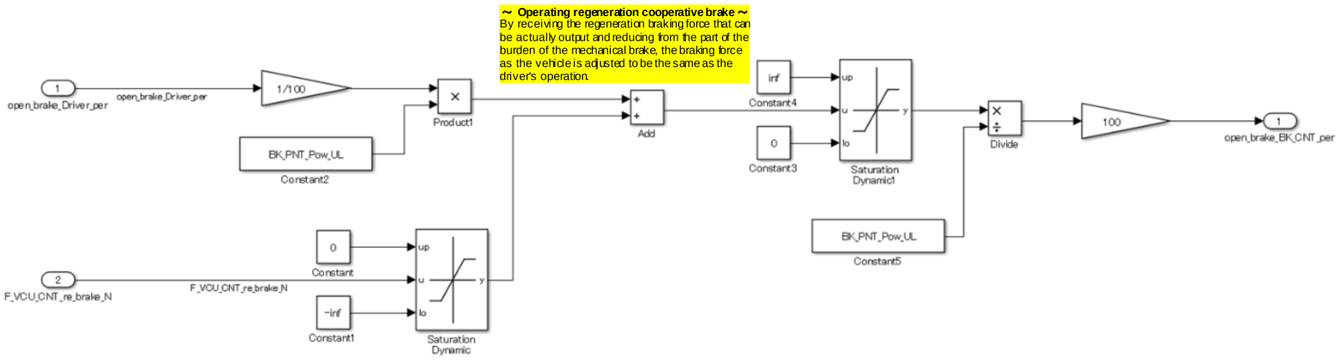


Fig. 5.3.4.2 Data flow diagram: third-layer BK_CNT System

5.3.4.3 Input/output specification

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

Input			
Name	Unit	Area	Description
open_brake_Driver_per	%	[0 100]	Brake opening ratio
F_VCU_CNT_re_brake_N	N	TBD	Regenerative braking force
Output			
Name	Unit	Area	Description
open_brake_BK_CNT_per	%	[0 100]	Brake opening ratio

5.3.4.4 Parameter specification

The parameter specification of this system is shown below.

Variable name	Setting value	Unit	Description
BK_PNT_Pow_UL	20000	N	Braking force upper limit value

5.3.4.5 Other information

None.

5.3.5. Functional specifications of [B12C： MG_CNT] system

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

5.3.5.1 Abstract

The abstract of this system is shown below.

① Modelized object
Motor control ECU model

② Modelized level
Calculate the target of back EMF coefficient and the target of U-phase current for controlling three-phase AC motor

③ Modelized function
Function to calculate the target of back electromotive force coefficient from inverter voltage and motor speed
Function to calculate the target of U-phase current from the target of motor torque and inverter voltage and motor speed

5.3.5.2 Data flow diagram

The data flow diagram of this system is shown below.

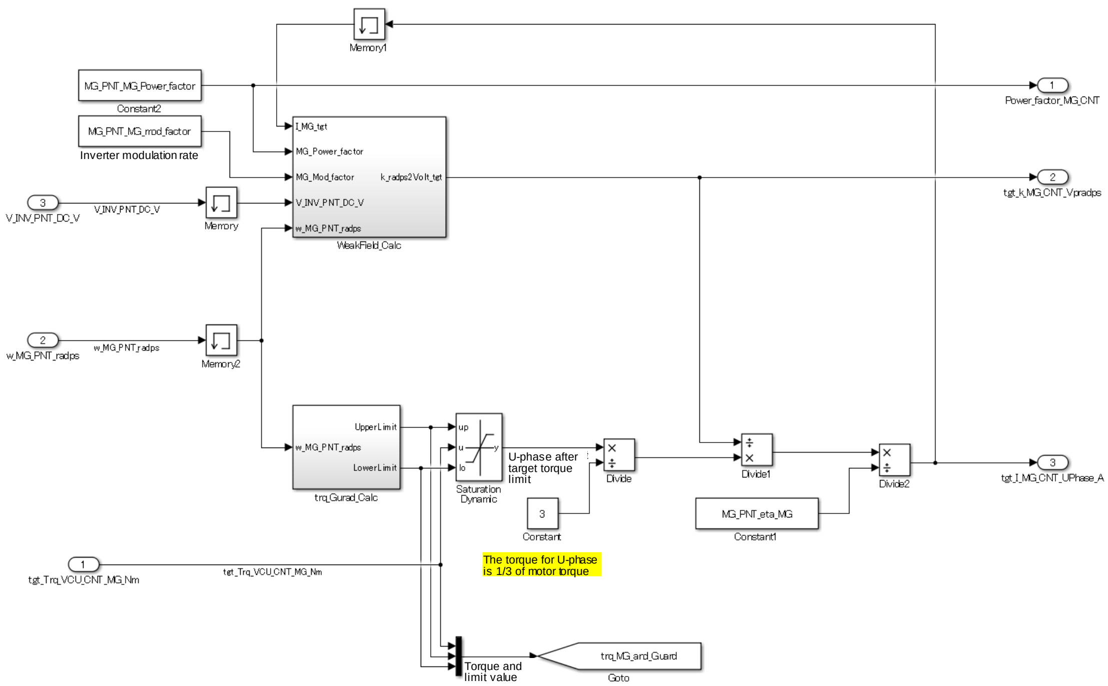


Fig. 5.3.5.2 Data flow diagram: third-layer MG_CNT system

5.3.5.3 Input/output specification

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

Input			
Name	Unit	Area	Description
Tgt_Trq_VCU_CNT_MG_Nm	Nm	TBD	Target motor torque
V_INV_PNT_DC_V	V	TBD	Voltage of inverter (DC side)
w_MG_PNT_radps	Rad/s	TBD	Motor rpm
Output			
Name	Unit	Area	Description
Tgt_I_MG_CNT_UPhase_A	A	TBD	Target U-phase current value
Tgt_k_MG_CNT_Vpradps	V/ (rad/s)	TBD	Counter electromotive force coefficient
Power_factor_MG_CNT	-	TBD	Motor power factor

5.3.5.4 Parameter specification

The parameter specification of this system is shown below.

Variable name	Setting value	Unit	Description
MG_CNT_MG_Const_trq_Gene_radps	343.75	radps	Constant torque rpm on power running side
MG_CNT_MG_Const_trq_ReGene_radps	262.295	radps	Rated rpm at regenerative side
MG_CNT_Pmax_MG_Gene_W	110000	W	Rated output at power running side
MG_CNT_Pmin_MG_ReGene_W	-80000	W	Rated output of regenerative side
MG_PNT_MG_Power_factor	0.85	-	Motor power factor
MG_PNT_MG_WeakField_LL	0.05	-	Lower limit value of the field weakening ratio
MG_PNT_MG_WeakField_UL	1.0	-	Upper limit value of the field weakening ratio
MG_PNT_MG_mod_factor	0.707	-	Inverter modulation rate
MG_PNT_V_MG_Rated	351	Ω	Line resistance U-phase of motor
MG_PNT_eta_MG	0.92	-	Motor efficiency
MG_PNT_w_ROT_MG_Rated	343.75	radps	Rated rpm. of motor

5.3.5.5 Other information

None.

5.3.6. Functional specification of [B13C: ELTH_CNT] system

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

5.3.6.1 Abstract

The abstract of this system is shown below.

① Modelized object
ECU model for power electronics thermal

② Modelized level
Calculate the required voltage of radiator fan to control radiator fan
Calculates the voltage of water pump to control water pump

③ Modelized function
Function to calculate the required voltage of radiator fan from thevoltage of radiator fan and the coolant temperature of radiator
Function to calculate the voltage od water pump from coolant temperature of radiator

5.3.6.2 Data flow diagram

The data flow diagram of this system is shown below.

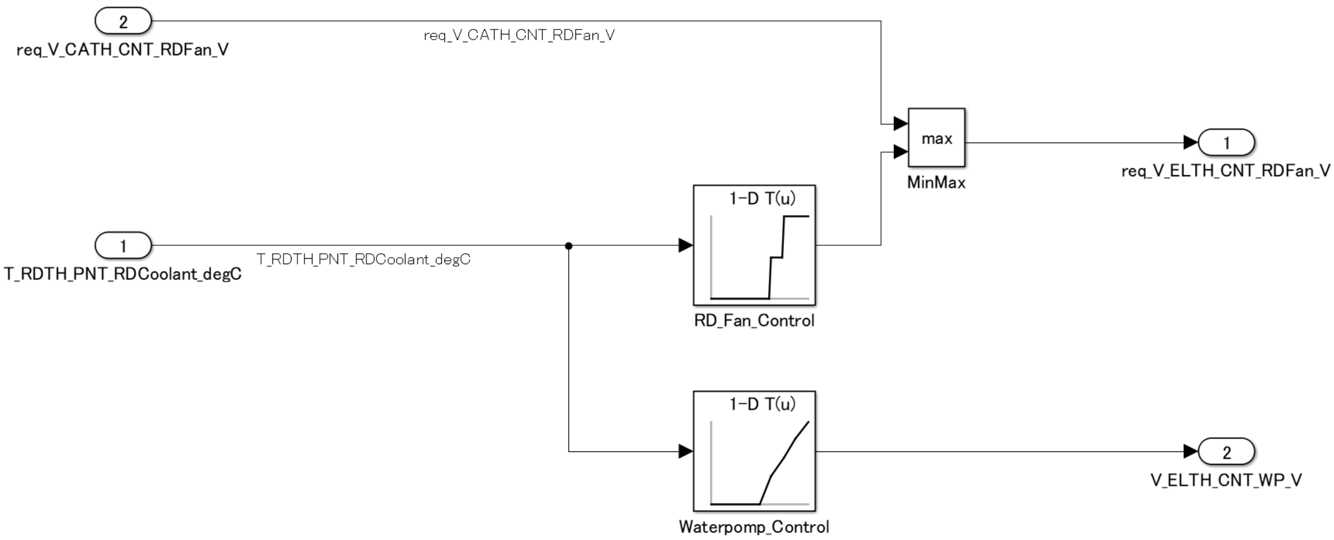


Fig. 5.3.6.2 Data flow diagram: third-layer ELTH_CNT system

5.3.6.3 Input/output specification

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

Input			
Name	Unit	Area	Description
req_V_CATH_CNT_RDFan_V	V	TBD	Required radiator fan voltage
T_RDTH_PNT_RDCoolant_degC	℃	TBD	Radiator coolant temp.
Output			
Name	Unit	Area	Description
req_V_ELTH_CNT_RDFan_V	V	TBD	Required radiator fan voltage
V_ELTH_CNT_WP_V	V	TBD	Voltage of water pump

5.3.6.4 Parameter specification

The parameter specification of this system is shown below.

Variable name	Setting value	Unit	Description
ELTH_CNT_V_RDFan_V	<1×6>	V	Radiator fan voltage map
ELTH_CNT_V_RDFan_x_T_Coolant	<1×6>	℃	Radiator fan voltage map: x-coolant temp.
ELTH_CNT_V_Water_Pump_V	<1×6>	V	Water pump voltage map
ELTH_CNT_V_Water_Pump_x_T_Coolant	<1×6>	℃	Water pump voltage map: x-temp. of coolant

5.3.6.5 Other information

None.

5.3.7. Functional specifications of [B14C: CATH_CNT] system

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

5.3.7.1 Abstract

The abstract of this system is shown below.

① Modelized object
ECU model for Cabin thermal control

② Modelized level
Calculate the voltage of blower fan for air conditioner, heat pump output, seat heater output and radiator fan voltage to control the air conditioning in the cabin

③ Modelized function
Function to calculate the voltage of blower fan for air conditioner according to the difference from the target temperature and the on / off state of automatic blower
Function to calculate the heat pump output and the required voltage of radiator fan according to the difference from the target temperature, the on / off state of the air conditioner and automatic air blowing, and the air conditioner indoor unit temperature
Function to calculate the PTC heater power according to the outside air temperature, PTC heater temperature, and the on / off state of the air conditioner and automatic air blowing
Function to calculate the seat heater output according to the difference from the target temperature and the seat heater temperature

5.3.7.2 Data flow diagram

The data flow diagram of this system is shown below.

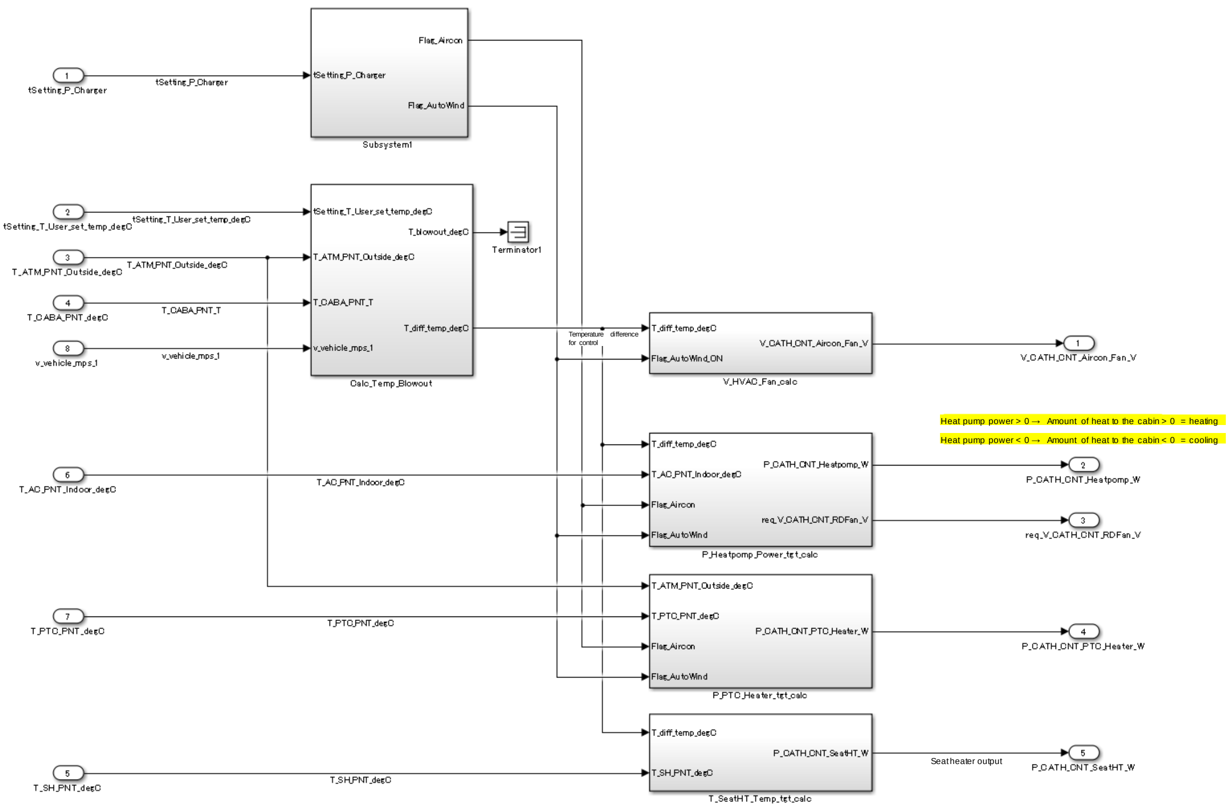


Fig. 5.3.7.2 Data flow diagram: third-layer CATH_CNT system

5.3.7.3 Input/output specification

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

Input			
Name	Unit	Area	Description
tSetting_P_Charger	W	[0 44000]	Maximum charging electric power of the charger
T_AC_PNT_Indoor_degC	℃	TBD	Air conditioner indoor unit temp.
T_CABA_PNT_degC	℃	TBD	Temp.of cabin
T_ATM_PNT_Outside_degC	℃	TBD	Outside ambient temp.
T_PTC_PNT_degC	℃	TBD	Temp. of PTC heater
T_SH_PNT_degC	℃	TBD	Temp. of seat heater
tSetting_T_User_set_temp_degC	℃	[18 26]	Air-conditioning temp.
v_vehicle_mps_1	m/s	TBD	Vehicle velocity(m/s)
Output			
Name	Unit	Area	Description
V_CATH_CNT_Aircon_Fan_V	V	-	Voltage of air conditioner fan
req_V_CATH_CNT_RDFan_V	V	-	Required radiator fan voltage
P_CATH_CNT_Heatpomp_W	W	-	Heat pump output
P_CATH_CNT_PTC_Heater_W	W	-	PTC heater output
P_CATH_CNT_SeatHT_W	W	-	Seat heater output

5.3.7.4 Parameter specification

The parameter specification of this system is shown below.

