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MODELLING OF AUTOMATIC TRANSMISSION CONTROLLER

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Section: B

Course Name :VEHICLE DYNAMICS
Course No. :18ME6D5
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Introduction

- In modern vehicles automatic transmission control is facilitated by the Transmission Control Unit (TCU).

- A TCU in a modern automatic transmission generally uses sensors from the vehicle, as well as data provided by the engine control unit (ECU), to calculate how and when to change gears in the vehicle for optimum performance, fuel economy and shift quality

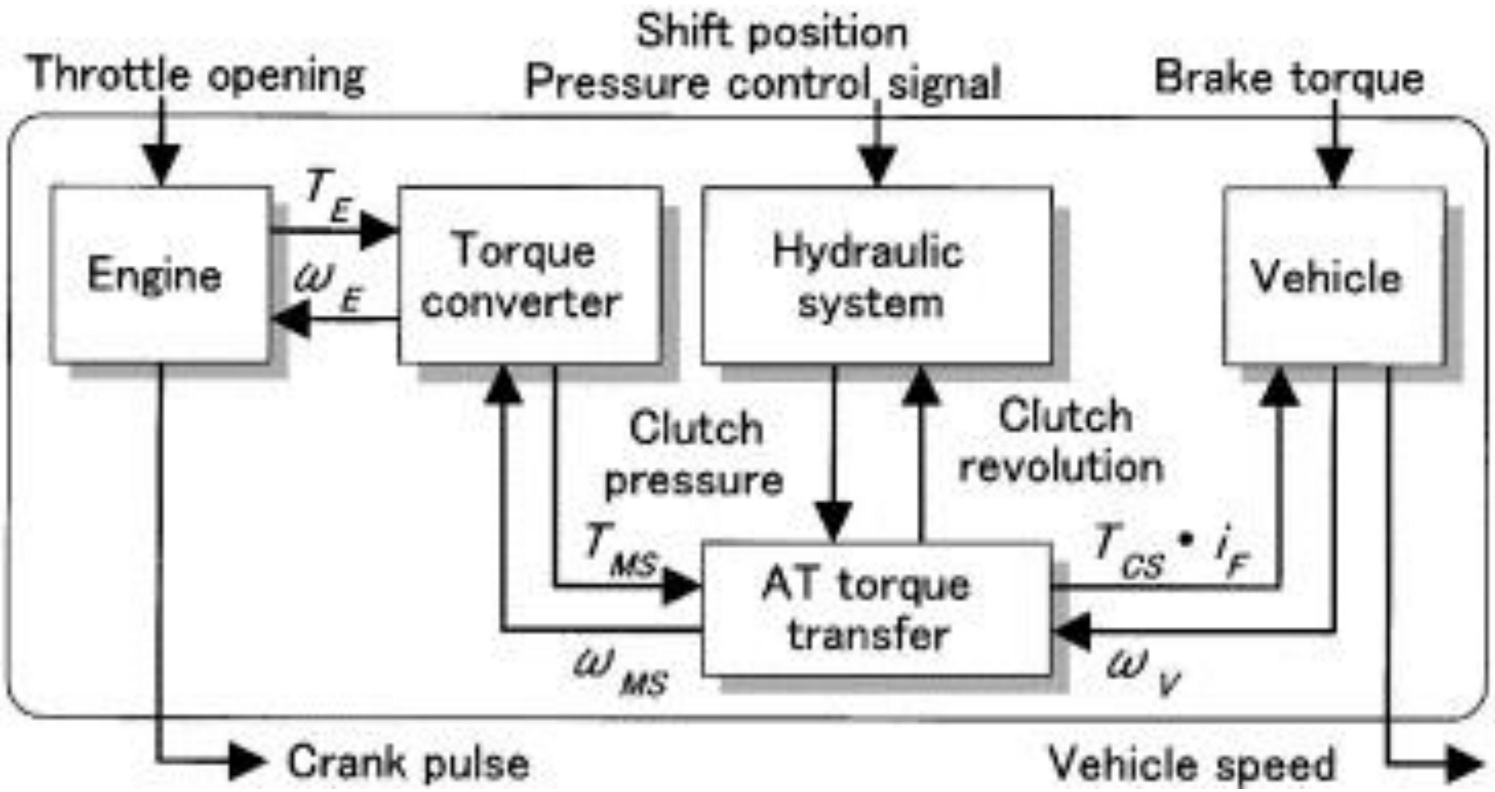
- Electronic automatic transmissions have been changing in design from purely hydromechanical controls to electronic controls since the late 1980s.

