Electric Vehicle Modeling

Computational Design Laboratory
Department of Automotive Engineering
Hanyang University, Seoul, Korea

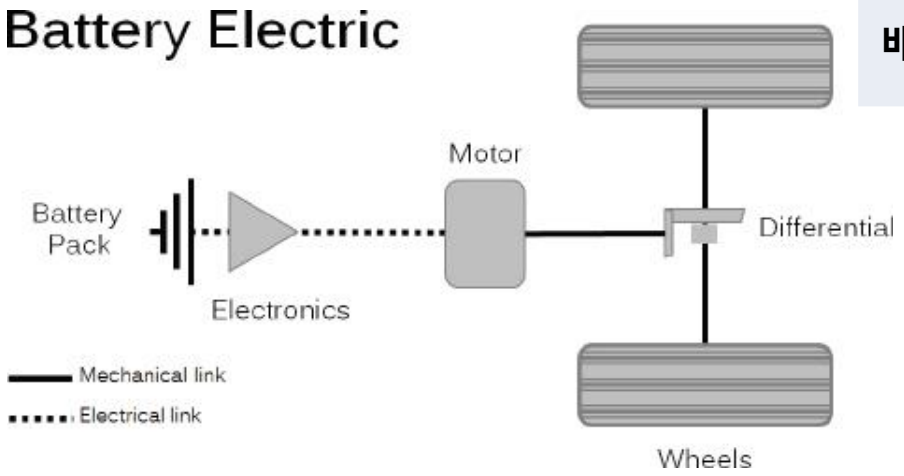
CONTENTS

- Reference: Chevrolet Bolt EV
- Model Layout
- Powertrain
- Driver Controller
- Resistance Torque
- Simulation: Driving Performance
- Battery
- Simulation: SOC consumption

REFERENCE MODEL

Chevrolet Bolt EV

항목		제원
차량중량		1,625 kg
전면투영면적		2.397 m^2
공기저항계수		0.308
타이어		215/50 R17 (0.323 m)
종감속기어비		7.05
구동 모터	최대토크	360 Nm
	최대출력	150 kW
	최고속도	8,800 RPM
배터리	공칭전압	350 V
	용량	60 kWh (171.4 Ah)



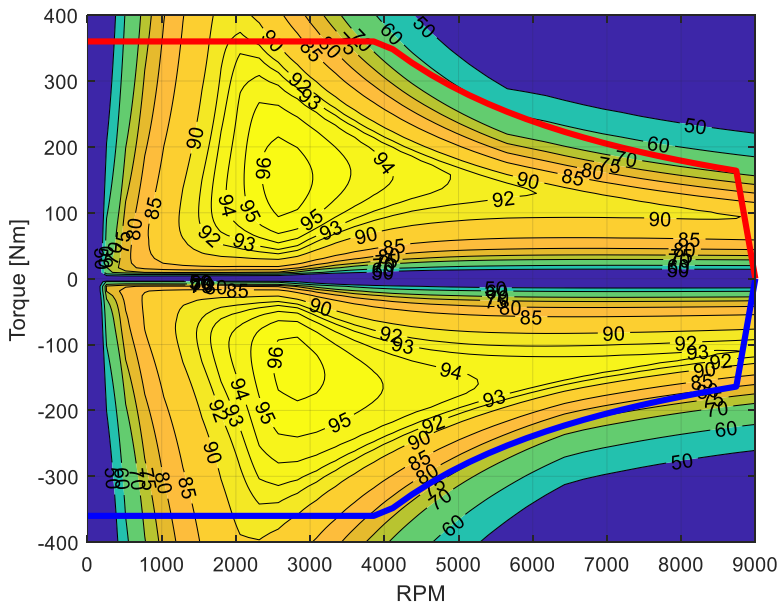
※ Ref. : Kim. D. *et al.*, Integrated Design of In-Wheel Motor System on Rear Wheels for Small Electric Vehicle, 2010, EVS25

REFERENCE MODEL

※ m-file 실행

```
%% input data
Kp=500; Ki=100; % Driver gain
FGR=7.05; % Gear ratio
Rtire=0.323; % Tire radius [m]
m=1625; % Vehicle mass [kg]
J_motor=0.1; % Motor inertia [kgm^2]
mu_roll=0.01; A=2.397; Cd=0.308; % Resistance
tau_filter=0.1;
brk_tq=1000; % Brake capacity [Nm]
tq_regen=250; % Regenerative brake capacity [Nm]
Tm=360; Pm=150; RPMm=8800; % Motor spec.
UDDS_source=importdata('cyc_UDDS.data');
UDDS=UDDS_source.data;
% HWFET=importdata('cyc_HWFET.data');
% HWFET(:,1)=HWFET(:,1)+1400;
% HWFET(:,2)=HWFET(:,2)/2.23694;
% UDDS_HWFET=cat(1,UDDS,HWFET);
% NEDC_source=importdata('cyc_NEDC.data');
% NEDC=NEDC_source.data;
SOC_ini=50; % initial SOC [%]
OCV_V=350; % open circuit voltage [V]
R_in=0.1; % internal resistance [ohm]
C_nom=60/350*1000; % rated capacity [Ah]
```

