Vehicle Dynamics Term Project Driveline Modelling

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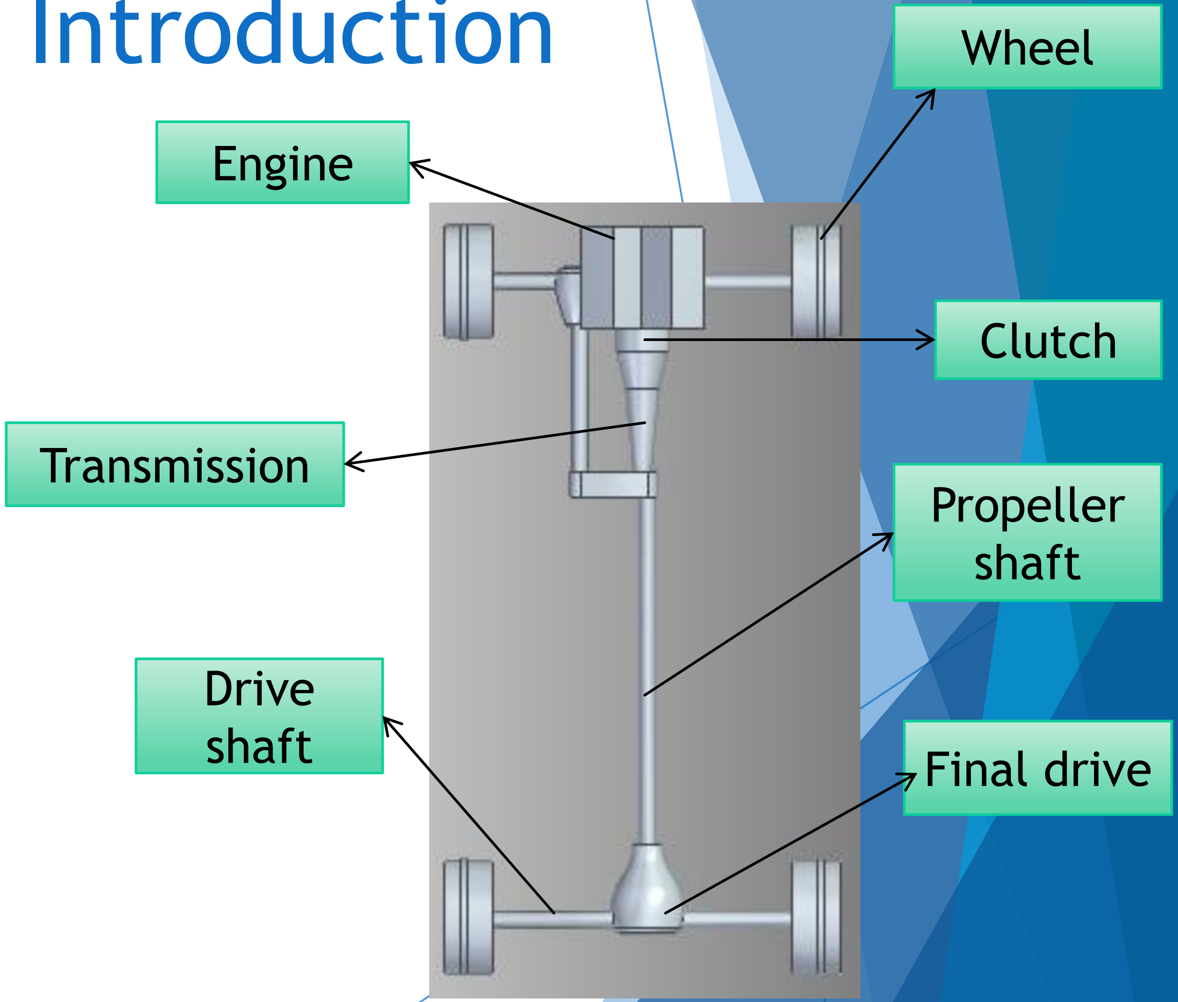
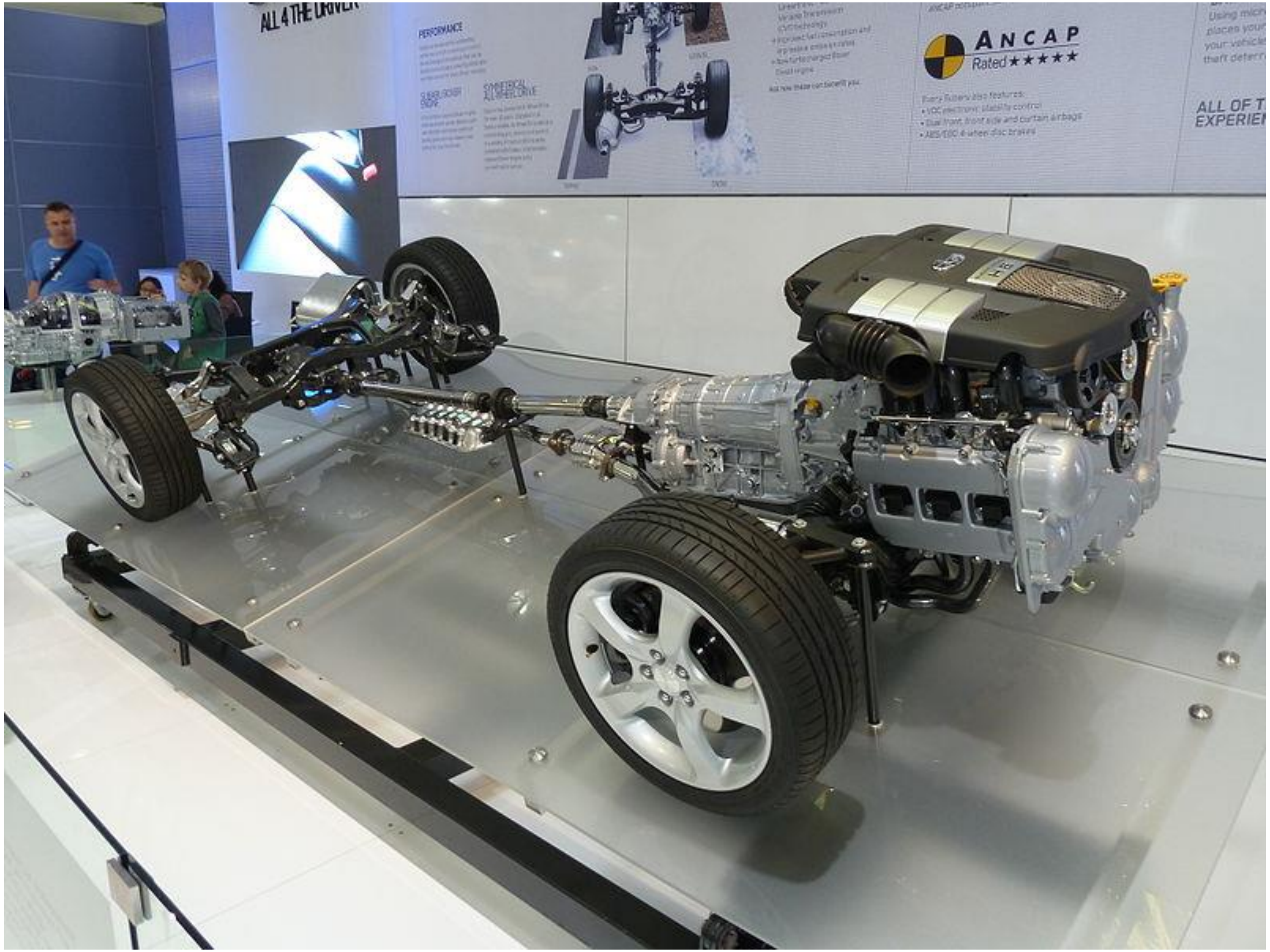
Vehicle Driveline
A brief Introduction

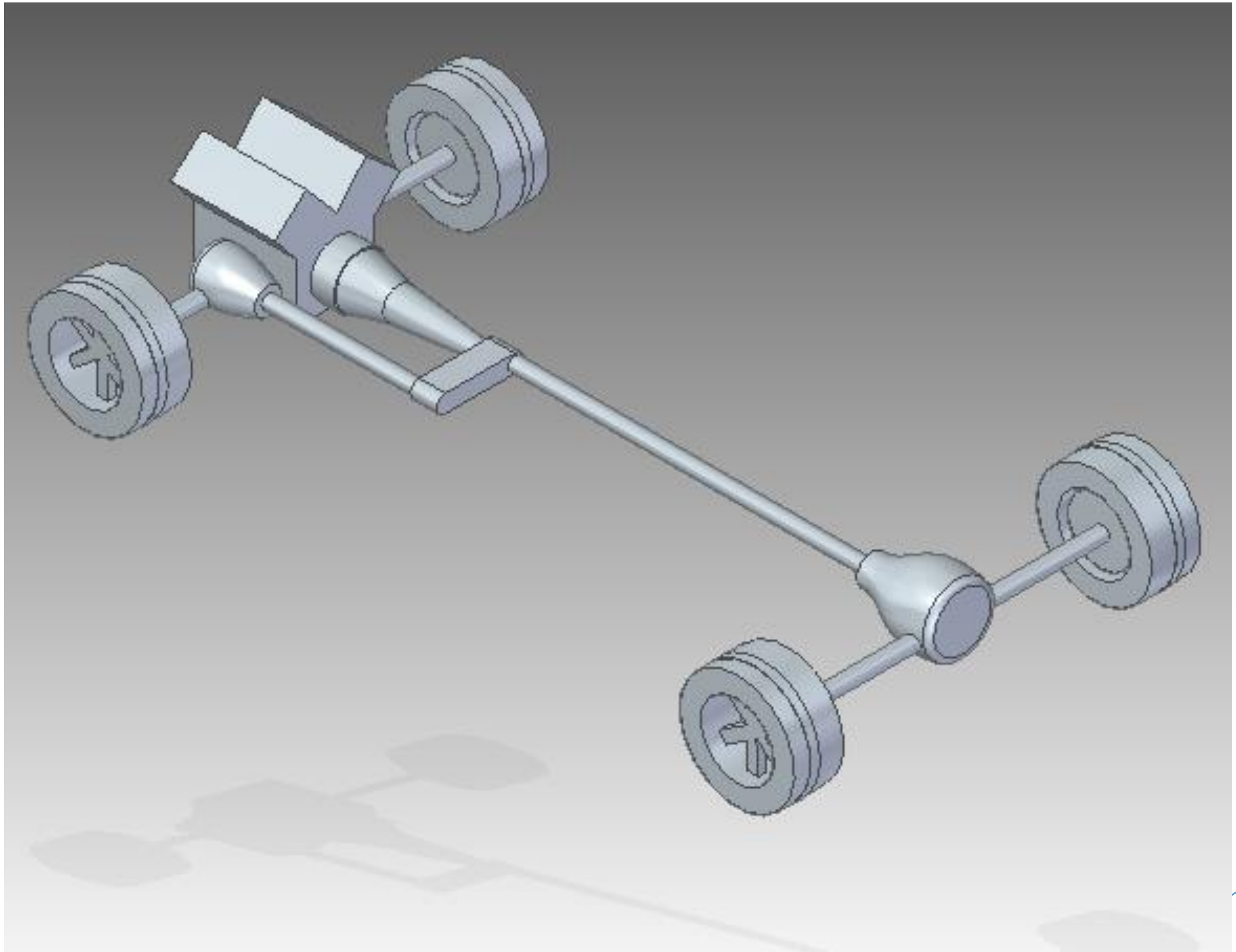
In a motor vehicles, the term vehicle driveline describes the main components that generate torque and deliver it to the wheels, which forms the interface.