Variable name	Setting value	Unit	Description
CATH_CNT_PGain_Temp_blowout	10.0	-	P gain value for blower air temp. control
CATH_CNT_P_Aircon_W_LL	-3000	W	Lower compressor output limit for heat pump cooling
CATH_CNT_P_Aircon_W_UL	2000	W	Upper compressor output limit for heat pump heating
CATH_CNT_P_Gain_Aircon	200	-	P gain value from temp. difference to output for air conditioning
CATH_CNT_P_Gain_PTC_Heater	100	-	P gain value from temp. difference to output when temp over upper limit
CATH_CNT_P_Gain_SeatHT	100	-	P gain value from temp. difference to output for seat heater
CATH_CNT_P_PTC_Heater	<1×4>	W	Target output map of PTC heater for hot air blower
CATH_CNT_P_PTC_Heater_W_LL	0.0	W	Lower limit value of PTC heater output
CATH_CNT_P_PTC_Heater_W_UL	1000	W	Upper limit value of PTC heater output
CATH_CNT_P_PTC_Heater_x_T_Outside_temp_degC	<1×4>	℃	Target output map of PTC heater for hot air blower: x-ambient temp.
CATH_CNT_P_SeatHT_W_LL	0.0	W	Lower limit value of seat heater output
CATH_CNT_P_SeatHT_W_UL	500	W	Upper limit value of seat heater output
CATH_CNT_T_Aircon_Indoor_degC	<1×6>	℃	Temperature control map for indoor unit of heat pump
CATH_CNT_T_Aircon_Indoor_degC_x_T_blowout_degC	<1×6>	℃	Temperature control map for indoor unit of heat pump: x-Temp.
CATH_CNT_T_PTC_Heater_degC_UL	80	℃	Upper limit value of PTC heater temp.
CATH_CNT_T_SeatHT_Temp_degC	<1×4>	℃	Target temp. map for sheet heater
CATH_CNT_T_SeatHT_Temp_degC_x_T_blowout_degC	<1×4>	℃	Target temp. map for sheet heater: x-Temperature
CATH_CNT_V_HVAC_Fan	<1×6>	m3/s	air flow map of blower fan for air conditioning
CATH_CNT_V_HVAC_Fan_x_T_blowout_degC	<1×6>	℃	Air flow map of blower fan for air conditioning: x-HVAC fan voltage
CATH_CNT_V_RDFan_V	<1×8>	V	Radiator fan voltage map
CATH_CNT_V_RDFan_x_P_Aircon_W	<1×8>	W	Radiator fan voltage map: x-heat pump power
CATH_PNT_Air_Convection_Heat_Resi_KpW	<1×13>	K/W	Thermal resistance map of thermal transfer by convection
CATH_PNT_Air_Convection_Heat_Resi_x_mps	<1×13>	m/s	Thermal resistance map of thermal transfer by convection: x- average air flow speed
CATH_PNT_CABIN_AIR_Heat_Capa_JpK	7037.976	J/K	Heat capacity of cabin space
CATH_PNT_CABIN_Glass_S_m2	4.0	m2	Glass area

5.3.7.5 Other information

None.

5.3.8. Functional specification of [B15C: BTTH_CNT] system

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

5.3.8.1 Abstract

The abstract of this system is shown below.

① Modelized object
ECU model for high voltage battery temperature control

② Modelized level
Calculate the target of battery heater output to control the battery heater
Calculate the voltage of battery fan to control the battery fan

③ Modelized function
Function to calculate the target of battery heater output according to the battery cell temperature
Function to calculate the voltage battery fan according to the battery cell temperature

5.3.8.2 Data flow diagram

The data flow diagram of this system is shown below.

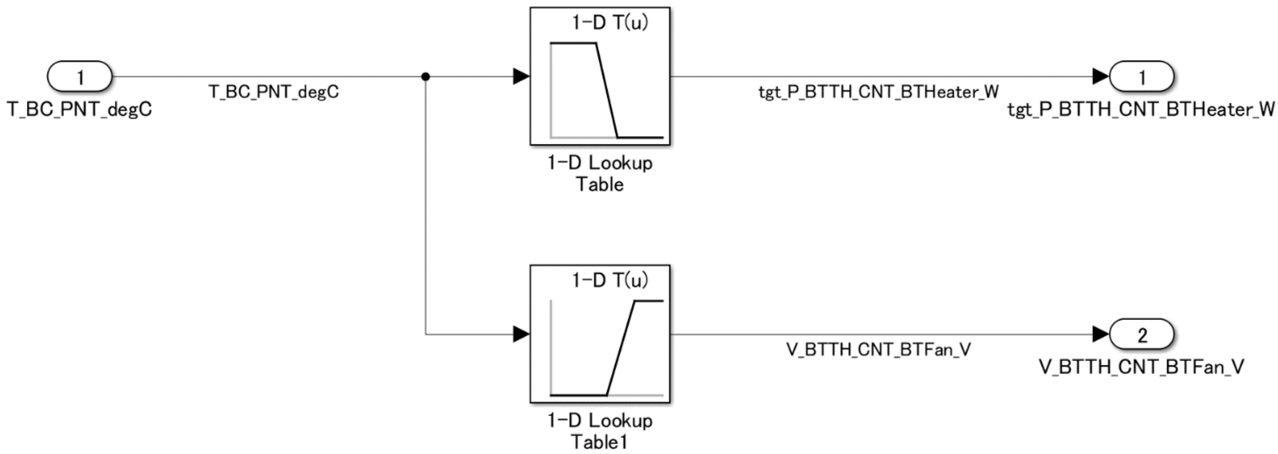


Fig. 5.3.8.2 Data flow diagram: third-layer BTTH_CNT system

5.3.8.3 Input/output specification

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

Input			
Name	Unit	Area	Description
T_BC_PNT_degC	℃	TBD	Temp. of battery cell
Output			
Name	Unit	Area	Description
tgt_P_BTTH_CNT_BTHeater_W	W	TBD	Target output of battery heater
V_BTTH_CNT_BTFan_V	V	TBD	Voltage of battery fan

5.3.8.4 Parameter specification

The parameter specification of this system is shown below.

Variable name	Setting value	Unit	Description
BTTH_CNT_P_BT_Heater_W	<1×4>	W	Target output map for battery heater
BTTH_CNT_P_BT_Heater_W_x_BTCells_degC	<1×4>	℃	Target output map for battery heater: x-battery Cell Temp
BTTH_CNT_Voltage_BTFan_V	<1×4>	V	Battery fan voltage map
BTTH_CNT_Voltage_BTFan_V_x_BTCells_degC	<1×4>	℃	Battery fan voltage map: x-Battery cell temp.

5.3.8.5 Other information

None.

5.3.9. Functional specification of [B16C: CHG_CNT] system

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

5.3.9.1 Abstract

The abstract of this system is shown below.

① Modelized object
ECU model for charger control

② Modelized level
Calculate the target of charging current to control the charger

③ Modelized function
Function to calculate the target of charging current from charging voltage, maximum charging power, high voltage battery SOC

5.3.9.2 Data flow diagram

The data flow diagram of this system is shown below.

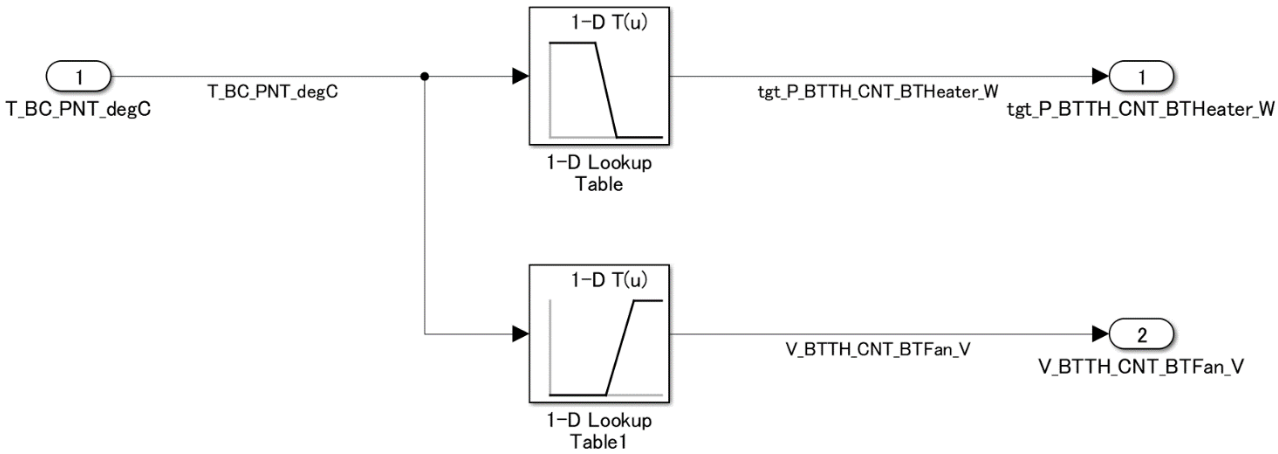


Fig. 5.3.9.2 Data flow diagram: third-layer CHG_CNT system

5.3.9.3 Input/output specification

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

Input			
Name	Unit	Area	Description
tSetting_P_Charger	W	[0 44000]	Maximum charging electric power of the charger
V_CHG_PNT_V	V	TBD	Charging voltage
SOC_BT_Hi_PNT_per	%	[0 100]	High voltage battery SOC
Output			
Name	Unit	Area	Description
tgt_I_CHG_CNT_Charge_A	A	TBD	Target charging current

5.3.9.4 Parameter specification

The parameter specification of this system is shown below.

Variable name	Setting value	Unit	Description
BT_PNT_Hi_R_hi_batt_cell	0.0096	Ω	Internal cell resistance value of high voltage battery
BT_PNT_Hi_ocv_SOC_hi_batt_OCV_V_table	<1×10>	V	High voltage battery OCV table
BT_PNT_Hi_ocv_SOC_hi_batt_OCV_V_table_x_SOC	<1×10>	%	High voltage battery OCV table x-SOC
CHG_CNT_Initial_Charge_Current_A	0.5	A	Initial charging current
CHG_CNT_Maximum_Charge_Current_A	125	A	Upper limit value of charger current
CHG_CNT_Maximum_Charge_Power_W	44000	W	Upper limit value of charger output
CHG_CNT_Maximum_Charge_Voltage_V	500	V	Upper limit value of charger voltage
CHG_CNT_SOC_Adapt_Charge_Current_A	<1×14>	A	Charging map current
CHG_CNT_SOC_Adapt_Charge_Current_x_SOC	<1×14>	%	Charging map: x-SOC
CHG_CNT_charge_UL_SOC	100	%	Charging stop SOC
CHG_CNT_charge_current_rate_LL	-20	A/sec	Lower limit value of charging current increase rate
CHG_CNT_charge_current_rate_UL	20	A/sec	Upper limit value of charging current increase rate
CHG_PNT_Charger_cable_R	0.0046	Ω	Resistance value of charging cable
CHG_PNT_Charger_internal_R	0.005	Ω	Internal resistance value of the charger
I_Gain_CV_Charge	0.0	-	I gain value of charging current
P_Gain_CV_Charge	5.0	-	P gain value for charge output

5.3.9.5 Other information

None.

5.3.10. Function specification of [B20C: BT_Hi_PNT] system

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

5.3.10.1 Abstract

The abstract of this system is shown below.

① Modelized object
High voltage battery model

② Modelized level
Calculate the OCV according to SOC, and determine the terminal voltage by adding the charge / discharge current and the voltage drop due to the internal resistance.
Calculation of high voltage battery heat flow

③ Modelized function
Function to calculate SOC from high voltage battery current
Function to calculate high voltage battery voltage from voltage drop due to internal resistance and OCV
Function to calculate heat flow by internal resistance

5.3.10.2 Data flow diagram

The data flow diagram of this system is shown below.