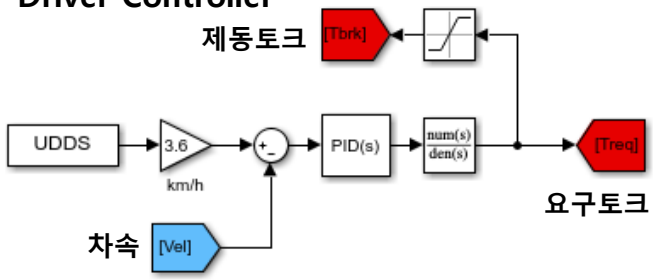
```
%% motor spec. Bolt
load('motor_data.mat')
Tweight=Tm/295;
RPM_loss=RPM_loss*9/7;
T_RPM=RPM_loss;
T_max=zeros(length(T_RPM),1); T_min=zeros(length(T_RPM),1);
for i=1:length(T_RPM)
    if T_RPM(i)<(Pm*1000/Tm*30/pi)
        T_max(i)=295*Tweight; T_min(i)=-T_max(i);
    else
        T_max(i)=Pm*1000/T_RPM(i)*30/pi(); T_min(i)=-T_max(i);
    end
end
T_max(end)=0; T_min(end)=0;
eff_rpm=RPM_loss;
eff_tq=T_loss*Tweight;
eff=zeros(length(T_loss),length(RPM_loss));
eff(:,:)=eff_map(:,:,1)*100;
load('eff_map_mod_Bolt.mat');
eff=eff_mod;
```