- An automatic transmission (sometimes abbreviated to auto or AT) is a multi-speed transmission used in internal combustion engine-based motor vehicles that does not require any driver input to change forward gears under normal driving conditions.

- It typically includes a transmission, axle, and differential in one integrated assembly, thus technically becoming a transaxle.

Introduction

- The figure below shows the power flow in a typical automotive drivetrain.



Introduction

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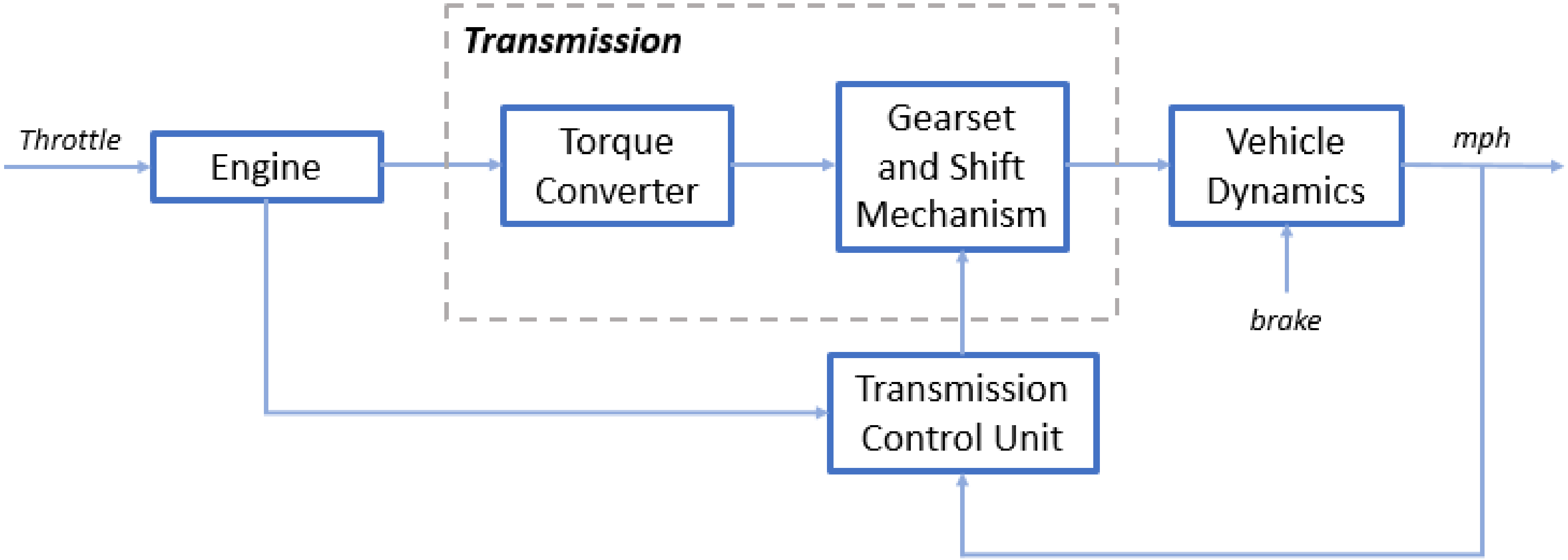
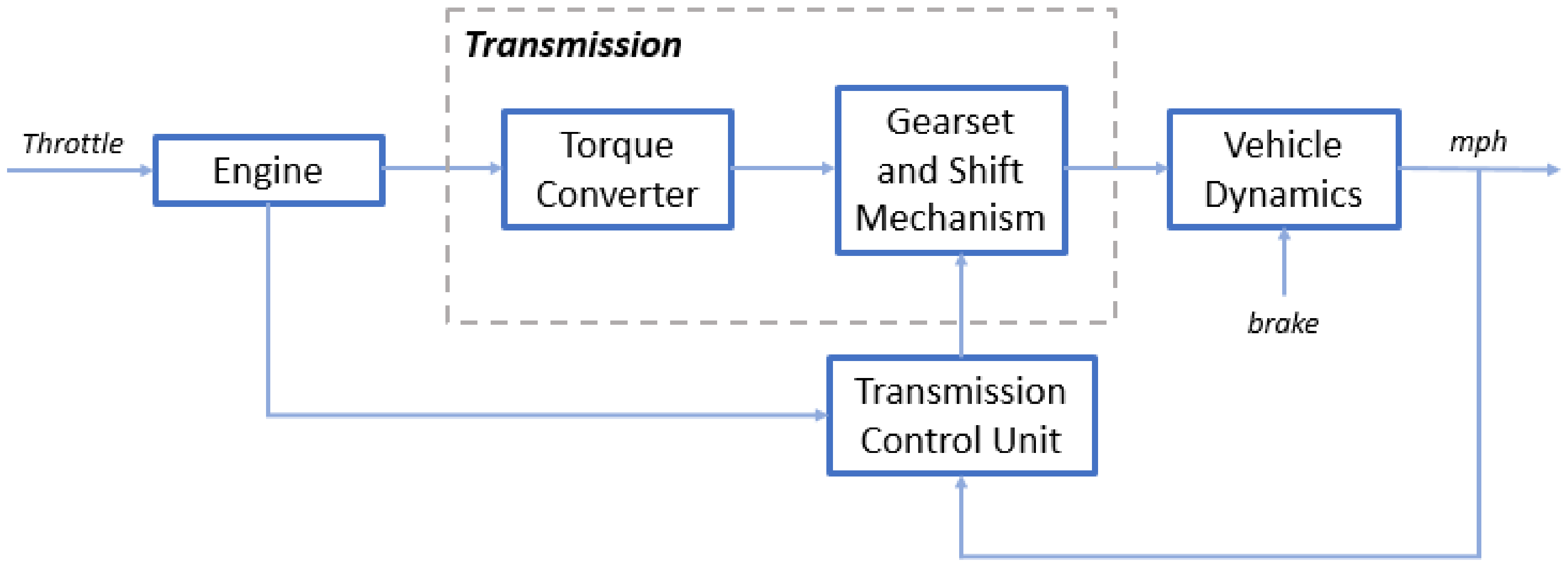