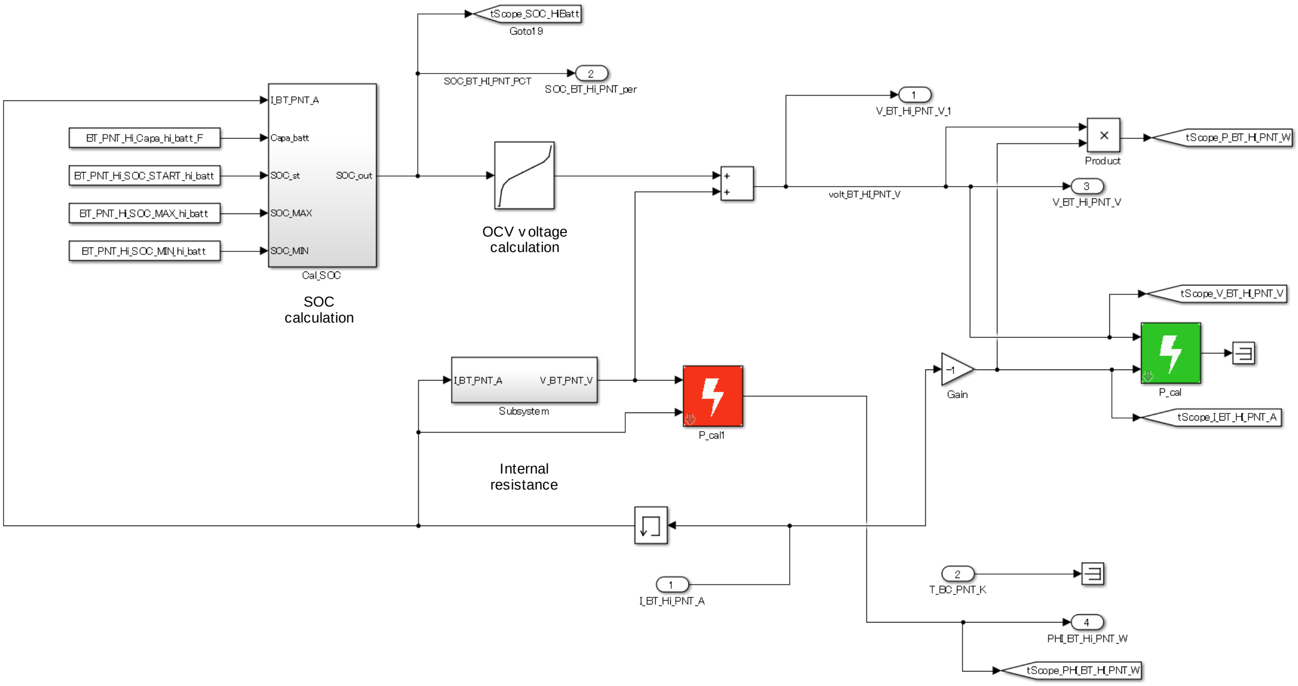


Fig. 5.3.10.2 Data flow diagram: third-layer BT_Hi_PNT system

5.3.10.3 Input/output specification

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

Input			
Name	Unit	Area	Description
I_BT_Hi_PNT_A	A	TBD	Battery voltage of high voltage battery
T_BC_PNT_K	K	TBD	Temp. of battery cell
Output			
Name	Unit	Area	Description
V_BT_Hi_PNT_V_1	V	TBD	Battery voltage for high voltage
SOC_BT_Hi_PNT_per	%	[0 100]	High voltage battery SOC
V_BT_Hi_PNT_V	V	TBD	Battery voltage for high voltage
PHI_BT_Hi_PNT_W	W	TBD	High voltage battery heat flow

5.3.10.4 Parameter specification

The parameter specification of this system is shown below.

Variable name	Setting value	Unit	Description
BT_PNT_Hi_C_pol_hi_batt	30	F	Polarization characteristics capacitor for high voltage battery
BT_PNT_Hi_Capa_hi_batt_F	115	Ah	High voltage battery capacity
BT_PNT_Hi_R_hi_batt_cell	0.0096	Ω	Internal cell resistance value of high voltage battery
BT_PNT_Hi_R_pol_hi_batt	0.096	Ω	Polarization characteristics resistance for high voltage battery
BT_PNT_Hi_SOC_MAX_hi_batt	100	%	Maximum SOC value of high voltage battery
BT_PNT_Hi_SOC_MIN_hi_batt	0.0	%	Minimum SOC value of high voltage battery
BT_PNT_Hi_SOC_START_hi_batt	50	%	Initial SOC value of high voltage battery
BT_PNT_Hi_ocv_SOC_hi_batt_OCV_V_table	<1×10>	V	High voltage battery OCV table
BT_PNT_Hi_ocv_SOC_hi_batt_OCV_V_table_x_SOC	<1×10>	%	High voltage battery OCV table x-SOC

5.3.10.5 Other information

None.

5.3.11. Functional specification of [B10P: INV_PNT] system

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

5.3.11.1 Abstract

The abstract of this system is shown below.

① Modelized object

Inverter model

② Modelized level

Calculate inverter current and voltage

Calculate the heat flow of inverter

③ Modelized function

Function to calculate the inverter current from the motor voltage (line voltage), phase current, and motor power factor

Function to calculate heat flow from inverter voltage and power consumption

5.3.11.2 Data flow diagram

The data flow diagram of this system is shown below.

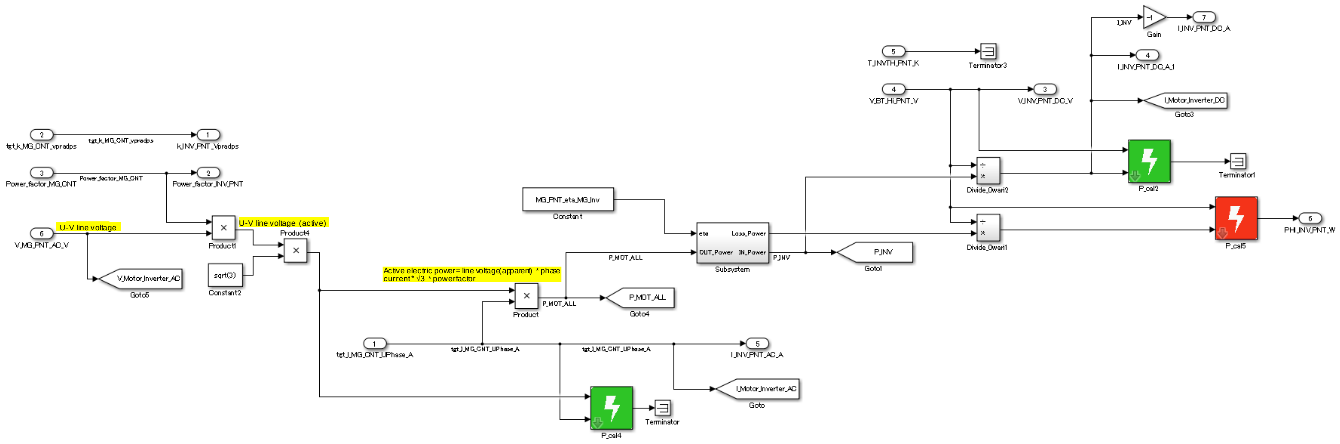


Fig. 5.3.11.2 Data flow diagram: third-layer INV_PNT system

5.3.11.3 Input/output specification

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

Input			
Name	Unit	Area	Description
tgt_I_MG_CNT_UPhase_A	A	TBD	Target U-phase current value
tgt_k_MG_CNT_vpradps	V/(rad/s)	TBD	Counter electromotive force coefficient
Power_factor_MG_CNT	-	TBD	Motor power factor
T_INVTH_PNT_K	K	TBD	Inverter temp.
V_MG_PNT_AC_V	V	TBD	Voltage of motor
V_BT_Hi_PNT_V	V	TBD	Battery voltage for high voltage
Output			
Name	Unit	Area	Description
I_INV_PNT_AC_A	A	TBD	Inverter (AC side) current
I_INV_PNT_DC_A	A	TBD	Inverter (DC side) current
I_INV_PNT_DC_A_1	A	TBD	Inverter (DC side) current
k_INV_PNT_Vpradps	V/(rad/s)	TBD	Counter electromotive force coefficient
Power_factor_INV_PNT	-	TBD	Inverter power factor
PHI_INV_PNT_W	W	TBD	Inverter heat flow
V_INV_PNT_DC_V	V	TBD	Voltage of inverter (DC side)

5.3.11.4 Parameter specification

The parameter specification of this system is shown below.

Variable name	Setting value	Unit	Description
MG_PNT_eta_MG_Inv	0.97	-	Inverter efficiency

5.3.11.5 Other information

None.

5.3.12. Functional specification of [B11P: MG_PNT] system

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

5.3.12.1 Abstract

The abstract of this system is shown below.

① Modelized object

Motor model

② Modelized level

Calculate torque and voltage that output from the motor during mode driving

Calculate generated motor heat flow

③ Modelized function

Function to calculate the motor voltage from motor power factor, rpm and back electromotive force coefficient

Function to calculate motor torque from inverter current and motor efficiency

Function to calculate motor heat flow from motor speed and loss torque

5.3.12.2 Data flow diagram

The data flow diagram of this system is shown below.

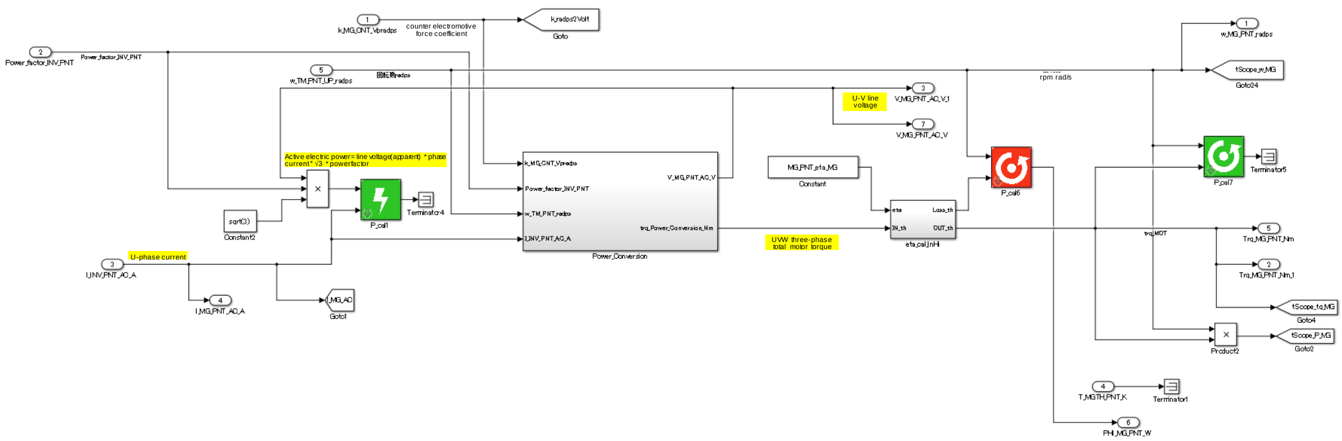


Fig. 5.3.12.2 Data flow diagram: third-layer MG_PNT system

5.3.12.3 Input/output specification

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

Input			
Name	Unit	Area	Description
I_INV_PNT_AC_A	A	TBD	Inverter (AC side) current
k_MG_CNT_Vpradps	V/(rad/s)	TBD	Counter electromotive force coefficient
Power_factor_INV_PNT	-	TBD	Inverter power factor
T_MGTH_PNT_K	K	TBD	Motor temp.
w_TM_PNT_UP_radps	rad/s	TBD	Motor rpm
Output			
Name	Unit	Area	Description
I_MG_PNT_AC_A	A	TBD	Motor current
PHI_MG_PNT_W	W	TBD	Motor heat flow
Trq_MG_PNT_Nm	Nm	TBD	Motor torque
Trq_MG_PNT_Nm_1	Nm	TBD	Motor torque
V_MG_PNT_AC_V	V	TBD	Voltage of motor
V_MG_PNT_AC_V_1	V	TBD	Voltage of motor
w_MG_PNT_radps	rad/s	TBD	Motor rpm

5.3.12.4 Parameter specification

The parameter specification of this system is shown below.

Variable name	Setting value	Unit	Description
MG_PNT_eta_MG	0.92	-	Motor efficiency

5.3.12.5 Other information

None.

5.3.13. Functional specification of [B12: TM_PNT] system

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

5.3.13.1 Abstract

The abstract of this system is shown below.

① Modelized object
Transmission model

② Modelized level
Gear changing function of inertia and transmission
Calculate transmission heat volume during mode driving

③ Modelized function
Transmission inertia of differential gear side
Function to calculate the torque of differential gear side according to the gear ratio of the transmission
Function to change the motor rpm.
Function to calculate transmission heat flow from motor speed and loss torque.

5.3.13.2 Data flow diagram

The data flow diagram of this system is shown below.

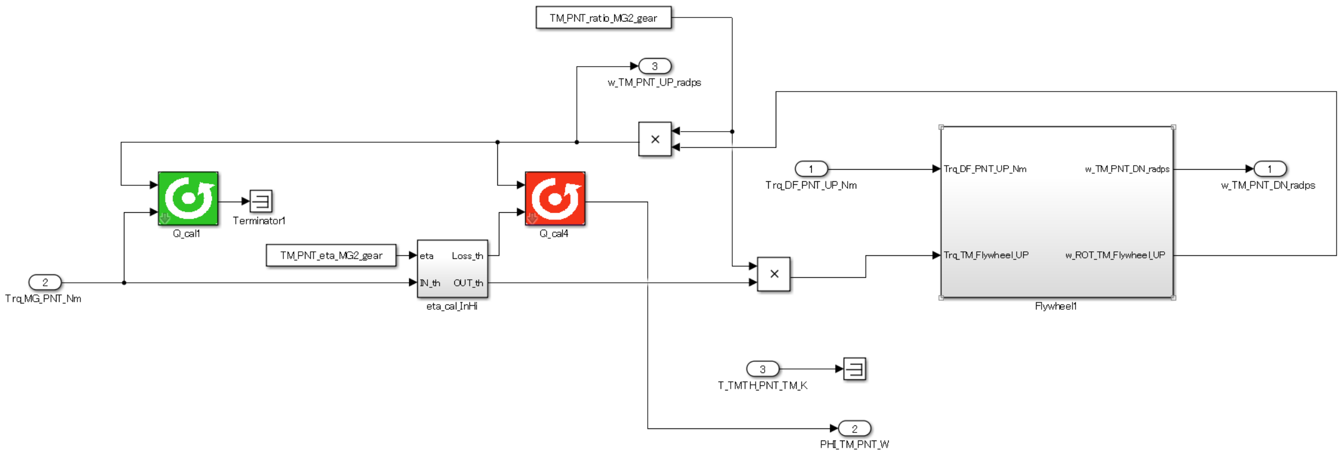


Fig. 5.3.13.2 Data flow diagram: third-layer TM_PNT system

5.3.13.3 Input/output specification

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

Input			
Name	Unit	Area	Description
T_TMTH_PNT_TM_K	K	TBD	Transmission of temp.
Trq_DF_PNT_UP_Nm	Nm	TBD	Torque at differential gear side
Trq_MG_PNT_Nm	Nm	TBD	Motor torque
Output			
Name	Unit	Area	Description
PHI_TM_PNT_W	W	TBD	Heat flow from transmission
w_TM_PNT_UP_radps	Rad/s	TBD	Motor rpm
w_TM_PNT_DN_radps	Rad/s	TBD	Rotational velocity of transmission

5.3.13.4 Parameter specification

The parameter specification of this system is shown below.

Variable name	Setting value	Unit	Description
TM_PNT_eta_MG2_gear	0.97	-	Primary deceleration efficiency of generator
TM_PNT_ratio_MG2_gear	2.52	-	Transmission gear ratio
TM_PNT_TM_Inertia	0.3	kgm2	Transmission inertia

5.3.13.5 Other information

None.