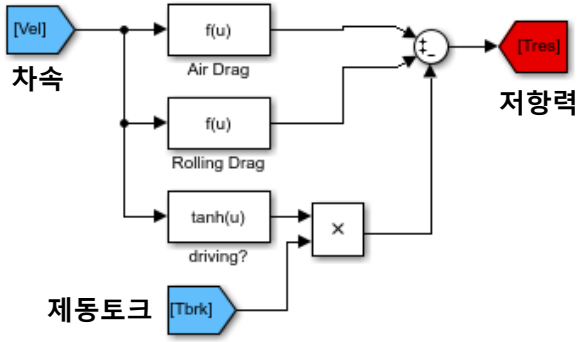
MODEL LAYOUT

: Input : Output

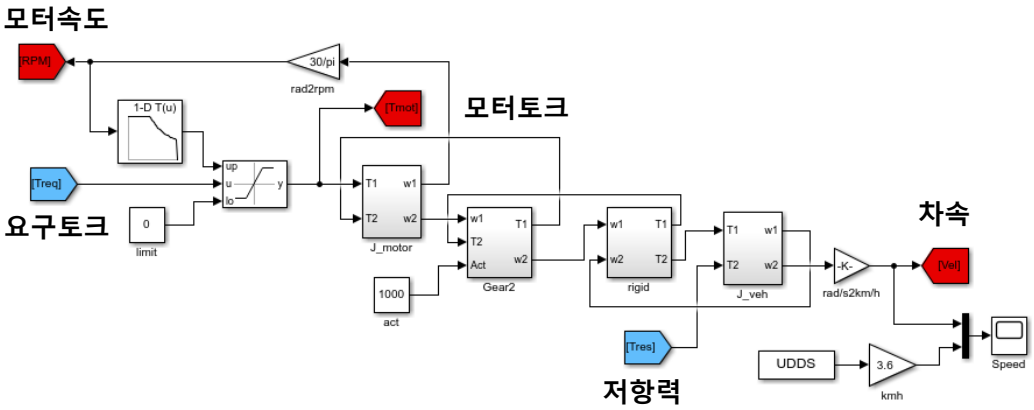
Driver Controller



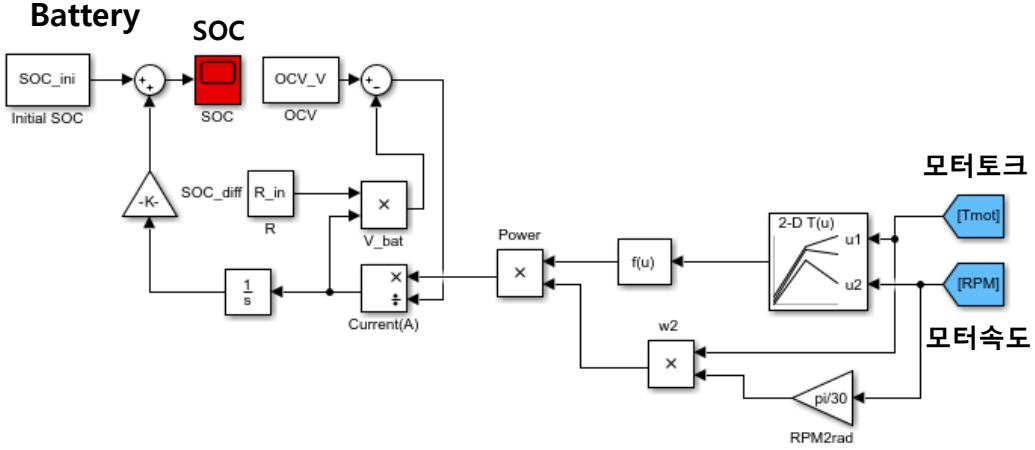
Resistance Torque



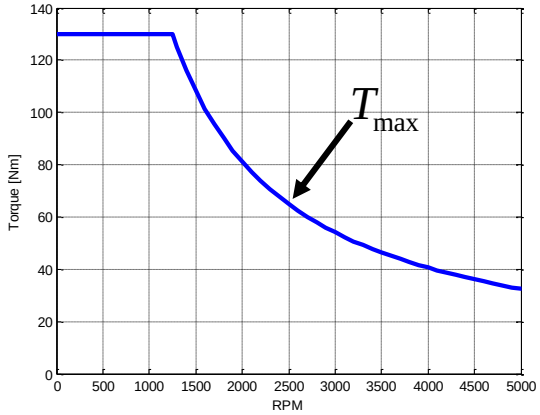
Powertrain



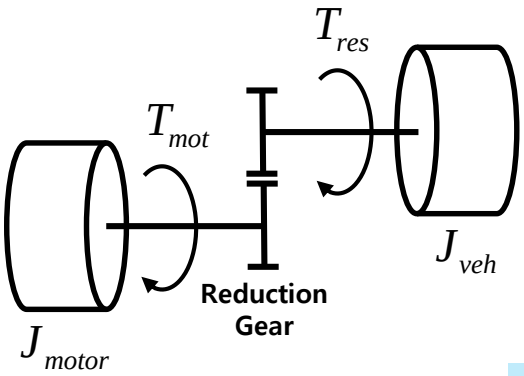
Battery



POWERTRAIN



$$T_{motor} = \min(T_{req}, T_{\max})$$

