Handbook of Plant Modeling IF Guidelines-Compatible Model (Vehicle dynamic performance) for Vehicle Development (Ver. 1.0)

Revision History

Rev.	Date	Revised contents	Company	Approver
1.0	Mar, 2019	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 2.0, 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 and electric system.
*Other domains are the challenges in the future.
The model assumes that the engine displacement of the vehicle is 1.5[L] and the drive system is CVT.
All of the models in this handbook is based on Matlab® Simulink®.

The guidelines-compatible model is generally based on “Handbook of Plant Modeling I/F Guidelines-Compatible Model for Vehicle Development (Ver. 1.0)” and was created by modifying “Plant Modeling I/F Guidelines-Compatible Model for Vehicle Development”, both publicly available. In consideration of this, references will be provided for items that have not been modified from “Handbook of Plant Modeling I/F Guidelines-Compatible Model for Vehicle Development (Ver. 1.0)”. Items that have been modified or added to will be noted in this text.

1.3. Functions of guidelines-compatible model

The modified and the added items are shown below. Refer to section 1.3 of “Handbook of Plant Modeling I/F Guidelines-Compatible Model for Vehicle Development (Ver. 1.0)” for other items.

- Controller function
  - EPS control (addition)

- Plant
  - Differential gear (modification)
  - EPS (addition)
  - Right front brake (addition)
  - Left front brake (addition)
  - Right rear brake (addition)
  - Left rear brake (addition)
  - Right front tire (addition)
  - Left front tire (addition)
  - Right rear tire (addition)
  - Left rear tire (addition)
  - Front suspension (addition)
  - Rear suspension (addition)
  - Vehicle (modification)
  - Vehicle running resistance (addition)
  - Road Environment (addition)

2. Operating/Usage environment

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

2.1. Operating requirement

Refer to chapter 2.1 of "Handbook of Plant Modeling I/F Guidelines-Compatible Model for Vehicle Development (Ver. 1.0)". However, model usage environment needs to be changed as below;

＜Model usage environment＞

Tool	MATLAB/Simulink
Tool ver.	R2015a (64bit)
Types	.slx
Library （Except for Simulink standard library）	METI_Lib_vehicle_model,

2.2. Usage environment

Refer to chapter 2.2 of "Handbook of Plant Modeling I/F Guidelines-Compatible Model for Vehicle Development (Ver. 1.0)". However, the model usage environment is changed as follows;

＜File composition of the guidelines-compatible model＞

No.	File Name	Description
1	Cornering_4wheel_20190215_2015a.slx	Simulator of vehicle dynamic performance
2	METI_Lib_vehicle_model	METI Library
3	init_setting.m	Script for initial setting / setting parameter data / setting pass
4	(subfolder) param	Parameter data folder
5	(subfolder) picture	Block image data folder

3. Usage

Refer to chapter 3 of "Handbook of Plant Modeling I/F for Vehicle Development (Ver. 1.0)".

4. Basic structure of guidelines-compatible model

The structures of the guidelines-compatible model's 1st (top) and 2nd layers, as well as the systems of the two layers is described below (those separated by Simulink's subsystem into each function).

4.1. Model structure of first-layer

Refer to chapter 4.1 of “Handbook of Plant Modeling I/F Guidelines-Compatible Model for Vehicle Development (Ver. 1.0)”

4.2. Model structure of second-layer

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

4.2.1. Structure of [A: Driver] system

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

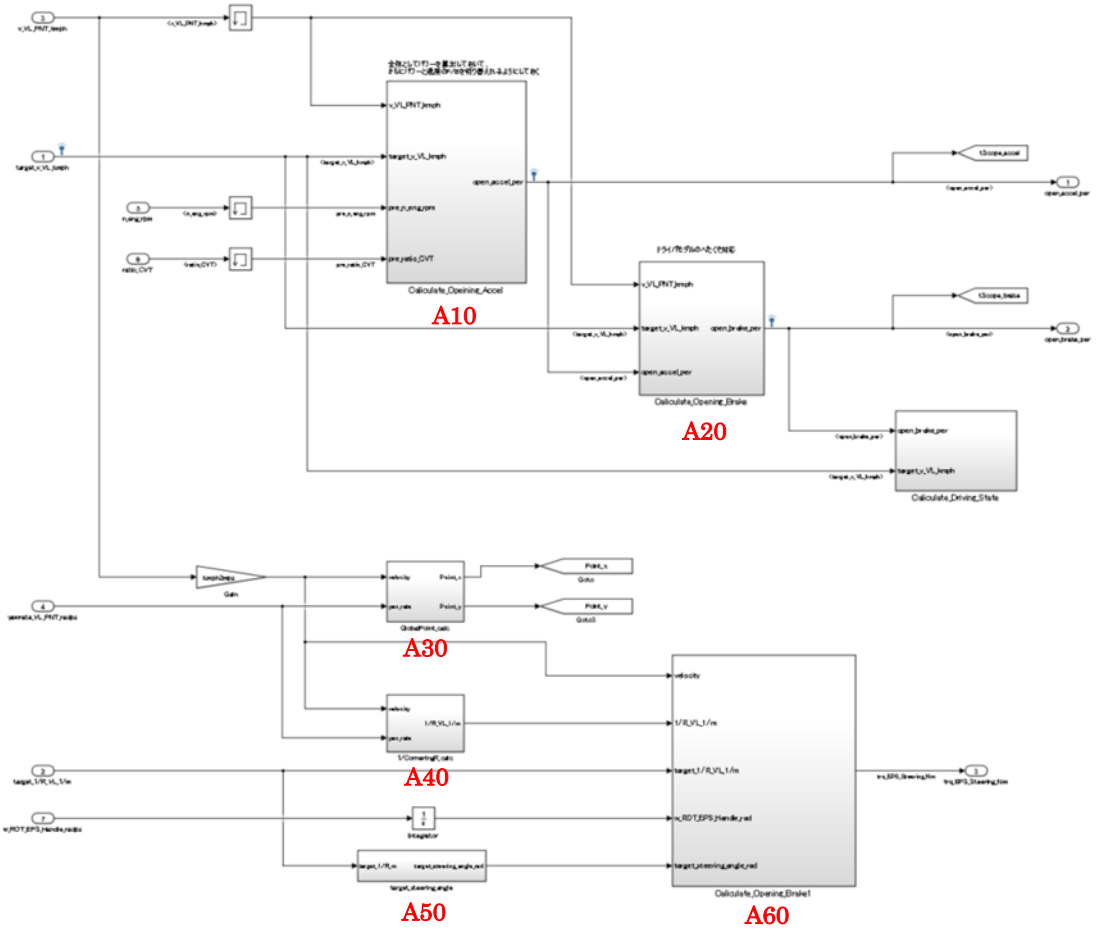

Fig. 4.2.1. Model structure of second-layer Driver system

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

The numbered elements(between A10 to A70) in the figure represent the system shown in Fig4.2.1

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

No.	System Name	Function Overview
A10	Accelerator opening	Refer to “Handbook of Plant Modeling I/F Guidelines-Compatible Model for Vehicle Development (Ver. 1.0)”
A20	Brake (opening)	Refer to “Handbook of Plant Modeling I/F Guidelines-Compatible Model for Vehicle Development (Ver. 1.0)”
A30	Vehicle position cordinate calculation	Calculate x and ycordinates from vehicle velocity and yaw angle. Yaw angle is calculated from integration of yaw rate.
A40	Turning curvature calculation	Calculate turning curvature from vehicle velocity and yaw rate.
A50	Calculation of target steering angle	Calculate the target of steering angle from target curvature, wheelbase, rack and pinion gear ratio and knuckle arm length.
A60	Steering torque calculation	Feedback control of steering torque.

4.2.2. Structure of [B: Vehicle] system

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

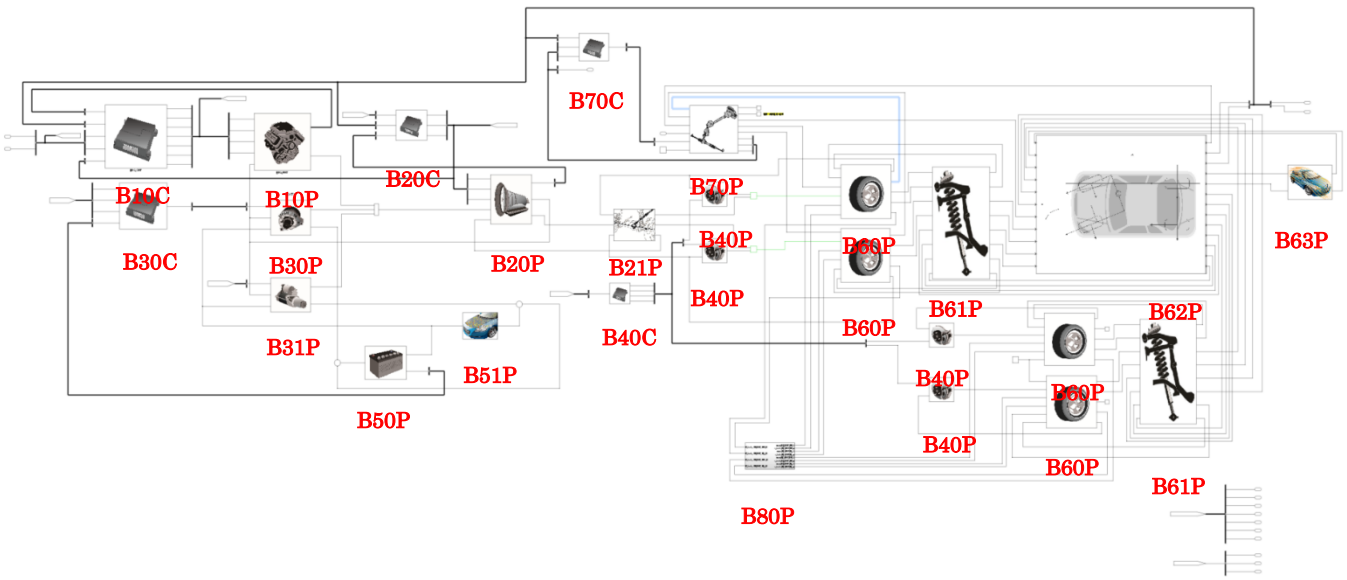

Fig. 4.2.2. Model structure of second-layer Vehicle system

The functional specifications of the second-layer Vehicle system of the guidelines-compatible model are described.The numbered elements in the figure represent the system shown in Fig4.2.2. 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 of second-layer [B: Vehicle] system and function overview

No.*	System Name	Function Overview
B10C	ENG_CNT	Controlling engine and Starter
B20C	TM_CNT	Refer to chapter 4.2.2 of “Handbook of Plant Modeling I/F Guidelines-Compatible Model for Vehicle Development (Ver. 1.0)”.
B30C	ALT_CNT	Refer to chapter 4.2.2 of “Handbook of Plant Modeling I/F Guidelines-Compatible Model for Vehicle Development (Ver. 1.0)”.
B40C	BK_CNT	Refer to chapter 4.2.2 of “Handbook of Plant Modeling I/F Guidelines-Compatible Model for Vehicle Development (Ver. 1.0)”.
B70C	EPS_CNT	Controlling EPS motor
B10P	ENG_PNT	Refer to chapter 4.2.2 of “Handbook of Plant Modeling I/F Guidelines-Compatible Model for Vehicle Development (Ver. 1.0)”.
B20P	TM_PNT	Shift toward engine rpm and torque
B21P	DF_PNT	Deceleration from transmission output to drive shaft
B30P	ALT_PNT	Refer to chapter 4.2.2 of “Handbook of Plant Modeling I/F Guidelines-Compatible Model for Vehicle Development (Ver. 1.0)”.
B31P	ST_PNT	Refer to chapter 4.2.2 of “Handbook of Plant Modeling I/F Guidelines-Compatible Model for Vehicle Development (Ver. 1.0)”.
B40P	BK_FL_PNT	Generate brake torque on the left front drive shaft
	BK_FR_PNT	Generate brake torque on the right front drive shaft
	BK_RL_PNT	Generate brake torque on the left rear drive shaft
	BK_RR_PNT	Generate brake torque on the right rear drive shaft
B50P	BT_LO_PNT	Refer to chapter 4.2.2 of “Handbook of Plant Modeling I/F Guidelines-Compatible Model for Vehicle Development (Ver. 1.0)".
B51P	EL_PNT	Refer to chapter 4.2.2 of “Handbook of Plant Modeling I/F Guidelines-Compatible Model for Vehicle Development (Ver. 1.0)”.
B60P	TR_FL_PNT	Convert rotational motion into linear motion of left front drive shaft Calculate rolling resistance and grip performance of tire
	TR_FR_PNT	Convert rotational motion into linear motion of right front drive shaft Calculate rolling resistance and grip performance of tire
	TR_RL_PNT	Convert rotational motion into linear motion of left rear drive shaft Calculate rolling resistance and grip performance of tire

No.*	System Name	Function Overview
	TR_RR_PNT	Convert rotational motion into linear motion of right rear drive shaft Calculate rolling resistance and grip performance of tire
B61P	SUS_F_PNT	Calculate vertical motion of front suspension
	SUS_R_PNT	Calculate vertical motion of rear suspension
B62P	VL_PNT	Calculate vehicle velocity in 3-axis and 6-degree-of-freedom
B63P	VR_PNT	Calculate running resistance
B70P	EPS_PNT	Calculate tire steering angular velocity from steering torque
B80P	RD_PNT	Calculate velocity and set friction coefficient on tire contact area

*"P" means "Plant" and "C" means "Controller"

4.2.3. Structure of [C: External environment] system

Refer to chapter 4.2.3 of "Handbook of Plant Modeling I/F Guidelines-Compatible Model for Vehicle Development (Ver. 1.0)".

4.2.4. Structure of [D: Monitor] system

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

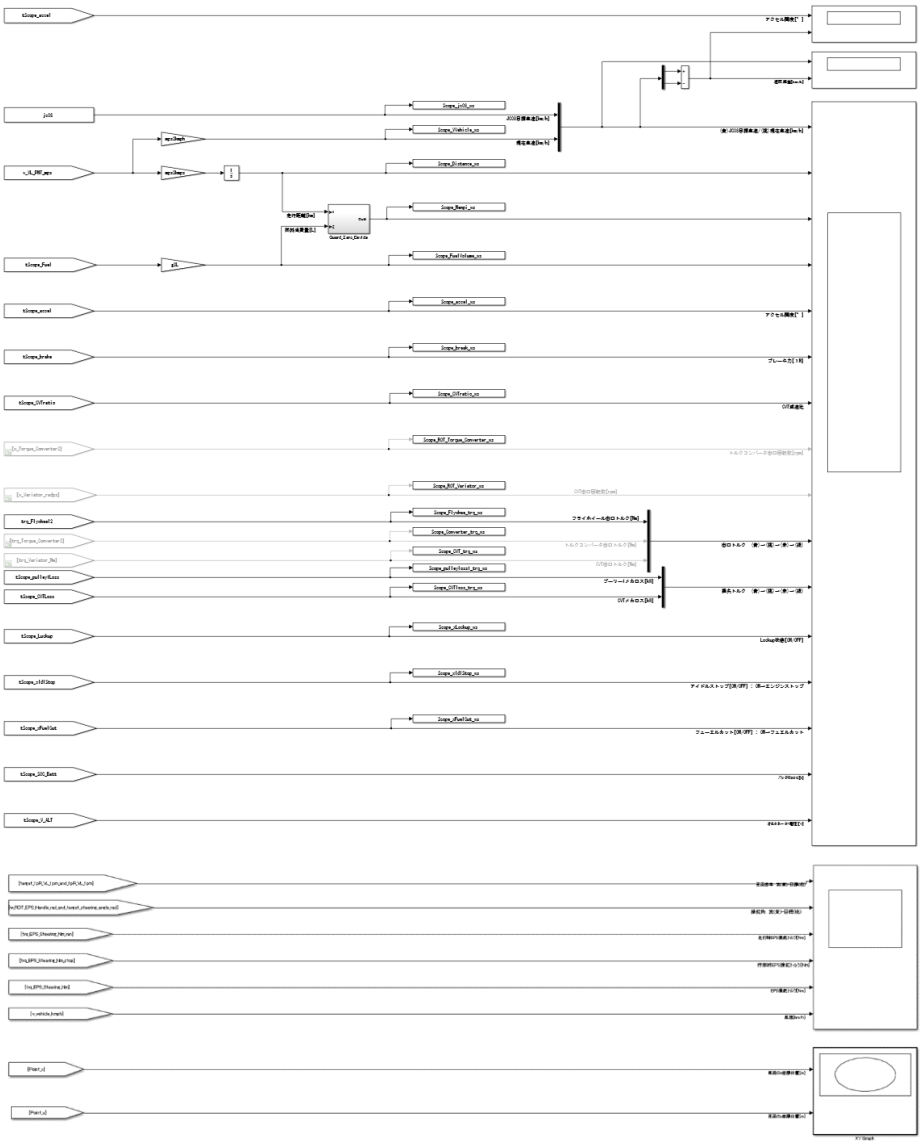

Fig. 4.2.4. Structure of second-layer monitor system

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

5. Functional specifications of guidelines-compatible model

5.1. Functional specification of first-layer model

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

5.1.1. Abstract

The accelerator and brake operating amounts are calculated according to the driving pattern, and the steering torque is calculated according to the target turning radius by using the driver model.