5.3.14. Functional specification of [B14P: BK_PNT] system

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

5.3.14.1 Abstract

The abstract of this system is shown below.

① Modelized object
Brake model

② Modelized level
Model to generate braking force during mode driving

③ Modelized function
A function to calculate the brake torque from the brake stroke and tire radius in consideration of the delay due to hydraulic pressure propagation

5.3.14.2 Data flow diagram

The data flow diagram of this system is shown below.

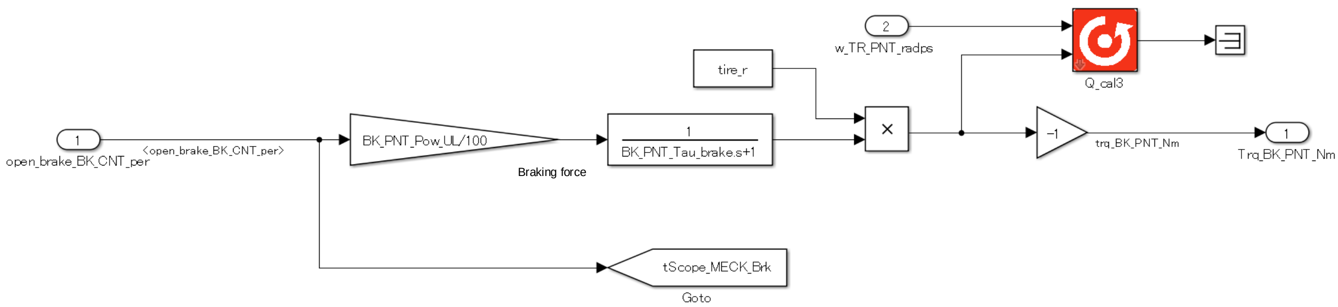


Fig. 5.3.14.2 Data flow diagram: third-layer BK_PNT system

5.3.14.3 Input/output specification

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

Input			
Name	Unit	Area	Description
open_brake_BK_CNT_per	%	[0 100]	Brake opening ratio
w_TR_PNT_radps	rad/s	TBD	Rotational velocity of tire
Output			
Name	Unit	Area	Description
Trq_BK_PNT_Nm	Nm	TBD	Braking forc

5.3.14.4 Parameter specification

The parameter specification of this system is shown below.

Variable name	Setting value	Unit	Description
BK_PNT_Pow_UL	20000	N	Braking force upper limit value
BK_PNT_Tau_brake	0.15	s	Time constant for braking force

5.3.14.5 Other information

None.

5.3.15. Functional specification of [B15: TR_PNT] system

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

5.3.15.1 Abstract

The abstract of this system is shown below.

① Modelized object
Tyre model

② Modelized level
Converts rotational movement of drive shaft into translational movement of vehicle
Add rolling resistance during mode driving

③ Modelized function
Function to translate between rotational and translational motion
Function to add rolling resistance to the acceleration force of translational motion

5.3.15.2 Data flow diagram

The data flow diagram of this system is shown below.

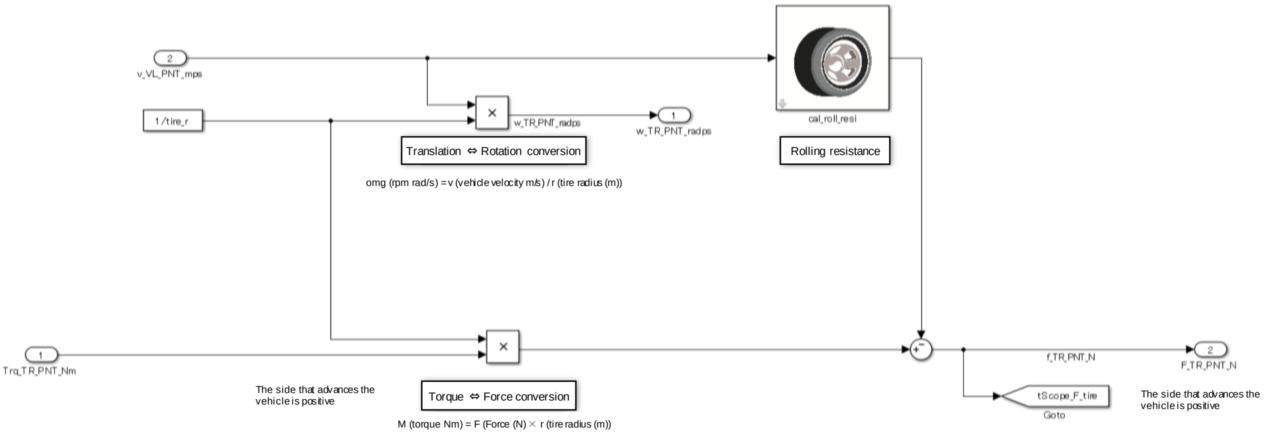


Fig. 5.3.15.2 Data flow diagram: third-layer TR_PNT system

5.3.15.3 Input/output specification

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

Input			
Name	Unit	Area	Description
Trq_TR_PNT_Nm	Nm	TBD	Braking force
v_VL_PNT_mps	m/s	TBD	Vehicle velocity(m/s)
Output			
Name	Unit	Area	Description
F_TR_PNT_N	N	TBD	Tire propulsion force (positive on the side of moving the vehicle forward)
w_TR_PNT_radps	Rad/s	TBD	Rotational velocity of tire

5.3.15.4 Parameter specification

No parameter in this system.

5.3.15.5 Other information

None.

5.3.16. Functional specification of [B16: VL_PNT] system

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

5.3.16.1 Abstract

The abstract of this system is shown below.

① Modelized object

The vehicle dynamics model

② Modelized level

Calculate vehicle translation speed

Add air resistance and uphill resistance on the vehicle to translational acceleration

③ Modelized function

Function to calculate the vehicle speed from the translational acceleration of the vehicle

Function to determine air resistance from the translational speed of a vehicle and add to the translational acceleration force

Function to calculate the uphill resistance on the vehicle and add to the translational acceleration force

5.3.16.2 Data flow diagram

The data flow diagram of this system is shown below.

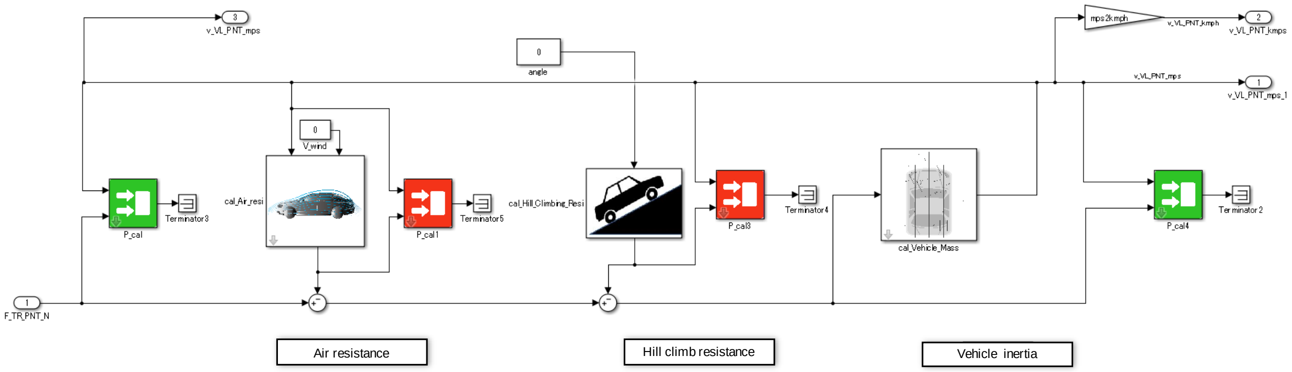


Fig. 5.3.16.2 Data flow diagram: third-layer VL_PNT system

5.3.16.3 Input/output specification

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

Input			
Name	Unit	Area	Description
F_TR_PNT_N	N	TBD	Tire propulsion force (positive on the side of moving the vehicle forward)
Output			
Name	Unit	Area	Description
v_VL_PNT_mps	m/s	TBD	Vehicle velocity(m/s)
v_VL_PNT_kmps	Km/h	TBD	Vehicle velocity(km/h)
v_VL_PNT_mps_1	m/s	TBD	Vehicle velocity(m/s)

5.3.16.4 Parameter specification

No parameter in this system.

5.3.16.5 Other information

None.

5.3.17. Functional specifications of [B13P: DF_PNT] system

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

5.3.17.1 Abstract

The abstract of this system is shown below.

① Modelized object
Def gear model

② Modelized level
Transmission mechanism that reflect transmission efficiency during mode driving
Calculate differential gear heat flow that generated during driving

③ Modelized function
Function to change gear with differential gear reduction ratio
Function to calculate the differential gear heat flow from the transmission rpm. and torque loss due to twisting of the drive shaft

5.3.17.2 Data flow diagram

The data flow diagram of this system is shown below.

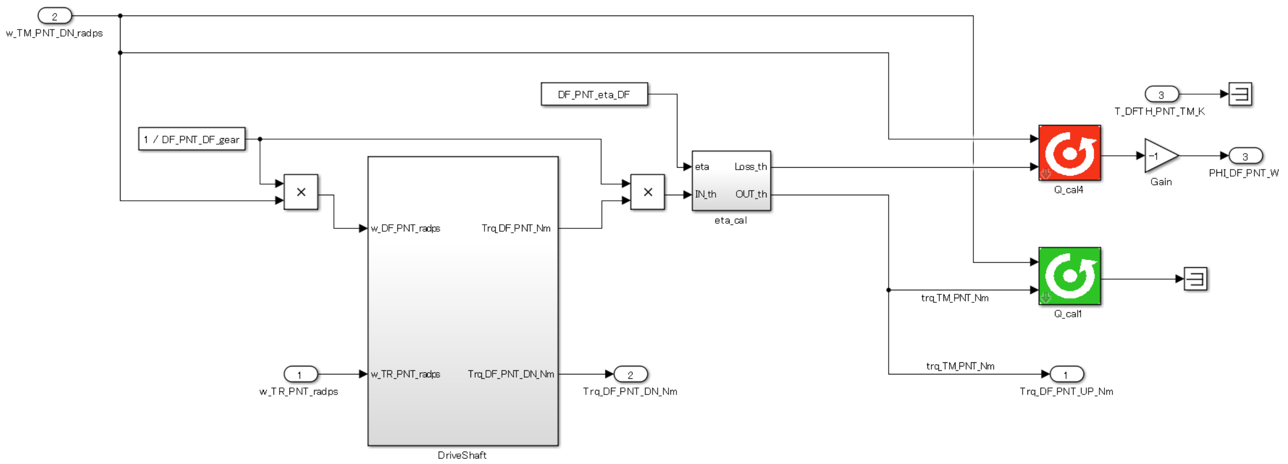


Fig. 5.3.17.2 Data flow diagram: third-layer DF_PNT system

5.3.17.3 Input/output specification

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

Input			
Name	Unit	Area	Description
T_DFTH_PNT_TM_K	K	TBD	Temp. of differential gear
w_TR_PNT_radps	rad/s	TBD	Rotational velocity of tire
w_TM_PNT_DN_radps	rad/s	TBD	Rotational velocity of transmission
Output			
Name	Unit	Area	Description
PHI_DF_PNT_W	W	TBD	Heat flow from the differential gear
Trq_DF_PNT_DN_Nm	Nm	TBD	Torque at tire side
Trq_DF_PNT_UP_Nm	Nm	TBD	Torque at differential gear side

5.3.17.4 Parameter specification

The parameter specification of this system is shown below.

Variable name	Setting value	Unit	Description
DF_PNT_DF_gear	3.25	-	Reduction gear ratio of differential gear
DF_PNT_Driveshaft_damper	252.982	Nm/(rad/s)	Damping coefficient for drive shaft
DF_PNT_Driveshaft_spring	10000	Nm/rad	Drive shaft spring coefficient
DF_PNT_eta_DF	0.96	-	Differential gear efficiency

5.3.17.5 Other information

None.

5.3.18. Functional specification of [B32P: PTTH_PNT] system

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

5.3.18.1 Abstract

The abstract of this system is shown below.

① Modelized object

Powertrain thermal model

② Modelized level

Calculate heat capacity and resistance of transmission

Calculate heat capacity and heat resistance of differential gear

③ Modelized function

Function to calculate transmission temperature

Function to calculate differential gear temperature

5.3.18.2 Data flow diagram

The data flow diagram of this system is shown below.

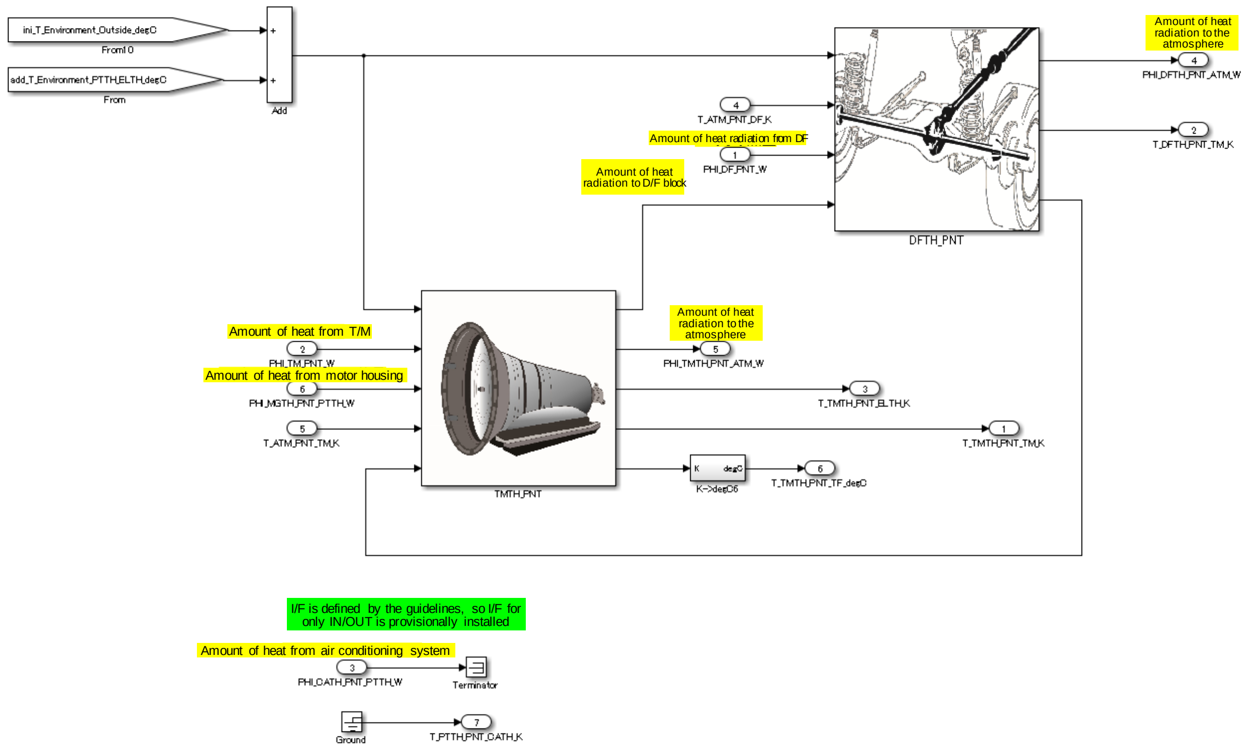


Fig. 5.3.18.2 Data flow diagram: third-layer PTTH_PNT system

5.3.18.3 Input/output specification

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

Input			
Name	Unit	Area	Description
ini_T_Environment_Outside_degC	℃	[-30 40]	Initial outside ambient temp.
add_T_Environment_PTTH_ELTH_degC	℃	[0 40]	Initial temp. difference between power sysytem and outside ambient temp.
PHI_CATH_PNT_PTTH_W	W	TBD	Heat flow from cabin thermal to power train thermal
PHI_DF_PNT_W	W	TBD	Heat flow from the differential gear
PHI_MGTH_PNT_PTTH_W	W	TBD	Heat flow from transmission to motor housing
PHI_TM_PNT_W	W	TBD	Heat flow from transmission
T_ATM_PNT_DF_K	K	TBD	Ambient temp. around differential gear
T_ATM_PNT_TM_K	K	TBD	Ambient temp. around transmission
Output			
Name	Unit	Area	Description
PHI_DFTH_PNT_ATM_W	W	TBD	Heat flow radiated from differential gear to the atmosphere
PHI_TMTH_PNT_ATM_W	W	TBD	Heat flow radiated from transmission to the atmosphere
T_PTTH_PNT_CATH_K	K	TBD	Transmission of temp.
T_DFTH_PNT_TM_K	K	TBD	Temp. of differential gear
T_TMTH_PNT_ELTH_K	K	TBD	Transmission of temp.
T_TMTH_PNT_TM_K	K	TBD	Transmission of temp.
T_TMTH_PNT_TF_degC	℃	TBD	TF temp.