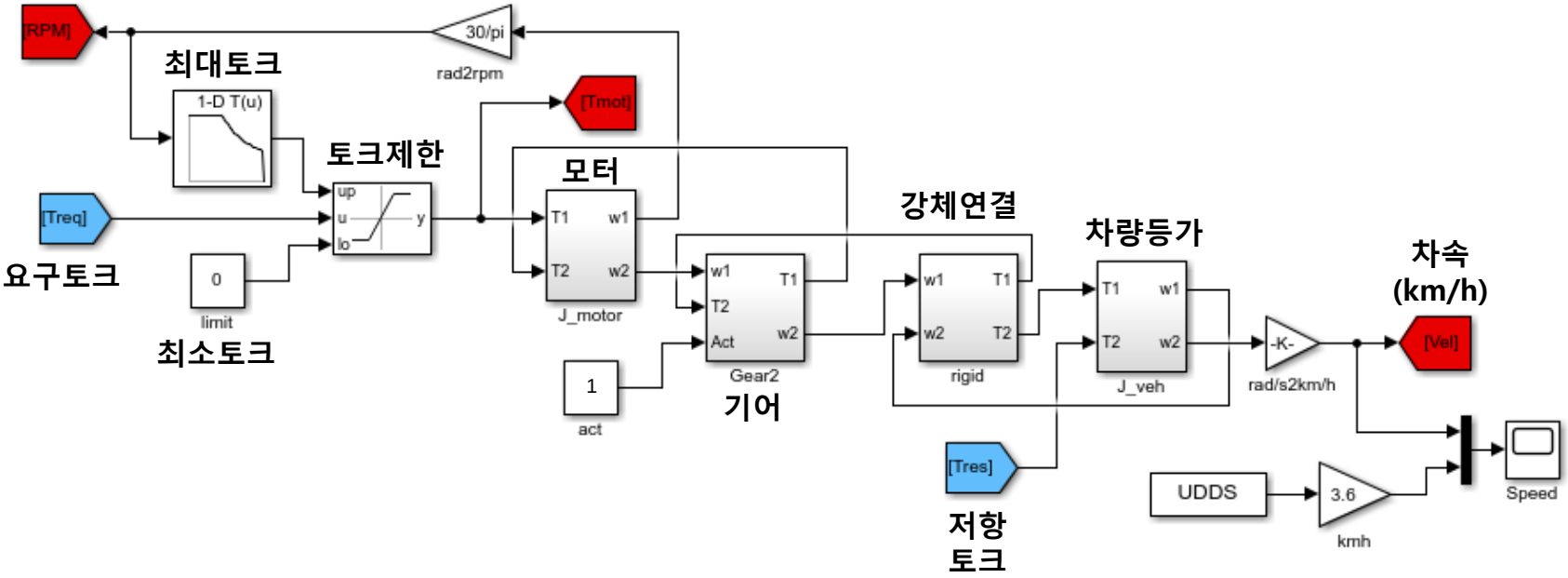


$$J_{veh} = m_{veh} R_{tire}^2$$

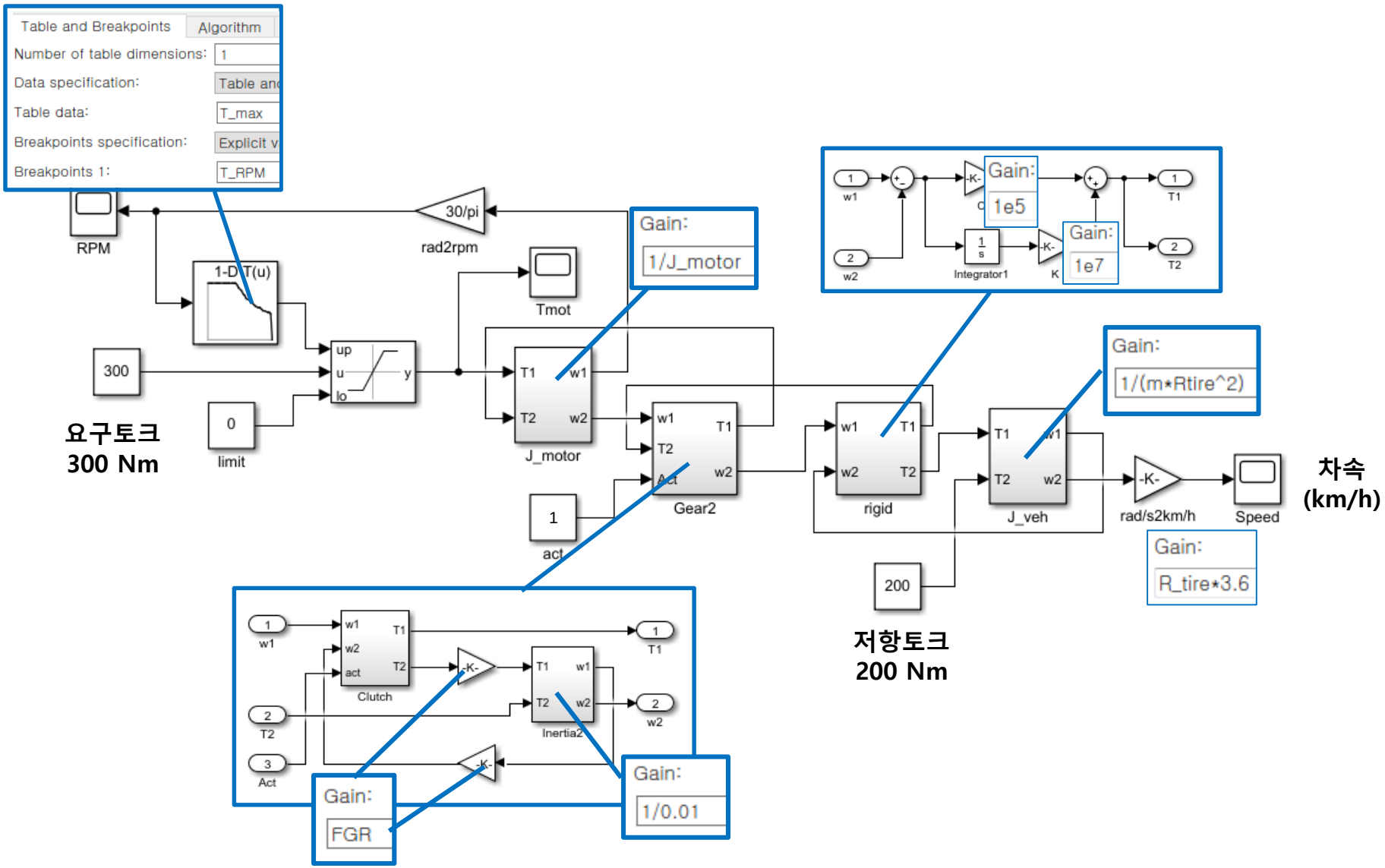
$$J_{eq} = R_{tire}^2 J_{motor} + J_{veh}$$

$$T_{mot} GR - T_{res} = J_{eq} \ddot{\theta}$$

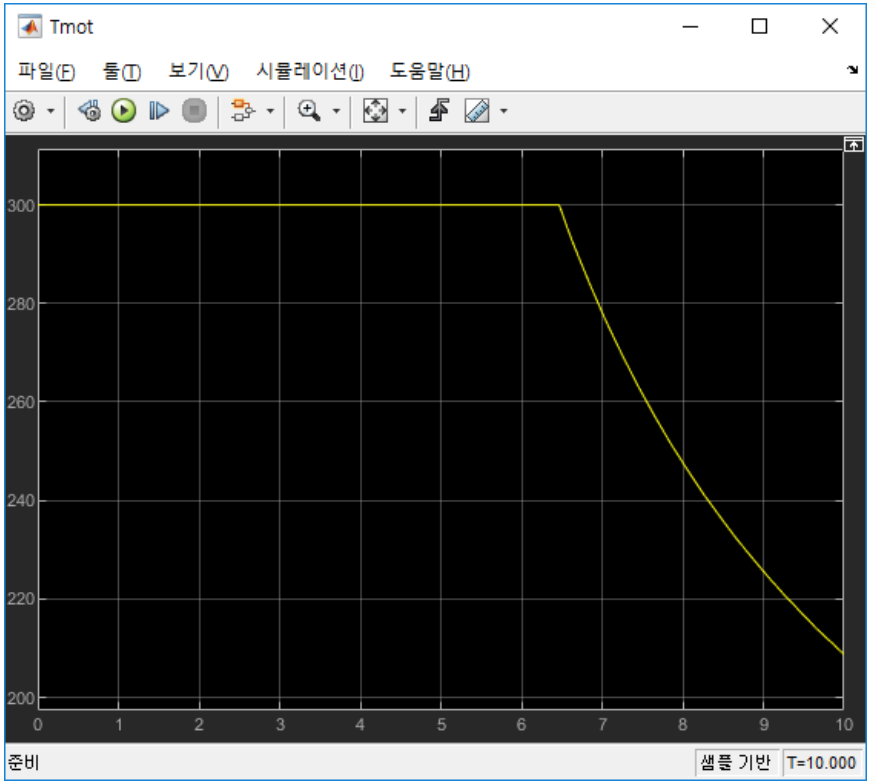
$$V_{veh} = R_{tire} \int \frac{T_{mot} GR - T_{res}}{J_{eq}} \, dt$$