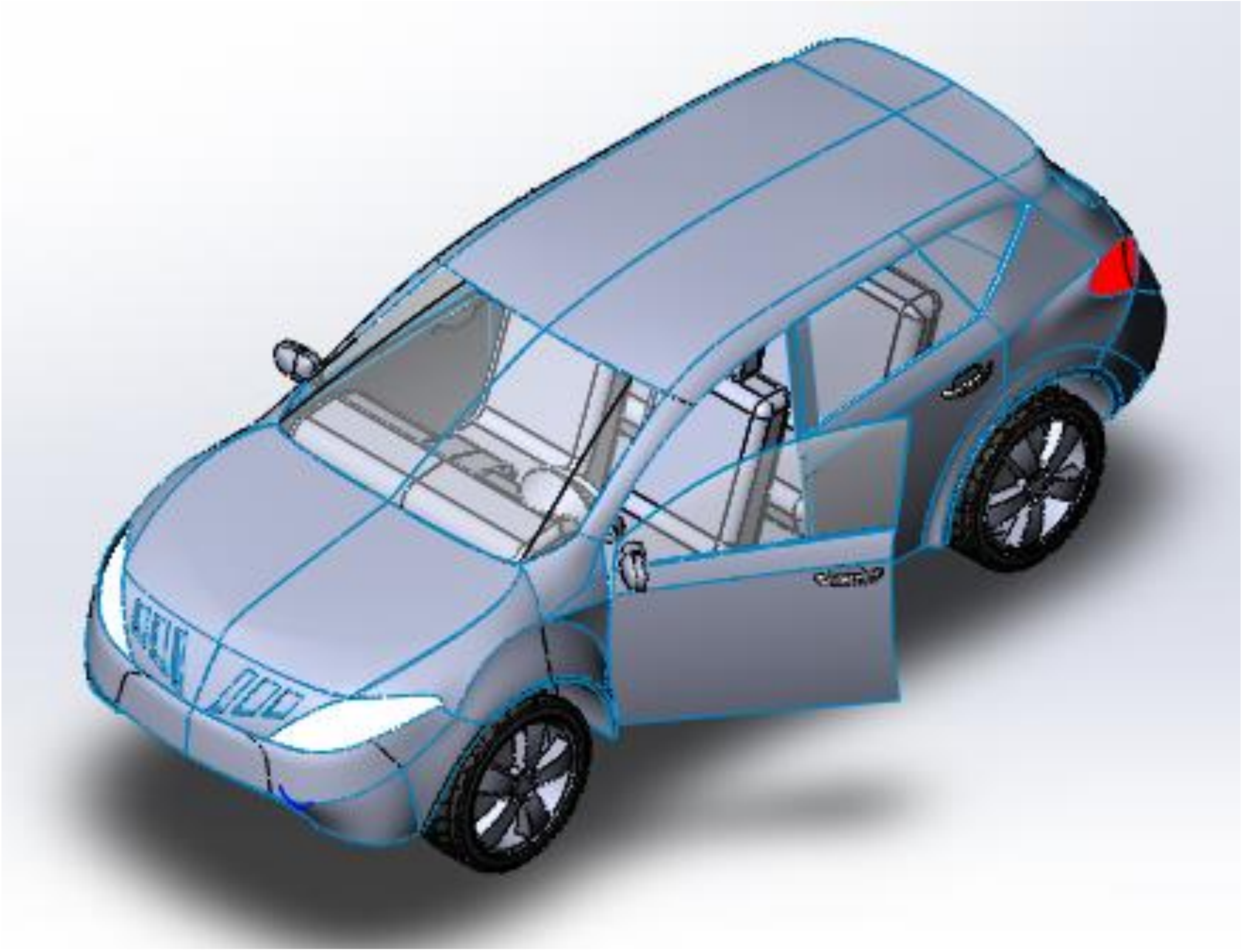
In layman language, this is the medium through which you connect the engine with the wheels.




ALL 4 THE DRIVER
PERFORMANCE
ANCAP
Rated ★★★★★

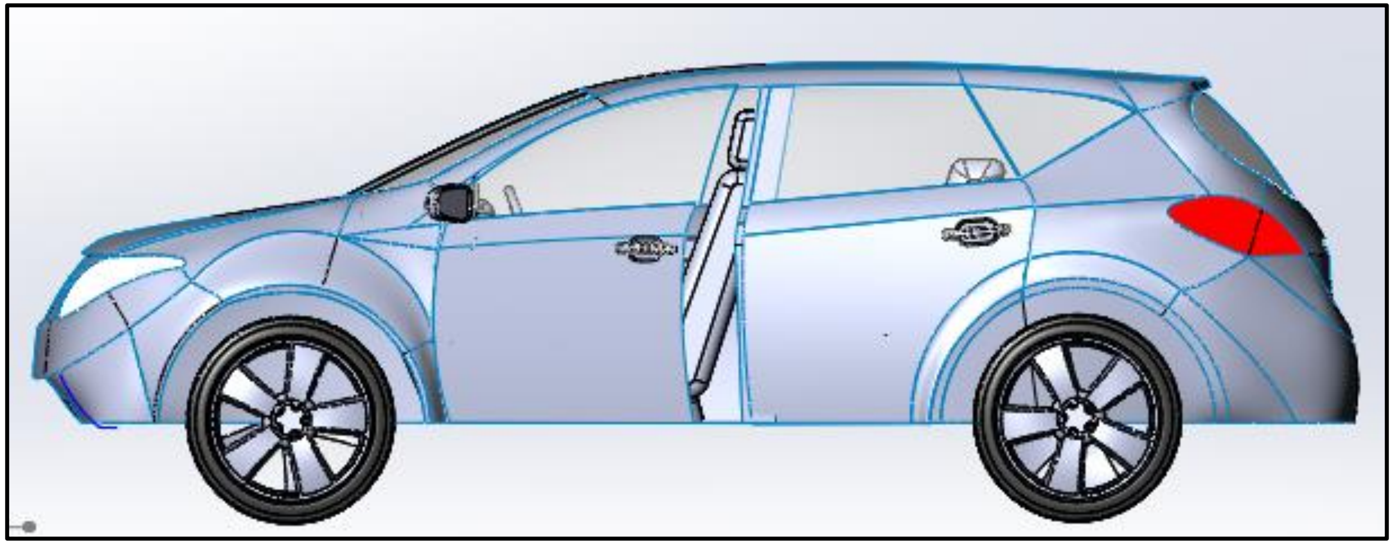
CAD MODEL OF DEIVELINE





Components of Drive Train

Engine → Clutch → Transmission → Propeller Shaft → Final Drive → Drive Shaft → Wheels



CAD MODEL OF CAR

Engine → Clutch → Transmission → Propeller Shaft → Final Drive → Drive Shaft → Wheels

In vehicle we use Internal combustion engines. These convert the chemical energy present in fuel into mechanical energy.

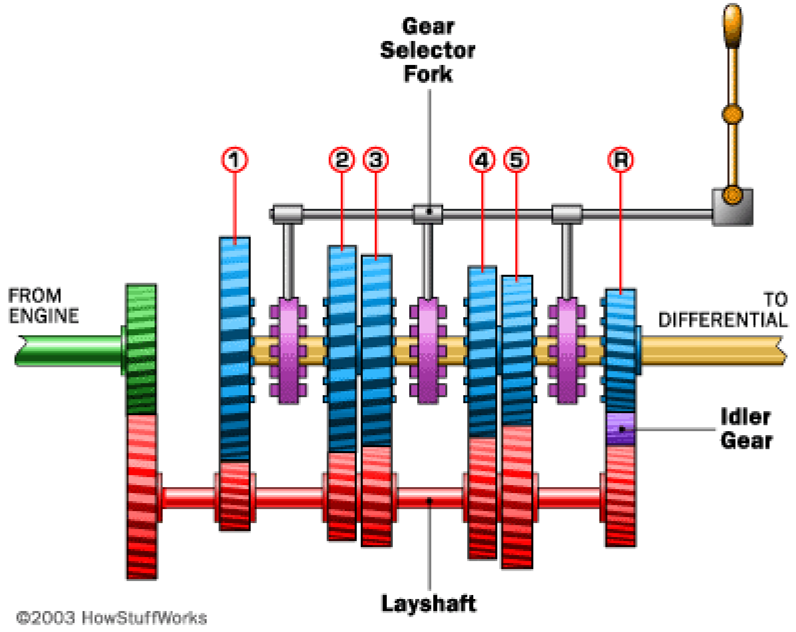
At around 100 km/hr the passenger cars produce about 7000 rpm.

Engine → Clutch → Transmission → Propeller Shaft → Final Drive → Drive Shaft → Wheels

It transmits engine power to the gearbox, and allows transmission to be interrupted while a gear is selected to move off from a stationary position, or when gears are changed while the car is moving.

Most cars now a days use a friction clutch operated either by fluid (hydraulic).

Engine → Clutch → Transmission → Propeller Shaft → Final Drive → Drive Shaft → Wheels



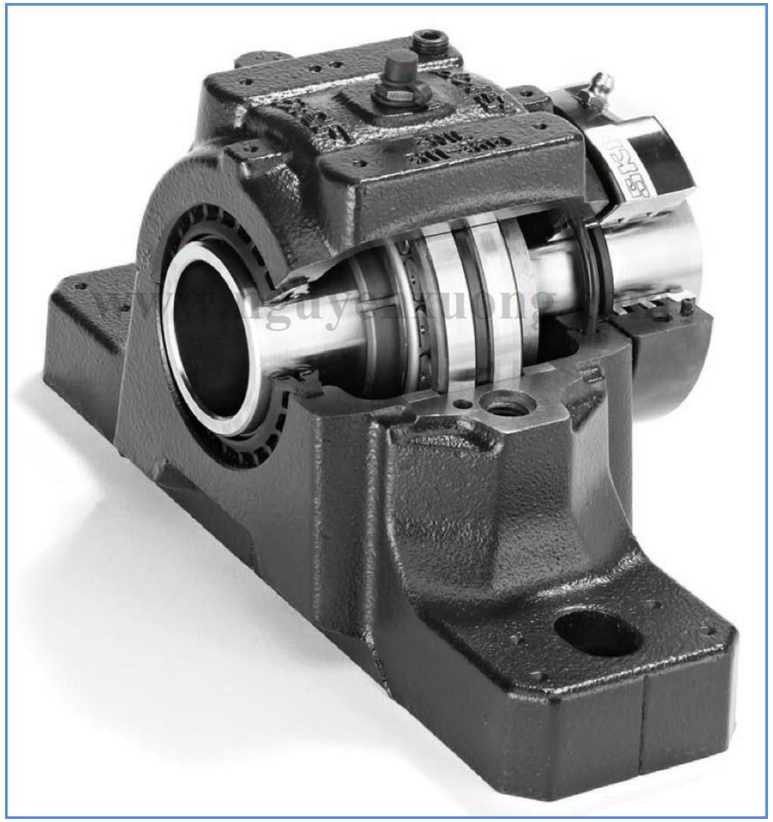
Engine torque is transmitted through the clutch to the transmission or transaxle. The transmission contains sets of gears that increase or decrease the torque, before it is transmitted to the rest of the drive train. The lower the gear ratio selected, the higher the torque transmitted.