5.3.18.4 Parameter specification

The parameter specification of this system is shown below.

Variable name	Setting value	Unit	Description
PTTH_PNT_DFBlock_Heat_Capa_JpK	10000	J/K	Heat capacity of DF block
PTTH_PNT_DFBlock2DFAir_Heat_Resi_KpW	0.3	K/W	Thermal resistance value between DF block and external environment
PTTH_PNT_DFOil_Heat_Capa_JpK	10000	J/K	Heat capacity of DF oil
PTTH_PNT_DFOil2DFBlock_Heat_Resi_KpW	0.01	K/W	Thermal resistance value between DF oil and DF block
PTTH_PNT_TF_Heat_Capa_JpK	10600	J/K	Heat capacity of TF
PTTH_PNT_TF2TMBlock_Heat_Resi_KpW	0.001	K/W	Thermal resistance value between TF and T/M block
PTTH_PNT_TMBlock_Heat_Capa_JpK	10000	J/K	Heat capacity of T/M block
PTTH_PNT_TMBlock2DFBlock_Heat_Resi_KpW	0.03	K/W	Thermal resistance value between TM block and DF block
PTTH_PNT_TMBlock2TMAir_Heat_Resi_KpW	0.3	K/W	Thermal resistance value between T/M block and external environment

5.3.18.5 Other information

None.

5.3.19. Functional specification of [B33P: ELTH_PNT] system

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

5.3.19.1 Abstract

The abstract of this system is shown below.

① Modelized object

Thermal models of motors, inverters, and radiators

② Modelized level

Calculate the heat capacity and heat resistance of motor
Calculate the heat capacity and heat resistance of inverter
Calculate heat capacity and resistance of radiator

③ Modelized function

Function to calculate motor temperature and heat flow to the atmosphere
unction to calculate inverter temperature
Function to calculate radiator temperature

5.3.19.2 Data flow diagram

The data flow diagram of this system is shown below.

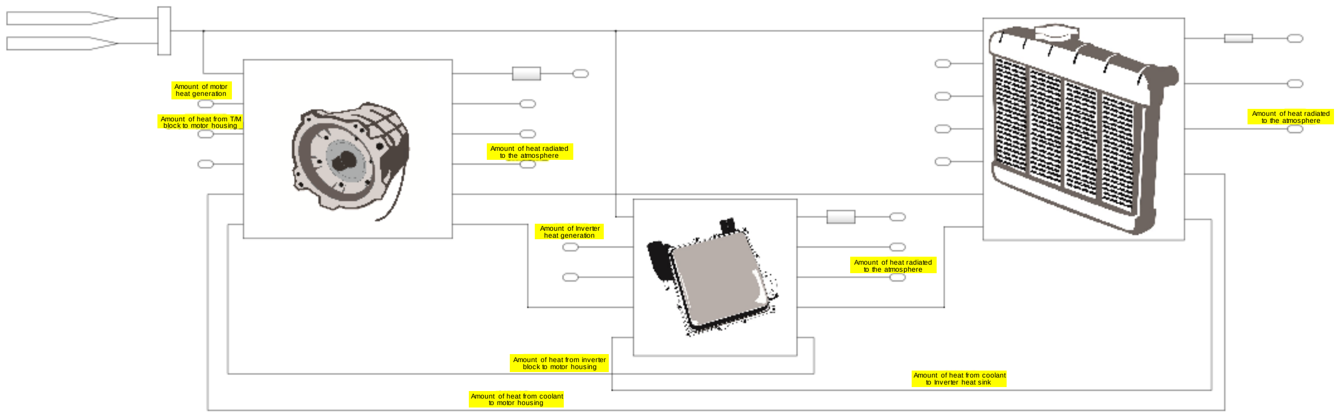


Fig. 5.3.19.2 Data flow diagram: third-layer ELTH_PNT system

5.3.19.3 Input/output specification

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

Input			
Name	Unit	Area	Description
Ini_T_Environment_Outside_degC	℃	[-30 40]	Initial outside ambient temp.
Add_T_Environment_PTTH_ELTH_degC	℃	[0 40]	Initial temp. difference between power sysytem and outside ambient temp.
PHI_MG_PNT_W	W	TBD	Motor heat flow
T_TMTH_PNT_ELTH_K	K	TBD	Transmission of temp.
T_ATM_PNT_MG_K	K	TBD	Ambient temp. around motor
PHI_INV_PNT_W	W	TBD	Inverter heat flow
T_ATM_PNT_INV_K	K	TBD	Ambient temp. around inverter
V_ELTH_CNT_WP_V	V	TBD	Voltage of water pump
V_ELTH_CNT_RDFan_V	V	TBD	Voltage of radiator fan
v_VL_PNT_kmph	km/h	TBD	Vehicle velocity(km/h)
T_ATM_PNT_RD_K	K	TBD	Ambient temp. around radiator
Output			
Name	Unit	Area	Description
T_MGTH_PNT_K	K	TBD	Motor temp.
PHI_MGTH_PNT_PTTH_W	W	TBD	Heat flow from transmission to motor housing
PHI_MGTH_PNT_ATM_W	W	TBD	Heat flow radiated from motor to the atmosphere
T_INVTH_PNT_K	K	TBD	Inverter temp.
T_MGTH_PNT_MGHousing_degC	℃	TBD	Motor housing temp.
PHI_INVTH_PNT_ATM_W	W	TBD	Heat flow radiated from inverter to the atmosphere
T_INVTH_PNT_INVHeatsink_degC	℃	TBD	Inverter heat sink temp.
PHI_RDTH_PNT_ATM_W	W	TBD	Heat flow radiated from radiator to the atmosphere
Heat_Resi_ELTH_PNT_AirconCore_KpW	K/W	TBD	Thermal resistance value between the radiator and the external environment
T_RDTH_PNT_RDCoolant_degC	℃	TBD	Radiator coolant temp.

5.3.19.4 Parameter specification

The parameter specification of this system is shown below.

Variable name	Setting value	Unit	Description
ELTH_PNT_INV2Coolant_Heat_Resi_KpW	<1×4>	K/W	Thermal resistance map between inverter heat sink and coolant
ELTH_PNT_INV2Coolant_Heat_Resi_x_qv_Coolant	<1×4>	m3/sec	Thermal resistance map between inverter heat sink and coolant: x-coolant flow
ELTH_PNT_INVBlock2DFAir_Heat_Resi_KpW	10.0	K/W	Thermal resistance value between inverter housing and external environment
ELTH_PNT_INVBlock_Heat_Capa_JpK	1000	J/K	Heat capacity of inverter housing
ELTH_PNT_INVHeatsink2INVBlock_Heat_Resi_KpW	1.0	K/W	Thermal resistance value between inverter heat sink and DF block
ELTH_PNT_INVHeatsink_Heat_Capa_JpK	1000	J/K	Heat capacity of inverter heat sink
ELTH_PNT_MG2Coolant_Heat_Resi_KpW	<1×4>	K/W	Thermal resistance map between motor housing and coolant
ELTH_PNT_MG2Coolant_Heat_Resi_x_qv_Coolant	<1×4>	m3/sec	Thermal resistance map between motor housing and coolant: x-coolant flow
ELTH_PNT_MG2INVBlock_Heat_Resi_KpW	1.0	K/W	Thermal resistance value between motor housing and inverter housing
ELTH_PNT_MGCoil2MGHousing_Heat_Resi_KpW	0.001	K/W	Thermal resistance value between MG coil to MG housing
ELTH_PNT_MGCoil_Heat_Capa_JpK	10600	J/K	Heat capacity of MG coil
ELTH_PNT_MGHousing2TMAir_Heat_Resi_KpW	1.0	K/W	Thermal resistance value between T/M block and external environment

Variable name	Setting value	Unit	Description
ELTH_PNT_MGHousing_Heat_Capa_JpK	10000	J/K	Heat capacity of T/M block
ELTH_PNT_PTTH2MGHousing_Heat_Resi_KpW	1.0	K/W	Thermal resistance value between PTTH and MG housings
ELTH_PNT_Qv_Water_Pump_m3ps	<1×5>	m3/s	Coolant flow map for water pump
ELTH_PNT_Qv_Water_Pump_x_V_WP	<1×5>	V	Coolant flow map for water pump: x-voltage
ELTH_PNT_RDCoolant_Heat_Capa_JpK	54000	J/K	Heat capacity of coolant in radiator
ELTH_PNT_RDCore_Heat_Resi_KpW	<1×6>	K/W	Thermal resistance map between the radiator and the external environment
ELTH_PNT_RDCore_Heat_Resi_KpW_x_Wind_m3ps	<1×6>	m3/s	Thermal resistance map between the radiator and the external environment: x- radiator air flow
ELTH_PNT_RDFan_area_m2	0.25	m2	Radiator fan area
ELTH_PNT_RDGrill_area_m2	0.20	m2	Radiator grill area
ELTH_PNT_v_RDFan_Wind_vel_mps	<1×2>	m/s	Voltage - air flow characteristics map of radiator fan
ELTH_PNT_v_RDFan_Wind_vel_mps_x_V_RDFan	<1×2>	V	Voltage - air flow characteristics map of radiator fan: x-radiator fan voltage

5.3.19.5 Other information

None.

5.3.20. Functional specification of [B40P: ATM_PNT] system

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

5.3.20.1 Abstract

The abstract of this system is shown below.

① Modelized object
Atmospheric model

② Modelized level
Ambient temperature and the direct sunlight heat flow

③ Modelized function
Function to calculate the ambient temperature of differential gear
Function to calculate the ambient temperature of transmission
Function to calculate the ambient temperature of radiator
Function to calculate the ambient temperature of motor
Function to calculate the ambient temperature of inverter
Function to calculate the ambient temperature of glass
Function to calculate the ambient temperature of wall
Function to calculate the ambient temperature of air conditioner
Function to calculate the ambient temperature of battery
Function to calculate the ambient temperature of battery fan
Function to absorb the heat generation of differential gear
Function to absorb the heat generated by transmission
Function to absorb the calorific value of radiator
Function to absorb the heat generated by motor
Function to absorb the heat generated by inverter
Function to absorb the calorific value of glass
Function to absorb the amount of heat generated by wall
Function to absorb the heat generated by air conditioner
Function to absorb the amount of heat generated by battery
Function to absorb the amount of heat generated by battery fan
Function to calculate the Heat flow of direct sunlight

5.3.20.2 Data flow diagram

The data flow diagram of this system is shown below.

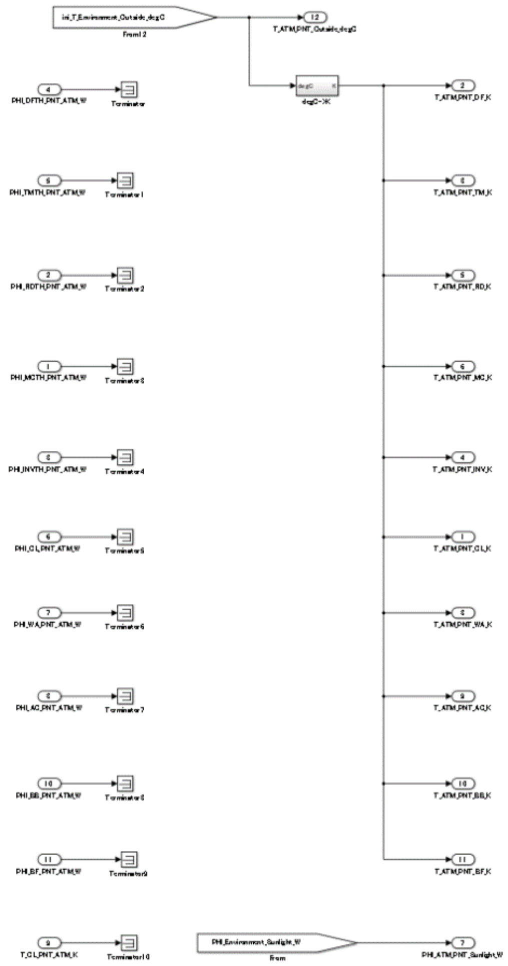


Fig. 5.3.20.2 Data flow diagram: third-layer ATM_PNT system

5.3.20.3 Input/output specification

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

Input			
Name	Unit	Area	Description
Ini_T_Environment_Outside_degC	℃	[-30 40]	Initial outside ambient temp.
PHI_DFTH_PNT_ATM_W	W	TBD	Heat flow radiated from differential gear to the atmosphere
PHI_TMTH_PNT_ATM_W	W	TBD	Heat flow radiated from transmission to the atmosphere
PHI_RDTH_PNT_ATM_W	W	TBD	Heat flow radiated from radiator to the atmosphere
PHI_MGTH_PNT_ATM_W	W	TBD	Heat flow radiated from motor to the atmosphere
PHI_INVTH_PNT_ATM_W	W	TBD	Heat flow radiated from inverter to the atmosphere
PHI_GL_PNT_ATM_W	W	TBD	Heat flow radiated from glass to the atmosphere
PHI_WA_PNT_ATM_W	W	TBD	Heat flow radiated from opaque wall to the atmosphere
PHI_AC_PNT_ATM_W	W	TBD	Heat flow released from the air conditioner outdoor unit to the atmosphere
PHI_BB_PNT_ATM_W	W	TBD	heat flow radiated from high voltage battery housing to the atmosphere
PHI_BF_PNT_ATM_W	W	TBD	Heat flow radiated from battery fan to the atmosphere
T_GL_PNT_ATM_K	K	TBD	Temp.of cabin
PHI_Environment_Sunlight_W	W	[0 1000]	Heat flow of solar radiation
Output			
Name	Unit	Area	Outside ambient temp.
T_ATM_PNT_Outside_degC	℃	[-30 40]	Outside ambient temp.
T_ATM_PNT_DF_K	K	TBD	Ambient temp. around differential gear
T_ATM_PNT_TM_K	K	TBD	Ambient temp. around transmission
T_ATM_PNT_RD_K	K	TBD	Ambient temp. around radiator
T_ATM_PNT_MG_K	K	TBD	Ambient temp. around motor
T_ATM_PNT_INV_K	K	TBD	Ambient temp. around inverter
T_ATM_PNT_GL_K	K	TBD	Ambient temp. around glass
T_ATM_PNT_WA_K	K	TBD	Ambient temp. of opaque wall
T_ATM_PNT_AC_K	K	TBD	Ambient temp. around air conditioner
T_ATM_PNT_BB_K	K	TBD	Ambient temp. around high voltage battery housing
T_ATM_PNT_BF_K	K	TBD	Ambient temp. around battery fan
PHI_ATM_PNT_Sunlight_W	W	[0 1000]	Heat flow of solar radiation

5.3.20.4 Parameter specification

No parameter in this system.