The vehicle model receives this operation and calculates the behavior including acceleration / deceleration and cornering.

Information such as the vehicle velocity is passed to the driver model and used to calculate operating amount for accelerator, brake, and steering torque.

In the external environment block, the driving environment can be set.

In the Monitor block, each variables in the driver model and vehicle model can be monitored.

5.1.2. Data flow diagram

Refer to chapter 5.1.2 of “Handbook of Plant Modeling I/F Guidelines-Compatible Model for Vehicle Development (Ver. 1.0)”.

5.1.3. Input/output specification

Refer to chapter 5.1.3 of “Handbook of Plant Modeling I/F Guidelines-Compatible Model for Vehicle Development (Ver. 1.0)”and below;

Input			
Name	Unit	Area	Description
target_1/R_VL_1/m	1/m	-	Target of curvature (reciprocal for straight running)
yawrate_VL_PNT_radps	rad/s	-	Vehicle body yaw rate
omg_EPS_Steering_radps	rad/s	-	Steering angular velocity
trq_EPS_Steering_Nm	Nm	-	Steering torque
Output			
Name	Unit	Area	Description
trq_EPS_Steering_Nm	Nm	-	Steering torque
yawrate_VL_PNT_radps	rad/s	-	Vehicle body yaw rate
omg_EPS_Steering_radps	rad/s	-	Steering angular velocity

5.1.4. Parameter specification

Refer to chapter 5.1.4 of “Handbook of Plant Modeling I/F Guidelines-Compatible Model for Vehicle Development (Ver. 1.0)”and below;

Variable Name	Setting value	Unit	Description
Driver_Steer_angle_Igain	0	-	Feedback control I gain value
Driver_Steer_angle_Pgain	50000	-	Feedback control P gain value
Driver_Steer_radius_Igain	50	-	Feedback control I gain value
Driver_Steer_radius_Pgain	100000	-	Feedback control P gain value
Driver_Steer_v_deadzone_mps	0.2	m/s	Ultimate low-velocity steering control exchange velocity
Driver_Steer_zerocross_gain	1	-	Ultimate low-velocity steering control exchange velocity gain
EPS_PNT_Ratio_EPS_Pinion2Rack	0.01	m/rad	Converting from pinion rolling motion to rack linear motion
VL_PNT_l_wheelbase_m	2.7	m	Vehicle Wheelbase
EPS_PNT_length_knuckle_arm_FR_m	0.2	m	Right front knuckle arm length
BK_PNT_brake_balance_front	0.6	-	Brake balance front ratio
TIRE_PNT_F_cor_tire_N	<4x17>	N	Cornering force map
TIRE_PNT_W_cor_tire_N	<1x4>	N	Cornering force map x-tire vertical load
TIRE_PNT_rad_cor_tire_rad	<1x17>	rad	Cornering force map y-tire slip angle
TIRE_PNT_length_pneumatic_trail_FL_m	-0.005	m	Pneumatic trail
TIRE_PNT_length_pneumatic_trail_FR_m	-0.005		
TIRE_PNT_length_pneumatic_trail_RL_m	-0.005		
TIRE_PNT_length_pneumatic_trail_RR_m	-0.005		
TIRE_PNT_sgn_tire	1000000	-	Tire angle sign
TIRE_PNT_lowergurad_rad_cor_tire_rad	-1.5708	rad	Tire steering angle lower guard
TIRE_PNT_uppergurad_rad_cor_tire_rad	1.5708	rad	Tire steering angle upper guard
TIRE_PNT_v_zerocross_gain	1	m/s	When vehicle velocity is below setting velocity [m/s], declining cornering force gradually to zero.
TIRE_PNT_z_stiffness_FL_Npm	260000	N/m	Tire upper and lower hardness
TIRE_PNT_z_stiffness_FR_Npm	260000		
TIRE_PNT_z_stiffness_RL_Npm	260000		
TIRE_PNT_z_stiffness_RR_Npm	260000		
TIRE_PNT_z_tire_FL_ini_m	0.0143	m	Tire initial displacement
TIRE_PNT_z_tire_FR_ini_m	0.0143		
TIRE_PNT_z_tire_RL_ini_m	0.0094		
TIRE_PNT_z_tire_RR_ini_m	0.0094		
SUS_PNT_tow_angle_FL_degree	0.2	deg	Toe angle setting
SUS_PNT_tow_angle_FR_degree	-0.2		
SUS_PNT_tow_angle_RL_degree	0.1		
SUS_PNT_tow_angle_RR_degree	-0.1		
tire_r	0.25	m	Tire dynamic radius
SUS_PNT_unsprung_mass_FR_kg	45	kg	Right unsprung mass
SUS_PNT_unsprung_mass_RR_kg	35		
SUS_PNT_unsprung_mass_FL_kg	45	kg	Left unsprung mass
SUS_PNT_unsprung_mass_RL_kg	35		
SUS_PNT_k_front_untiroll_Npm	7000	N/m	Anti-roll bar rigidity
SUS_PNT_k_rear_untiroll_Npm	7000		
SUS_PNT_k_front_sus_Npm	25000	N/m	Spring rigidity

Variable Name	Setting value	Unit	Description
SUS_PNT_k_rear_sus_Npm	30000		
SUS_PNT_z_front_sus_ini_m	0.1313	m	Suspension initial displacement
SUS_PNT_z_rear_sus_ini_m	0.0702		
SUS_PNT_front_sus_speed_mps	<29x1>	m/s	Damper speed
SUS_PNT_rear_sus_speed_mps			
SUS_PNT_front_sus_rate_Nspm	<29x1>	N/(m/s)	Damper rate
SUS_PNT_rear_sus_rate_Nspm			
SUS_PNT_front_sus_fric_N	40	N	Friction force
SUS_PNT_rear_sus_fric_N	30		
SUS_PNT_front_sus_fric_gain	10000	-	Coefficient of friction when velocity is zero
SUS_PNT_rear_sus_fric_gain	10000		
SUS_PNT_RollSteer_FR_rad	<1x2>	rad	Roll steer map
SUS_PNT_RollSteer_RR_rad			
SUS_PNT_RollSteer_FR_SamePhaseStroke_m	<1x2>	m	Roll steer map x-same phase stroke
SUS_PNT_RollSteer_RR_SamePhaseStroke_m			
SUS_PNT_RollSteer_FR_AntiPhaseStroke_m	<1x2>	m	Roll steer map y-antiphase stroke
SUS_PNT_RollSteer_RR_AntiPhaseStroke_m			
SUS_PNT_CamberAngle_FR_rad	<1x2>	rad	Camber angle map
SUS_PNT_CamberAngle_RR_rad			
SUS_PNT_CamberAngle_FR_SamePhaseStroke_m	<1x2>	m	Camber angle map x-same phase stroke
SUS_PNT_CamberAngle_RR_SamePhaseStroke_m			
SUS_PNT_CamberAngle_FR_AntiPhaseStroke_m	<1x2>	m	Camber angle map y-antiphase stroke
SUS_PNT_CamberAngle_RR_AntiPhaseStroke_m			
SUS_PNT_LinkMomentArm_xaxis_FR_m	<1x2>	m	Moment Arm Link x-axis map
SUS_PNT_LinkMomentArm_xaxis_RR_m			
SUS_PNT_LinkMomentArm_xaxis_FR_SamePhaseStroke_m	<1x2>	m	Moment Arm Link x-axis map x-same phase stroke
SUS_PNT_LinkMomentArm_xaxis_RR_SamePhaseStroke_m			
SUS_PNT_LinkMomentArm_xaxis_FR_AntiPhaseStroke_m	<1x2>	m	Moment Arm Link x-axis map y-antiphase stroke
SUS_PNT_LinkMomentArm_xaxis_RR_AntiPhaseStroke_m			
SUS_PNT_LinkMomentArm_yaxis_FR_m	<2x2>	m	Moment Arm Link y-axis map
SUS_PNT_LinkMomentArm_yaxis_RR_m			
SUS_PNT_LinkMomentArm_yaxis_FR_SamePhaseStroke_m	<1x2>	m	Moment Arm Link y-axis map x-same phase stroke
SUS_PNT_LinkMomentArm_yaxis_RR_SamePhaseStroke_m			
SUS_PNT_LinkMomentArm_yaxis_FR_AntiPhaseStroke_m	<1x2>	m	Moment Arm Link y-axis map y-antiphase stroke
SUS_PNT_LinkMomentArm_yaxis_RR_AntiPhaseStroke_m			
VL_PNT_hight_pitch_center_gravity_m	0.1	m	Pitch center of gravity height
VL_PNT_hight_roll_center_gravity_m	0.1362	m	Roll center of gravity height
VL_PNT_Inertia_pitch_axis	1500	kgm^2	Pitch poll moment of inertia
VL_PNT_Inertia_roll_axis	400	kgm^2	Roll poll moment of inertia
VL_PNT_Inertia_yaw_axis	1300	kgm^2	Yaw poll moment of inertia
VL_PNT_l_center2front_m	1.0714	m	Distance between front and center of gravity
VL_PNT_l_center2rear_m	1.6286	m	Distance between rear and center of gravity
VL_PNT_slip_angle_vel_guard_mps	1	m/s	Reference velocity to prevent divergence in calculation of slip angle of gravity center divided by vehicle velocity
VL_PNT_width_tread_front_m	1.5	m	Front tread width
VL_PNT_width_tread_rear_m	1.5	m	Rear tread width

Variable Name	Setting value	Unit	Description
VL_PNT_V_wind	0	m/s	Wind speed
VL_PNT_Vehicle_theta_degree	0	deg	Climbing angle
M_car	1260	kg	Weight of vehicle
EPS_PNT_Inertia_EPS_Handle	0.038	kgm^2	Steering wheel inertia
EPS_PNT_K_EPS_TorsionBar	135	Nm/rad	Torsion spring torsional rigidity
EPS_PNT_D_EPS_TorsionBar	22.6495	Nm/(rad/s)	Torsion spring damping
EPS_PNT_LocktoLock_rad	6.2832	rad	Lock to lock is 2 cycle
EPS_PNT_Ratio_EPS_Motor2Pinion	18	-	Motor gear ratio
EPS_PNT_Ratio_EPS_Pinion2Rack	0.01	m/rad	Converting from pinion rolling motion to rack linear motion
EPS_PNT_M_EPS_rack_kg	100	kg	Rack weight of EPS
EPS_PNT_D_EPS_rack_Nspm	500	N/（m/s）	Attenuation of EPC rack
EPS_PNT_R_EPS_Motor	0.01	Ω	Motor windings resistance
EPS_PNT_k_EPS_Motor_radps2Volt	0.024	V/(rad/s)	Motor counter electromotive force constant.
EPS_PNT_length_knuckle_arm_FR_m	0.02	m	FR knuckle arm
EPS_PNT_length_knuckle_arm_FL_m	0.02	m	FL knuckle arm
ROAD_ENV_myu_road_surface	0.9	-	Tire surface friction coefficient
deg2rad	0.0175	-	deg → rad
rad2deg	57.2958	-	rad → deg
M_car	1200	kg	Weight of vehicle
M_front	750	kg	Weight of front vehicle
M_rear	450	kg	Weight of rear vehicle
myu_road_surface	0.9	-	Road surface friction coefficient
myu_RRC	0.007	-	Rolling resistance coefficient

*Parameters in the white boxes 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 of the guidelines-compatible model are described.

5.2.1.1 Abstract

The abstract of this system is shown below.

① Modelized object
The driver model for vehicle dynamic performance evaluation

② Modelized level
The model to operate accelerator, brake, and steering for mode-driving pattern

③ Modelized function
The function to calculate operating amount of accelerator, brake
The function to calculate operating steering torque

5.2.1.2 Data flow diagram

The data flow diagram of this system is shown below.

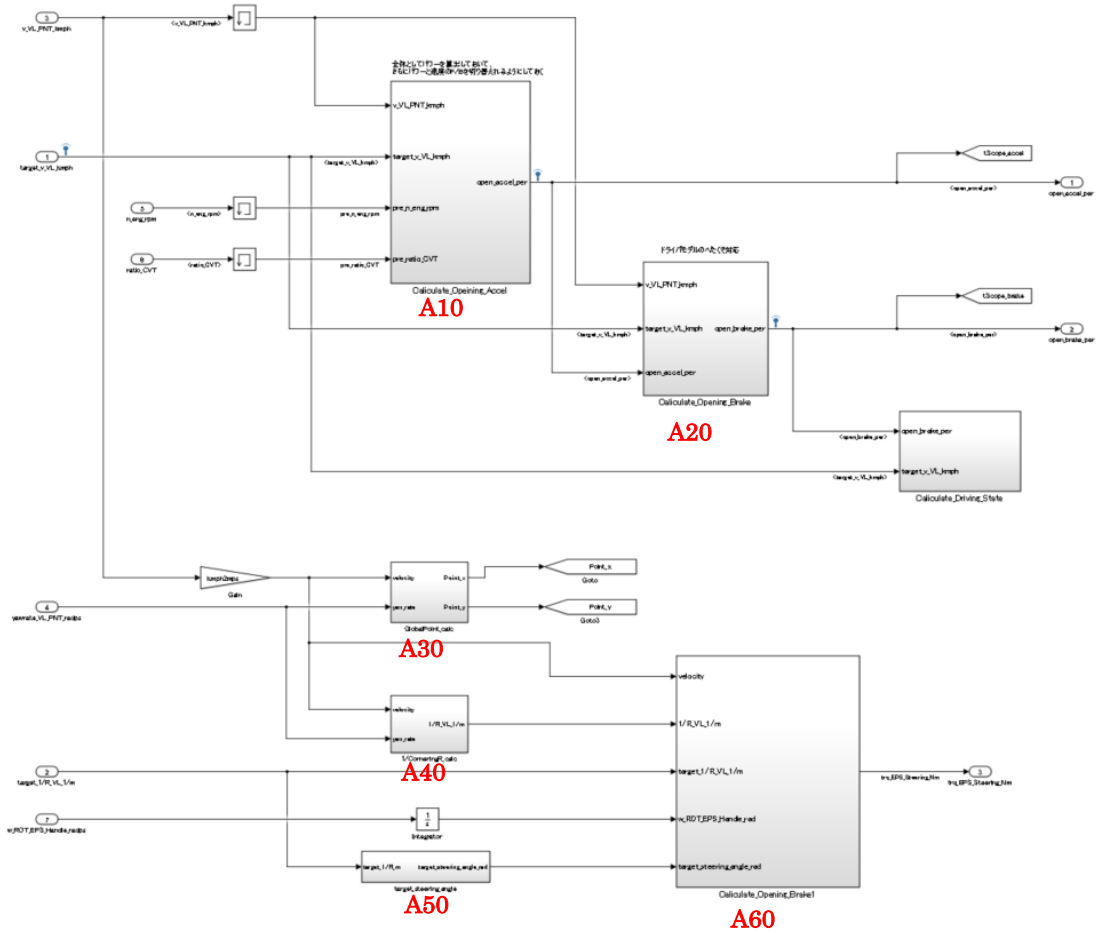

Fig. 5.2.1.2. Data flow diagram : second-layer Driver system

5.2.1.3 Input/output specification

Refer to chapter 5.2.1.3 of “Handbook of Plant Modeling I/F Guidelines-Compatible Model for Vehicle Development (Ver. 1.0)”and below;

Input			
Name	Unit	Area	Description
target_1/R_VL_1/m	1/m	-	Target of curvature (reciprocal for straight running)
yawrate_VL_PNT_radps	rad/s	-	Vehicle body yaw rate
omg_EPS_Steering_radps	rad/s	-	Steering angular velocity
Output			
Name	Unit	Area	Description
trq_EPS_Steering_Nm	rad/s	-	Steering torque

5.2.1.4 Parameter specification

Refer to chapter 5.2.1.4 of “Handbook of Plant Modeling I/F Guidelines-Compatible Model for Vehicle Development (Ver. 1.0)”and below;

Variable Name	Setting value	Unit	Description
Driver_Steer_angle_Igain	0	-	Feedback control I gain value
Driver_Steer_angle_Pgain	500	-	Feedback control P gain value
Driver_Steer_radius_Igain	50	-	Feedback control I gain value
Driver_Steer_radius_Pgain	100000	-	Feedback control P gain value
Driver_Steer_v_deadzone_mps	0.2	m/s	Ultimate low-velocity steering control exchange velocity
Driver_Steer_zerocross_gain	1	-	Ultimate low-velocity steering control exchange velocity gain
EPS_PNT_Ratio_EPS_Pinion2Rack	0.01	m/rad	Convert pinion rotation into rack linear motion
VL_PNT_l_wheelbase_m	2.7	m	Vehicle wheelbase length
EPS_PNT_length_knuckle_arm_FR_m	0.2	m	Right front knuckle arm length

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 of the guidelines-compatible model are described.