Engine → Clutch → Transmission → Propeller Shaft → Final Drive → Drive Shaft → Wheels

It is used to transmit the torque from the gear box or transmission to the final drive.

Usually around 4 feet for cars to about 9 feet for trucks

Engine → Clutch → Transmission → Propeller Shaft → Final Drive → Drive Shaft → Wheels



The final drive provides a final gear reduction, to multiply the torque before applying it to the driving axles.

Inside the final drive, a differential gear set divides the torque to the axles, and allows for the difference in speed of each wheel when cornering.

Engine → Clutch → Transmission → Propeller Shaft → Final Drive → Drive Shaft → Wheels

It transmits the differential torque to driving wheels.
These along with the propeller shafts experience the highest twist

Material”

Driveline modeling

<u>**Model 1: Drive Shaft Flexibility**</u>

The clutch and the propeller shafts are assumed to be stiff, and the drive shaft is described as a damped torsional flexibility. The transmission and the final drive are assumed to multiply the torque with the conversion ratio, without losses.

$$M_w = M_d = k(\theta_f - \theta_w) + c(\dot{\theta}_f - \dot{\theta}_w)$$

$$M_w = M_d = k\left(\frac{\theta_m}{\tau_f \tau_g} - \theta_w\right) + c\left(\frac{\dot{\theta}_m}{\tau_f \tau_g} - \dot{\theta}_w\right)$$

$$(J_f + J_t \tau_f^{\,2})\ddot{\theta}_m = M_c \tau_g^{\,2} \tau_f^{\,2} - b_t \dot{\theta}_m \tau_f^{\,2} - b_f \dot{\theta}_m - k(\theta_m - \theta_w \tau_f \tau_g) - c(\dot{\theta}_m - \dot{\theta}_w \tau_f \tau_g)$$

This forms a state space form.

$$\dot{x} = Ax + BU + Hl$$

$$x_1 = \frac{\theta_m}{\tau_f \tau_g} - \theta_w \qquad x_2 = \dot{\theta}_m \qquad x_3 = \dot{\theta}_w$$

Where

$$A = \begin{matrix} 0 & \frac{1}{\tau} & -1 \\ \frac{-k}{\tau J_1} & \frac{-(B_1 + c/\tau^2)}{J_1} & \frac{c}{\tau J_1} \\ \frac{k}{J_2} & \frac{c}{\tau J_2} & \frac{-(c+b_2)}{J_2} \end{matrix} \qquad B = \begin{matrix} 0 \\ \frac{1}{J_1} \\ 0 \end{matrix} \qquad H = \begin{matrix} 0 \\ 0 \\ \frac{-1}{J_2} \end{matrix}$$

$$l = r_w m(c_{r1} + g\sin\alpha)$$

$$b_1 = \frac{b_t}{\tau_g^{\,2}} + \frac{b_f}{\tau_g^{\,2}\tau_f^{\,2}}$$

$$J_2 = J_w + m r_w^{\,2}$$

$$b_2 = b_w + m c_{r2} r_w^{\,2}$$

$$J_1 = J_m + \frac{J_t}{\tau_g^{\,2}} + \frac{J_f}{\tau_f \tau_g}$$

$$\tau = \tau_t = \tau_f \tau_g$$

Model 2: Flexible Clutch and Drive Shafts

A model with a linear clutch and one torsional flexibility (the drive shaft) is derived by repeating the procedure for Model 1 with the difference that the model for the clutch is a flexibility with stiffness k_c and internal damping c_c.

$$(J_t + J_f/i_f^2)\ddot{\theta}_t = i_t\left(k_c(\theta_m - \theta_t i_t) + c_c(\dot{\theta}_m - \dot{\theta}_t i_t)\right) - (b_t + b_f/i_f^2)\dot{\theta}_t - M_d/i_f$$

Model 3: Flexible Propeller Shaft

A model with a flexible propeller and drive shaft, is derived by repeating the procedure for Model 1 with the difference that the model for the propeller shaft is a flexibility with stiffness k_p and internal damping c_p.

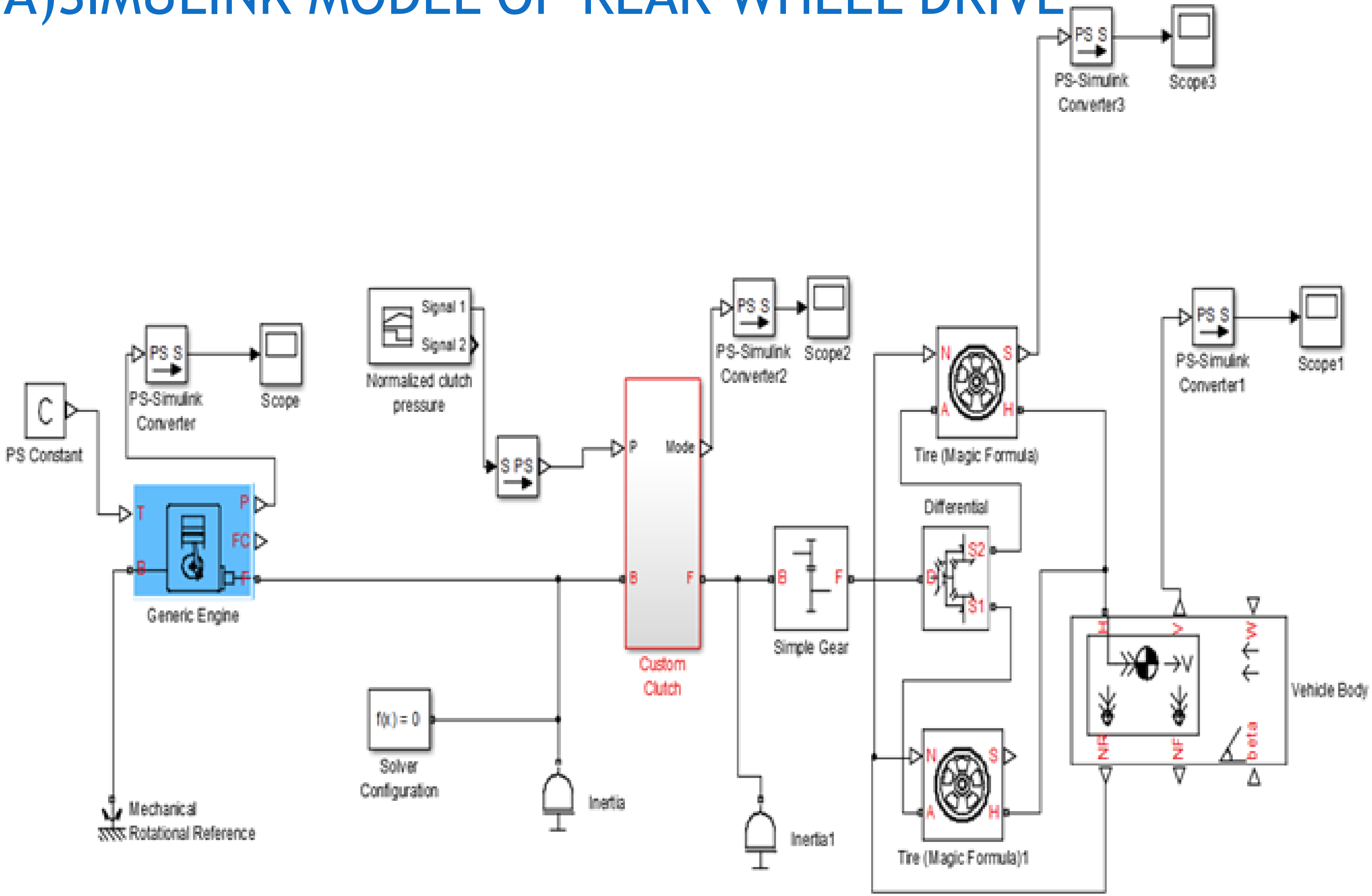
$$\begin{aligned}(J_w + mr_w^2)\ddot{\theta}_w &= k_d(\theta_p/i_f - \theta_w) + c_d(\dot{\theta}_p/i_f - \dot{\theta}_w) \\ &-b_w\dot{\theta}_w - \frac{1}{2}c_w A_a \rho_a r_w^3 \dot{\theta}_w^2 - mc_{r2} r_w^2 \dot{\theta}_w - r_w m\left(c_{r1} + gsin(\alpha)\right)\end{aligned}$$

PERFORMANCE ANALYSIS OF DRIVELINE SYSTEM USING SIMDRIVELINE

Parameters and Assumptions

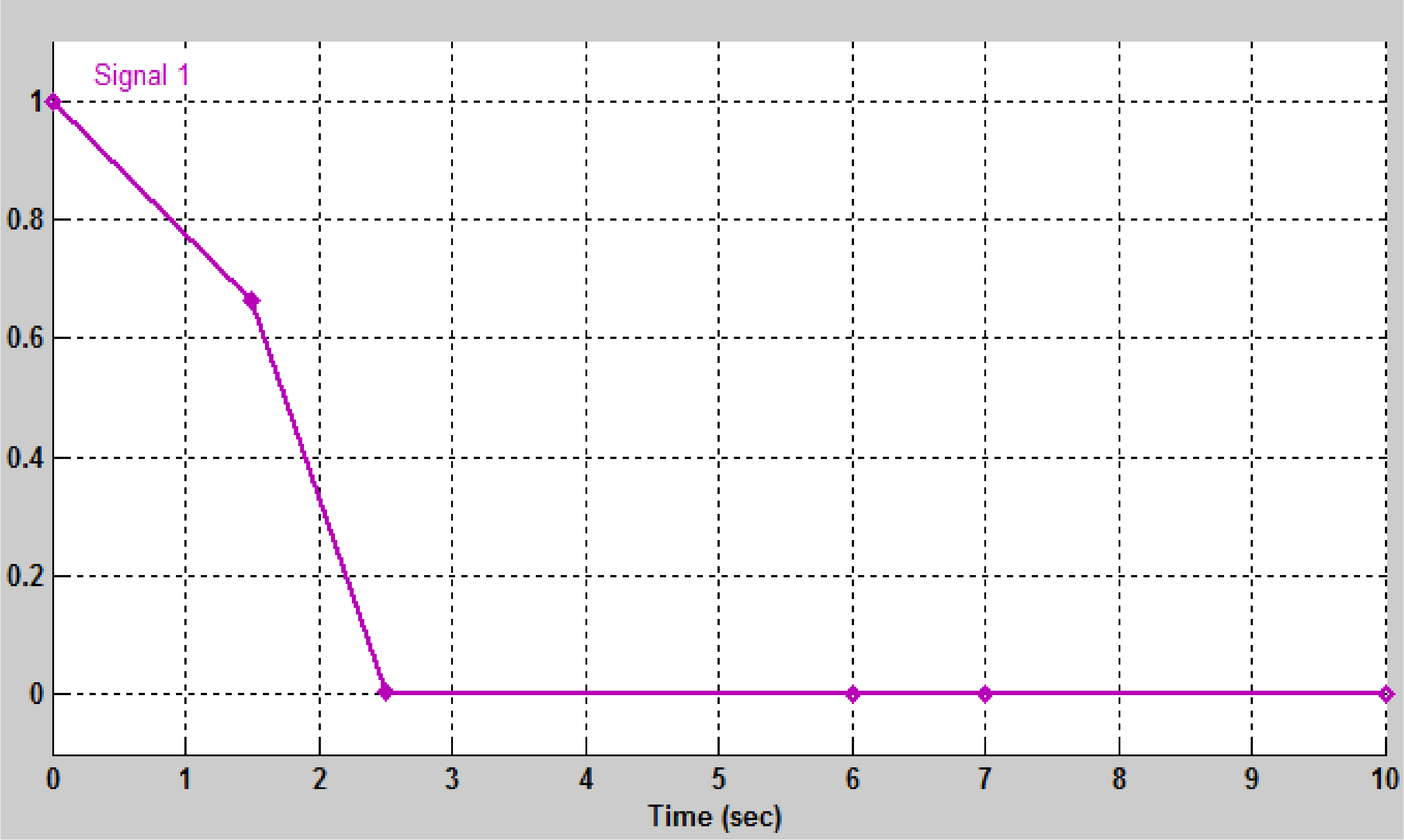
- Engine type: spark engine
- Maximum power : 45000W
- Speed at maximum power : 3800rpm
- Maximum speed : 6000rpm
- Stall speed : 350 rpm
- Engine inertia : 0.2 kg-m^2
- Fuel consumption per revolution:25mg/rev
- Inertia of shaft 1 : 0.2 kg-m^2
- Inertia of shaft 2 : 1kg-m^2
- Single Gear, No meshing and viscous losses
- Single Custom clutch
- Throttle 100 % open for the engine
- No flexibility assumed for any component