5.3.20.5 Other information

None.

5.3.21. Functional specification of [B21P: CHG_PNT] system

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

5.3.21.1 Abstract

The abstract of this system is shown below.

① Modelized object
Charger model

② Modelized level
Calculate charging current
Charge voltage calculation

③ Modelized function
Function to calculate charging current from target charging current
Function to calculate charging voltage from battery voltage from high voltage side

5.3.21.2 Data flow diagram

The data flow diagram of this system is shown below.

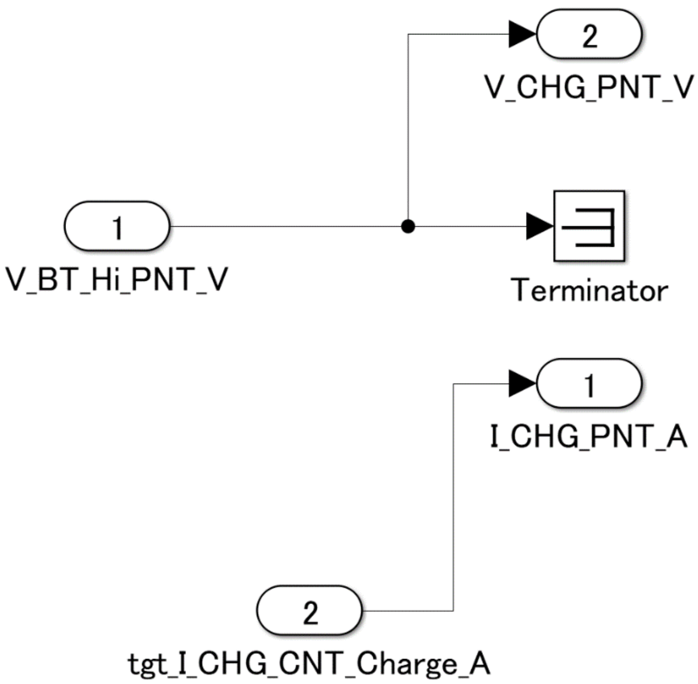


Fig. 5.3.22.2 Data flow diagram: third-layer CHG_PNT system

5.3.21.3 Input/output specification

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

Input			
Name	Unit	Area	Description
tgt_I_CHG_CNT_Charge_A	A	TBD	Target charging current
V_BT_Hi_PNT_V	V	TBD	Battery voltage for high voltage
Output			
Name	Unit	Area	Description
I_CHG_PNT_A	A	TBD	Charging current
V_CHG_PNT_V	V	TBD	Charging voltage

5.3.21.4 Parameter specification

No parameter in this system.

5.3.21.5 Other information

None.

5.3.22. Functional specification of [B17P: DCDC_PNT] system

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

5.3.22.1 Abstract

The abstract of this system is shown below.

① Modelized object
Buck converter model

② Modelized level
Drop the voltage from high voltage side

③ Modelized function
Function to drop high voltage

5.3.22.2 Data flow diagram

The data flow diagram of this system is shown below.

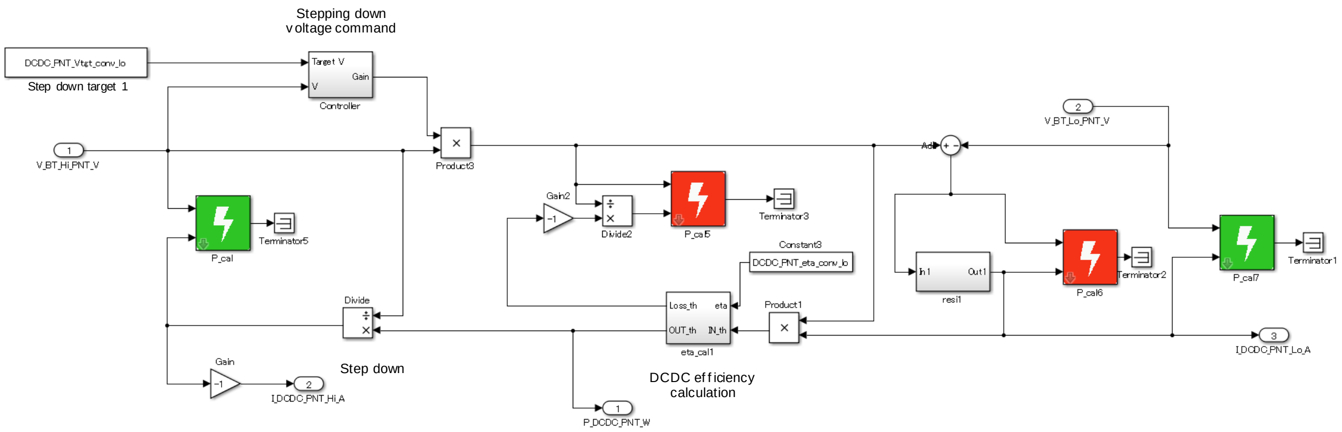


Fig. 5.3.23.2 data flow diagram: third-layer DCDC_PNT System

5.3.22.3 Input/output specification

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

Input			
Name	Unit	Area	Description
V_BT_Hi_PNT_V	V	TBD	Battery voltage for high voltage
V_BT_Lo_PNT_V	V	TBD	Battery voltage for low voltage
Output			
Name	Unit	Area	Description
I_DCDC_PNT_Hi_A	A	TBD	Current at high voltage side
I_DCDC_PNT_Lo_A	A	TBD	Current at low voltage side
P_DCDC_PNT_W	W	TBD	Electric consumption of low voltage auxiliary unit

5.3.22.4 Parameter specification

The parameter specification of this system is shown below.

Variable name	Setting value	Unit	Description
DCDC_PNT_eta_conv_lo	0.95	-	Buck converter efficiency
DCDC_PNT_R_conv_lo	0.02	Ω	Resistance value of buck converter
DCDC_PNT_Vtgt_conv_lo	14.0	V	Target voltage for buck converter

5.3.22.5 Other information

None.

5.3.23. Function specification of [B22P: BT_Lo_PNT] system

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

5.3.23.1 Abstract

The abstract of this system is shown below.

① Modelized object

Low voltage battery model

② Modelized level

Model to calculate terminal voltage by calculating OCV according to SOC and adding charge/discharge current and voltage drop due to internal resistance

③ Modelized function

Function to calculate SOC from battery current of low voltage side

Function to calculate the battery voltage of low voltage side by voltage drop due to internal resistance and OCV

5.3.23.2 Data flow diagram

The data flow diagram of this system is shown below.

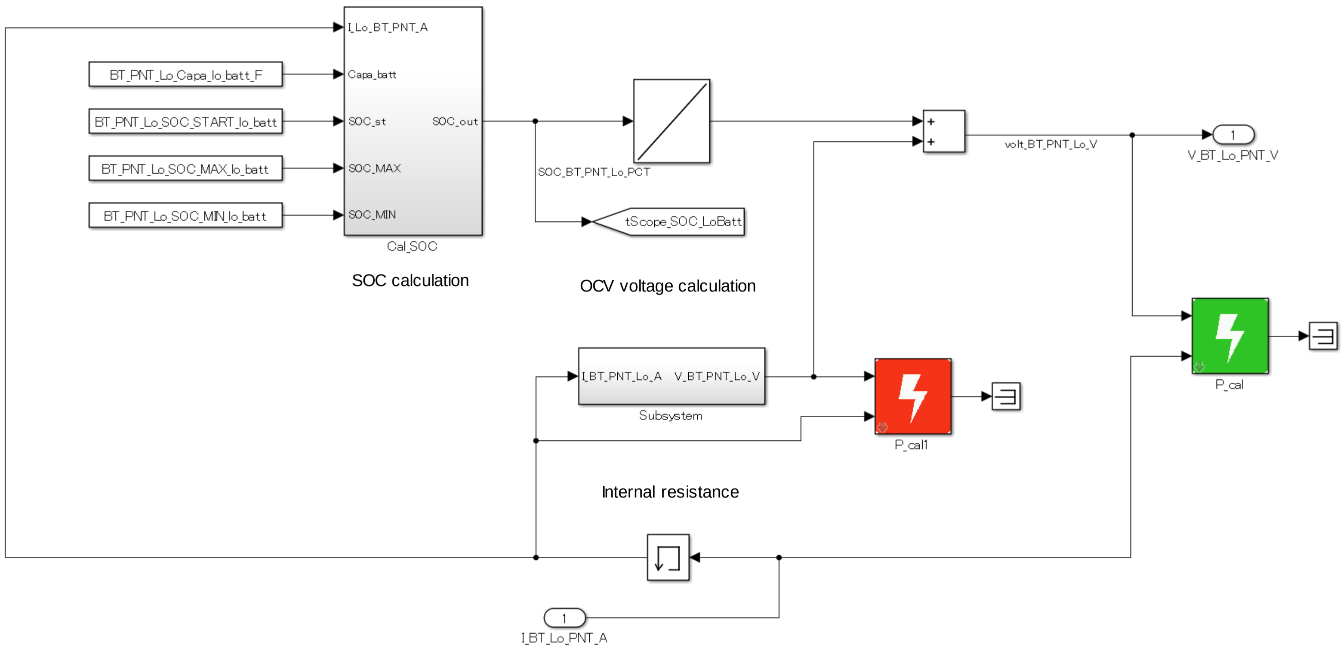


Fig. 5.3.23.2 Data flow diagram: third-layer BT_Lo_PNT system

5.3.23.3 Input/output specification

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

Input			
Name	Unit	Area	Description
I_BT_Lo_PNT_A	A	TBD	Battery current of low voltage battery
Output			
Name	Unit	Area	Description
V_BT_Lo_PNT_V	V	TBD	Battery voltage for low voltage

5.3.23.4 Parameter specification

The parameter specification of this system is shown below.

Variable name	Setting value	Unit	Description
BT_PNT_Lo_Capa_lo_batt_F	45	Ah	Low voltage battery capacity: GS YUASA 45Ah
BT_PNT_Lo_ocv_SOC_lo_batt_OCV_V_table	<1×2>	V	Low voltage battery OCV table
BT_PNT_Lo_ocv_SOC_lo_batt_OCV_V_table_x_SOC	<1×2>	%	Low voltage battery OCV table x-SOC
BT_PNT_Lo_R_lo_batt_ohm	0.01	Ω	Internal resistance value of low voltage battery
BT_PNT_Lo_SOC_MAX_lo_batt	120	%	Maximum SOC value of low voltage battery
BT_PNT_Lo_SOC_MIN_lo_batt	0.0	%	Minimum SOC value of low voltage battery
BT_PNT_Lo_SOC_START_lo_batt	95	%	Initial SOC value of low voltage battery

5.3.23.5 Other information

None.

5.3.24. Functional specification of [B30P: CATH_PNT] system

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

5.3.24.1 Abstract

The abstract of this system is shown below.

① Modelized object

Model of cabin thermal

② Modelized level

Heat capacity and heat resistance for HVAC

Heat capacity and heat resistance for Cabin

Heat capacity and thermal resistance for Seat heater

③ Modelized function

Function to calculate HVAC temperature

Function to calculate cabin temperature

Function to calculate seat heater temperature

5.3.24.2 Data flow diagram

The data flow diagram of this system is shown below.