Methodology

1. Nonlinear ordinary differential equations model the engine, four-speed automatic transmission, and vehicle.
2. Modular Simulink subsystems are used directly to model these equations.
3. TCU is better suited for a Stateflow representation. Stateflow monitors the events which correspond to important relationships within the system and takes the appropriate action as they occur.



Methodology

The throttle opening is one of the inputs to the engine. The engine is connected to the impeller of the torque converter which couples it to the transmission

$$I_{ei}\dot{N}_e = T_e - T_i$$

$N_e =$ engine speed (RPM)

$I_{ei} =$ moment of inertia of the engine and the impeller

$T_e, T_i =$ engine and impeller torque

Methodology

The input-output characteristics of the torque converter can be expressed as functions of the engine speed and the turbine speed.

$$T_i = \frac{N_e^2}{K^2}$$

$$K = f_2 \frac{N_{in}}{N_e} = \text{ K-factor (capacity)}$$

$$N_{in} = \text{ speed of turbine (torque converter output)} = \text{transmission input speed (RPM)}$$

$$R_{TQ} = f_3 \frac{N_{in}}{N_e} = \text{ torque ratio}$$

The transmission model is implemented via static gear ratios, assuming small shift times

$$R_{TR} = f_4(gear) = \text{ transmission ratio}$$

$$T_{out} = R_{TR} T_{in}$$

$$N_{in} = R_{TR} N_{out}$$

$$T_{in}, T_{out} = \text{ transmission input and output torques}$$

$$N_{in}, N_{out} = \text{ transmission input and output speed (RPM)}$$

Methodology

The final drive, inertia, and a dynamically varying load constitute the vehicle dynamics

$$I_v \dot{N}_w = R_{fd}(T_{out} - T_{load})$$

$I_v =$ vehicle inertia

$N_w =$ wheel speed (RPM)

$R_{fd} =$ final drive ratio

$T_{load} = f_5(N_w) =$ load torque

The load torque includes both the road load and brake torque. The road load is the sum of frictional and aerodynamic losses