(A)SIMULINK MODEL OF REAR WHEEL DRIVE-

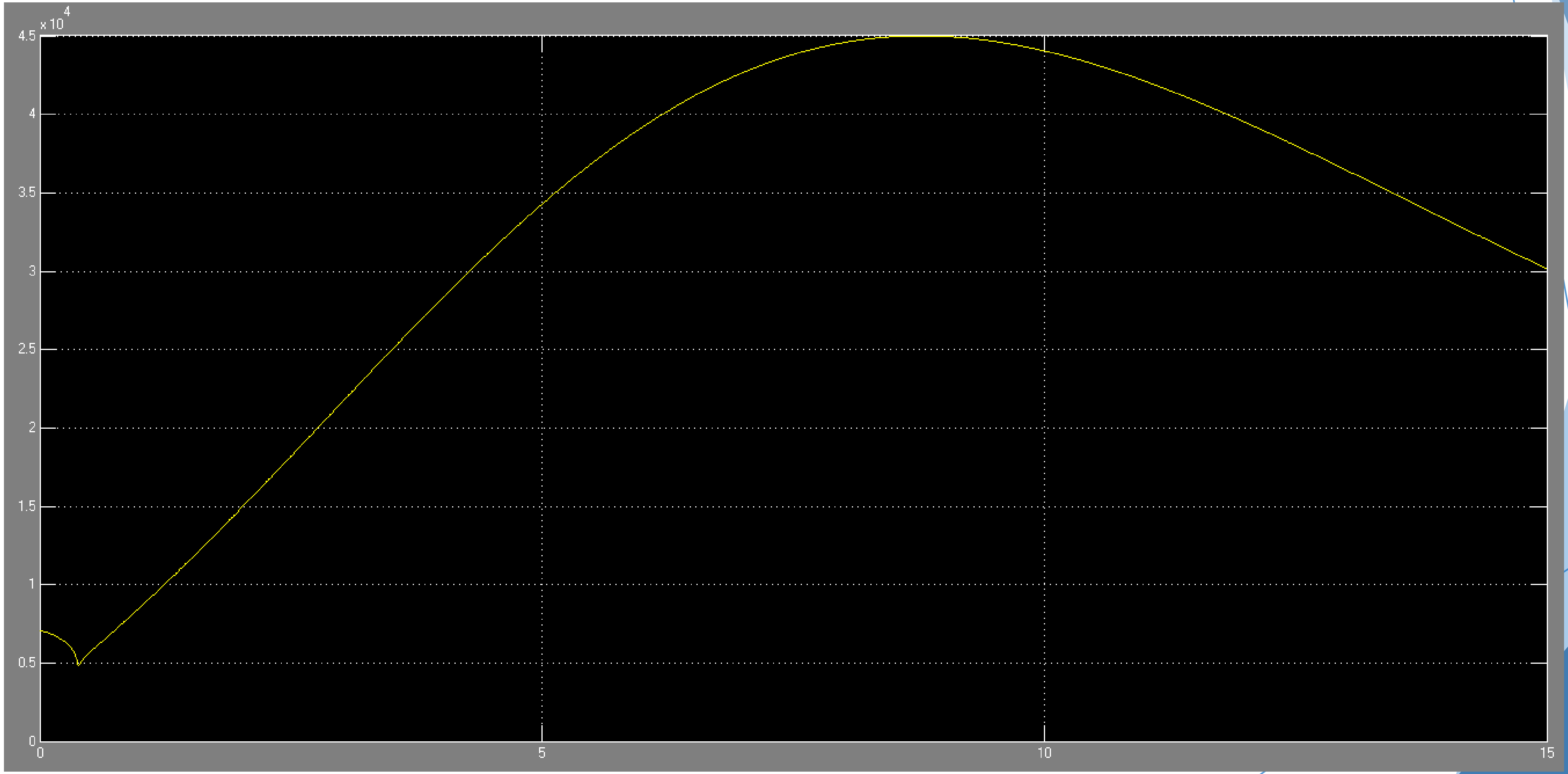


1.INPUT OF CLUTCH

Normalized pressure vs time(sec)