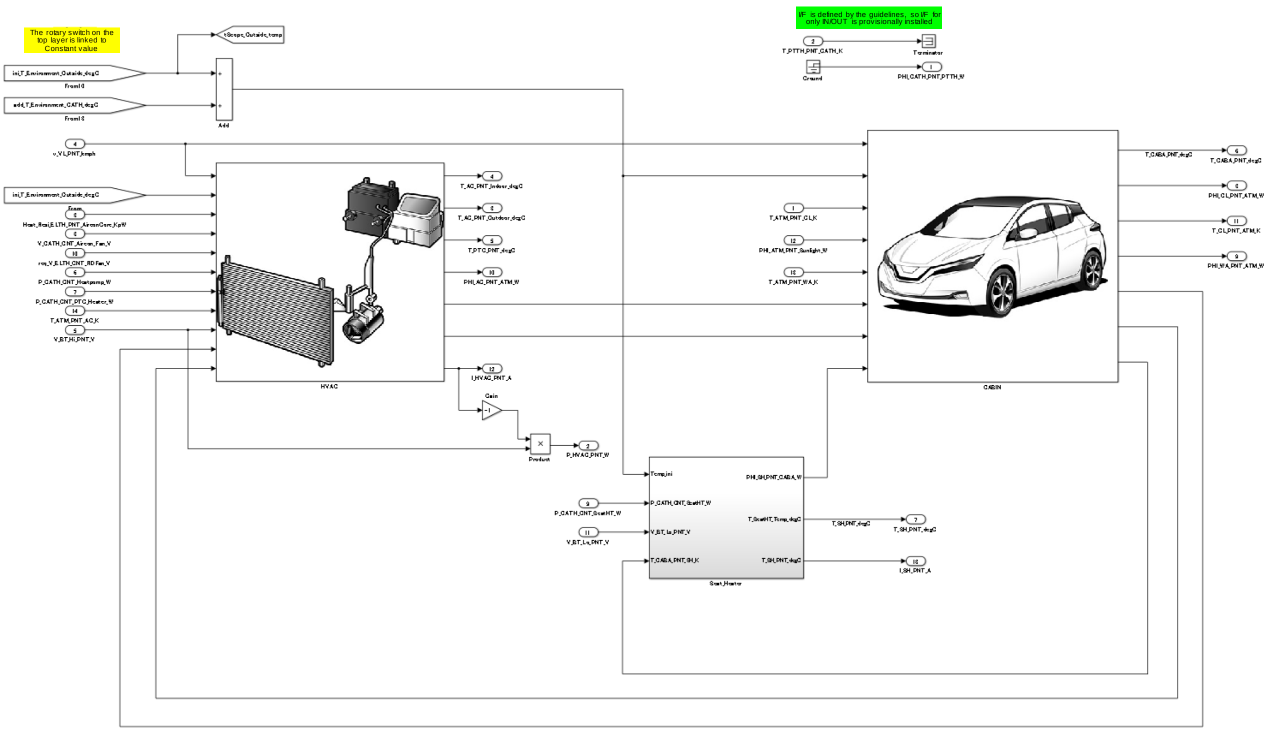


Fig. 5.3.24.2 Data flow diagram: third-layer CATH_PNT system

5.3.24.3 Input/output specification

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

Input			
Name	Unit	Area	Description
ini_T_Environment_Outside_degC	℃	[-30 40]	Initial outside ambient temp.
add_T_Environment_CATH_degC	℃	[0 30]	Initial temp. difference between cabin and outside ambient temp.
v_VL_PNT_kmph	km/h	TBD	Vehicle velocity(km/h)
P_CATH_CNT_PTC_Heater_W	W	TBD	PTC heater output
P_CATH_CNT_Heatpomp_W	W	TBD	Heat pump output
req_V_ELTH_CNT_RDFan_V	V	TBD	Required radiator fan voltage
V_CATH_CNT_Aircon_Fan_V	V	TBD	Voltage of air conditioner fan
Heat_Resi_ELTH_PNT_AirconCore_KpW	K/W	TBD	Thermal resistance value between the radiator and the external environment
V_BT_Hi_PNT_V	V	TBD	Battery voltage for high voltage
P_CATH_CNT_SeatHT_W	W	TBD	Seat heater output
V_BT_Lo_PNT_V	V	TBD	Battery voltage for low voltage
T_PTTH_PNT_CATH_K	K	TBD	Transmission of temp.
T_ATM_PNT_AC_K	K	TBD	Ambient temp. around air conditioner
PHI_ATM_PNT_Sunlight_W	W	TBD	Heat flow of solar radiation
T_ATM_PNT_GL_K	K	TBD	Ambient temp. around glass
T_ATM_PNT_WA_K	K	TBD	Ambient temp. of opaque wall
Output			
Name	Unit	Area	Description
I_HVAC_PNT_A	A	TBD	HVAC current
P_HVAC_PNT_W	W	TBD	HVAC electric power
T_PTC_PNT_degC	℃	TBD	Temp. of PTC heater
T_AC_PNT_Outdoor_degC	℃	TBD	Air conditioner outdoor unit temp.
T_AC_PNT_Indoor_degC	℃	TBD	Air conditioner indoor unit temp.
I_SH_PNT_A	A	TBD	Seat heater current
T_SH_PNT_degC	℃	TBD	Temp. of seat heater
PHI_CATH_PNT_PTTH_W	W	TBD	Heat flow from cabin thermal to power train thermal
PHI_AC_PNT_ATM_W	W	TBD	Heat flow released from the air conditioner outdoor unit to the atmosphere
T_GL_PNT_ATM_K	K	TBD	Temp.of cabin
PHI_GL_PNT_ATM_W	W	TBD	Heat flow radiated from glass to the atmosphere
PHI_WA_PNT_ATM_W	W	TBD	Heat flow radiated from opaque wall to the atmosphere
T_CABA_PNT_degC	℃	TBD	Temp.of cabin

5.3.24.4 Parameter specification

The parameter specification of this system is shown below.

Variable name	Setting value	Unit	Description
CATH_PNT_Air_Convection_Heat_Resi_KpW	<1×13>	K/W	Thermal resistance map of thermal transfer by convection
CATH_PNT_Air_Convection_Heat_Resi_x_mps	<1×13>	m/s	Thermal resistance map of thermal transfer by convection: x- average air flow speed
CATH_PNT_Aircon_Indoor_Unit_Heat_Capa_JpK	4400	J/K	Heat capacity of indoor unit for air conditioners
CATH_PNT_Aircon_Outdoor_Unit_Heat_Capa_JpK	4400	J/K	Heat capacity of outdoor unit for air conditioners
CATH_PNT_CABIN_AIR_Heat_Capa_JpK	7037.976	J/K	Heat capacity of cabin space
CATH_PNT_CABIN_Glass_S_m2	4.0	m2	Glass area
CATH_PNT_CABIN_SeatHT_Heat_Resi_KpW	0.01	K/W	Thermal resistance value between sheet heater and cabin space
CATH_PNT_CABIN_Wall_S_m2	10.0	m2	Opaque wall area
CATH_PNT_COP_Aircon	3.0	-	Performance coefficient of air conditioning
CATH_PNT_Glass_Heat_Capa_JpK	209.25e8	J/K	Heat capacity of window glass
CATH_PNT_Glass_Heat_Resi_m2KpW	0.005	m2K/W	Thermal resistance value of window glass area
CATH_PNT_Glass_emissivity	0.3	-	Emissivity of glass
CATH_PNT_HVAC_Heat_Resi_KpW	<1×4>	K/W	Thermal resistance map of the air conditioning heat exchanger
CATH_PNT_HVAC_Heat_Resi_KpW_x_Wind_m3ps	<1×4>	m3/s	Thermal resistance map of the air conditioning heat exchanger: x-air flow of HVAC fan
CATH_PNT_PHI_Human_body_W	140	W	Amount of heat generation from occupant (2 occupants)
CATH_PNT_PTC_Heater_Heat_Capa_JpK	1000	J/K	Heat capacity of PTC heater for air conditioner
CATH_PNT_Seat_Heater_Capa_JpK	100	J/K	Heat capacity of seat heater
CATH_PNT_Wall_Heat_Capa_JpK	5231.25e7	J/K	Heat capacity of opaque wall
CATH_PNT_Wall_Heat_Resi_m2KpW	1	m2K/W	Thermal resistance value of window glass area
CATH_PNT_Wall_Radiation_W	0.0	W	Radiation (infrared re-radiation) heat amount from opaque wall
CATH_PNT_Wall_emissivity	0.5	-	Emissivity of the opaque wall
CATH_PNT_v_HVAC_Fan_Wind_vel_m3ps	<1×3>	m3/s	air flow map of blower fan for air conditioning
CATH_PNT_v_HVAC_Fan_Wind_vel_m3ps_x_V_HVAC_Fan	<1×3>	V	Air flow map of blower fan for air conditioning: x-HVAC fan voltage
sigma_Stefan_Boltzmann	5.67e-8	W/m2K4	Stefan-Boltzmann constant

5.3.24.5 Other information

None.

5.3.25. Functional specification of [B23P: EL_PNT] system

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

5.3.25.1 Abstract

The abstract of this system is shown below.

① Modelized object
Low voltage electric load model

② Modelized level
Calculate current consumptionof low voltage side

③ Modelized function
Function to calculate the current consumption according to terminal voltage of low voltage electric load

5.3.25.2 Data flow diagram

The data flow diagram of this system is shown below.

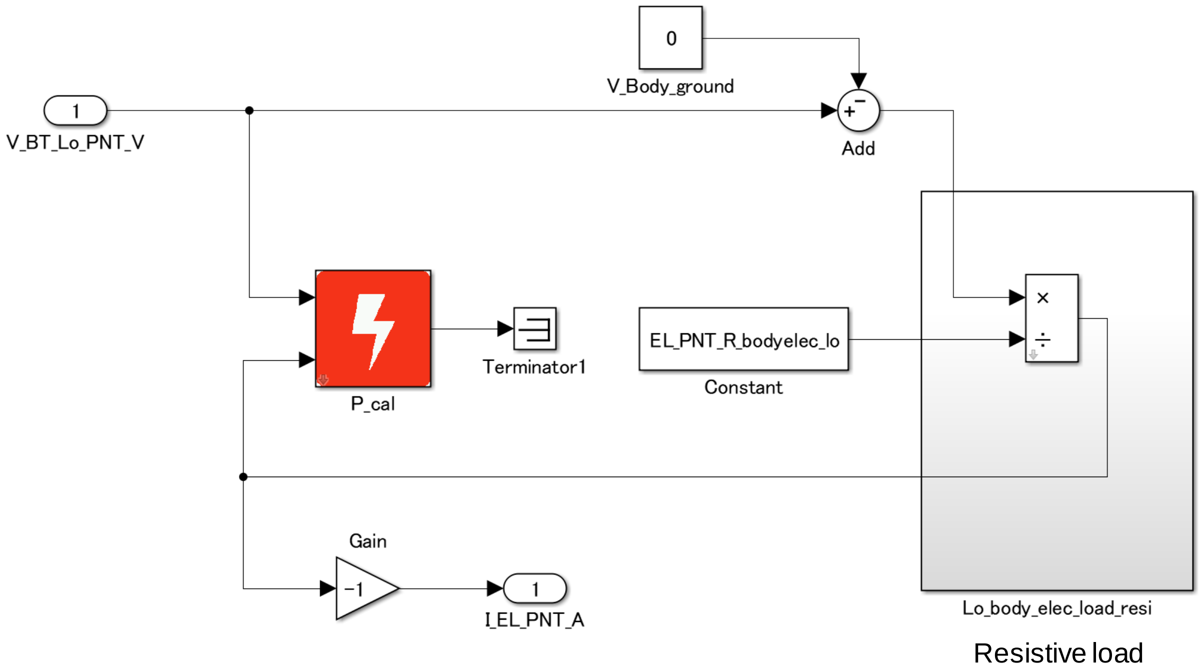


Fig. 5.3.26.2 Data flow diagram: third-layer EL_PNT system

5.3.25.3 Input/output specification

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

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

5.3.25.4 Parameter specification

The parameter specification of this system is shown below.

Variable name	Setting value	Unit	Description
EL_PNT_R_bodyelec_lo	14/30	V/A	Electrical load resistance at low voltage side

5.3.25.5 Other information

None.

5.3.26. Functional specification of [B31P: BTTH_PNT] system

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

5.3.26.1 Abstract

The abstract of this system is shown below.

① Modelized object
Model of high voltage battery thermal

② Modelized level
Thermal resistance of battery fan
Thermal capacity and thermal resistance of high voltage battery cells
Thermal capacity and thermal resistance of high voltage battery chassis
Thermal capacity and thermal resistance of battery heater

③ Modelized function
Function to calculate the heat flow that radiate from the battery fan to the atmosphere
Function to calculate high voltage battery cell temperature
Function to calculate the heat flow that radiate from the high voltage battery chassis to the atmosphere
Function to calculate battery heater current

5.3.26.2 Data flow diagram

The data flow diagram of this system is shown below.

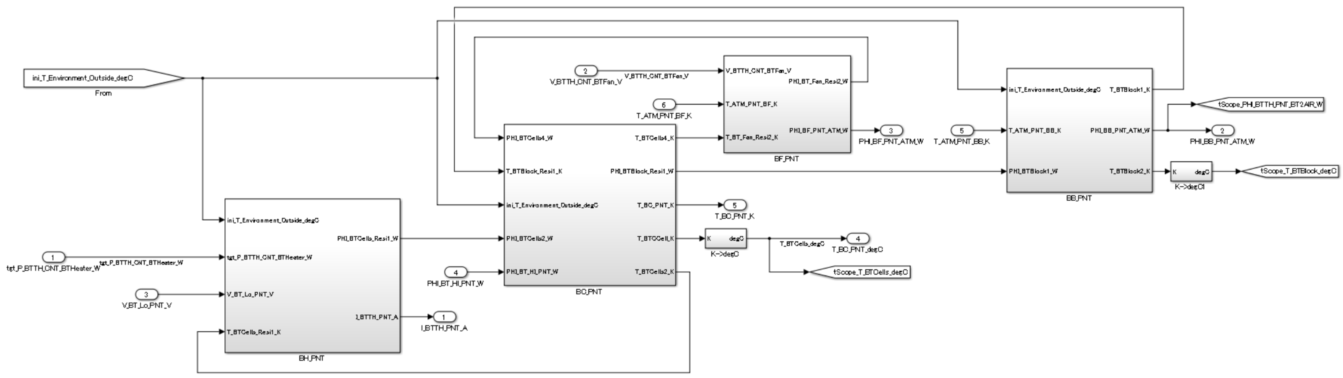


Fig. 5.3.26.2 Data flow diagram: third-layer BTTH_PNT system

5.3.26.3 Input/output specification

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

Input			
Name	Unit	Area	Description
ini_T_Environment_Outside_degC	℃	[-30 40]	Initial outside ambient temp.
tgt_P_BTTH_CNT_BTHeater_W	W	TBD	Target output of battery heater
V_BTTH_CNT_BTFan_V	V	TBD	Voltage of battery fan
PHI_BT_HI_PNT_W	W	TBD	High voltage battery heat flow
T_ATM_PNT_BB_K	K	TBD	Ambient temp. around high voltage battery housing
T_ATM_PNT_BF_K	K	TBD	Ambient temp. around battery fan
V_BT_Lo_PNT_V	V	TBD	Battery voltage for low voltage
Output			
Name	Unit	Area	Description
I_BTTH_PNT_A	A	TBD	Battery heater current
PHI_BB_PNT_ATM_W	W	TBD	heat flow radiated from high voltage battery housing to the atmosphere
PHI_BF_PNT_ATM_W	W	TBD	Heat flow radiated from battery fan to the atmosphere
T_BC_PNT_degC	℃	TBD	Temp. of battery cell
T_BC_PNT_K	K	TBD	Temp. of battery cell

5.3.26.4 Parameter specification

The parameter specification of this system is shown below.