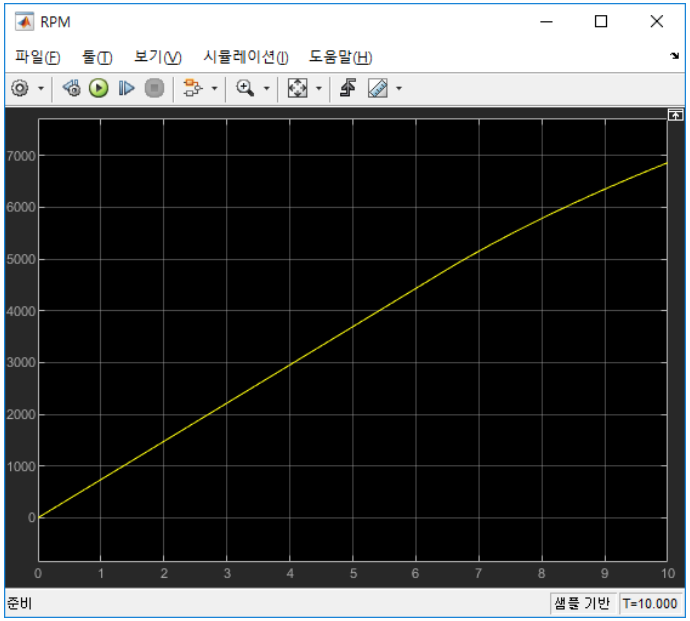


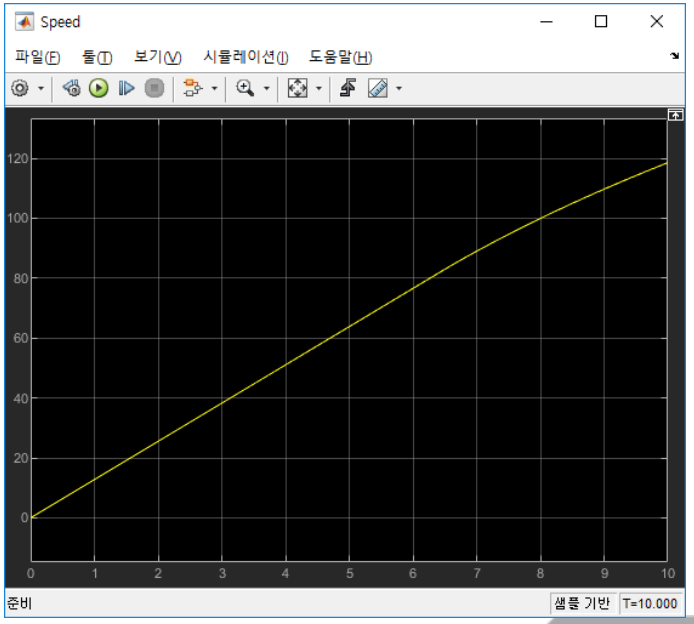
POWERTRAIN



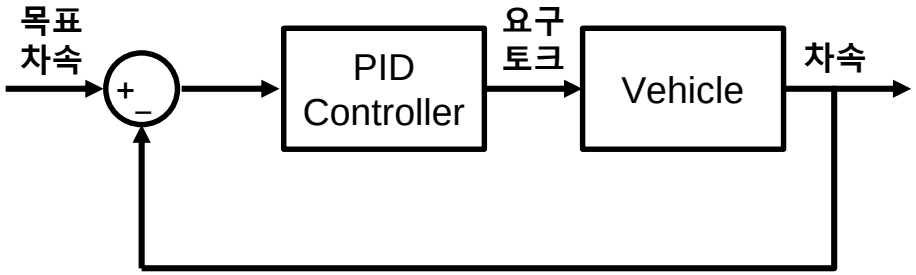
POWERTRAIN





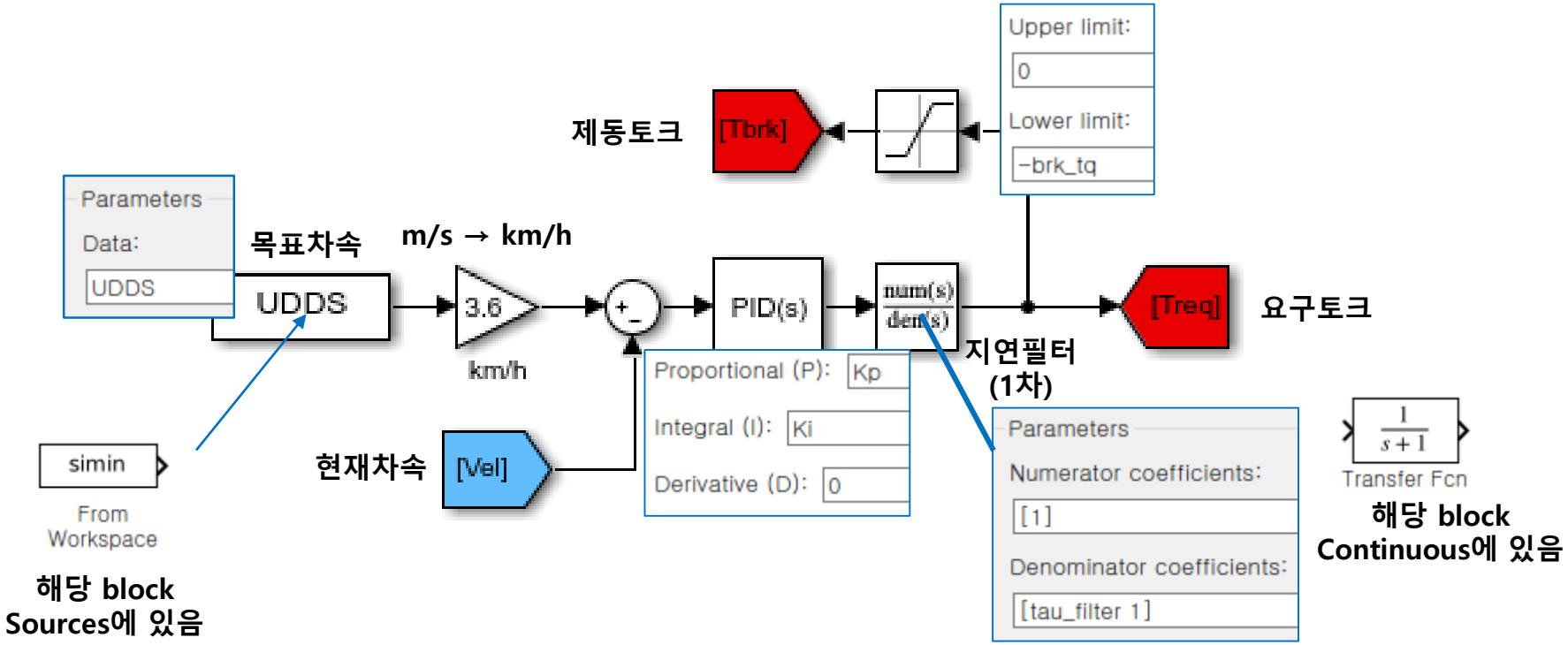


DRIVER CONTROLLER



$$T_{req} = K_p e(t) + K_i \int e(t)\,dt + K_d \frac{de(t)}{dt} \qquad \begin{cases} e(t) \geq 0 : \text{accelation} \\ e(t) < 0 : \text{braking} \end{cases}$$

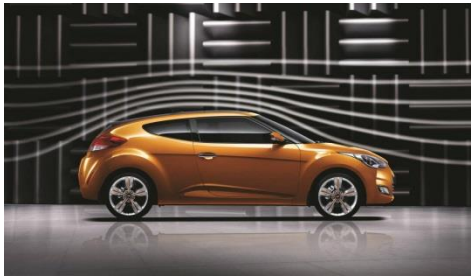