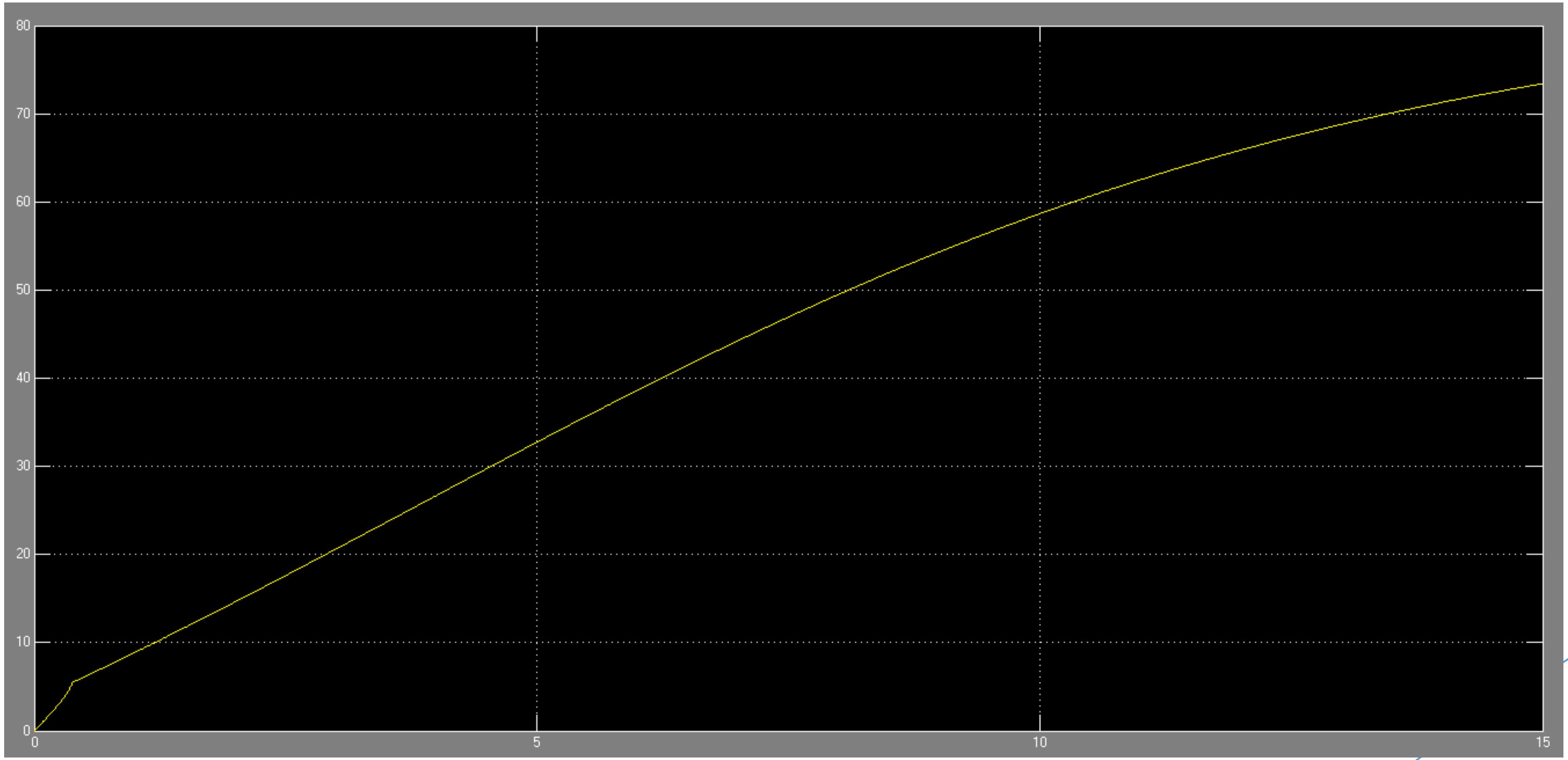


2. POWER OUTPUT OF ENGINE
Power output (in Watt) vs time(in sec)



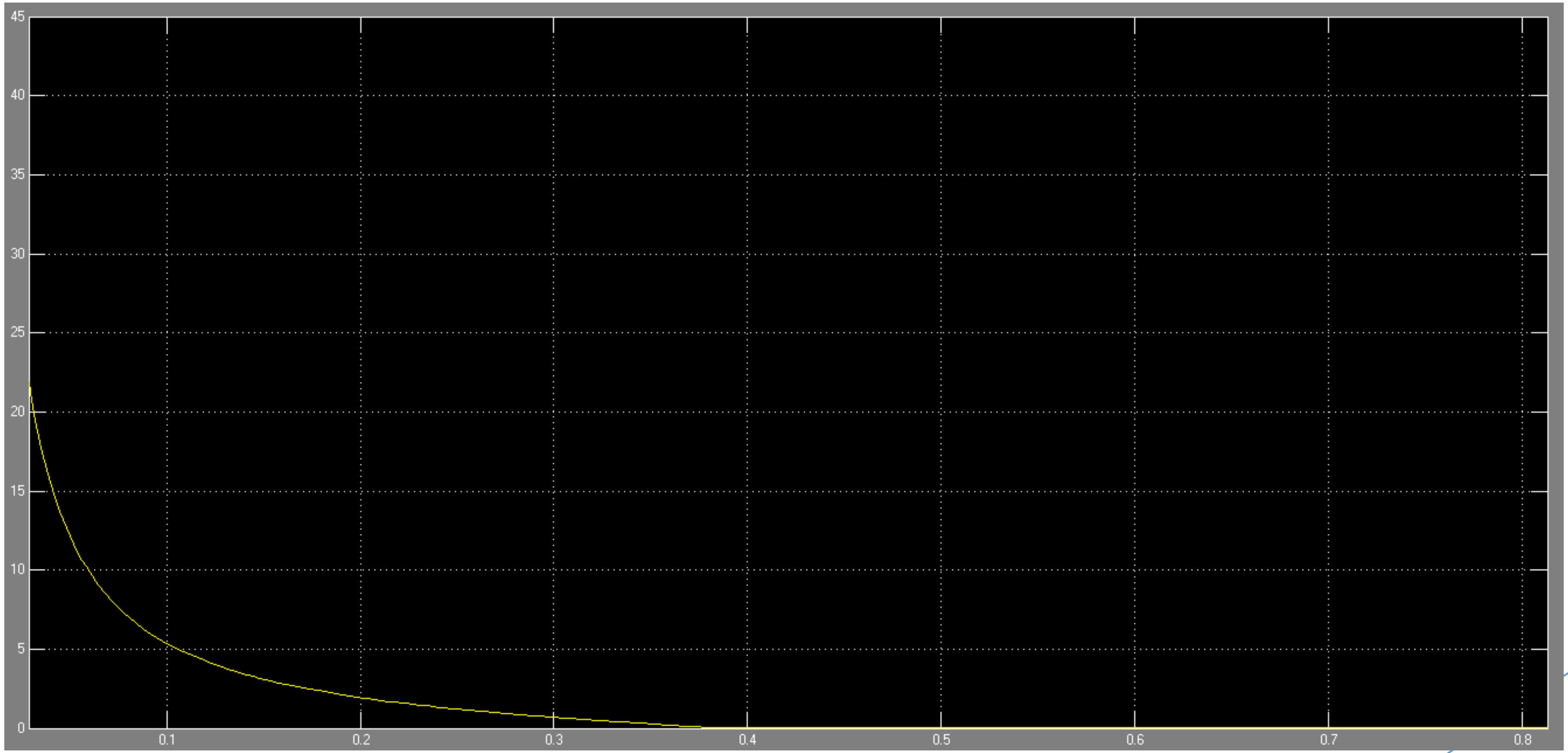
3. VELOCITY OF VEHICLE

Velocity (in km/hr) vs time (in sec)



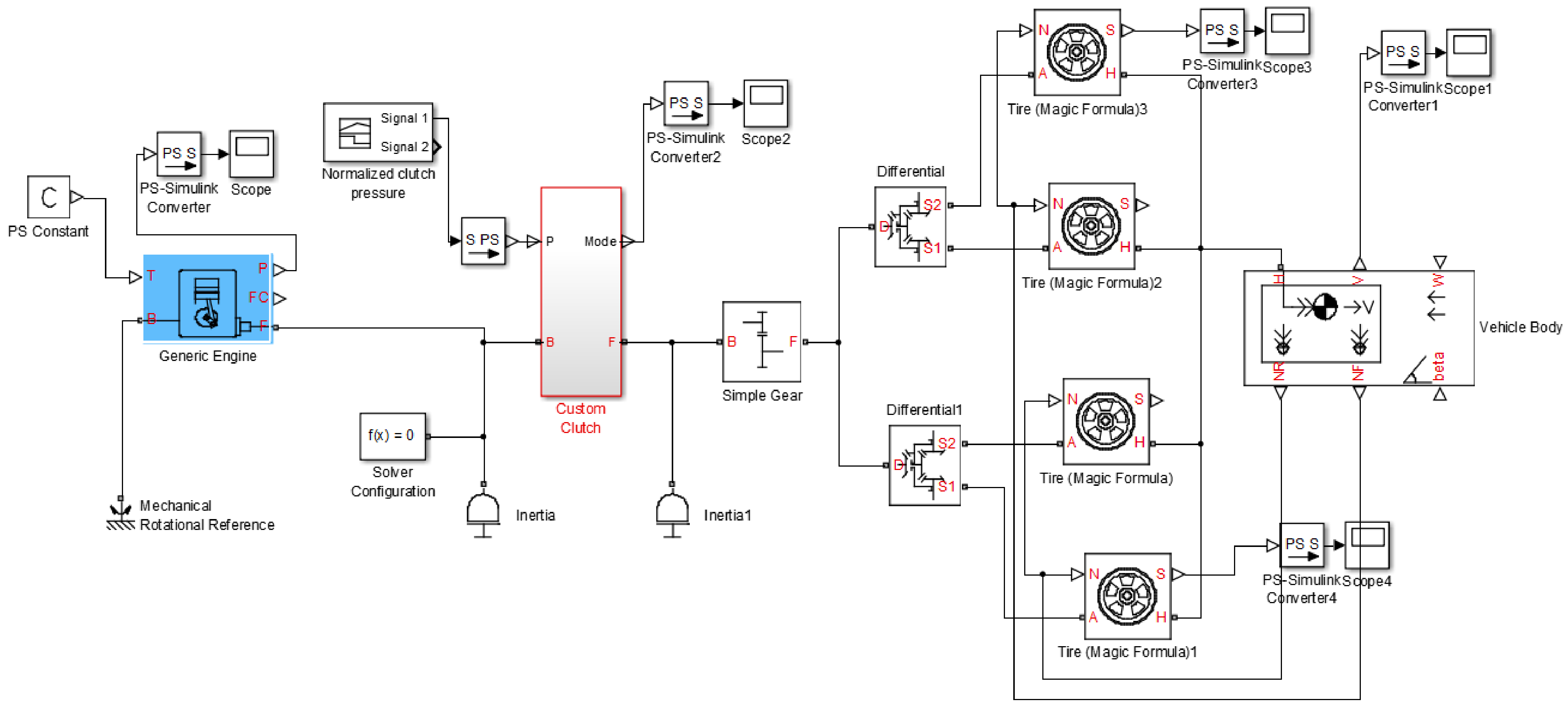
4. SLIP OF THE WHEEL

Tire slip vs time(in sec)

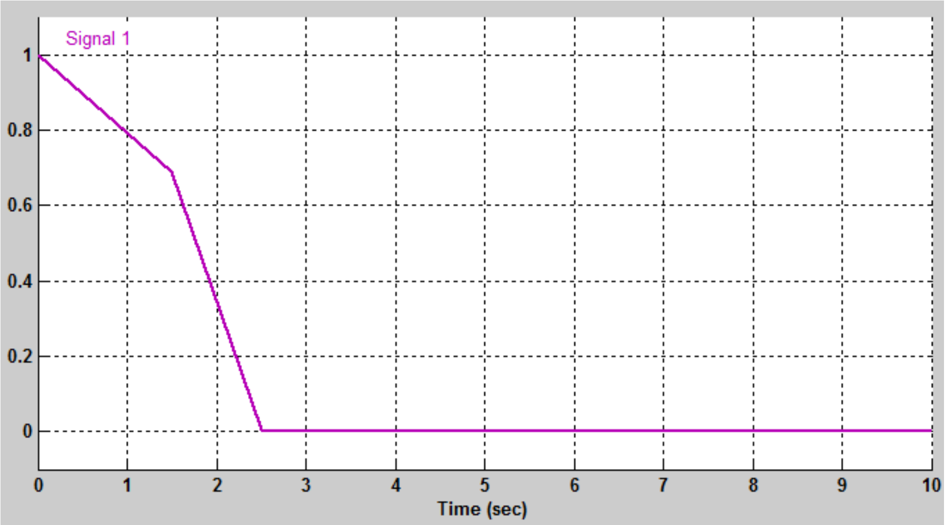


(B) SIMULINK MODEL OF FOUR WHEEL DRIVE

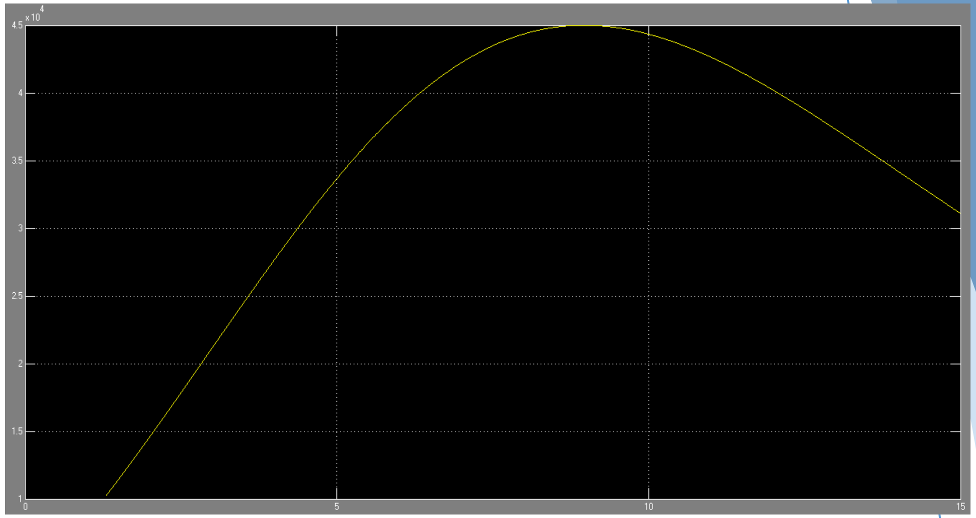
(Using same parameters and assumptions)



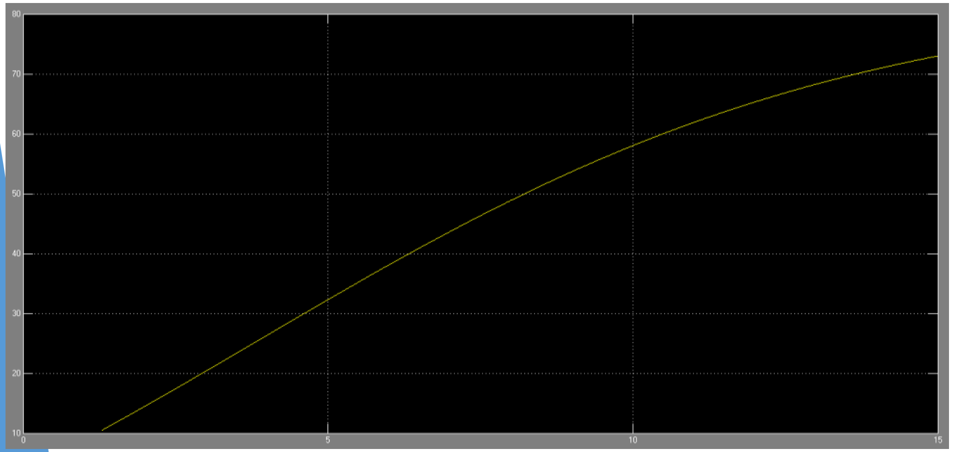
Clutch pressure vs time(in sec)[input]



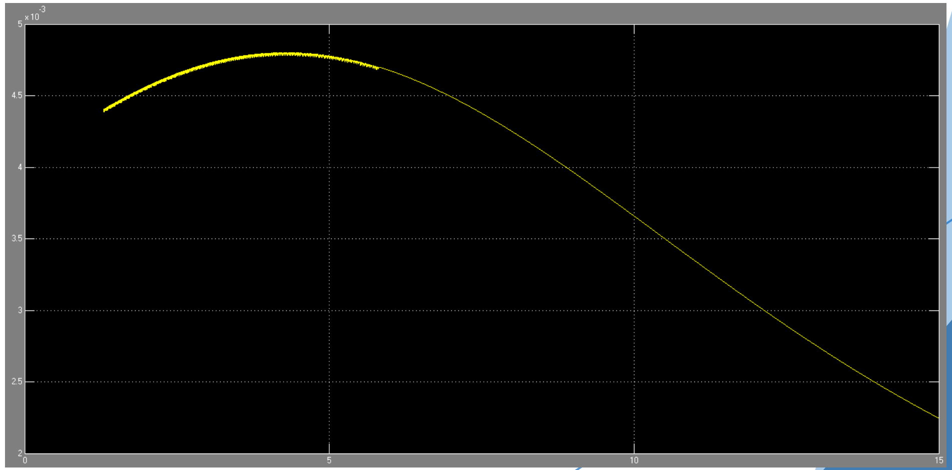
Engine power(Watt) vs Time(in sec)