5.2.2.1 Abstract

The abstract of this system is shown below.

① Modelized object
The vehicle model for vehicle dynamic performance evaluation

② Modelized level
The model to confirm vehicle behavior in steady-state cornering test
定常円旋廻における車両の挙動を確認するモデル

③ Modelized function
The function that accelerate / decelerate and corner to follow the mode driving pattern by the driver's accelerator, brake and steering operations.

5.2.2.2 Data flow diagram

The data flow diagram of this system is shown below.

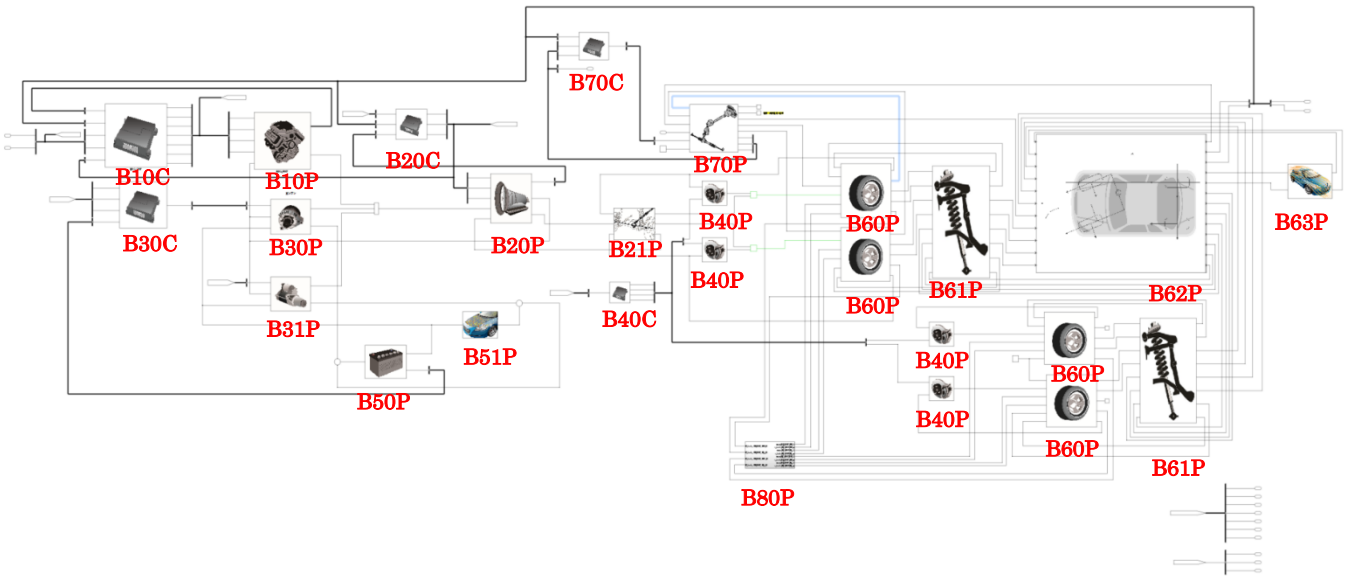

Fig. 5.2.2.2. Data flow diagram: second-layer Vehicle system

5.2.2.3 Input/output specification

Refer to chapter 5.2.2.3 of “Handbook of Plant Modeling I/F Guidelines-Compatible Model for Vehicle Development (Ver. 1.0)”and below;

Input			
Name	Unit	Area	Description
trq_Steering_EPS_PNT_Nm	Nm	-	Seering torque
Output			
Name	Unit	Area	Description
yawrate_VL_PNT_radps	rad/s	-	Vehicle body yaw rate
w_ROT_EPS_Steering_radps	rad/s	-	Steering angular velocity

5.2.2.4 Parameter specification

Refer to chapter 5.2.2.4 of “Handbook of Plant Modeling I/F Guidelines-Compatible Model for Vehicle Development (Ver. 1.0)”and below;

Variable Name	Setting value	Unit	Description
BK_PNT_brake_balance_front	0.6	-	Brake balance front ratio
TIRE_PNT_F_cor_tire_N	<4x17>	N	Cornering force map
TIRE_PNT_W_cor_tire_N	<1x4>	N	Cornering force map x-tire vertical load
TIRE_PNT_rad_cor_tire_rad	<1x17>	rad	Tire slip angle Cornering force map y-tire slip angle
TIRE_PNT_length_pneumatic_trail_FL_m TIRE_PNT_length_pneumatic_trail_FR_m TIRE_PNT_length_pneumatic_trail_RL_m TIRE_PNT_length_pneumatic_trail_RR_m	-0.005 -0.005 -0.005 -0.005	m	Pneumatic trail
TIRE_PNT_sgn_tire	1000000	-	Tire angle sign
TIRE_PNT_lowergurad_rad_cor_tire_rad	-1.5708	rad	Tire steering angle lower guard
TIRE_PNT_uppergurad_rad_cor_tire_rad	1.5708	rad	Tire steering angle upper guard
TIRE_PNT_v_zerocross_gain	1	m/s	When vehicle velocity is below this setting velocity, cornering force would be decline to zero.
TIRE_PNT_z_stiffness_FL_Npm TIRE_PNT_z_stiffness_FR_Npm TIRE_PNT_z_stiffness_RL_Npm TIRE_PNT_z_stiffness_RR_Npm	260000 260000 260000 260000	N/m	Tire upper and lower hardness
TIRE_PNT_z_tire_FL_ini_m TIRE_PNT_z_tire_FR_ini_m TIRE_PNT_z_tire_RL_ini_m TIRE_PNT_z_tire_RR_ini_m	0.0143 0.0143 0.0094 0.0094	m	Tire initial displacement
SUS_PNT_tow_angle_FL_degree SUS_PNT_tow_angle_FR_degree SUS_PNT_tow_angle_RL_degree SUS_PNT_tow_angle_RR_degree	0.2 -0.2 0.1 -0.1	deg	Toe angle setting
Tire_r	0.25	m	Tire dynamic radius
myu_RRC	0.007	-	Rolling resistance coefficient
SUS_PNT_unsprung_mass_FR_kg SUS_PNT_unsprung_mass_RR_kg	45 35	kg	Right unsprung mass
SUS_PNT_unsprung_mass_FL_kg SUS_PNT_unsprung_mass_RL_kg	45 35	kg	Left unsprung mass

Variable Name	Setting value	Unit	Description
SUS_PNT_k_front_untiroll_Npm SUS_PNT_k_rear_untiroll_Npm	7000 7000	N/m	Anti-roll bar rigidity
SUS_PNT_k_front_sus_Npm SUS_PNT_k_rear_sus_Npm	25000 30000	N/m	Spring rigidity
SUS_PNT_z_front_sus_ini_m SUS_PNT_z_rear_sus_ini_m	0.1313 0.0702	m	Suspension initial displacement
SUS_PNT_front_sus_speed_mps SUS_PNT_rear_sus_speed_mps	<29x1> <29x1>	m/s	Damper speed
SUS_PNT_front_sus_rate_Nspm SUS_PNT_rear_sus_rate_Nspm	<29x1>	Ns/m	Damper rate
SUS_PNT_front_sus_fric_N SUS_PNT_rear_sus_fric_N	40 30	N	Friction force
SUS_PNT_front_sus_fric_gain SUS_PNT_rear_sus_fric_gain	10000 10000	-	Coefficient of friction when velocity is zero
SUS_PNT_RollSteer_FR_rad SUS_PNT_RollSteer_RR_rad	<1x2>	rad	Roll Steer map
SUS_PNT_RollSteer_FR_SamePhaseStroke_m SUS_PNT_RollSteer_RR_SamePhaseStroke_m	<1x2>	rad	Roll Steer map x-same phase stroke
SUS_PNT_RollSteer_FR_AntiPhaseStroke_m SUS_PNT_RollSteer_RR_AntiPhaseStroke_m	<1x2>	m	Roll steer map y-antiphase stroke
SUS_PNT_CamberAngle_FR_rad SUS_PNT_CamberAngle_RR_rad	<1x2>	rad	Camber angle map
SUS_PNT_CamberAngle_FR_SamePhaseStroke_m SUS_PNT_CamberAngle_RR_SamePhaseStroke_m	<1x2>	m	Camber angle map x-same phase stroke
SUS_PNT_CamberAngle_FR_AntiPhaseStroke_m SUS_PNT_CamberAngle_RR_AntiPhaseStroke_m	<1x2>	m	Camber angle map y-antiphase stroke
SUS_PNT_LinkMomentArm_xaxis_FR_m SUS_PNT_LinkMomentArm_xaxis_RR_m	<1x2>	m	Moment Arm Link x-axis map
SUS_PNT_LinkMomentArm_xaxis_FR_SamePhaseStroke_m SUS_PNT_LinkMomentArm_xaxis_RR_SamePhaseStroke_m	<1x2>	m	Moment Arm Link x-axis map x-same phase stroke
SUS_PNT_LinkMomentArm_xaxis_FR_AntiPhaseStroke_m SUS_PNT_LinkMomentArm_xaxis_RR_AntiPhaseStroke_m	<1x2>	m	Moment Arm Link x-axis map y-antiphase stroke
SUS_PNT_LinkMomentArm_yaxis_FR_m SUS_PNT_LinkMomentArm_yaxis_RR_m	<2x2>	m	Moment Arm Link y-axis map
SUS_PNT_LinkMomentArm_yaxis_FR_SamePhaseStroke_m SUS_PNT_LinkMomentArm_yaxis_RR_SamePhaseStroke_m	<1x2>	m	Moment Arm Link y-axis map x-same phase stroke
SUS_PNT_LinkMomentArm_yaxis_FR_AntiPhaseStroke_m SUS_PNT_LinkMomentArm_yaxis_RR_AntiPhaseStroke_m	<1x2>	m	Moment Arm Link y-axis map y-antiphase stroke
VL_PNT_hight_pitch_center_gravity_m	0.1	m	Pitch center of gravity height
VL_PNT_hight_roll_center_gravity_m	0.1362	m	Front roll center height
VL_PNT_Inertia_pitch_axis	1500	kgm^2	Pitch poll moment of inertia
VL_PNT_Inertia_roll_axis	400	kgm^2	Roll poll moment of inertia
VL_PNT_Inertia_yaw_axis	1300	kgm^2	Yaw poll moment of inertia
VL_PNT_l_center2front_m	1.0714	m	Distance between front and center of gravity
VL_PNT_l_center2rear_m	1.6286	m	Distance between rear and center of gravity
VL_PNT_slip_angle_vel_guard_mps	1	m/s	Reference velocity to prevent divergence in calculation of slip angle of gravity center divided by vehicle velocity

Variable Name	Setting value	Unit	Description
VL_PNT_width_tread_front_m	1.5	m	Front tread width
VL_PNT_width_tread_rear_m	1.5	m	Rear tread width
VL_PNT_V_wind	0	m/s	Wind velocity
VL_PNT_Vehicle_theta_degree	0	deg	Climbing angle
M_car	1260	kg	Weight of vehicle
EPS_PNT_Inertia_EPS_Handle	0.038	kgm^2	Steering wheel inertia
EPS_PNT_K_EPS_TorsionBar	135	Nm/rad	Torsion spring torsional rigidity
EPS_PNT_D_EPS_TorsionBar	22.6495	Nm/(rad/s)	Torsion spring damping
EPS_PNT_LocktoLock_rad	6.2832	rad	Lock to lock is 2 cycle
EPS_PNT_Ratio_EPS_Motor2Pinion	18	-	Motor gear ratio
EPS_PNT_Ratio_EPS_Pinion2Rack	0.01	m/rad	Converting from pinion rolling motion to rack linear motion
EPS_PNT_M_EPS_rack_kg	100	kg	Rack weight of EPS
EPS_PNT_D_EPS_rack_Nspm	500	N/（m/s）	Attenuation of EPC rack
EPS_PNT_R_EPS_Motor	0.01	Ω	Motor windings resistance
EPS_PNT_k_EPS_Motor_radps2Volt	0.024	V/(rad/s)	Motor counter electromotive force constant.
EPS_PNT_length_knuckle_arm_FR_m	0.02	m	FR knuckle arm
EPS_PNT_length_knuckle_arm_FL_m	0.02	m	FL knuckle arm
ROAD_ENV_myu_road_surface	0.9	-	Tire surface friction coefficient

5.2.2.5 Other information

None.

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

Refer to chapter 5.2.3 of “Handbook of Plant Modeling I/F Guidelines-Compatible Model for Vehicle Development (Ver. 1.0)”.

5.2.4. Functional specification of [D: Monitor] system

5.2.4.1 Abstract

Refer to chapter 5.2.4.1 of “Handbook of Plant Modeling I/F Guidelines-Compatible Model for Vehicle Development (Ver. 1.0)”.

5.2.4.2 Data flow diagram

The data flow diagram of this system is shown below.