$$(e(t) = V_{req.} - V_{real})$$



DRAG TORQUE

$$F_{drag} = F_{air} + F_{roll} + F_{grad} \longrightarrow T_{drag} = (F_{air} + F_{roll} + F_{grad})R_{tire}$$

< 공기저항 >



$$F_{air} = \frac{1}{2} C_d A_{fr} \rho_{air} V_{veh}^2$$

< 구름저항 >

$$F_{roll} = \mu_r m_{veh} g$$

< 구배저항 >

$$F_{roll} = m_{veh} g \sin\theta_{grad}$$

①

Expression:

0.5*Cd*1.226*A*(u/3.6)^2*Rtire

②

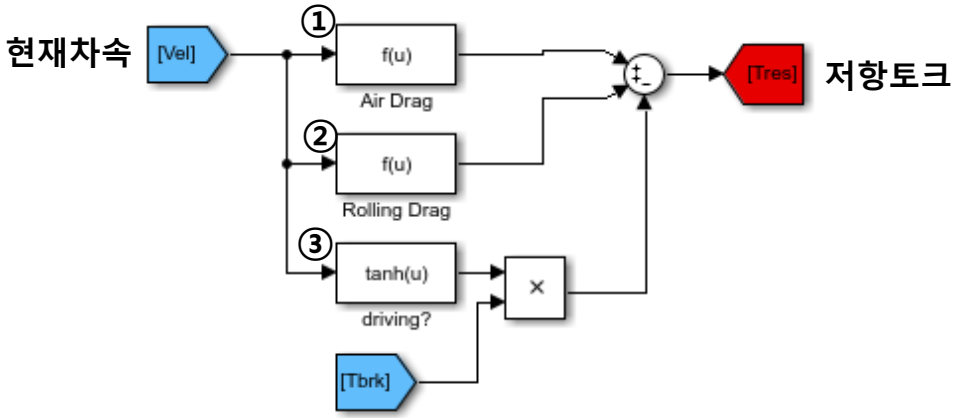
Expression:

(mu_roll*m*9.81*tanh(u))*Rtire

③

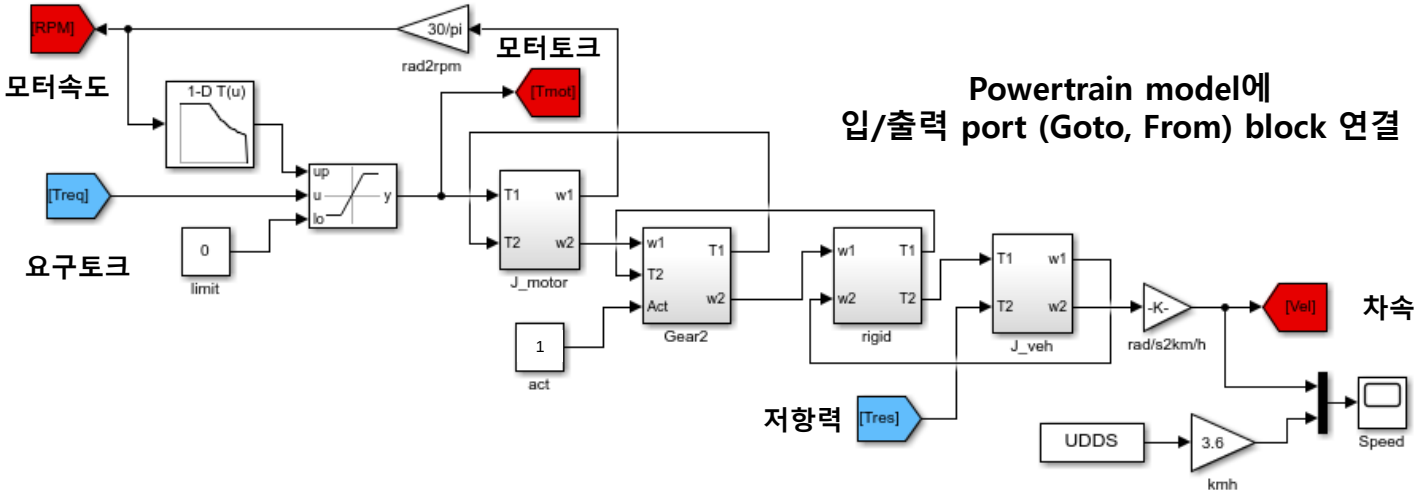
Expression:

tanh(u)