Vehicle velocity(km/hr) vs time(in sec)



Tire slip(10^{-3}) vs time(in sec)



Four wheel and Two wheel drive

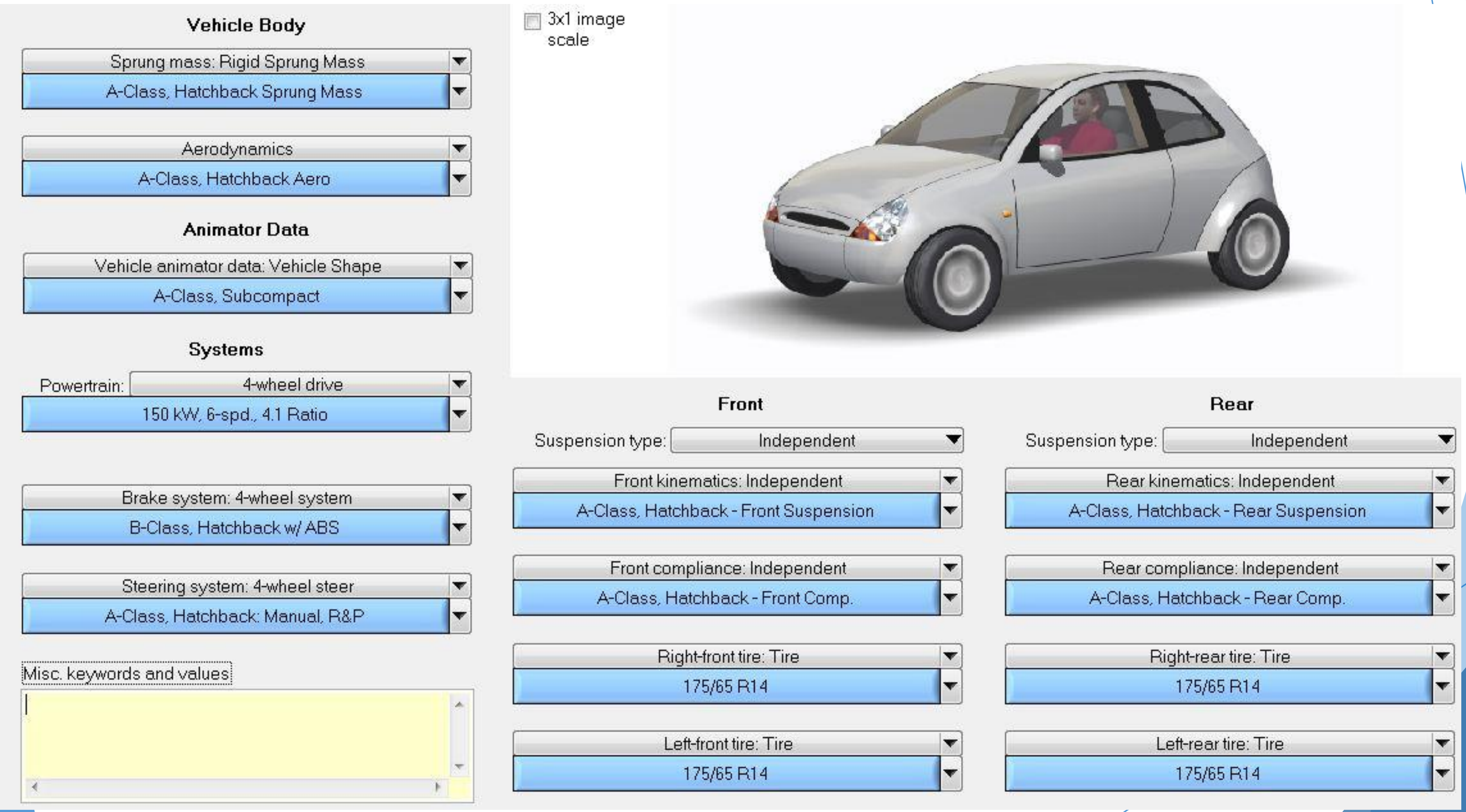
Four wheel drive (4WD) is a form of all-wheel drive powertrain capable of providing power to all wheels of a four wheeled vehicle simultaneously. The car has a way to send engine power to both the front and rear tires. Four Wheel drive means all four wheels are motorized, and that gives better traction in extreme conditions.

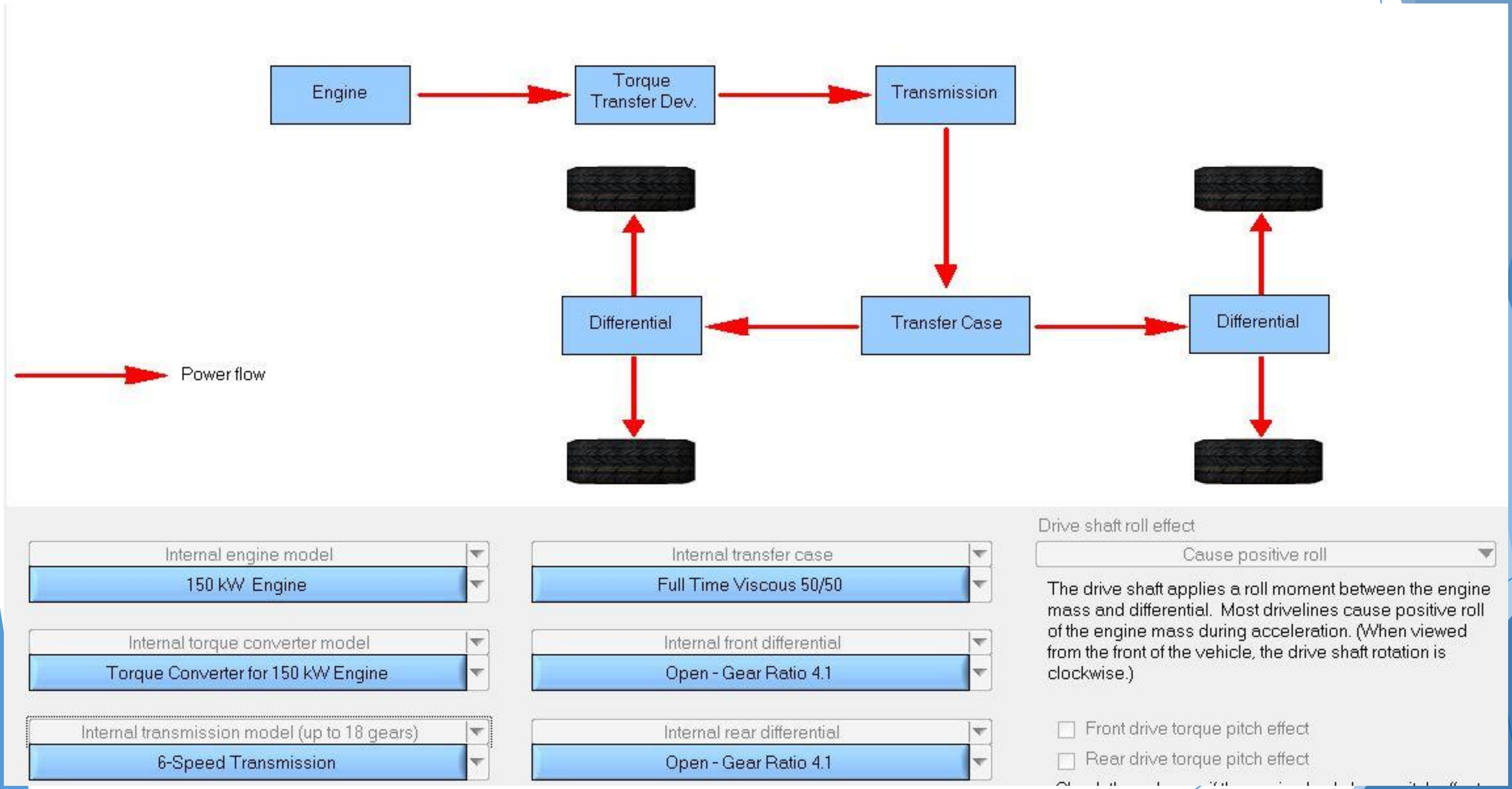
Two-wheel drive (FWD) is a form of engine and transmission layout used in motor vehicles, where the engine drives the front wheels only. The direct connection between engine and transaxle reduces the mass and mechanical inertia of the drivetrain.

COMPARISON OF TWO WHEEL AND FOUR WHEEL DRIVE USING CARSIM

Four wheel
Front wheel

Parameters for four wheel drive




Engine
Torque Transfer Dev.
Transmission
Differential
Transfer Case
Differential
Power flow
Internal engine model
150 kW Engine
Internal torque converter model
Torque Converter for 150 kW Engine
Internal transmission model (up to 18 gears)
6-Speed Transmission
Internal transfer case
Full Time Viscous 50/50
Internal front differential
Open - Gear Ratio 4.1
Internal rear differential
Open - Gear Ratio 4.1
Drive shaft roll effect
Cause positive roll
The drive shaft applies a roll moment between the engine mass and differential. Most drivelines cause positive roll of the engine mass during acceleration. (When viewed from the front of the vehicle, the drive shaft rotation is clockwise.)
Front drive torque pitch effect
Rear drive torque pitch effect