$$T_{load} = sgn(mph)(R_{load0} + R_{load2}mph^2 + T_{brake})$$

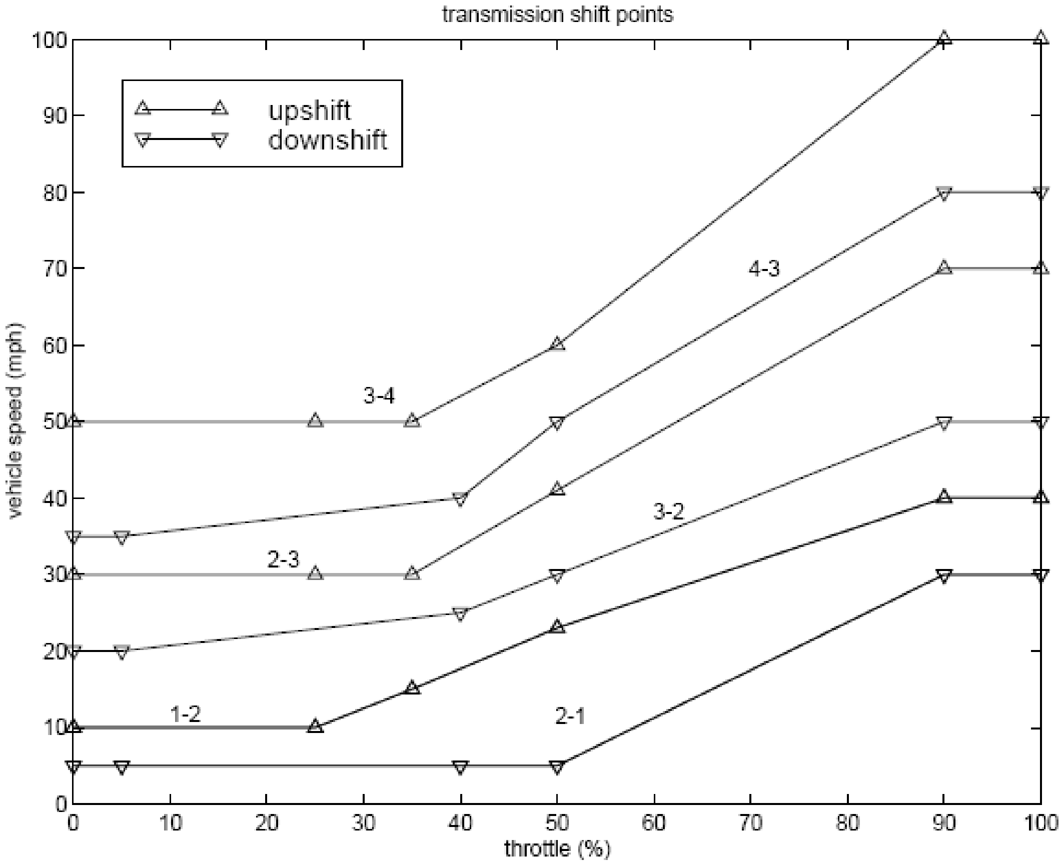
$R_{load0}, R_{load2} =$ friction and aerodynamic drag coefficients