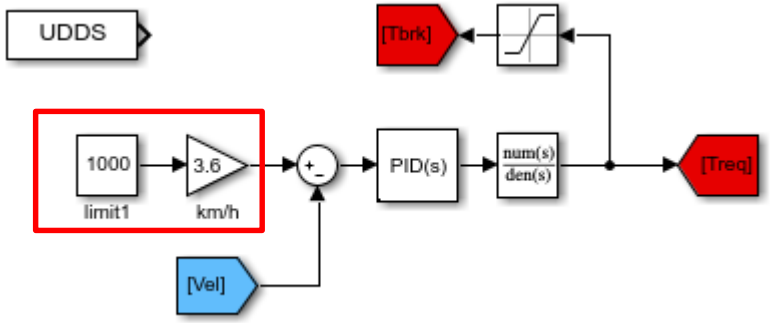
제동토크

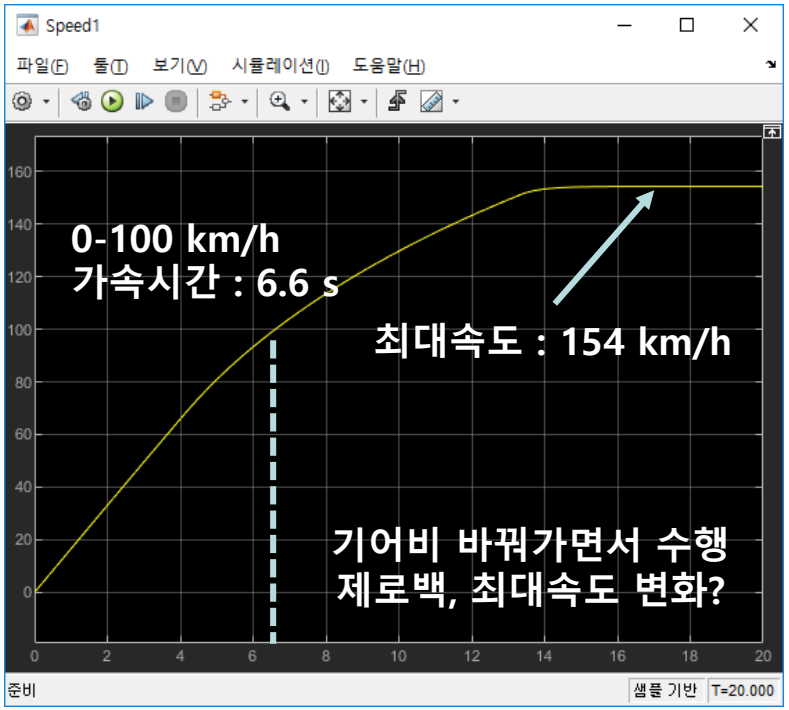
DRIVING PERFORMANCE



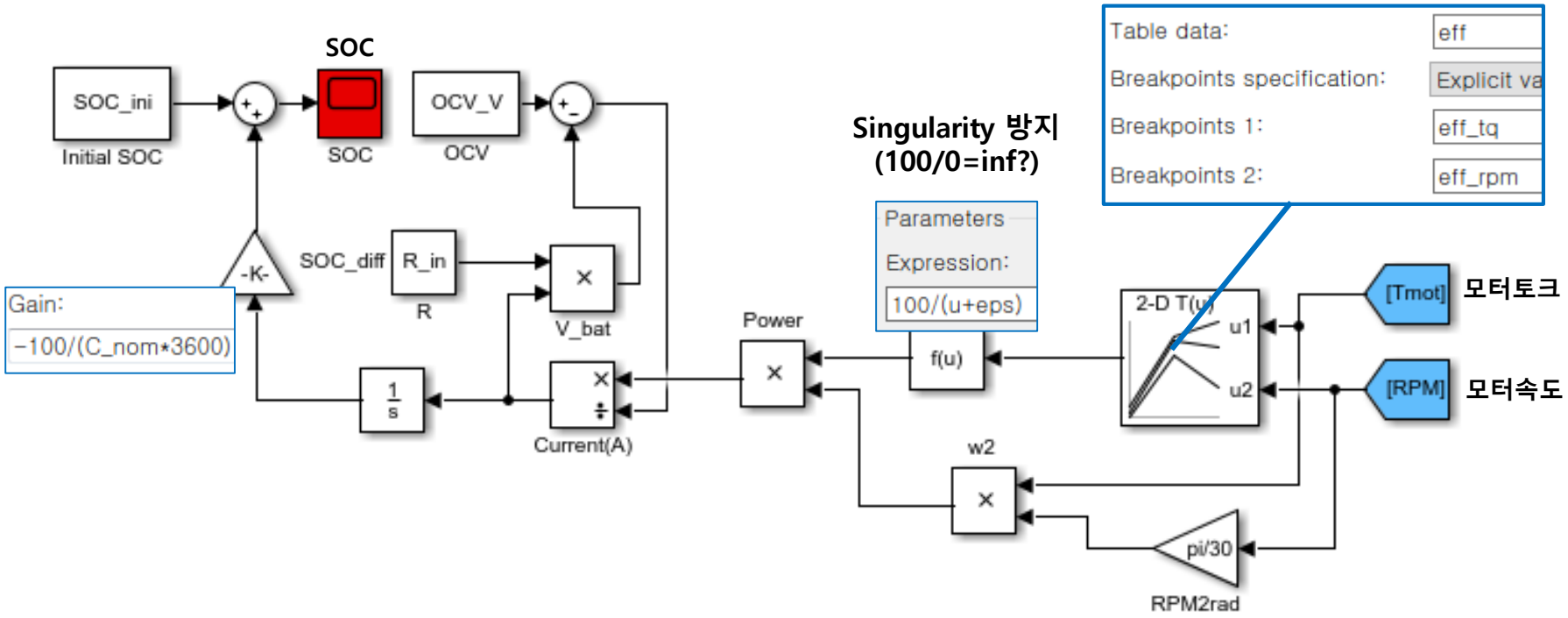
Powertrain model에
입/출력 port (Goto, From) block 연결

일정하게 매우 큰 값으로
요구토크 출력, full APS 모사





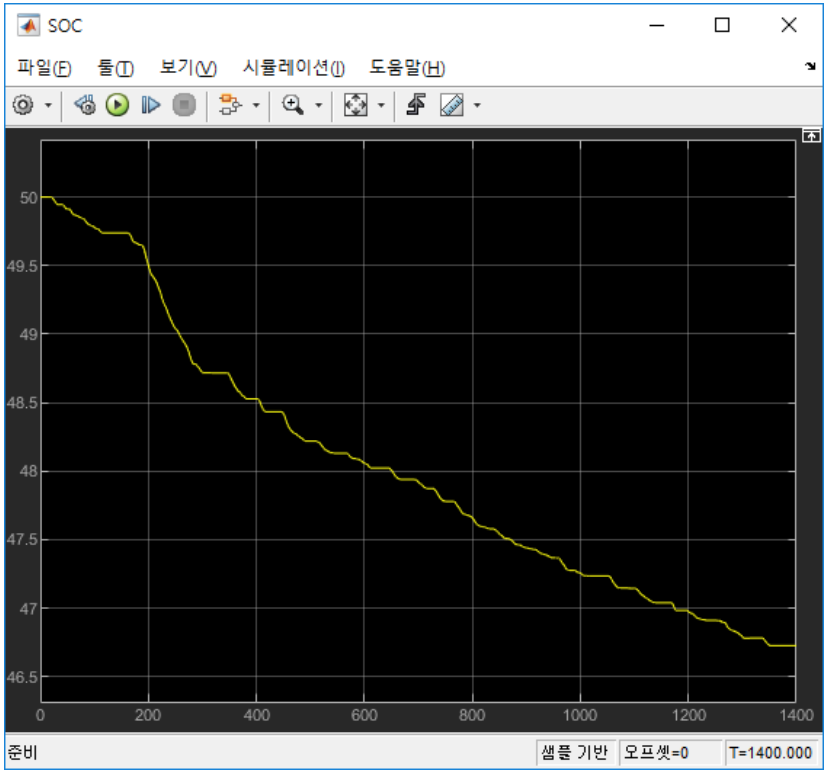
BATTERY



SOC CONSUMPTION

Simulation Time : 1400 s, Solver : ode23tb

SOC 변화



차속 변화(목표/실제차속)