Parameters for front wheel drive

Vehicle Body

Sprung mass: Rigid Sprung Mass
A-Class, Hatchback Sprung Mass

Aerodynamics
A-Class, Hatchback Aero

Animator Data

Vehicle animator data: Vehicle Shape
A-Class, Subcompact

Systems

Powertrain: Front-wheel drive
150 kW, 6-spd., 4.1 Ratio

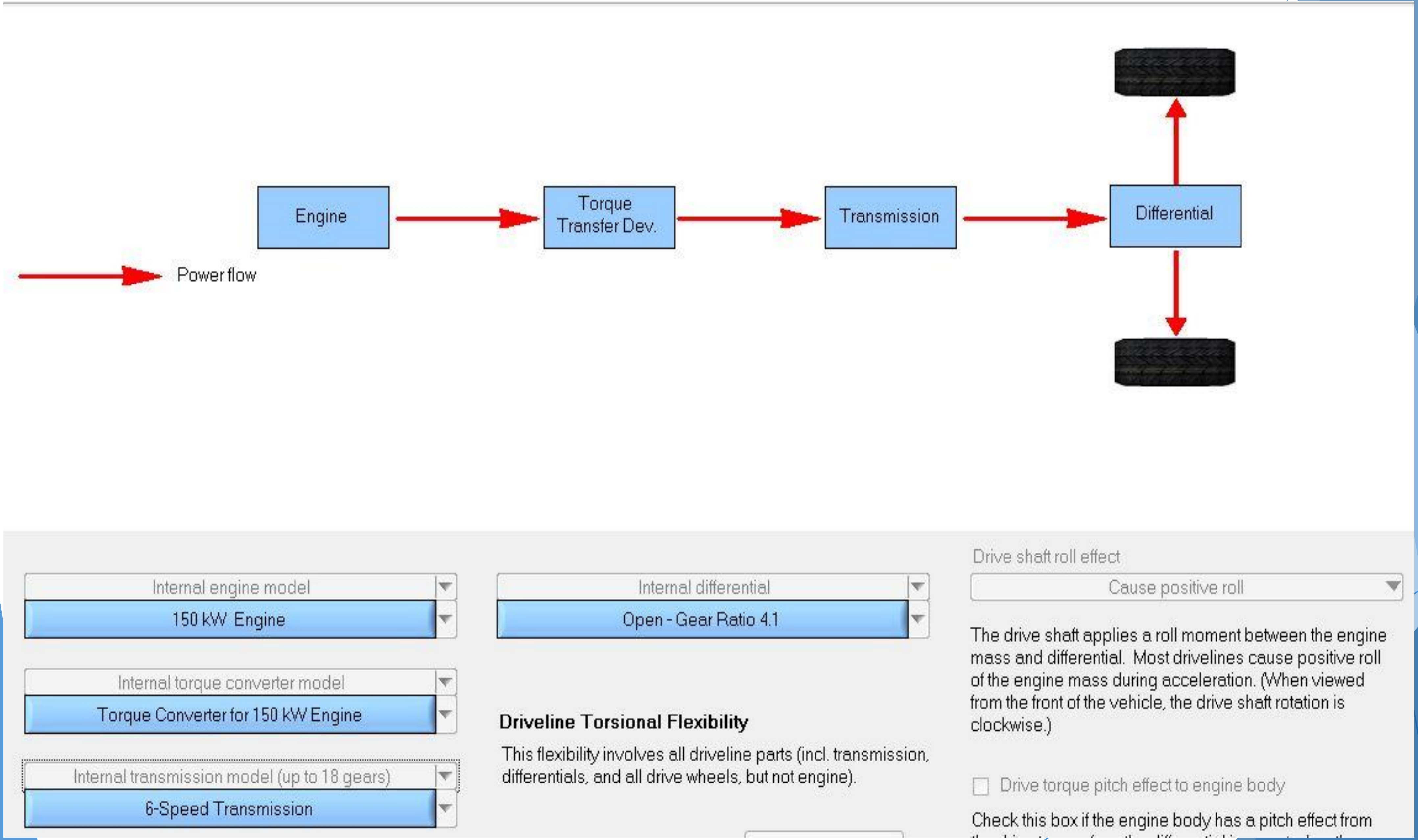
Brake system: 4-wheel system
B-Class, Hatchback w/ ABS

Steering system: 4-wheel steer
A-Class, Hatchback: Manual, R&P

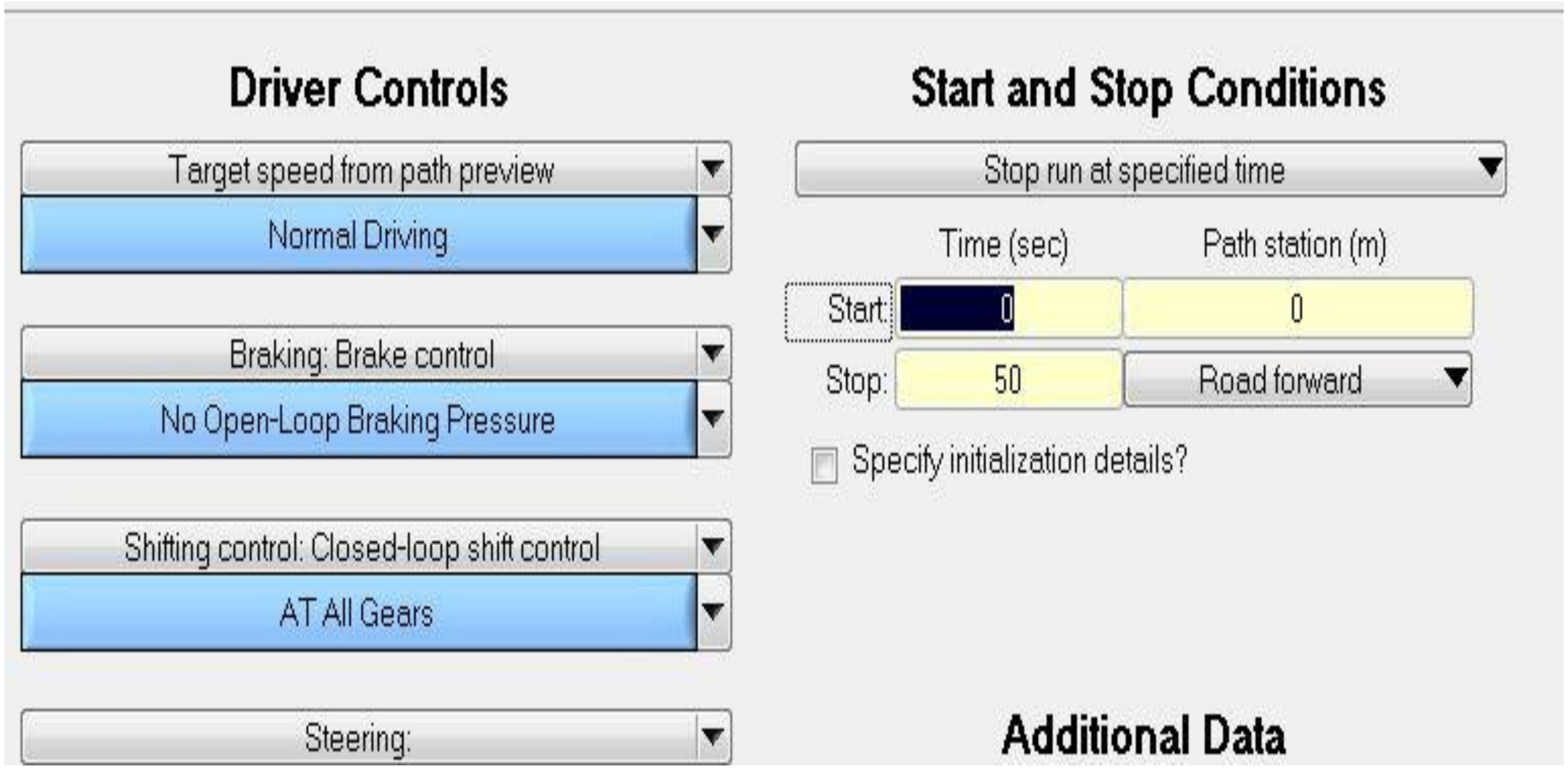
Misc. keywords and values

3x1 image scale

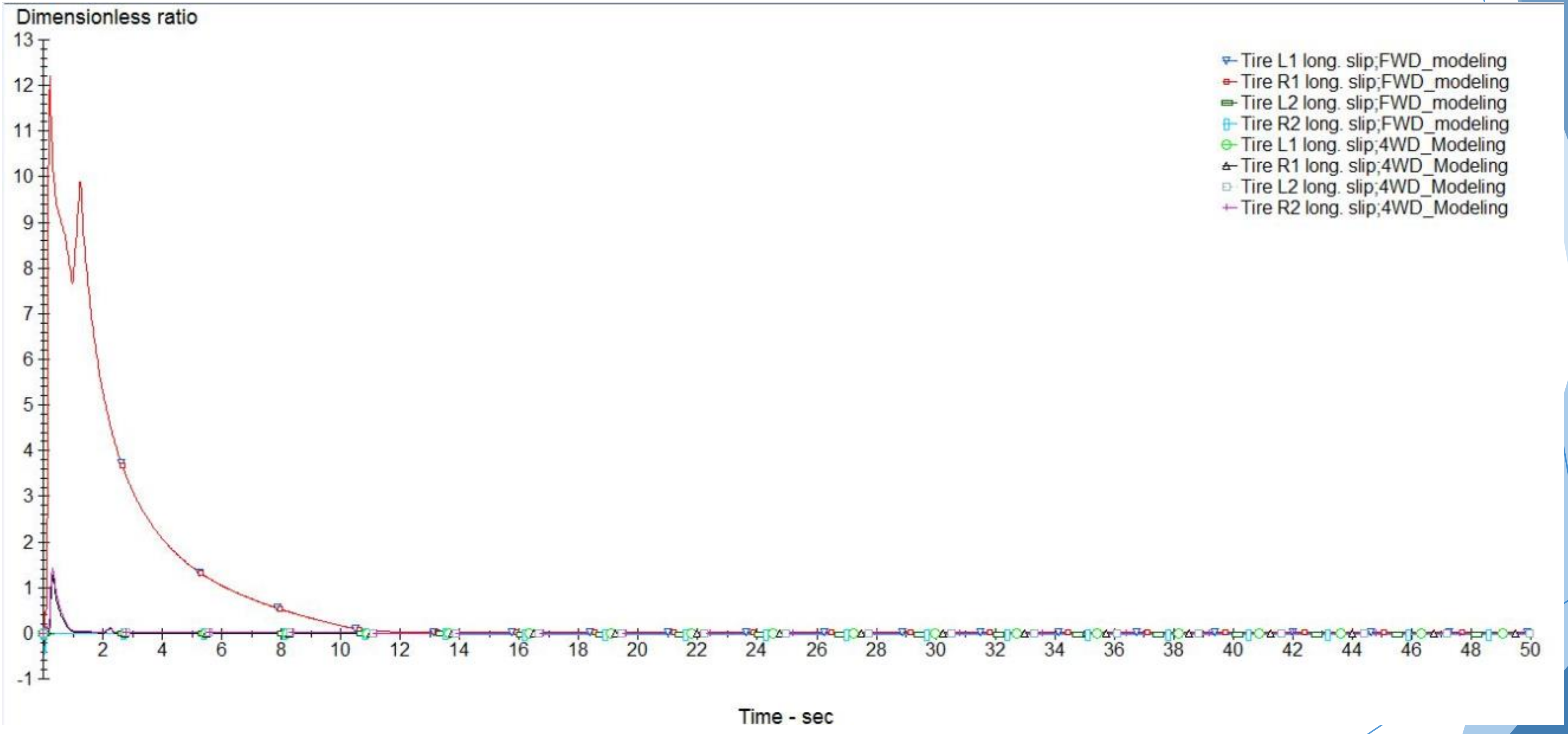
Front	Rear
Suspension type: Independent	Suspension type: Independent
Front kinematics: Independent	Rear kinematics: Independent
A-Class, Hatchback - Front Suspension	A-Class, Hatchback - Rear Suspension
Front compliance: Independent	Rear compliance: Independent
A-Class, Hatchback - Front Comp.	A-Class, Hatchback - Rear Comp.
Right-front tire: Tire	Right-rear tire: Tire
175/65 R14	175/65 R14
Left-front tire: Tire	Left-rear tire: Tire
175/65 R14	175/65 R14


Engine
Torque Transfer Dev.
Transmission
Differential
Power flow
Internal engine model
150 kW Engine
Internal torque converter model
Torque Converter for 150 kW Engine
Internal transmission model (up to 18 gears)
6-Speed Transmission
Internal differential
Open - Gear Ratio 4.1
Driveline Torsional Flexibility
This flexibility involves all driveline parts (incl. transmission, differentials, and all drive wheels, but not engine).
Drive shaft roll effect
Cause positive roll
The drive shaft applies a roll moment between the engine mass and differential. Most drivelines cause positive roll of the engine mass during acceleration. (When viewed from the front of the vehicle, the drive shaft rotation is clockwise.)
Drive torque pitch effect to engine body
Check this box if the engine body has a pitch effect from