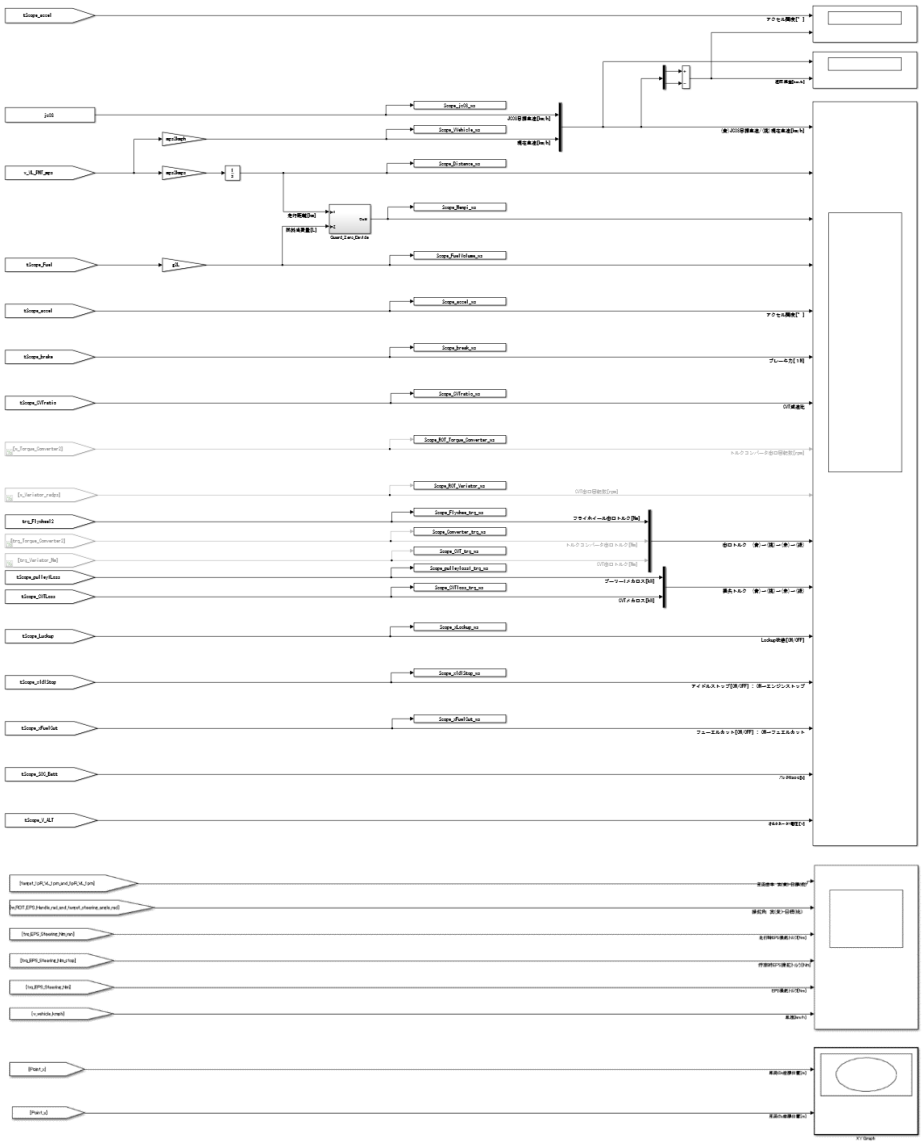

Fig. 5.2.4.2. Data flow diagram：second-layer Monitor system

5.2.4.3 Input/output specification

Refer to chapter 5.2.4.3 of “Handbook of Plant Modeling I/F Guidelines-Compatible Model for Vehicle Development (Ver. 1.0)”and below;

Input			
Name	Unit	Area	Description
real_and_target_1pR_VL_1pm	1/m	-	Real and target of cornering curvature
real_and_target_omg_steering_angle_rad	rad	-	Real and target of steering angle
trq_EPS_Steering_Nm_ran	Nm	-	Steering torque (running)
trq_EPS_Steering_Nm_stop	Nm	-	Steering torque (stopping)
trq_EPS_Steering_Nm	Nm	-	Steering torque
v_vehicle_kmph	km/h	-	Vehicle velocity
Point_x	m	-	Vehicle x-point
Point_y	m	-	Vehicle y-point
Output			
Name	Unit	Area	Description
None	-	-	-

5.2.4.4 Parameter specification

No parameter in this system.

5.2.4.5 Other information

None.

5.3. Functional specification of third-layer model

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

Refer to chapter 5.3.1 of “Handbook of Plant Modeling I/F Guidelines-Compatible Model for Vehicle Development (Ver. 1.0)”.

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

Refer to chapter 5.3.2 of “Handbook of Plant Modeling I/F Guidelines-Compatible Model for Vehicle Development (Ver. 1.0)”.

5.3.3. Functional specification of [A30: Vehicle position cordinate calculation] system

5.3.3.1 Abstract

The abstract of this system is shown below.

① Modelized object
The model to calculate vehicle position in absolute coordinate

② Modelized level
The model to calculate vehicle position in x/y axis

③ Modelized function
The function to calculate vehicle position in x/y axis based on the X and Y direction velocity calculated from the yaw rate and the vehicle velocity

5.3.3.2 Data flow diagram

The data flow diagram of this system is shown below.

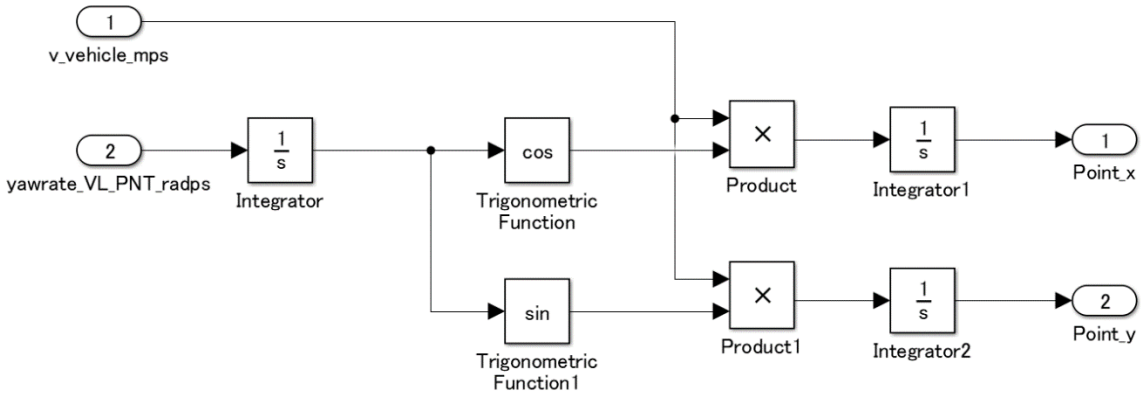

Fig. 5.3.3.2. Data flow diagram：third-layer vehicle x/y axis location calculating system

5.3.3.3 Input/output specification

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

Input			
Name	Unit	Area	Description
v_VL_mps	m/s	-	Vehicle velocity
yawrate_VL_PNT_radps	rad/s	-	Vehicle body yaw rate
Output			
Name	Unit	Area	Description
Point_x	m	-	Vehicle x-axis
Point_y	m	-	Vehicle y-axis

5.3.3.4 Parameter specification

No parameter in this system.

5.3.3.5 Other information

None.

5.3.4. Functional specification of [A40: Turning curvature calculation] system

The functional specifications of the third-layer cornering curvature calculation system model of the model are described.

5.3.4.1 Abstract

The abstract of this system is shown below.

① Modelized object
The model to calculate curvature of vehicle going around a curve

② Modelized level
The model to calculate curvature of vehicle going around a curve

③ Modelized function
The function to calculate from yaw late and vehicle velocity

5.3.4.2 Data flow diagram

The data flow diagram of this system is shown below.

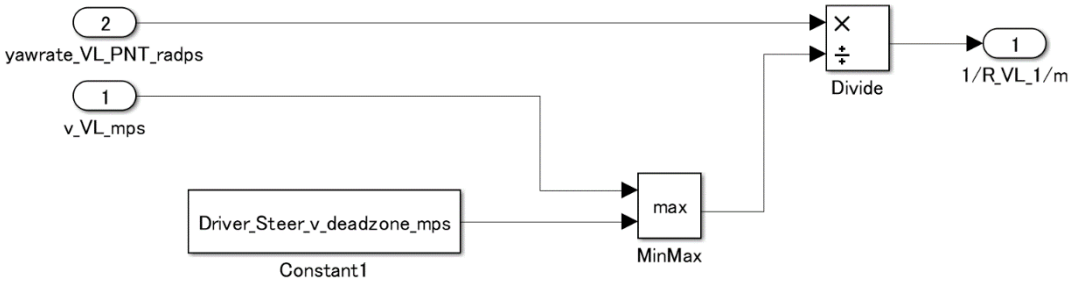

Fig. 5.3.4.2. Data flow diagram：third-layer Cornering curvature calculation system

5.3.4.3 Input/output specification

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

Input			
Name	Unit	Area	Description
v_VL_mps	m/s	-	Vehicle velocity
yawrate_VL_PNT_radps	rad/s	-	Vehicle body yaw rate
Output			
Name	Unit	Area	Description
1/R_VL_1/m	1/m	-	Cornering curvature（reciprocal for straight running）

5.3.4.4 Parameter specification

The parameter specification of this system is shown below.

Variable Name	Setting value	Unit	Description
Driver_Steer_v_deadzone_mps	0.2	m/s	Ultimate low-velocity steering control exchange velocity

5.3.4.5 Other information

None.

5.3.5. Functional specification of [A50: Steering angle calculation] system

The functional specifications of the third-layer steering angle calculation system model of the model are described.

5.3.5.1 Abstract

The abstract of this system is shown below.

① Modelized object
The model to calculate steering angle from cornering curvature

② Modelized level
The model to calculate steering angle follow target cornering curvature

③ Modelized function
The function to calculate steering angle follow target cornering curvature

5.3.5.2 Data flow diagram

The data flow diagram of this system is shown below.

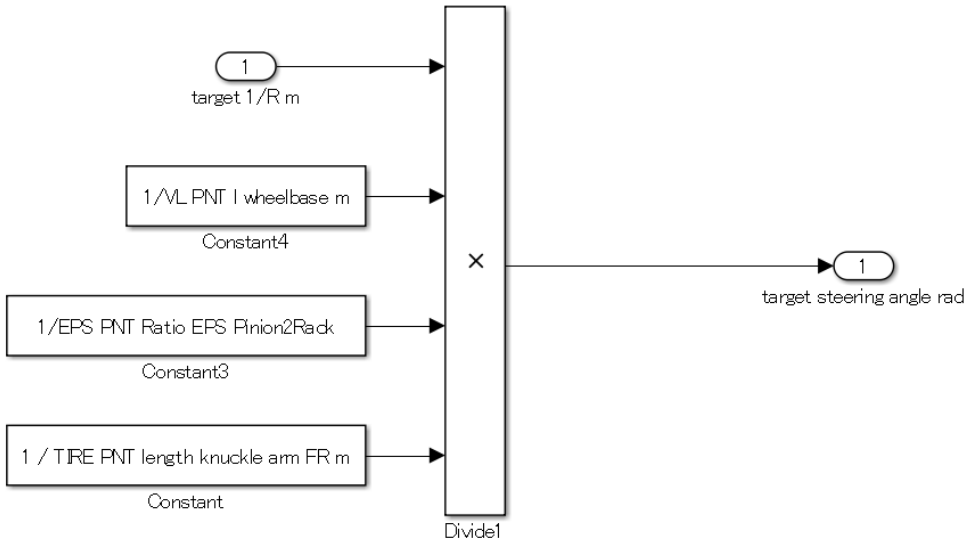

Fig. 5.3.5.2. Data flow diagram：third-layer steering angle system

5.3.5.3 Input/output specification

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

Input			
Name	Unit	Area	Description
target_1/R_VL_1/m	1/m	-	Target of curvature（reciprocal for straight running）
Output			
Name	Unit	Area	Description
target_Steering_angle_rad	rad	-	Steering angle

5.3.5.4 Parameter specification

The parameter specification of this system is shown below.

Variable Name	Setting value	Unit	Description
VL_PNT_l_wheelbase_m	2.7	m	Wheelbase length
EPS_PNT_Ratio_EPS_Pinion2Rack	0.01	-	Pinion rack ratio
EPS_PNT_length_knuckle_arm_FR_m	0.2	m	Right front knuckle arm length

5.3.5.5 Other information

None.

5.3.6. Functional specification of [A60: Steering torque calculation] system

The functional specifications of the third-layer steering torque calculation system model of the model are described.

5.3.6.1 Abstract

The abstract of this system is shown below.

① Modelized object
The model to calculate driver's steering torque

② Modelized level
The model to calculate steering torque needed to follow curvature and steering angle

③ Modelized function
The function for PI control that calculates the steering torque based on the difference between the target curvature and the actual curvature at standard veloscity
The function for PI control that calculates the steering torque based on the difference between the target steering angle and the actual steering angle at extremely low velocity

5.3.6.2 Data flow diagram

The data flow diagram of this system is shown below.

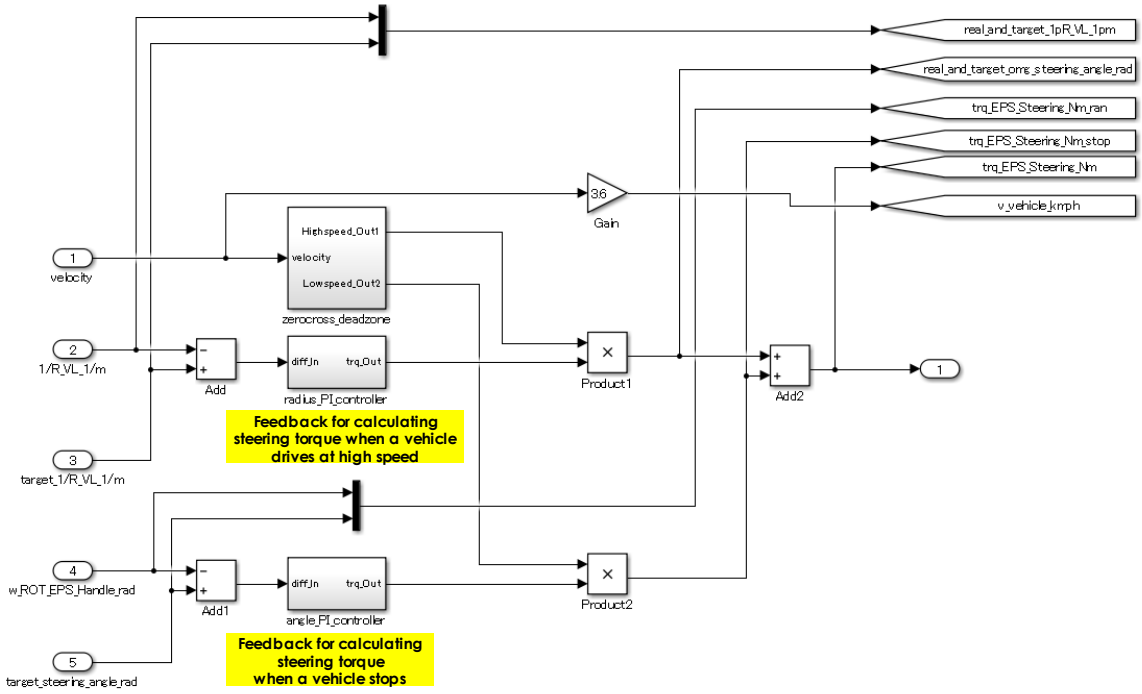

Fig. 5.3.6.2. Data flow diagram : third-layer steering torque calculation system

5.3.6.3 Input/output specification

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

Input			
Name	Unit	Area	Description
v_VL_mps	m/s	-	Vehicle velocity
1/R_VL_1/m	1/m	-	Cornering curvature (reciprocal for straight running)
target_1/R_VL_1/m	1/m	-	Target of curvature (reciprocal for straight running)
theta_EPS_Steering_rad	rad/s	-	Steering angle
target_Steering_angle_rad	rad	-	Target of steering angle
Output			
Name	Unit	Area	Description
trq_EPS_Steering_Nm	Nm	-	Steering torque

5.3.6.4 Parameter specification

The parameter specification of this system is shown below.

Variable Name	Setting value	Unit	Description
Driver_Steer_angle_Igain	0	-	Feedback control I gain value
Driver_Steer_angle_Pgain	500	-	Feedback control P gain value
Driver_Steer_radius_Igain	50000	-	Feedback control I gain value
Driver_Steer_radius_Pgain	100000	-	Feedback control P gain value
Driver_Steer_v_deadzone_mps	0.2	m/s	Ultimate low-velocity steering control exchange velocity
Driver_Steer_zerocross_gain	1	-	Ultimate low-velocity steering control exchange velocity gain

5.3.6.5 Other information

None.

5.3.7. Functional specification of [B10C: ENG_CNT] system

Refer to chapter 5.3.3 of “Handbook of Plant Modeling I/F Guidelines-Compatible Model for Vehicle Development (Ver. 1.0)”.