Variable name	Setting value	Unit	Description
BTTH_PNT_BTBlock2BTAir_Heat_Resi_KpW	0.005	K/W	Thermal resistance value between battery housing and external environment
BTTH_PNT_BTBlock_Heat_Capa_JpK	8800	J/K	Heat capacity of battery housing
BTTH_PNT_BTCells2BTBlock_Heat_Resi_KpW	0.02	K/W	Thermal resistance value between battery cell and battery housing
BTTH_PNT_BTCells_Heat_Capa_JpK	300000	J/K	heat capacity of battery cell
BTTH_PNT_BT_Heat_Resi_KpW	<1×3>	K/W	Thermal resistance map for battery cooling
BTTH_PNT_BT_Heat_Resi_KpW_x_Wind_m3ps	<1×3>	m3/s	Thermal resistance map for battery cooling: x-Battery fan air flow
BTTH_PNT_BT_Heater2BTCells_Heat_Resi_KpW	0.001	K/W	Thermal resistance value between battery heater and battery cell
BTTH_PNT_BT_Heater_Heat_Capa_JpK	1060	J/K	Heat capacity of battery heater
BTTH_PNT_v_BTFan_Wind_vel_mps	<1×3>	m/s	Wind velocity map of battery fan
BTTH_PNT_v_BTFan_Wind_vel_mps_x_V_BTFan	<1×3>	V	Wind velocity map of battery fan: x-Battery fan voltage

5.3.26.5 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

First-layer			Second-layer			Third-layer			Forth-layer		
Part	Notation	abbreviation	Part	Notation	abbreviation	Part	Notation	abbreviation	Part	Notation	abbreviation
Driver	Driver										
Vehicle	Vehicle		Vehicle Control	Vehicle Control	VC	Vehicle control	VehicleControl	VCU_CNT			
						Brake control	BrakeControl	BK_CNT			
						Motor control	MotorGeneratorControl	MG_CNT			
						Power electrical thermal control	ElectricalThermalControl	ELTH_CNT			
						Cabin thermal control	CabinThermalControl	CATH_CNT			
						Battery thermal control	BatteryThermalControl	BTHL_CNT			
						Charger control	ChargerControl	CHG_CNT			
			Vehicle Plant	Vehicle Body	VB	High voltage battery	BatteryHighVoltage	BT_Hi_PNT			
						Inverter	Inverter	INV_PNT			
						Motor	MotorGenerator	MG_PNT			
						Transmission	Transmission	TM_PNT	Flywheel	Flywheel	FW_PNT
						Brake	Brake	BK_PNT			
						Tire	Tire	TR_PNT			
						Vehicle load	VehicleLoad	VL_PNT			
						Differential gear	DifferentialGear	DF_PNT	Drive shaft	DriveShaft	DS_PNT
						Power train thermal	PowerTrainThermal	PTTH_PNT	Transmission thermal	TransmissionThermal	TMTH_PNT
									Differential gear thermal	DifferentialGearThermal	DFTH_PNT
						Power electrical thermal	ElectricalThermal	ELTH_PNT	Inverter thermal	InverterThermal	INVTH_PNT
									Motor thermal	MotorThermal	MGTH_PNT
									Radiator thermal	RadiatorThermal	RDTH_PNT
						Atmosphere	Atmosphere	ATM_PNT			
						Charger	Charger	CHG_PNT			
						DCDC converter	DCDCConverteer	DCDC_PNT			
						Battery	BatteryLowVoltage	BT_Lo_PNT			
						Cabin thermal	CabinThermal	CATH_PNT	HVAC	HVAC	HVAC_PNT
									Cabin	Cabin	CAB_PNT
									Sheat heater	SheatHeater	SH_PNT
						Electriical Load	ElectriicalLoad	EL_PNT			
						Battery thermal	BatteryThermal	BTTH_PNT	Battery fan	BatteryFan	BF_PNT
									Battery heater	BatteryHeater	BH_PNT
									High voltage battery cell	BatteryCell	BC_PNT
									High voltage battery housing	BatteryBlock	BB_PNT
Environmental Monitor	Environment Monitor										

6.4.3. Signal name

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

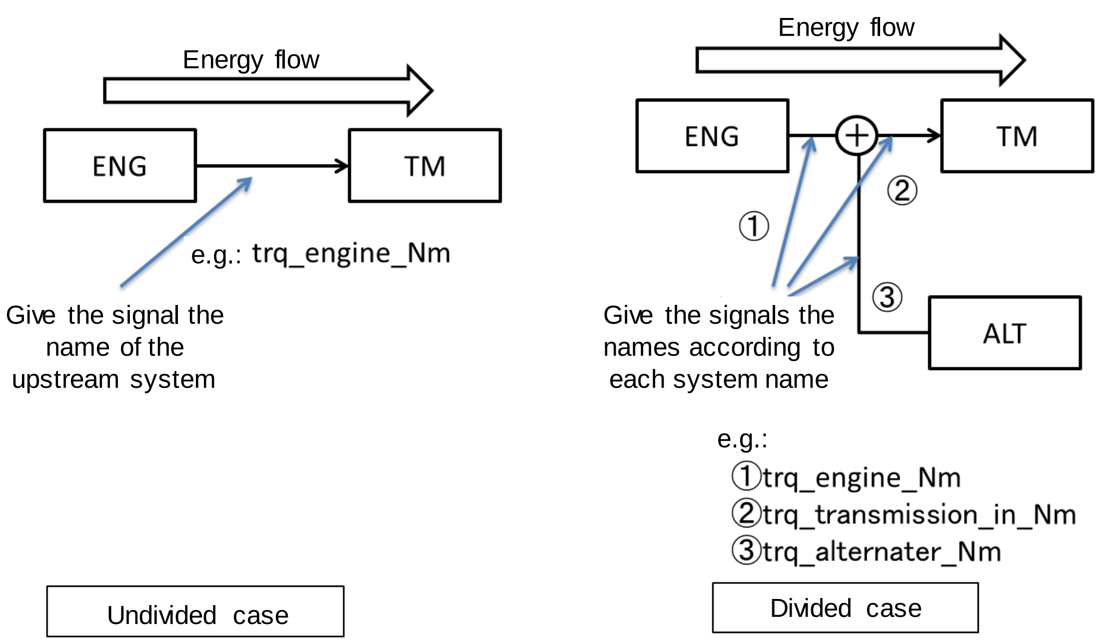


Fig. 6.4.3. How to name the signals

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 options below were proposed for the structure of the plant model, 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.
Make the control model and the plant model of the current Simulink model independent. The reason for this is that although control and plant should be a single entity, some suppliers only have controls and some suppliers only have plants. 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.

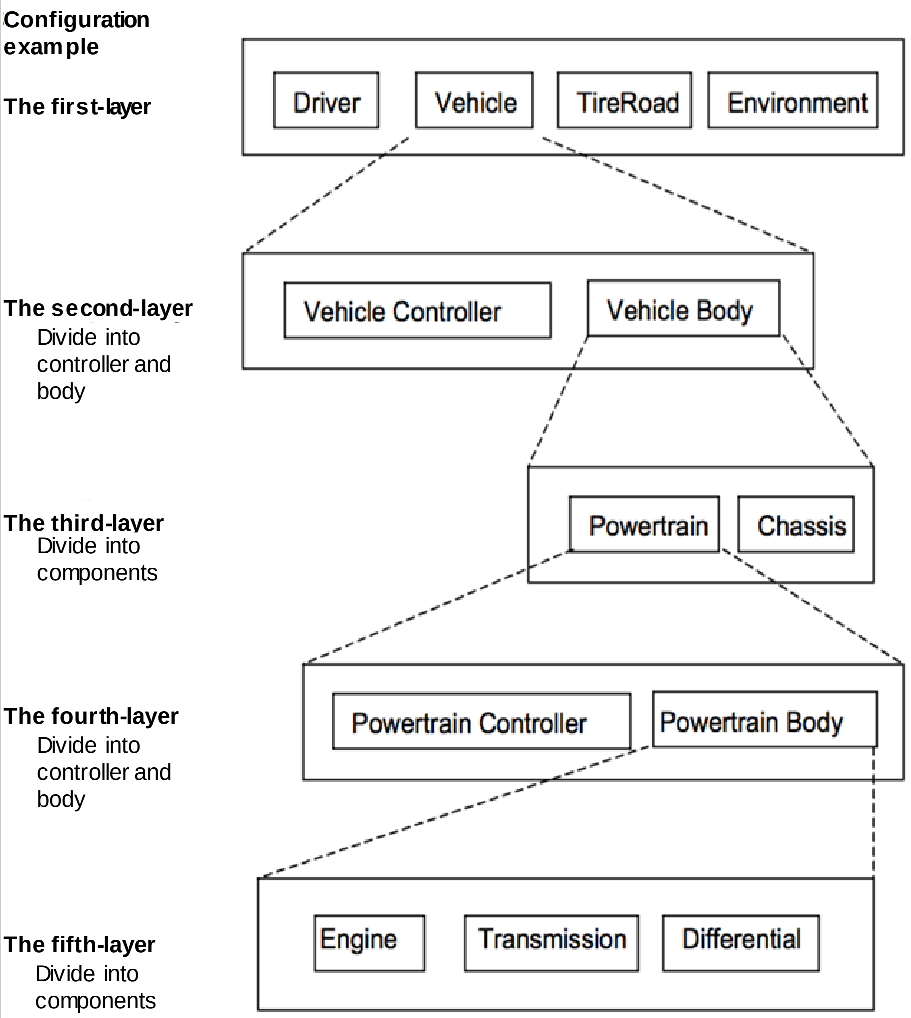


Fig. 6.5.1. JP3001 “Plant model structure”

<Option 2>
The plant and control model are on the same layer.
This is based on the idea that it is better to have the system ECU and mechanics in a single subsystem so that this model can be distributed as the basis for other models (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 is to clarify the new Guidelines.

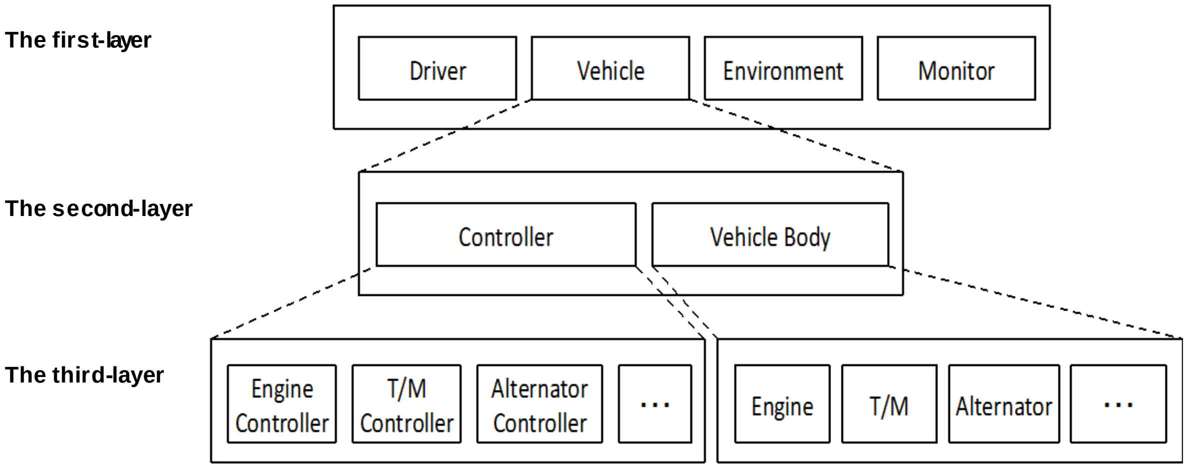


Fig. 6.5.2. Structure broadly divides control and plant in the same layer

6.6. Interface

6.6.1. Type

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

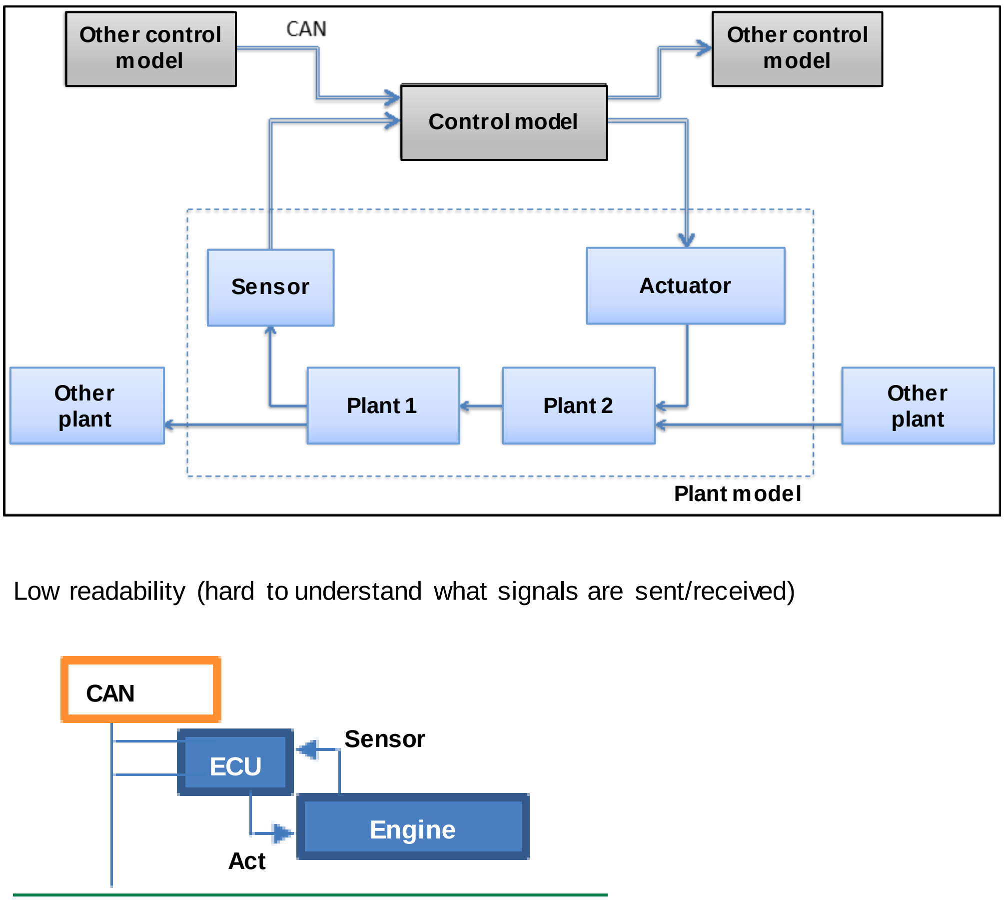


Fig. 6.6.1. I/F type and description method

6.6.2. Bus

Buses are generally used for control, sensor, and actuator signals.
The reason for this is that there are too many inputs and outputs, which will result in spaghetti code if buses are not used. However, there is a demerit in that the 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.

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

② Control 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	℃	degC(＝degree Celsius)
Inductance	Henry	H	H

6.8. Parameter operation

Each system parameter should have a .m file, and the run file should load all of these .m files.
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 using the double type
- 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