$T_{load}, T_{brake} =$ load and brake torques

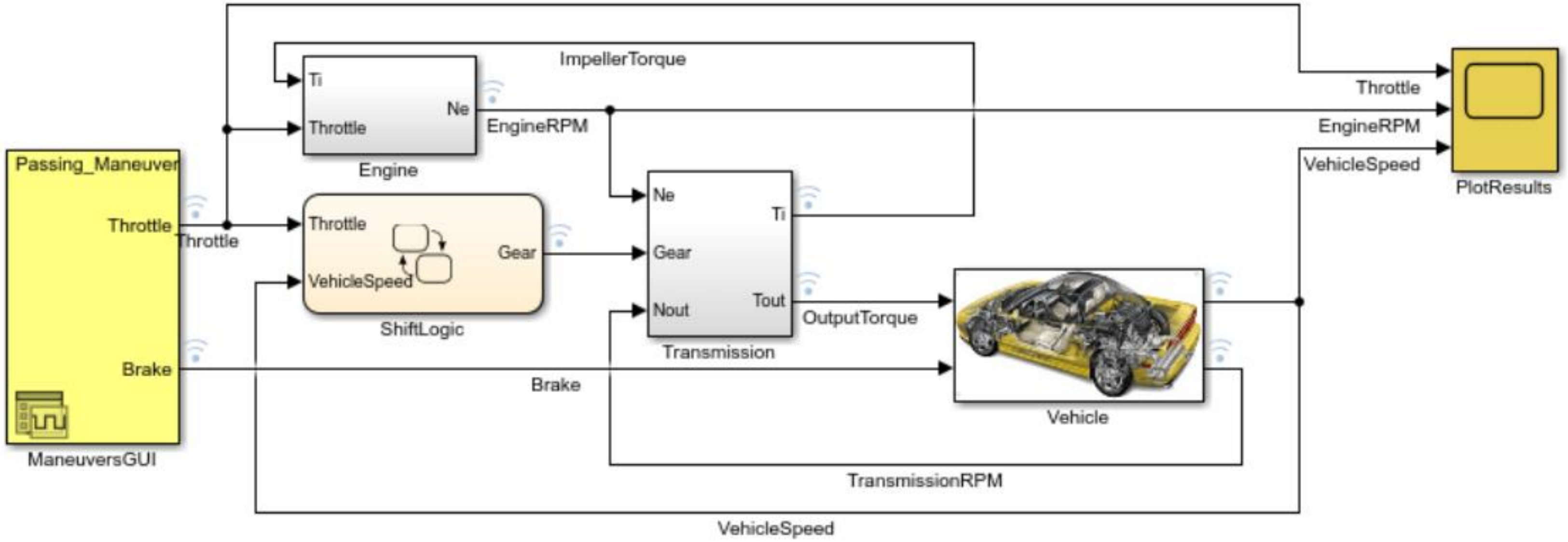
$mph =$ vehicle linear velocity

Introduction

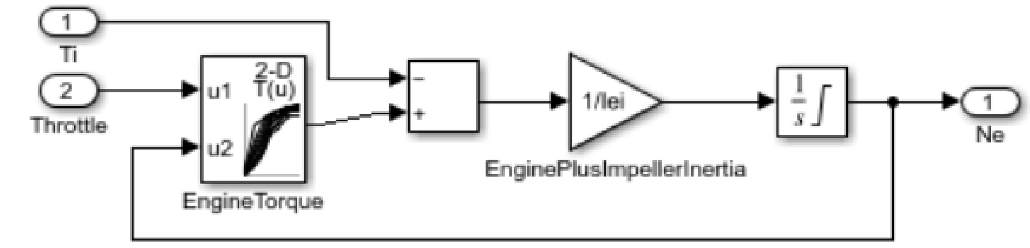
- The model programs the shift points for the transmission according to the schedule shown in the figure below. For a given throttle in a given gear, there is a unique vehicle speed at which an upshift takes place. The simulation operates similarly for a downshift..



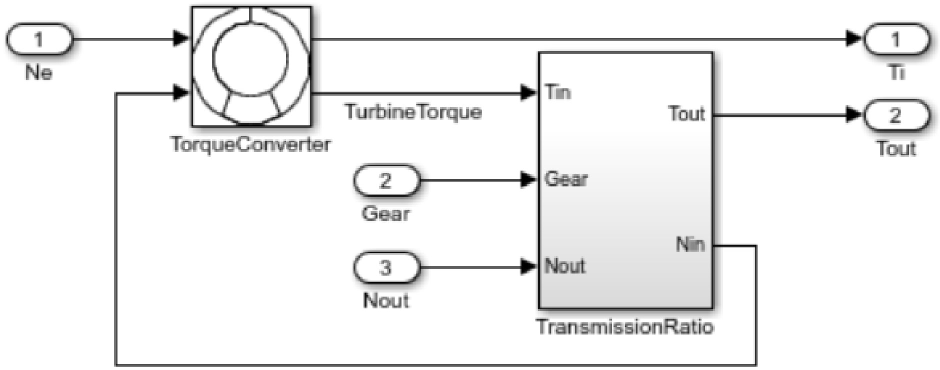
MODELLING:


ImpellerTorque
Ti
Throttle
Ne
EngineRPM
Engine
Passing_Maneuver
Throttle
Throttle
Throttle
VehicleSpeed
Gear
ShiftLogic
Ne
Ti
Gear
Nout
Tout
OutputTorque
Transmission
Brake
Brake
Vehicle
ManeuversGUI
TransmissionRPM
VehicleSpeed
Throttle
EngineRPM
VehicleSpeed
PlotResults