5.3.8. Functional specification of [B20C: TM_CNT] system

Refer to chapter 5.3.8 of “Handbook of Plant Modeling I/F Guidelines-Compatible Model for Vehicle Development (Ver. 1.0)”.

5.3.9. Functional specification of [B30C: ALT_CNT] system

Refer to chapter 5.3.9 of “Handbook of Plant Modeling I/F Guidelines-Compatible Model for Vehicle Development (Ver. 1.0)”.

5.3.10. Functional specification of [B40C: BK_CNT] system

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

5.3.10.1 Abstract

The abstract of this system is shown below.

① Modelized object
The brake control ECU model for vehicle dynamic performance evaluation

② Modelized level
The control model to contribute to brake in mode-driving

③ Modelized function
Braking
The function to distribute braking forces

5.3.10.2 Data flow diagram

The data flow diagram of this system is shown below.

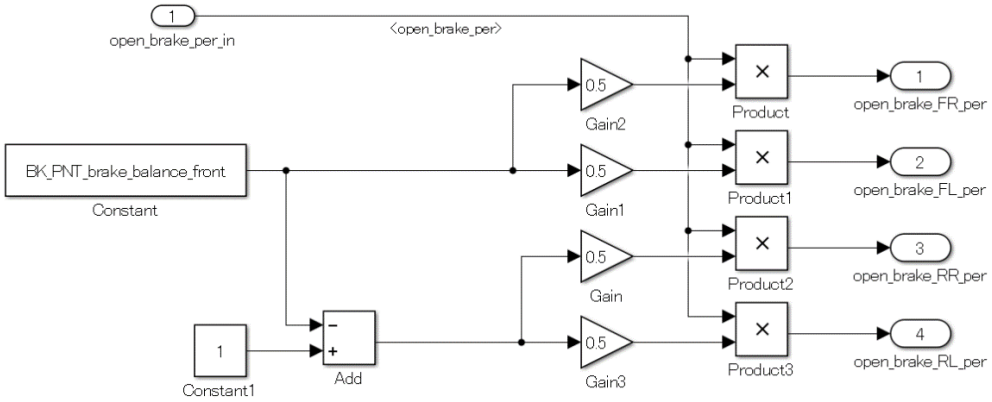

Fig. 5.3.10.2. Data flow diagram: third-layer BK_CNT system

5.3.10.3 Input/output specification

Refer to chapter 5.3.6.3 of "Handbook of Plant Modeling I/F Guidelines-Compatible Model for Vehicle Development (Ver. 1.0)"and below;

Output			
Name	Unit	Area	Description
open_BK_CNT_FR_per	%	[0 100]	Right front brake opening
open_BK_CNT_FL_per	%	[0 100]	Left front brake opening
open_BK_CNT_RR_per	%	[0 100]	Right rear brake opening
open_BK_CNT_RL_per	%	[0 100]	Left rear brake opening

5.3.10.4 Parameter specification

The parameter specification of this system is shown below.

Variable Name	Setting value	Unit	Description
BK_PNT_brake_balance_front	0.6	-	Brake balance front ratio

5.3.10.5 Other information

None.

5.3.11. Functional specification of [B70C: EPS_CNT] system

The functional specifications of the third-layer EPS_CNT system model of the model are described.

5.3.11.1 Abstract

The abstract of this system is shown below.

① Modelized object
The EPS control ECU model for vehicle dynamic performance evaluation

② Modelized level
The model to calculate target torque of motor by actual steering torque and motor rpm

③ Modelized function
The function to control for torque assist that is proportional to actual steering torque
The function for damping control to suppress extremely high motor rpm

5.3.11.2 Data flow diagram

The data flow diagram of this system is shown below.

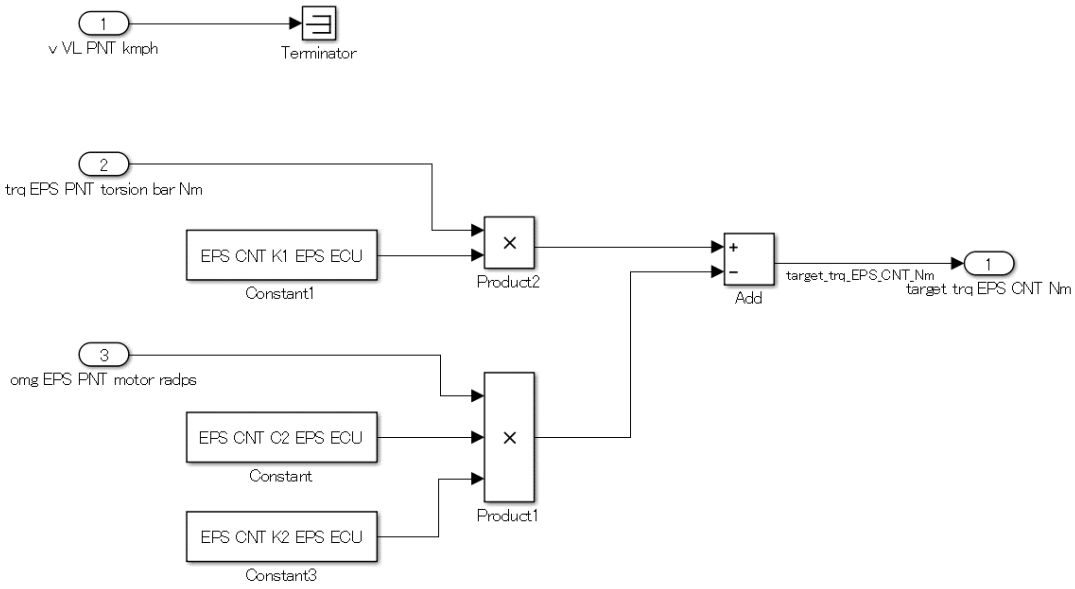

Fig. 5.3.11.2. Data flow diagram : third-layer EPS_ECU system

5.3.11.3 Input/output specification

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

Input			
Name	Unit	Area	Description
v_VL_PNT_kmph	km/h	[0 200]	Vehicle velocity
trq_EPS_PNT_torsion_bar_Nm	Nm	-	Steering torque
omg_EPS_PNT_motor_radps	rad/s	-	Motor angular velocity
Output			
Name	Unit	Area	Description
target_trq_EPS_Motor_Nm	Nm	-	Target motor torque

5.3.11.4 Parameter specification

The parameter specification of this system is shown below.

Variable Name	Setting value	Unit	Description
EPS_CNT_C2_EPS_ECU	300	-	Damping coefficient
EPS_CNT_K1_EPS_ECU	1	-	Assist coefficient of steering force
EPS_CNT_K2_EPS_ECU	0.5	-	Damping coefficient

5.3.11.5 Other information

None.

5.3.12. Functional specification of [B10P: ENG_PNT] system

Refer to chapter 5.1.7 of “Handbook of Plant Modeling I/F Guidelines-Compatible Model for Vehicle Development (Ver. 1.0)”.

5.3.13. Functional specification of [B20P: TM_PNT] system

Refer to chapter 5.3.8 of “Handbook of Plant Modeling I/F Guidelines-Compatible Model for Vehicle Development (Ver. 1.0)”.

5.3.14. Functional specification of [B21P: DF_PNT] system

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

5.3.14.1 Abstract

The abstract of this system is shown below.

① Modelized object
Differential gear model for vehicle dynamic performance evaluation

② Modelized level
The model for transmission mechanism that is reflected transmission efficiency during mode driving

③ Modelized function
The function to change gear by differential gear ratio
The function to lose the torque by differential gear efficiency
The function to distribute the torque for left/right drive shaft

5.3.14.2 Data flow diagram

The data flow diagram of this system is shown below.

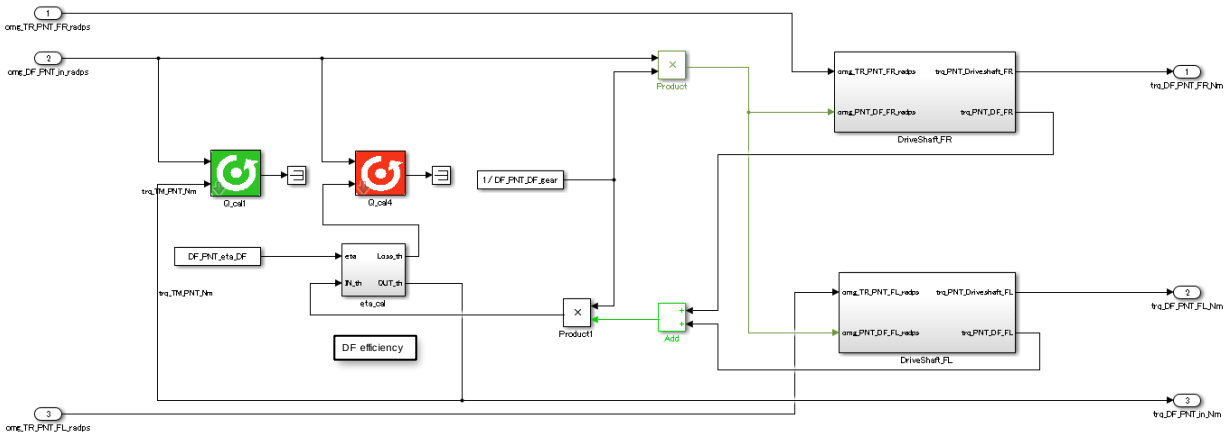

Fig. 5.3.14.2. Data flow diagram : third-layer DF_PNT system

5.3.14.3 Input/output specification

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

Input			
Name	Unit	Area	Description
omg_TR_PNT_FR_radps	rad/s	-	Right front tire rpm
omg_TR_PNT_FL_radps	rad/s	-	Left front tire rpm
omg_DF_PNT_in_radps	rad/s	-	Input rpm
Output			
Name	Unit	Area	Description
trq_DF_PNT_FL_Nm	Nm	-	Left front torque of output
trq_DF_PNT_FR_Nm	Nm	-	Right front torque of output
trq_DF_PNT_in_Nm	Nm	-	Input torque

5.3.14.4 Parameter specification

Refer to chapter 5.3.9.4 of “Handbook of Plant Modeling I/F Guidelines-Compatible Model for Vehicle Development (Ver. 1.0)”.

5.3.14.5 Other information

None.

5.3.15. Functional specification of [B30P: ALT_PNT] system

Refer to chapter 5.3.10 of “Handbook of Plant Modeling I/F Guidelines-Compatible Model for Vehicle Development (Ver. 1.0)”.

5.3.16. Functional specification of [B31P: ST_PNT] system

Refer to chapter 5.3.11 of “Handbook of Plant Modeling I/F Guidelines-Compatible Model for Vehicle Development (Ver. 1.0)”.

5.3.17. Functional specification of [B40P: BK_FL_PNT/ BK_FR_PNT/ BK_RL_PNT/ BK_RR_PNT] system

The functional specifications of the third-layer BK_FL_PNT/ BK_FR_PNT/ BK_RL_PNT/ BK_RR_PNT system model of the model are described.

5.3.17.1 Abstract

The abstract of this system is shown below.

① Modelized object
The left and right front brake, left and right rear brake model for fuel economy evaluation

② Modelized level
The model tp generate braking in mode-driving

③ Modelized function
The function to convert braking into drive shaft torque

5.3.17.2 Data flow diagram

The data flow diagram of this system is shown below.
BK_FR_PNT/ BK_RL_PNT/ BK_RR_PNT are same as Fig. 5.3.17.2 except for Input/output specification name and variable name.

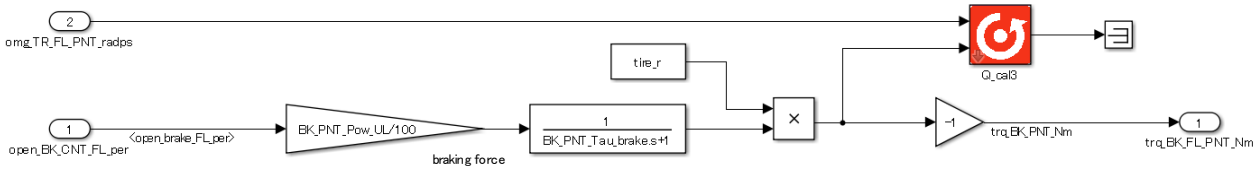

Fig. 5.3.17.2. Data flow diagram : third-layer BK_FL_PNT system

5.3.17.3 Input/output specification

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

Input			
Name	Unit	Area	Description
open_BK_CNT_FL_per open_BK_CNT_FR_per open_BK_CNT_RL_per open_BK_CNT_RR_per	%	[0 100]	Brake opening
omg_TR_FL_PNT_radps omg_TR_FR_PNT_radps omg_TR_RL_PNT_radps omg_TR_RR_PNT_radps	rad/s	-	Tire rpm
Output			
Name	Unit	Area	Description
trq_BK_FL_PNT_Nm trq_BK_FR_PNT_Nm trq_BK_RL_PNT_Nm trq_BK_RR_PNT_Nm	Nm	-	Braking control torque

5.3.17.4 Parameter specification

Refer to chapter 5.3.12.4of “Handbook of Plant Modeling I/F Guidelines-Compatible Model for Vehicle Development (Ver. 1.0)”.

5.3.17.5 Other information

None.

5.3.18. Functional specification of [B50P: BT_LO_PNT] system

Refer to chapter 5.3.13of “Handbook of Plant Modeling I/F Guidelines-Compatible Model for Vehicle Development (Ver. 1.0)”.

5.3.19. Functional specification of [B51P: EL_PNT] system

Refer to chapter 5.3.14of “Handbook of Plant Modeling I/F Guidelines-Compatible Model for Vehicle Development (Ver. 1.0)”.

5.3.20. Functional specification of [B60P: TR_FL_PNT/ TR_FR_PNT/ TR_RL_PNT/ TR_RR_PNT] system

The functional specifications of the third-layer TR_FL_PNT/ TR_FR_PNT/ TR_RL_PNT/ TR_RR_PNT system model of the model are described.

5.3.20.1 Abstract

The abstract of this system is shown below.

① Modelized object

The tire model (left front, right front, left rear, right rear) for vehicle dynamic performance evaluation

② Modelized level

The model to convert drive shaft rotational motion into translational motion

Considering rolling resistance in mode-driving

Tire lateral force in steering

Tire deflection according to vertical motion of the road surface

③ Modelized function

The function to convert for rotational and translational motion

The function to add rolling resistance for tire to accelerating force of translational motion

The function to restrict grip by friction circle

The function to calculate tire lateral force according to tire side-slip angle

The function to calculate tire load according to vertical movement on road surface

5.3.20.2 Data flow diagram

The data flow diagram of this system is shown below.

TR_FR_PNT/ TR_RL_PNT/ TR_RR_PNT are same as Fig. 5.3.20.2 except for input / output name and variable name.