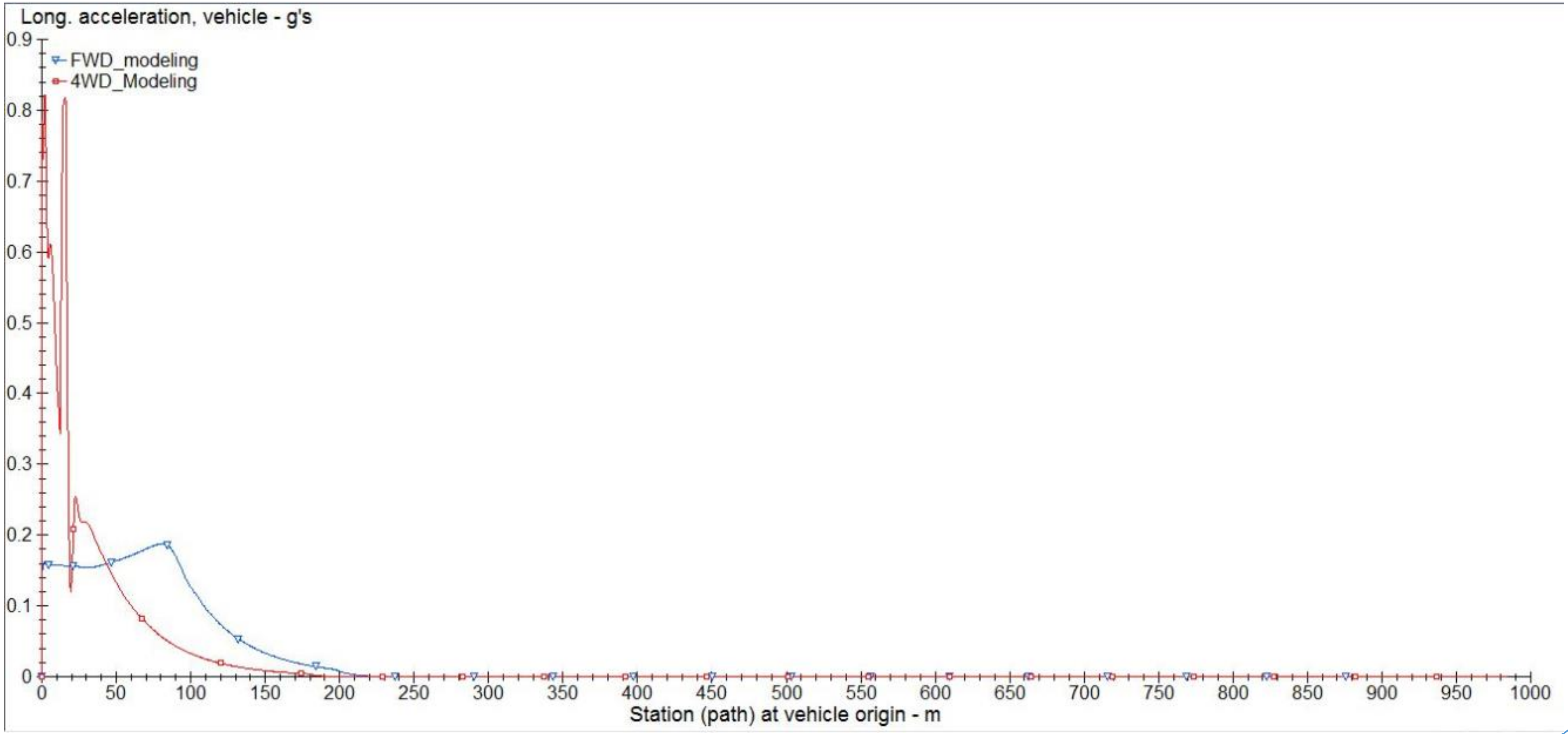
Driver Controls



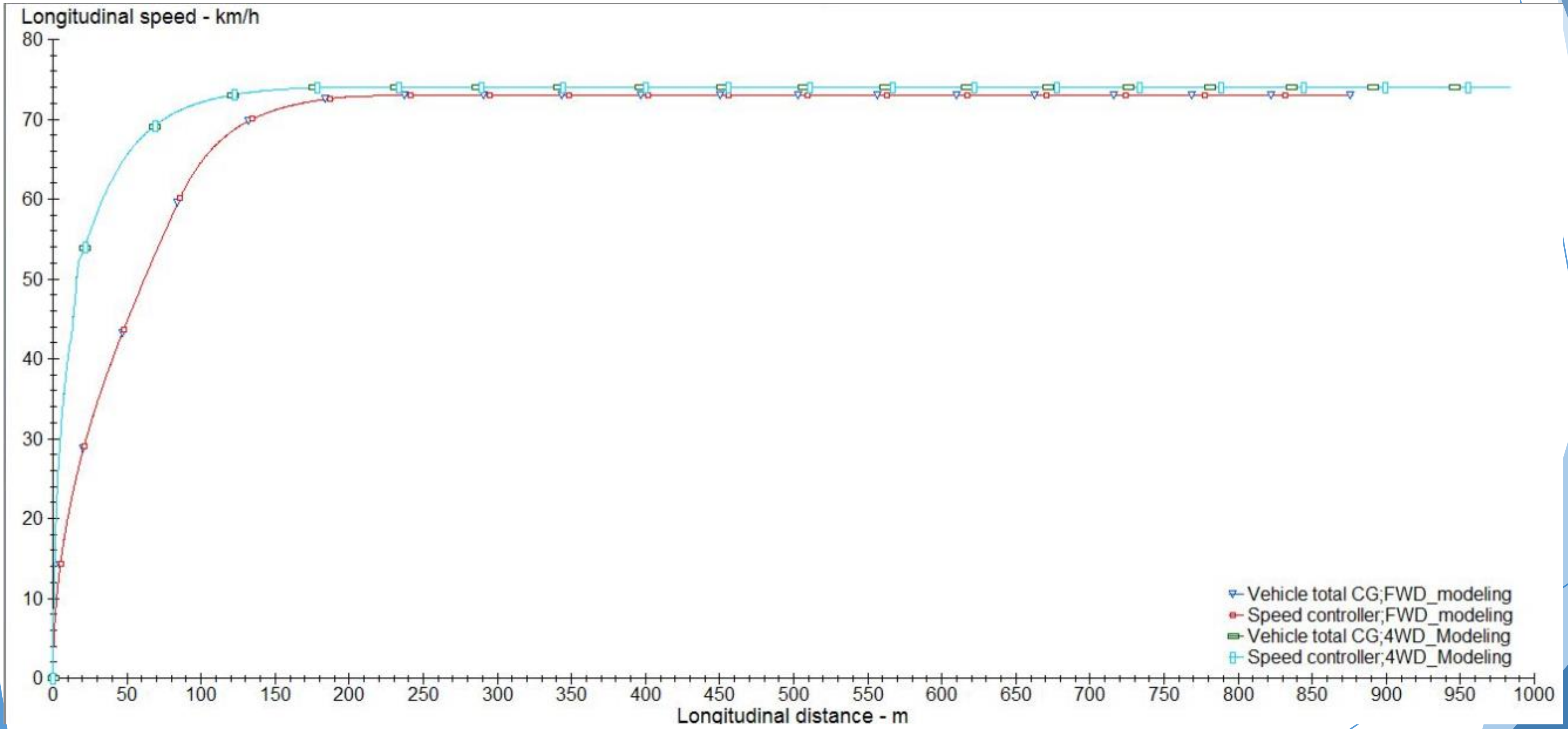
1.Slip vs time-



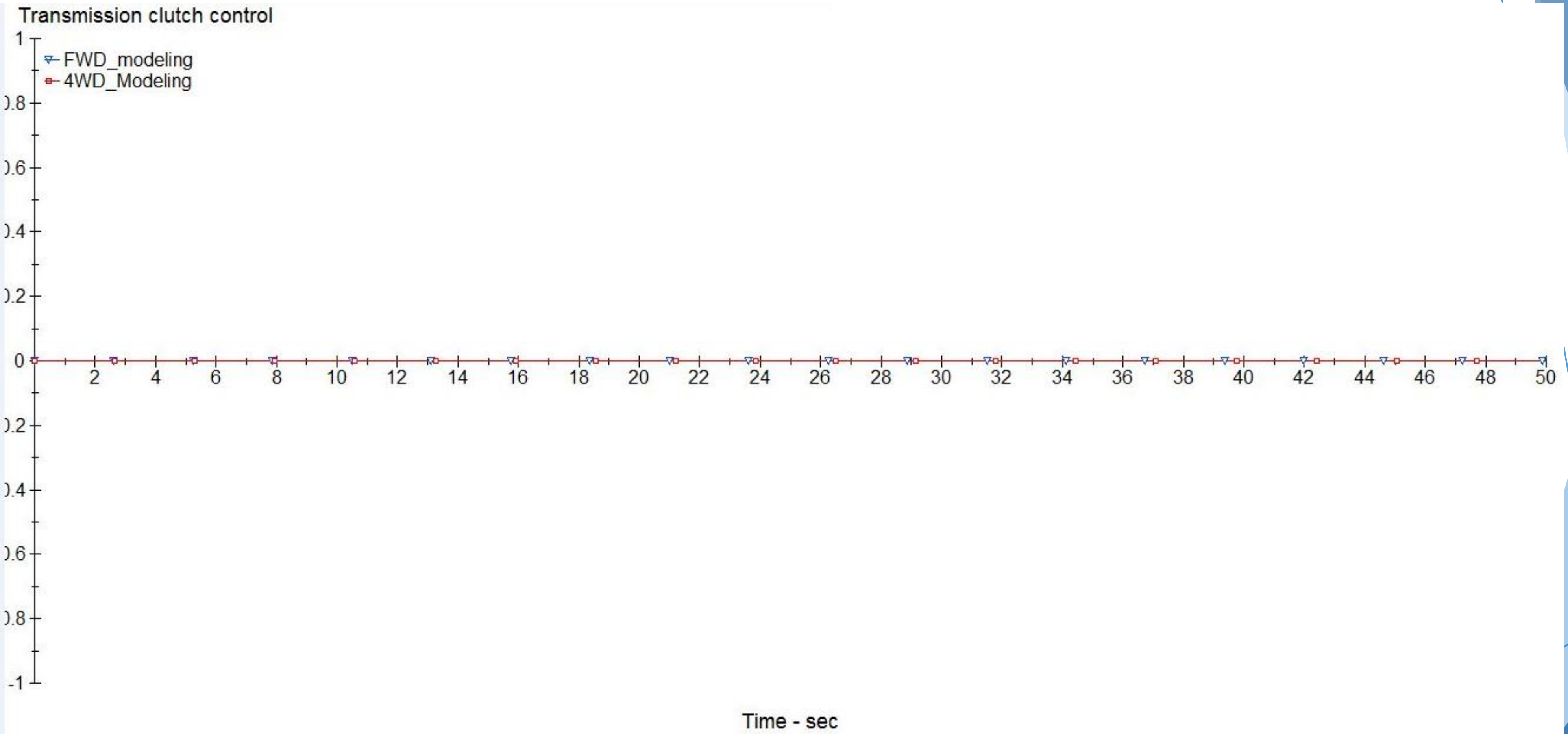
2. Acceleration vs distance-



3. Longitudinal velocity vs distance-



4. Transmission clutch control vs time-



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THANK YOU