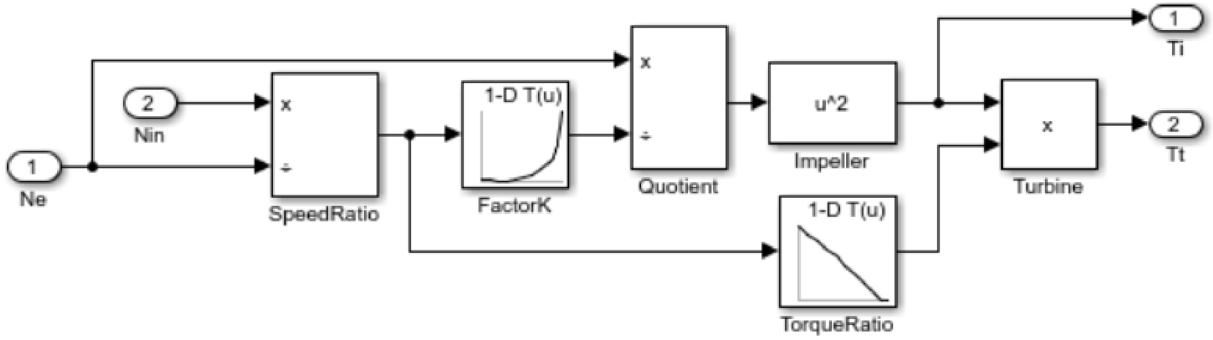
COMPONENTS



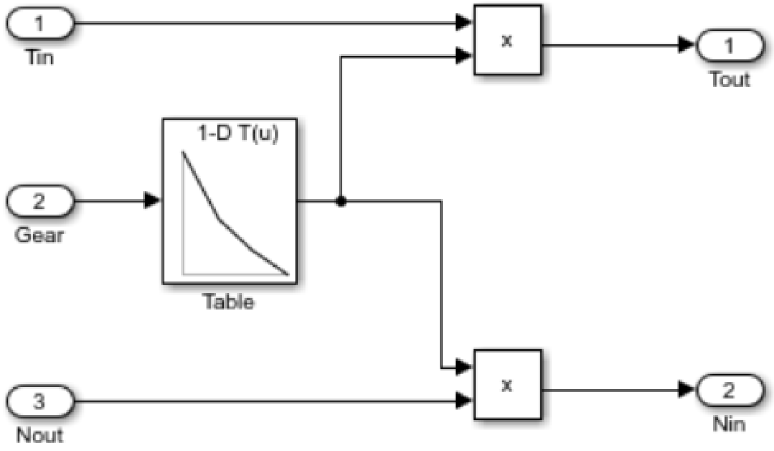
Engine



Transmission

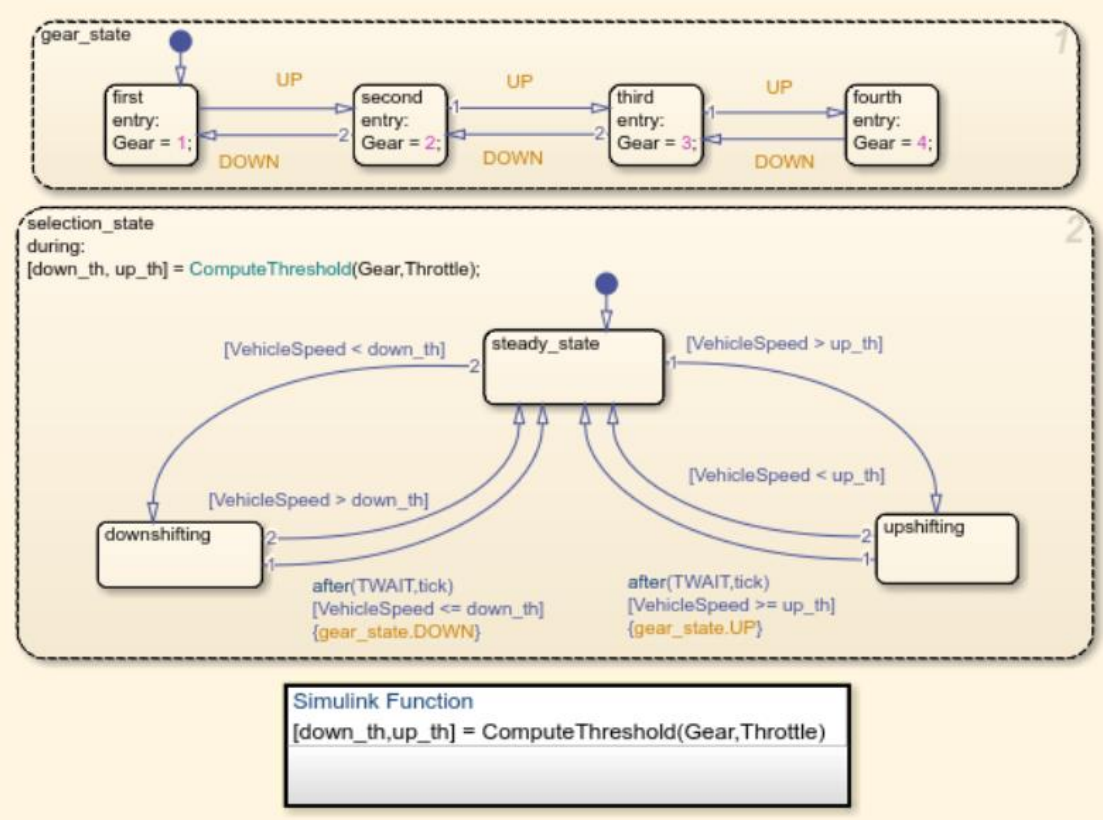


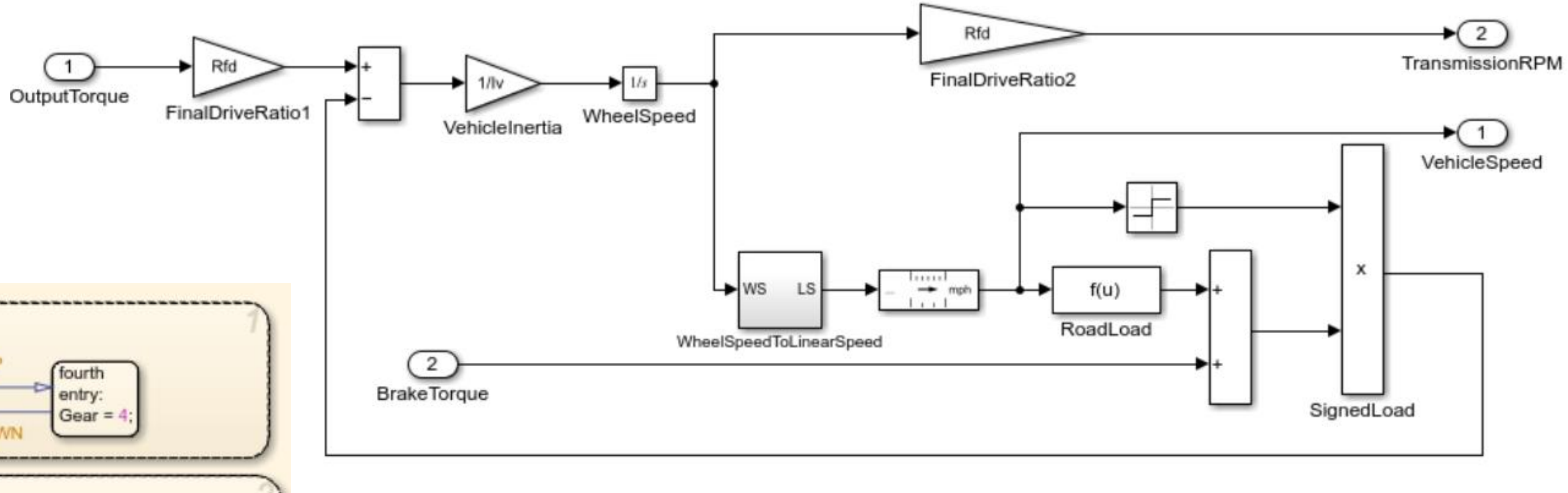
Torque Converter



Transmission Gear Ratio

COMPONENTS





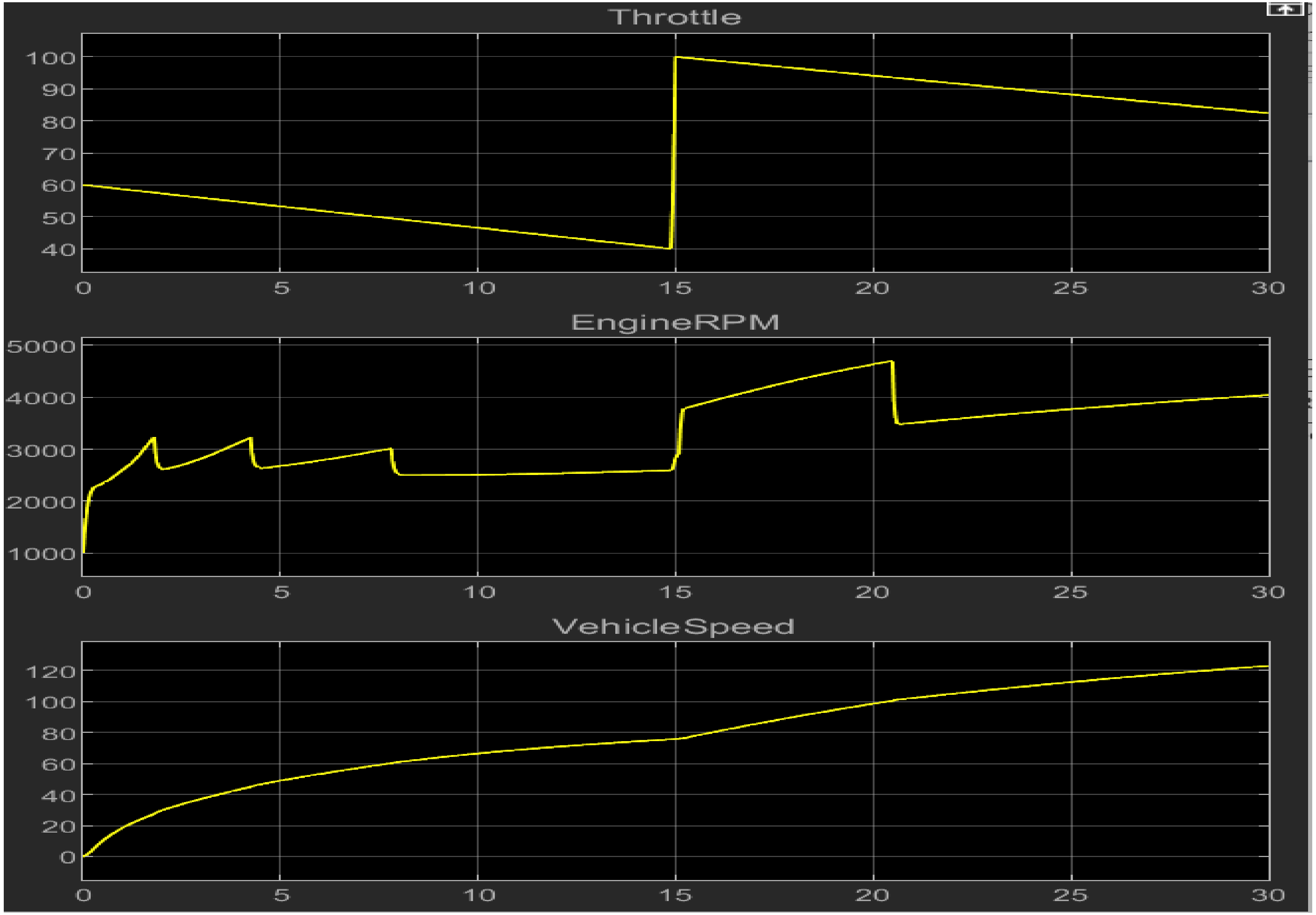
Vehicle

RESULTS

STUDIES:

- The engine torque map, and torque converter characteristics used in the simulations are to be obtained.
- The variation of vehicle speed with time is also studied.
- The variation of throttle with time is also determined.
- Further parametric studies can also be carried out.

RESULTS


Throttle
100
90
80
70
60
50
40
0
5
10
15
20
25
30
EngineRPM
5000
4000
3000
2000
1000
0
5
10
15
20
25
30
VehicleSpeed
120
100
80
60
40
20
0
0
5
10
15
20
25
30

CONCLUSION

1.A model of Automatic Transmission Control has been implemented using MATLAB and SIMULINK software.

2.Input physical signals of brake provided and the throttle provided to the engine are studied.

3.The block properties and parameters are provided in SIMULINK as a combination of both custom and predefined MATLAB codes.

4. The engine torque map, and torque converter characteristics used in the simulations are to be obtained.

5.The gear shifting mechanism has been implemented via Stateflow since it is based on control logic.

FUTURE SCOPE

- More emphasis can be placed on hydraulic properties.
- Detailed blocks for Master cylinder and Secondary cylinder to model variation of pressure within these blocks.

- Incorporating more flexibility in the engine block to get more accurate variation of engine speed with more customisation.

- MATLAB code can be implemented to incorporate more advanced control logic along with stateflow.

- Include ANSYS FLUENT for modelling Fluid Structure Interactions in the engine and the torque converter elements.

Thank You