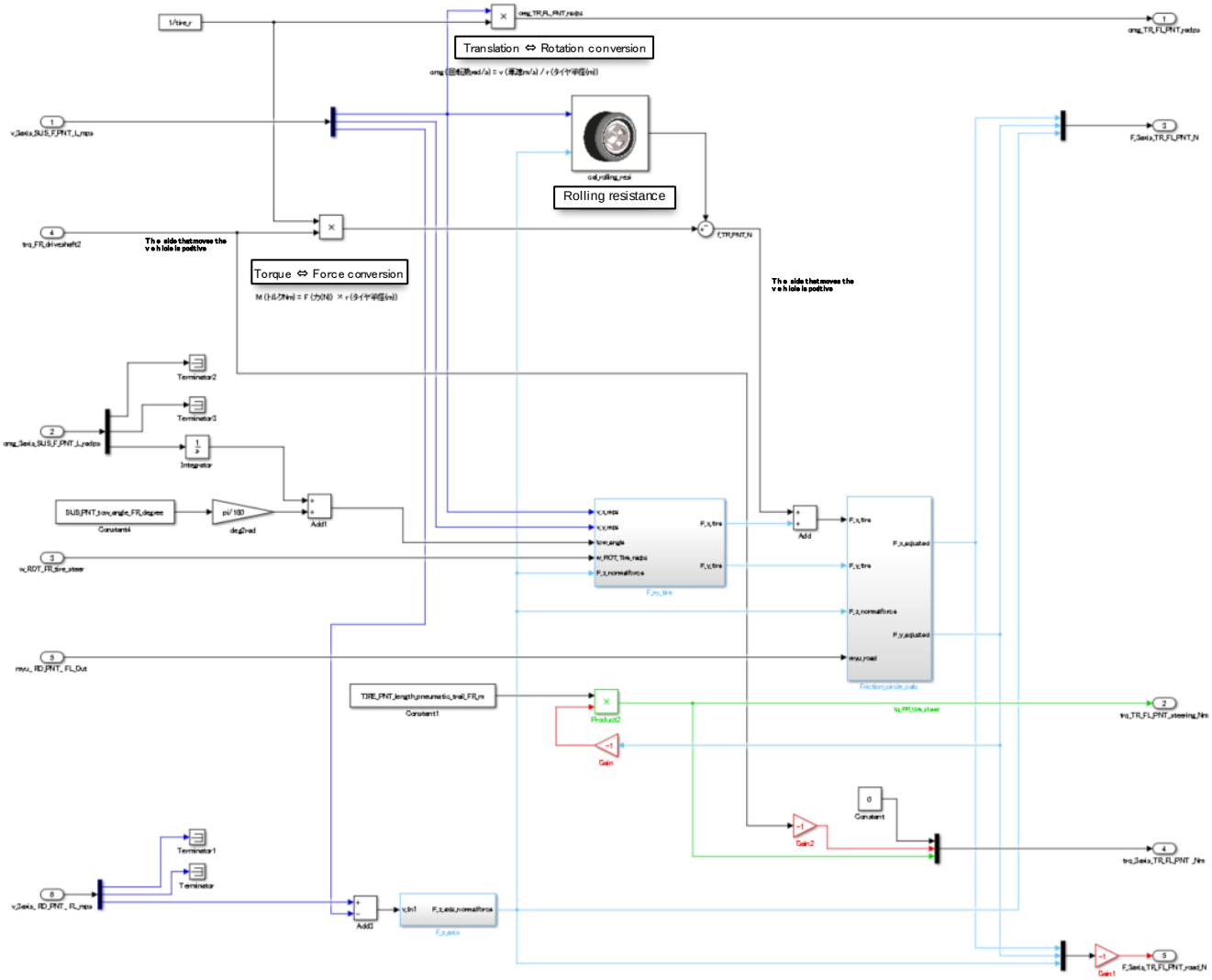

Fig. 5.3.20.2. Data flow diagram：third-layer TR_FL_PNT system

5.3.20.3 Input/output specification

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

Input			
Name	Unit	Area	Description
omg_EPS_PNT_steering_FL_radps omg_EPS_PNT_steering_FR_radps omg_EPS_PNT_steering_RL_radps omg_EPS_PNT_steering_RR_radps	rad/s	-	Tire steering angular velocity
trq_ driveshaft_ FL_Nm trq_ driveshaft_ FR_Nm trq_ driveshaft_ RL_Nm trq_ driveshaft_ RR_Nm	Nm	-	Differential gear outlet torque braking force
omg_3axis_SUS_F_PNT_L_TR_radps omg_3axis_SUS_F_PNT_R_TR_radps omg_3axis_SUS_R_PNT_L_TR_radps omg_3axis_SUS_R_PNT_R_TR_radps	rad/s	-	Tire 3-axis rotational angular velocity
v_3axis_SUS_F_PNT_L_TR_mps v_3axis_SUS_F_PNT_R_TR_mps v_3axis_SUS_R_PNT_L_TR_mps v_3axis_SUS_R_PNT_R_TR_mps	m/s	-	Tire 3-axis velocity of
v_3axis_ RD_PNT_ FL_mps v_3axis_ RD_PNT_ FR_mps v_3axis_ RD_PNT_ RL_mps v_3axis_ RD_PNT_ RR_mps	m/s	-	Ground 3-axis velocity of tire
myu_ RD_PNT_ FL_Out myu_ RD_PNT_ FR_Out myu_ RD_PNT_ RL_Out myu_ RD_PNT_ RR_Out	-	-	Friction coefficient of tire-road surface
Output			
Name	Unit	Area	Description
trq_TR_FL_PNT_steering_Nm trq_TR_FR_PNT_steering_Nm trq_TR_RL_PNT_steering_Nm trq_TR_RR_PNT_steering_Nm	Nm	-	Tire z-axis steering torque
trq_3axis_TR_FL_PNT _TR_Nm trq_3axis_TR_FR_PNT _TR_Nm trq_3axis_TR_RL_PNT _TR_Nm trq_3axis_TR_RR_PNT _TR_Nm	Nm	-	3-axis torque of tire
F_3axis_TR_FL_PNT_TR_N F_3axis_TR_FR_PNT_TR_N F_3axis_TR_RL_PNT_TR_N F_3axis_TR_RR_PNT_TR_N	N	-	3-axis force of left front tire
omg_TR_FL_PNT_radps omg_TR_FR_PNT_radps omg_TR_RL_PNT_radps omg_TR_RR_PNT_radps	rad/s	-	Drive shaft rotational velocity

Output			
Name	Unit	Area	Description
F_3axis_TR_FL_PNT_road_N F_3axis_TR_FR_PNT_road_N F_3axis_TR_RL_PNT_road_N F_3axis_TR_RR_PNT_road_N	N	-	3-axis force of left front tire-ground surface

5.3.20.4 Parameter specification

The parameter specification of this system is shown below.

Variable Name	Setting value	Unit	Description
TIRE_PNT_F_cor_tire_N	<4x17>	N	Cornering force
TIRE_PNT_W_cor_tire_N	<1x4>	N	Tire vertical load
TIRE_PNT_rad_cor_tire_rad	<1x17>	rad	Tire slip angle
TIRE_PNT_length_pneumatic_trail_FL_m TIRE_PNT_length_pneumatic_trail_FR_m TIRE_PNT_length_pneumatic_trail_RL_m TIRE_PNT_length_pneumatic_trail_RR_m	-0.005 -0.005 -0.005 -0.005	m	Pneumatic trail
TIRE_PNT_sgn_tire	1000000	-	Tire angle sign
TIRE_PNT_lowergurad_rad_cor_tire_rad	-1.5708	rad	Tire steering angle lower guard
TIRE_PNT_uppergurad_rad_cor_tire_rad	1.5708	rad	Tire steering angle upper guard
TIRE_PNT_v_zerocross_gain	1	m/s	When vehicle velocity is below this setting velocity, cornering force would be decline to zero
TIRE_PNT_z_stiffness_FL_Npm TIRE_PNT_z_stiffness_FR_Npm TIRE_PNT_z_stiffness_RL_Npm TIRE_PNT_z_stiffness_RR_Npm	260000 260000 260000 260000	N/m	Tire upper and lower hardness
TIRE_PNT_z_tire_FL_ini_m TIRE_PNT_z_tire_FR_ini_m TIRE_PNT_z_tire_RL_ini_m TIRE_PNT_z_tire_RR_ini_m	0.0143 0.0143 0.0094 0.0094	m	Tire initial displacement
SUS_PNT_tow_angle_FL_degree SUS_PNT_tow_angle_FR_degree SUS_PNT_tow_angle_RL_degree SUS_PNT_tow_angle_RR_degree	0.2 -0.2 0.1 -0.1	deg	Knuckle arm length
tire_r	0.25	m	Tire radius
myu_RRC	0.007	-	Rolling resistance coefficient

5.3.20.5 Other information

None.

5.3.21. Functional specification of [B61P: SUS_F_PNT/ SUS_R_PNT] system

The functional specifications of the third-layer SUS_F_PNT/ SUS_R_PNT system model of the model are described.

5.3.21.1 Abstract

The abstract of this system is shown below.

① Modelized object
The front suspension model for vehicle dynamic performance evaluation

② Modelized level
The model to calculate vertical motion of front suspension

③ Modelized function
Right/left spring / damper / unsprung mass
Anti-roll bar

5.3.21.2 Data flow diagram

The data flow diagram of this system is shown below.
SUS_R_PNT are same as Fig. 5.3.21.2 except for input / output name and variable name.

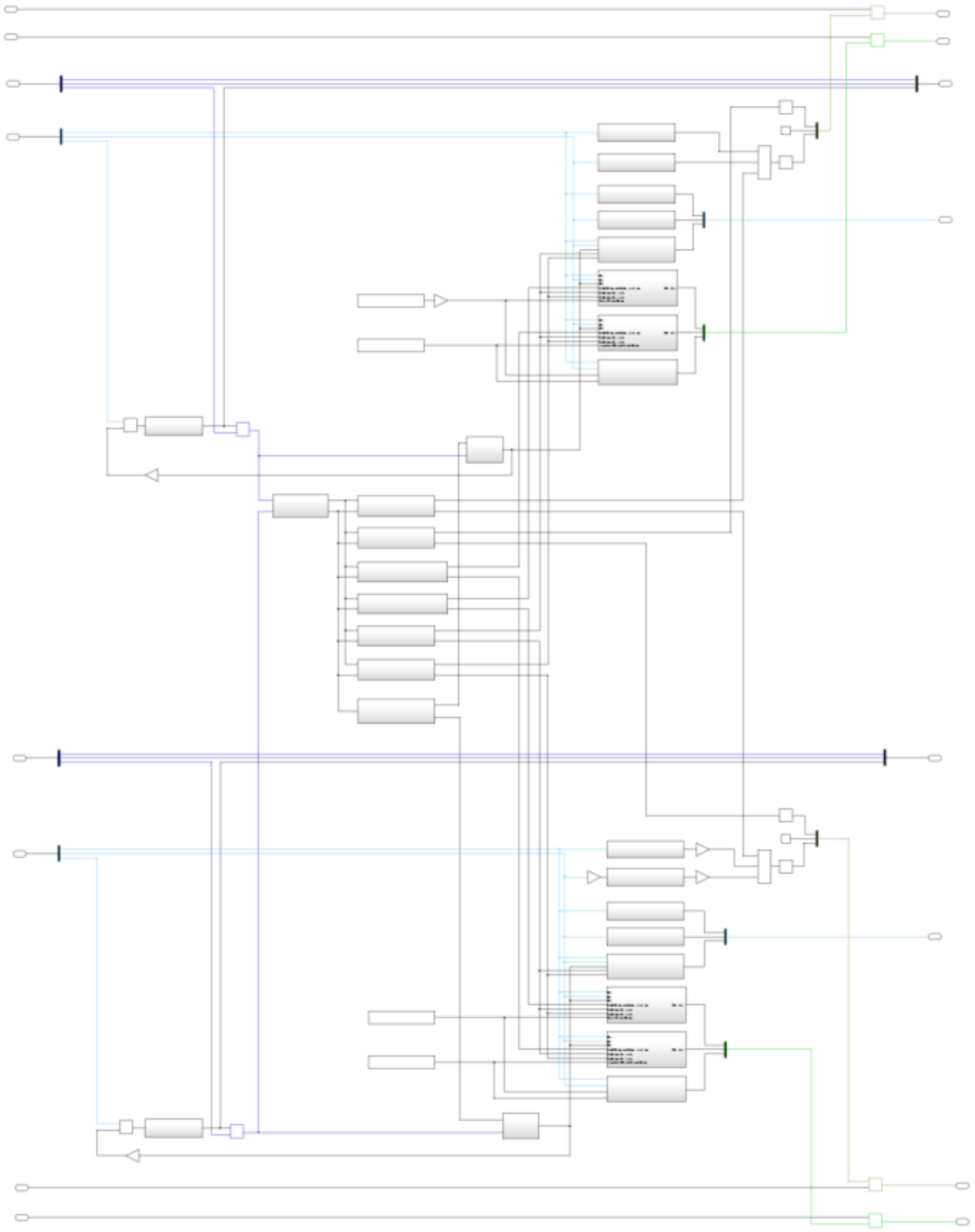

図 5.3.21.2. Data flow diagram : third-layer SUS_F_PNT system

5.3.21.3 Input/output specification

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

Input			
Name	Unit	Area	Description
F_3axis_TR_FL_PNT_TR_N F_3axis_TR_RL_PNT_TR_N	N	-	3-axis force of left tire supported point
trq_3axis_TR_FL_PNT _TR_Nm trq_3axis_TR_RL_PNT _TR_Nm	Nm	-	3-axis torque of left tire supported point
F_3axis_TR_FR_PNT_TR_N F_3axis_TR_RR_PNT_TR_N	N	-	3-axis force of right tire supported point
trq_3axis_TR_FR_PNT _TR_Nm trq_3axis_TR_RR_PNT _TR_Nm	Nm	-	3-axis torque of right tire supported point
v_3axis_VL_PNT_FL_SUS_mps v_3axis_VL_PNT_RL_SUS_mps	m/s	-	3-axis velocity of vehicle mounted point of left suspension
omg_3axis_VL_PNT_FL_SUS_radps omg_3axis_VL_PNT_RL_SUS_radps	rad/s	-	3-axis angular velocity of vehicle body mounted point of left suspension
v_3axis_VL_PNT_FR_SUS_mps v_3axis_VL_PNT_RR_SUS_mps	m/s	-	3-axis velocity of vehicle body mounted point of right suspension
omg_3axis_VL_PNT_FR_SUS_radps omg_3axis_VL_PNT_RR_SUS_radps	rad/s	-	3-axis angular velocity of vehicle body mounted point of right suspension
Output			
Name	Unit	Area	Description
v_3axis_SUS_F_PNT_L_TR_mps v_3axis_SUS_R_PNT_L_TR_mps	m/s	-	3-axis velocity of left tire supported point
omg_3axis_SUS_F_PNT_L_TR_radps omg_3axis_SUS_R_PNT_L_TR_radps	rad/s	-	3-axis rotational angular velocity of left tire supported point
v_3axis_SUS_F_PNT_R_TR_mps v_3axis_SUS_R_PNT_R_TR_mps	m/s	-	3-axis velocity of right tire supported point
omg_3axis_SUS_F_PNT_R_TR_radps omg_3axis_SUS_R_PNT_R_TR_radps	rad/s	-	3-axis rotational angular velocity of right tire supported point
F_3axis_SUS_F_PNT_L_N F_3axis_SUS_R_PNT_L_N	N	-	3-axis force of vehicle mounted point of left suspension
trq_3axis_SUS_F_PNT_L_Nm trq_3axis_SUS_R_PNT_L_Nm	Nm	-	3-axis torque of vehicle mounted point of left suspension
F_3axis_SUS_F_PNT_R_N F_3axis_SUS_R_PNT_R_N	N	-	3-axis force of vehicle mounted point of right suspension
trq_3axis_SUS_F_PNT_R_Nm trq_3axis_SUS_F_PNT_R_Nm	Nm	-	3-axis torque of vehicle mounted point of right suspension

5.3.21.4 Parameter specification

The parameter specification of this system is shown below.

Variable Name	Setting value	Unit	Description
SUS_PNT_unsprung_mass_FR_kg SUS_PNT_unsprung_mass_RR_kg	45 35	kg	Right unsprung mass
SUS_PNT_unsprung_mass_FL_kg SUS_PNT_unsprung_mass_RL_kg	45 35	kg	Left unsprung mass
SUS_PNT_k_front_untiroll_Npm SUS_PNT_k_rear_untiroll_Npm	7000 7000	N/m	Anti-roll bar rigidity
SUS_PNT_k_front_sus_Npm SUS_PNT_k_rear_sus_Npm	25000 30000	N/m	Spring rigidity
SUS_PNT_z_front_sus_ini_m SUS_PNT_z_rear_sus_ini_m	0.1313 0.0702	m	Suspension initial displacement
SUS_PNT_front_sus_speed_mps SUS_PNT_rear_sus_speed_mps	<29x1>	m/s	Damper speed
SUS_PNT_front_sus_rate_Nspm SUS_PNT_rear_sus_rate_Nspm	<29x1>	N/(m/s)	Damper rate
SUS_PNT_front_sus_fric_N SUS_PNT_rear_sus_fric_N	40 30	N	Friction force
SUS_PNT_front_sus_fric_gain SUS_PNT_rear_sus_fric_gain	10000 10000	-	Coefficient of friction when velocity is zero
SUS_PNT_RollSteer_FR_rad SUS_PNT_RollSteer_RR_rad	<1x2>	rad	Roll steer
SUS_PNT_RollSteer_FR_SamePhaseStroke_m SUS_PNT_RollSteer_RR_SamePhaseStroke_m	<1x2>	m	Roll steer x-same phase stroke
SUS_PNT_RollSteer_FR_AntiPhaseStroke_m SUS_PNT_RollSteer_RR_AntiPhaseStroke_m	<1x2>	m	Roll steer y-anti phase stroke
SUS_PNT_CamberAngle_FR_rad SUS_PNT_CamberAngle_RR_rad	<1x2>	rad	Camber angle
SUS_PNT_CamberAngle_FR_SamePhaseStroke_m SUS_PNT_CamberAngle_RR_SamePhaseStroke_m	<1x2>	m	Camber angle x-same phase stroke
SUS_PNT_CamberAngle_FR_AntiPhaseStroke_m SUS_PNT_CamberAngle_RR_AntiPhaseStroke_m	<1x2>	m	Camber angle y-anti phase stroke
SUS_PNT_LinkMomentArm_xaxis_FR_m SUS_PNT_LinkMomentArm_xaxis_RR_m	<1x2>	m	Link moment arm (x-axis)
SUS_PNT_LinkMomentArm_xaxis_FR_SamePhaseStroke_m SUS_PNT_LinkMomentArm_xaxis_RR_SamePhaseStroke_m	<1x2>	m	Link moment arm (x-axis) x-same phase stroke
SUS_PNT_LinkMomentArm_xaxis_FR_AntiPhaseStroke_m SUS_PNT_LinkMomentArm_xaxis_RR_AntiPhaseStroke_m	<1x2>	m	Link moment arm (x-axis) x-anti phase stroke
SUS_PNT_LinkMomentArm_yaxis_FR_m SUS_PNT_LinkMomentArm_yaxis_RR_m	<2x2>	m	Link moment arm (y-axis)
SUS_PNT_LinkMomentArm_yaxis_FR_SamePhaseStroke_m SUS_PNT_LinkMomentArm_yaxis_RR_SamePhaseStroke_m	<1x2>	m	Link moment arm (y-axis) x-same phase stroke
SUS_PNT_LinkMomentArm_yaxis_FR_AntiPhaseStroke_m SUS_PNT_LinkMomentArm_yaxis_RR_AntiPhaseStroke_m	<1x2>	m	Link moment arm (y-axis) x-anti phase stroke

Variable Name	Setting value	Unit	Description
SUS_PNT_LinkAngle_xaxis_FR_rad SUS_PNT_LinkAngle_xaxis_RR_rad	<2x2>	rad	Link angle (x-axis)
SUS_PNT_LinkAngle_xaxis_FR_SamePhaseStroke_m SUS_PNT_LinkAngle_xaxis_RR_SamePhaseStroke_m	<1x2>	m	Link angle (x-axis) x-same phase stroke
SUS_PNT_LinkAngle_xaxis_FR_AntiPhaseStroke_m SUS_PNT_LinkAngle_xaxis_RR_AntiPhaseStroke_m	<1x2>	m	Link angle (x-axis) x-anti phase stroke
SUS_PNT_LinkAngle_yaxis_FR_rad SUS_PNT_LinkAngle_yaxis_RR_rad	<1x2>	rad	Link angle (y-axis)
SUS_PNT_LinkAngle_yaxis_FR_SamePhaseStroke_m SUS_PNT_LinkAngle_yaxis_RR_SamePhaseStroke_m	<1x2>	m	Link angle (y-axis) x-same phase stroke
SUS_PNT_LinkAngle_yaxis_FR_AntiPhaseStroke_m SUS_PNT_LinkAngle_yaxis_RR_AntiPhaseStroke_m	<1x2>	m	Link angle (y-axis) x-anti phase stroke
SUS_PNT_LongitudinalComplianceSteer_FR_rad SUS_PNT_LongitudinalComplianceSteer_RR_rad	<1x2>	rad	Longitudinal compliance steer
SUS_PNT_LongitudinalComplianceSteer_FR_Fx_N SUS_PNT_LongitudinalComplianceSteer_RR_Fx_N	<1x2>	N	Longitudinal compliance steer x-tire force
SUS_PNT_LateralComplianceSteer_FR_rad SUS_PNT_LateralComplianceSteer_RR_rad	<1x2>	rad	Lateral compliance steer
SUS_PNT_LateralComplianceSteer_FR_Fy_N SUS_PNT_LateralComplianceSteer_RR_Fy_N	<1x2>	N	Lateral compliance steer map x-tire force
VL_PNT_l_center2front_m VL_PNT_l_center2rear_m	1.0714 1.6286	m	Distance from center to axle
VL_PNT_width_tread_front_m VL_PNT_width_tread_rear_m	1.5 1.5	m	Tread width

5.3.21.5 Other information

None.

5.3.22. Functional specification of [B62P: VL_PNT] system

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

5.3.22.1 Abstract

The abstract of this system is shown below.

① Modelized object
The dynamics model for vehicle dynamic performance evaluation

② Modelized level
The model to calculate 3-axis 6-flexibility vehicle velocity

③ Modelized function
The function of vehicle velocity from vehicle translational acceleration force
The following item's calculation
Yaw rate
Pitch rate
Roll rate
Center of gravity vertical motion velocity
Center of gravity slip angle
4-tires vertical motion velocity
4-tires all directions motion velocity

5.3.22.2 Data flow diagram

The data flow diagram of this system is shown below.

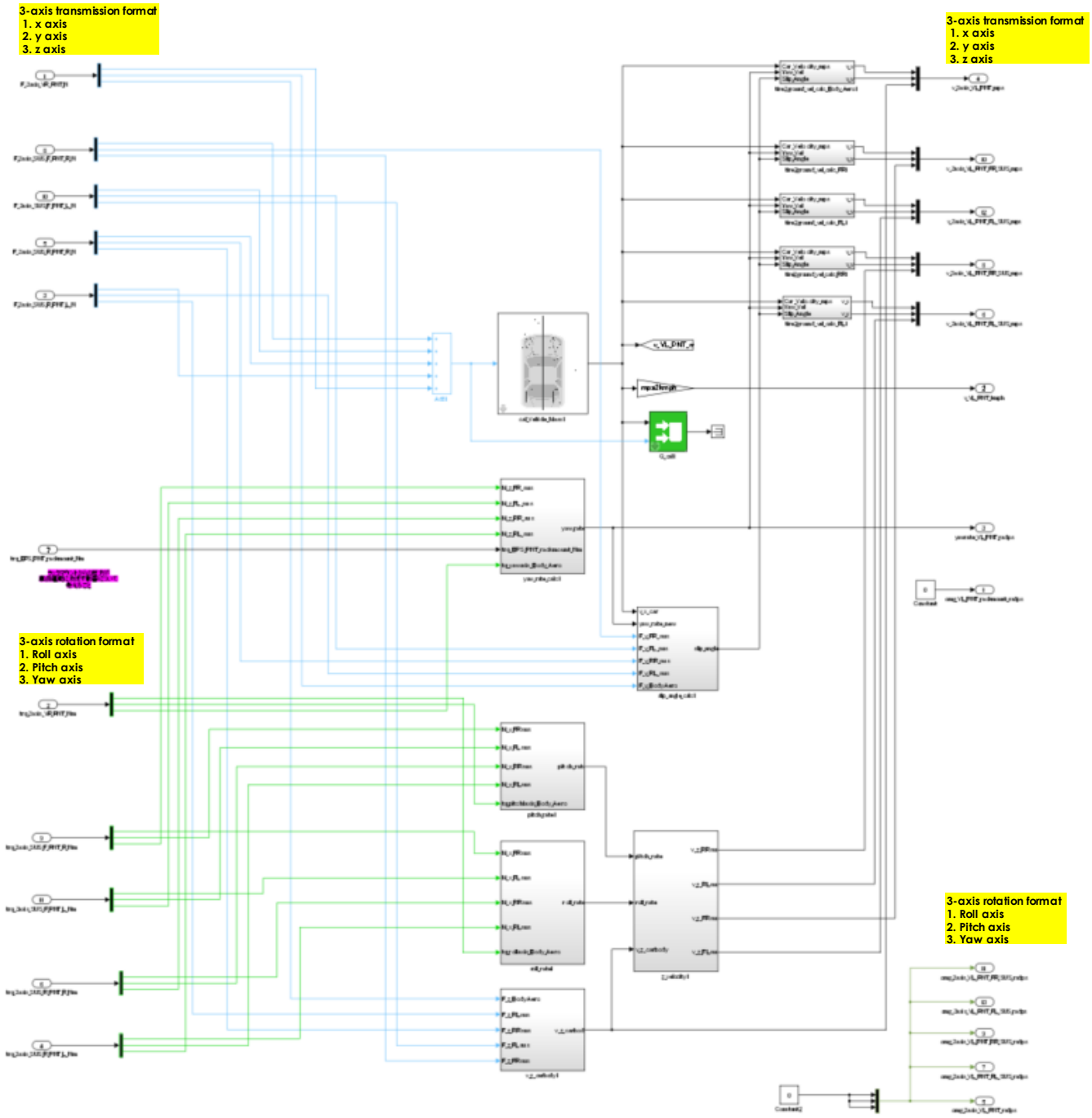

Fig. 5.3.22.2. Data flow diagram: third-layer VL_PNT system

5.3.22.3 Input/output specification

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

Input			
Name	Unit	Area	Description
F_3axis_VR_PNT_N	N	-	3-axis resistance force
trq_3axis_VR_PNT_Nm	Nm	-	3-axis wind force torque
F_3axis_SUS_F_PNT_L_N	N	-	Left front suspension vehicle 3-axis force
F_3axis_SUS_F_PNT_R_N	N	-	Right front suspension vehicle 3-axis force
F_3axis_SUS_R_PNT_R_N	N	-	Right rear suspension vehicle 3-axis force
F_3axis_SUS_R_PNT_L_N	N	-	Left rear suspension vehicle 3-axis force
trq_3axis_SUS_F_PNT_L_Nm	Nm	-	Left front suspension vehicle 3-axis torque
trq_3axis_SUS_F_PNT_R_Nm	Nm	-	Right front suspension vehicle 3-axis torque
trq_3axis_SUS_R_PNT_L_Nm	Nm	-	Left rear suspension vehicle 3-axis torque
trq_3axis_SUS_R_PNT_R_Nm	Nm	-	Right rear suspension vehicle 3-axis torque
trq_EPS_PNT_rackmount_Nm	Nm	-	EPS steering anti-torque
Output			
Name	Unit	Area	Description
v_VL_PNT_kmph	km/h	[0 200]	Vehicle velocity
v_3axis_VL_PNT_mps	m/s	-	3-axis vehicle velocity
omg_3axis_VL_PNT_radps	rad/s	-	3-axis vehicle angular velocity
v_3axis_VL_PNT_FL_SUS_mps	m/s	-	Left front suspension vehicle 3-axis velocity
v_3axis_VL_PNT_FR_SUS_mps	m/s	-	Right front suspension vehicle 3-axis velocity
v_3axis_VL_PNT_RL_SUS_mps	m/s	-	Left rear suspension 3-axis velocity
v_3axis_VL_PNT_RR_SUS_mps	m/s	-	Right rear suspension 3-axis velocity
omg_3axis_VL_PNT_FL_SUS_radps	rad/s	-	Left front suspension vehicle 3-axis angular velocity
omg_3axis_VL_PNT_FR_SUS_radps	rad/s	-	Right front suspension vehicle 3-axis angular velocity
omg_3axis_VL_PNT_RL_SUS_radps	rad/s	-	Left rear suspension 3-axis angular velocity
omg_3axis_VL_PNT_RR_SUS_radps	rad/s	-	Right rear suspension 3-axis angular velocity
omg_VL_PNT_rackmount_radps	rad/s	-	Rackmount angular velocity
yawrate_VL_PNT_radps	rad/s	-	Vehicle body yaw rate

5.3.22.4 Parameter specification

The parameter specification of this system is shown below.

Variable Name	Setting value	Unit	Description
VL_PNT_hight_pitch_center_gravity_m	0.1	m	Pitch center of gravity height
VL_PNT_hight_roll_center_gravity_m	0.1362	m	Roll center of gravity height
VL_PNT_Inertia_pitch_axis	1500	kgm^2	Pitch poll moment of inertia
VL_PNT_Inertia_roll_axis	400	kgm^2	Roll poll moment of inertia
VL_PNT_Inertia_yaw_axis	1300	kgm^2	Yaw poll moment of inertia
VL_PNT_l_center2front_m	1.0714	m	Distance between front and center of gravity
VL_PNT_l_center2rear_m	1.6286	m	Distance between rear and center of gravity
VL_PNT_slip_angle_vel_guard_mps	1	m/s	Reference velocity to prevent divergence in calculation of slip angle of gravity center divided by vehicle velocity
VL_PNT_width_tread_front_m	1.5	m	Front tread width
VL_PNT_width_tread_rear_m	1.5	m	Rear tread width

5.3.22.5 Other information

None.

5.3.23. Functional specification of [B63P: VR_PNT] system

The functional specifications of the third-layer VR_PNT system model of the model are described.

5.3.23.1 Abstract

The abstract of this system is shown below.

① Modelized object
The dynamics model for vehicle dynamic performance evaluation

② Modelized level
The model to calculate vehicle driving resistance force

③ Modelized function
Air resistance
Climbing resistance
Cross-wind

5.3.23.2 Data flow diagram

The data flow diagram of this system is shown below.

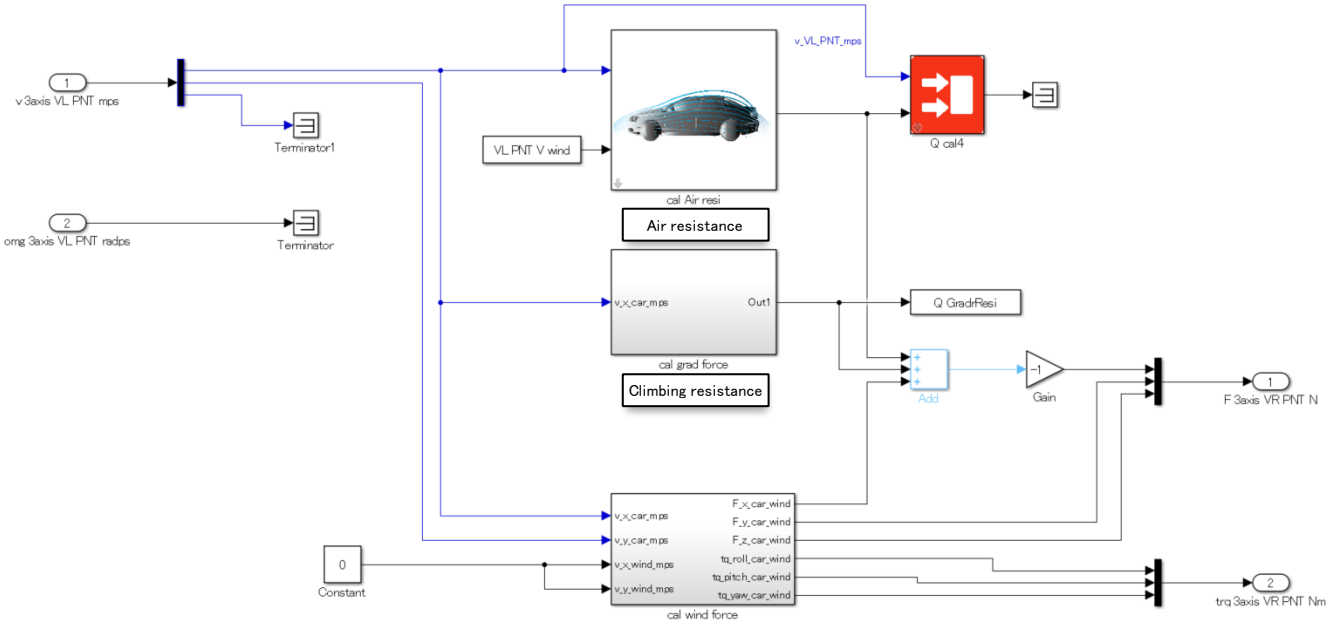

Fig. 5.3.23.2. Data flow diagram : third-layer VR_PNT system

5.3.23.3 Input/output specification

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

Input			
Name	Unit	Area	Description
v_3axis_VL_PNT_mps	m/s	-	3-axis vehicle velocity
omg_3axis_VL_PNT_radps	rad/s	-	3-axis vehicle angular velocity
Output			
Name	Unit	Area	Description
F_3axis_VR_PNT_N	N	-	3-axis running resistance
trq_3axis_VR_PNT_Nm	Nm	-	3-axis running resistance torque

5.3.23.4 Parameter specification

The parameter specification of this system is shown below.

Variable Name	Setting value	Unit	Description
VL_PNT_V_wind	0	m/s	Wind velocity
VL_PNT_Vehicle_theta_degree	0	deg	Climbing angle
M_car	1260	kg	Weight of vehicle

5.3.23.5 Other information

None.

5.3.24. Functional specification of [B70P: EPS_PNT] system

The functional specifications of the third-layer EPS_PNT system model of the model are described.

5.3.24.1 Abstract

The abstract of this system is shown below.

① Modelized object
The EPS model for vehicle dynamic performance evaluation

② Modelized level
The model to transmit steering torque to tires
The model to assist the torque by motor

③ Modelized function
The function to transmit steering torque to tires
The function to assist the torque according to target torque

5.3.24.2 Data flow diagram

The data flow diagram of this system is shown below.

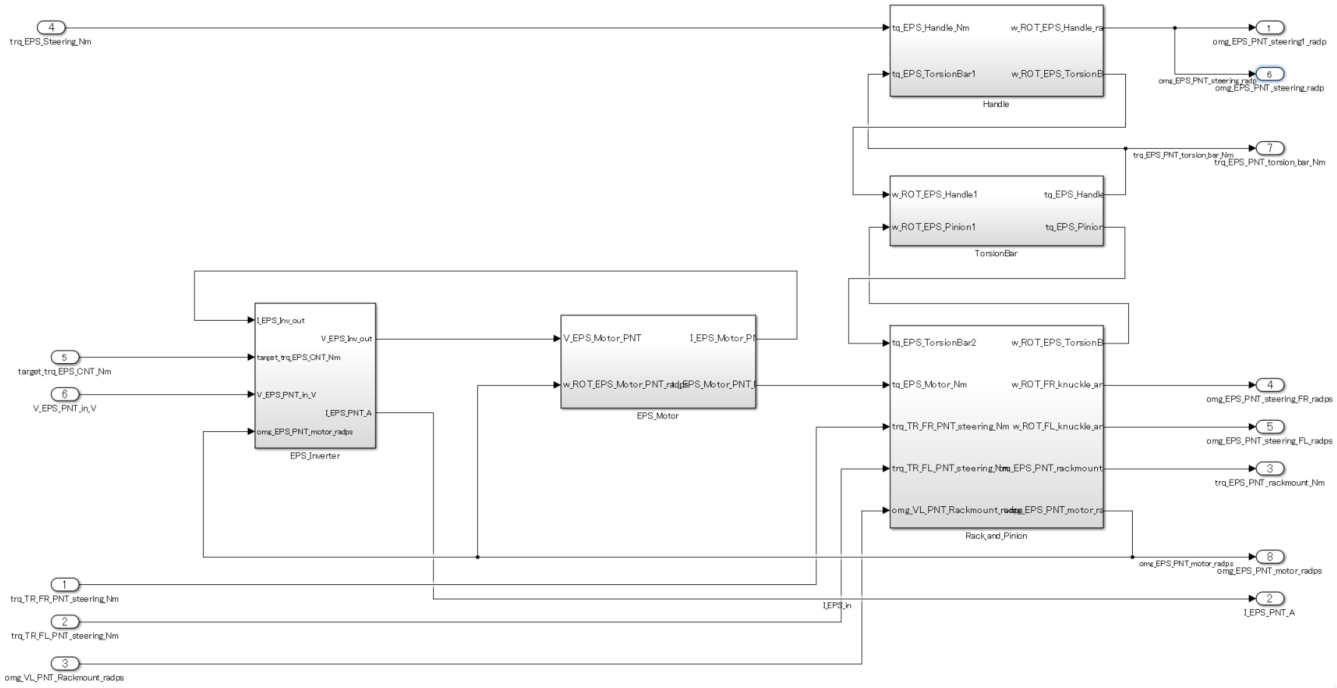

Fig. 5.3.24.2. Data flow diagram : third-layer EPS_PNT system

5.3.24.3 Input/output specification

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

Input			
Name	Unit	Area	Description
trq_TR_FL_PNT_steering_Nm	Nm	-	Left front tire steering torque
trq_TR_FR_PNT_steering_Nm	Nm	-	Right front tire steering torque
omg_VL_PNT_rackmount_radps	rad/s	-	Rackmount angular velocity
trq_EPS_Steering_Nm	Nm	-	Driver's steering torque
target_trq_EPS_CNT_Nm	Nm	-	Target motor torque
V_EPS_PNT_in_V	V	-	Battery voltage
Output			
Name	Unit	Area	Description
omg_EPS_PNT_steering_radps	rad/s	-	Steering angular velocity
trq_EPS_PNT_rackmount_Nm	Nm	-	Anti-steering torque to vehicle
omg_EPS_PNT_steering_FL_radps	rad/s	-	Left front tire steering angular velocity
omg_EPS_PNT_steering_FR_radps	rad/s	-	Right front tire steering angular velocity
omg_EPS_PNT_steering1_radps	rad/s	-	Steering angular velocity
trq_EPS_PNT_torsion_bar_Nm	Nm	-	torsion spring torque
omg_EPS_PNT_motor_radps	rad/s	-	EPS motor rotational velocity
I_EPS_PNT_A	A	-	EPS consumed electric current

5.3.24.4 Parameter specification

The parameter specification of this system is shown below.

Variable Name	Setting value	Unit	Description
EPS_PNT_Inertia_EPS_Handle	0.038	kgm^2	Steering wheel inertia
EPS_PNT_K_EPS_TorsionBar	135	Nm/rad	Torsion spring torsional rigidity
EPS_PNT_D_EPS_TorsionBar	22.6495	Nm/(rad/s)	Torsion spring damping
EPS_PNT_LocktoLock_rad	6.2832	rad	Lock to lock is 2 cycle
EPS_PNT_Ratio_EPS_Motor2Pinion	18	-	Motor gear ratio
EPS_PNT_Ratio_EPS_Pinion2Rack	0.01	m/rad	Converting from pinion rolling motion to rack linear motion
EPS_PNT_M_EPS_rack_kg	100	kg	EPS rack weight
EPS_PNT_D_EPS_rack_Nspm	500	N/(m/s)	Attenuation of EPS rack
EPS_PNT_R_EPS_Motor	0.01	Ω	Motor windings resistance
EPS_PNT_k_EPS_Motor_radps2Volt	0.024	V/(rad/s)	Motor counter electromotive force constant.
EPS_PNT_length_knuckle_arm_FR_m	0.02	m	Right front knuckle arm length
EPS_PNT_length_knuckle_arm_FL_m	0.02	m	Left front knuckle arm length

5.3.24.5 Other information

None.

5.3.25. Functional specification of [B80P: RD_PNT] system

The functional specifications of the third-layer RD_PNT system model of the model are described.

5.3.25.1 Abstract

The abstract of this system is shown below.

① Modelized object
The road environment model for vehicle dynamic performance evaluation

② Modelized level
The model to output information of road surface for each tire

③ Modelized function
The function to calculae road surface velocity for each tire
The function to set friction coefficient of road surface for each tire

5.3.25.2 Data flow diagram

The data flow diagram of this system is shown below.

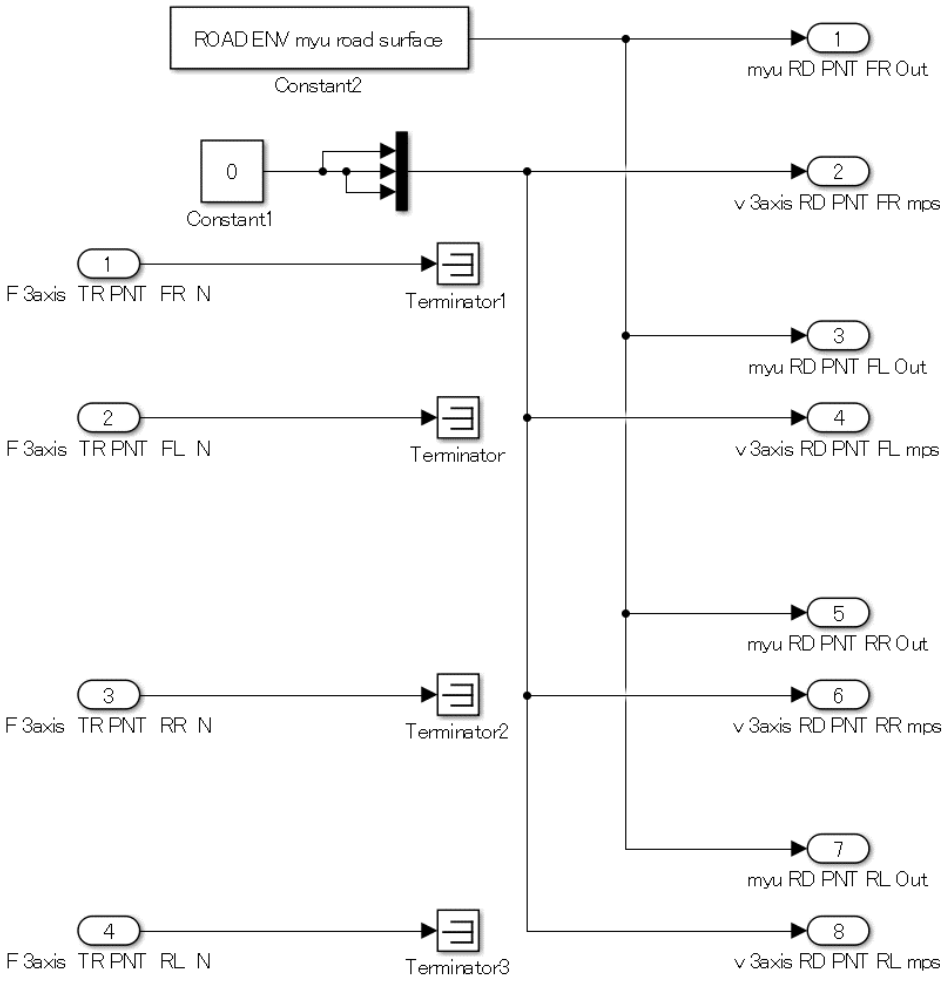

Fig. 5.3.25.2. Data flow diagram : third-layer RD_PNT system

5.3.25.3 Input/output specification

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

Input			
Name	Unit	Area	Description
F_3axis_TR_FL_PNT_road_N	N	−	3-axis force of left front tire road surface
F_3axis_TR_FR_PNT_road_N	N	−	3-axis force of right front tire road surface
F_3axis_TR_RL_PNT_road_N	N	−	3-axis force of left rear tire road surface
F_3axis_TR_RR_PNT_road_N	N	−	3-axis force of right rear tire road surface
Output			
Name	Unit	Area	Description
v_3axis_RD_PNT_FL_mps	m/s	-	3-axis velocity of left front tire road surface
v_3axis_RD_PNT_FR_mps	m/s	-	3-axis velocity of right front tire road surface
v_3axis_RD_PNT_RL_mps	m/s	-	3-axis velocity of left rear tire road surface
v_3axis_RD_PNT_RR_mps	m/s	-	3-axis velocity of right rear tire road surface
myu_RD_PNT_FL	-	-	Friction coefficient of left front tire road surface
myu_RD_PNT_FR	-	-	Friction coefficient of right front tire road surface
myu_RD_PNT_RL	-	-	Friction coefficient of left rear tire road surface
myu_RD_PNT_RR_Out	-	-	Friction coefficient of right rear tire road surface

5.3.25.4 Parameter specification

The parameter specification of this system is shown below.

Variable Name	Setting value	Unit	Description
ROAD_ENV_myu_road_surface	0.9	-	Friction coefficient of road surface

5.3.25.5 Other information

None.

6. Description in this model

Refer to Chapter 6 of “Handbook of Plant Modeling I/F Guidelines-Compatible Model for Vehicle Development (Ver. 1.0)” except for 6.4 naming 6.4.2 subsystem name.

The list of subsystem names is described below.

Table 6. Subsystem name

First-layer			Second-layer			Third-layer			Fourth-layer		
Part	Notation	abbreviation	Part	Notation	abbreviation	Part	Notation	abbreviation	Part	Notation	abbreviation
Driver	Driver										
Vehicle	Vehicle		Vehicle control	VehicleController	VC	Engine control	EngineControl	ENG_CNT			
						Transmission control	TransmissionControl	TM_CNT			
						Brake control	BrakeControl	BK_CNT			
						Alternator control	AlternatorControl	ALT_CNT			
						EPS control	EPSControl	EPS_CNT			
			Vehicle plant	VehicleBody	VB	Engine	Engine	ENG_PNT			
						Transmission	Transmission	TM_PNT	Torque converter	TorqueConverter	TC_PNT
									Lock up clutch	LockUpClutch	LU_PNT
									Variator	Variator	VR_PNT
						Differential gear	DifferentialGear	DF_PNT			
						Right front tire	TireFR	TR_FR_PNT			
						Left front tire	TireFL	TR_FL_PNT			
						Right rear tire	TireRR	TR_RR_PNT			
						Left rear tire	TireRL	TR_RL_PNT			
						Right front brake	BrakeFR	BK_FR_PNT			
						Left front brake	BrakeFL	BK_FL_PNT			
						Right rear brake	BrakeRR	BK_RR_PNT			
						Left rear brake	BrakeRL	BK_RL_PNT			
						Front suspention	SuspentionFront	SUS_F_PNT	Right front spring damper	SuspentionFR	SUS_FR_PNT
									Right front unsprung mass	UnsprungMassFR	MUS_FR_PNT
									Left front spring damper	SuspentionFL	SUS_FL_PNT
									Left front unsprung mass	UnsprungMassFL	MUS_FL_PNT
									Front anti-roll bar	AntiRollBarF	ARB_F_PNT
						Rear suspention	SuspentionRear	SUS_R_PNT	Right rearspring damper	SuspentionRR	SUS_RR_PNT
									Right rear unsprung mass	UnsprungMassRR	MUS_RR_PNT
									Left rear spring damper	SuspentionRL	SUS_RL_PNT
									Left rear unsprung mass	UnsprungMassRL	MUS_RL_PNT
									Rear anti-roll bar	AntiRollBarR	ARB_R_PNT
						Load vehicle	VehicleLoad	VL_PNT			
						Vehicle resistance	VehicleResistance	VR_PNT			
						EPS	EPS	EPS_PNT	Steering wheel	SteeringWheel	EPS_SW_PNT
									Torsion bar	TorsionBar	EPS_TB_PNT
									Rack and pinion	RackandPinion	EPS_RP_PNT
									Motor	EPSMotor	EPS_MM_PNT
									Inverter	EPSInverter	EPS_INV_PNT
						Battery	Battery	BT_LO_PNT			
						Alternator	Alternator	ALT_PNT			
						Sterter	Sterter	ST_PNT			
						Load electrical	ElectricalLoad	EL_PNT			
						Road environment	RoadEnviroment	RD_PNT			
Environment Monitor	Environment Monitor										

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
[3] ”Handbook of Plant Modeling I/F Guidelines-Compatible Model for Vehicle Development (Ver. 1.0)”