Automatic Transmission Controller

Automotive Automatic Transmission Controller Using MATLAB Simulink

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# **Introduction**

An **automatic transmission** (sometimes abbreviated to **auto** or **AT**) is multi-speed transmission used in motor vehicles that does not require any driver input to change gears under normal driving conditions. The most common type of automatic transmission is the hydraulic automatic, which uses a planetary gearset, hydraulic controls, and a torque convertor. Other types of automatic transmissions include continuously variable transmissions (CVT), automated manual transmissions (AMT), and dual-clutch transmissions (DCT) [1].

In conventional vehicles powered by gasoline engines, the accelerator pedal actuated by the driver is mechanically linked to the engine throttle which regulates the airflow to the intake manifold. When the driver holds the accelerator pedal constant, the power and torque generated by the engine will change with engine speed, and thus, the driver needs to vary the pedal position to obtain constant torque (acceleration) or power from the engine. Since each powertrain has its own torque/power characteristics, drivers bear the responsibility to adapt to the powertrain, instead of the other way around [4].

# **Automotive Transmission**

The device in the power train of a motor vehicle that provides different gear ratios between the engine and drive wheels, as well as neutral and reverse. An internal combustion engine develops relatively low torque at low speed and maximum torque at only one speed, with the crankshaft always rotating in the same direction. To meet the tractive-power demand of the vehicle, the transmission converts the engine speed and torque into an output speed and torque in the selected direction for the final drive. This arrangement permits a smaller engine to provide acceptable performance and fuel economy while moving the vehicle from standstill to maximum speed. The transmission may be a separate unit as in front-engine rear-drive vehicles or may be combined with the drive axle to form a transaxle as in most front-drive vehicles [2].

# **Purpose of Automatic Transmission**

Just like that of a manual transmission, the automatic transmission's primary job is to allow the engine to operate in its narrow range of speeds while providing a wide range of output speeds. Without a transmission, cars would be limited to one gear ratio, and that ratio would have to be selected to allow the car to travel at the desired top speed. If you wanted a top speed of 80 mph, then the gear ratio would be similar to third gear in most manual transmission cars [3].

# Modeling Transmission

The Transmissions library provides subsystem templates for modelling geared transmission systems with four to nine speed settings. The templates use Simscape™ Driveline™ and Simscape blocks to represent the transmission components—their gears, clutches, and brakes. An embedded Simulink® subsystem defines the clutch schedule [5].

# Block Diagram

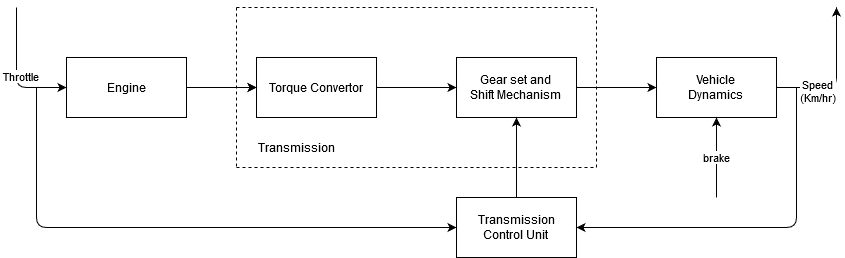


Figure 1: Block Diagram of Typical Automotive Drivetrain

The above figure show the typical automotive drivetrain, nonlinear ordinary equations model Engine, four-speed automatic transmission and vehicle dynamics.

# Equation governing the Blocks

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.

### Equation 1

*Equation i*

The input-output characteristics of the torque converter can be expressed as functions of the engine speed and the turbine speed. In this example, the direction of power flow is always assumed to be from the impeller to the turbine.

### Equation 2

*Equation ii*

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

### Equation 3

*Equation iii*

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

### Equation 4

*Equation iv*

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

### Equation 5

*Equation v*

# Modeling in MATLAB Simulink

1. In Engine block a two dimensional (2-D look up table is used) to emulate the look up table to interpolate engine torque versus throttle and engine speed.
2. The torque Convertor bock is made using equation 2.
3. The transmission block determines the ratio shown in below table and using it to compute the transmission output torque and input speed, as indicated in equation 3.

Table 1: Gear Ratio

|  |  |
| --- | --- |
| Gear | Rtr = Nin/Ne |
| 1 | 2.393 |
| 2 | 1.450 |
| 3 | 1.000 |
| 4 | 0.677 |

1. The chart of ShiftLogic implements when to change the gears depending on the throttle position and vehicle speed. It has two parallel states, one parallel to upshift or downshift the gear and other to check the condition to and so that upshifts and downshifts and triggered also a condition with TWAIT (a delay) is used to remove noise.
2. Vehicle block is made using equation 5, to emulate the dynamics of the vehicle.

# MATLAB Function block

With a MATLAB Function block, you can write a MATLAB function for use in a Simulink model. Double-clicking the MATLAB Function block opens its editor, where you write the MATLAB function.

Here in the Automatic Transmission Model, a MATLAB function Simulink block is used to generate net torque. This is done by taking the inputs as output torque signal from Transmission subsystem and brake torque from user input (Signal builder block). The difference of this input is computed in MATLAB function block and the absolute value is given back to the Simulink model.

# Callback

Call back are used to evaluate specific action points, as in Automatic Transmission model, to get the Torque, Speed and Power Characteristics the plot between Engine RPM versus Torque, Speed or Power is required. To achieve this, the values is Torque, Vehicle Speed and Engine RPM are connected to output port to gain there access in workspace.

The Model explore calls the function to plot the above given characteristics after the end of the simulation.

# Solver details

For the simulation of the Automatic Transmission model the variable step ode45, Dormand-Prince is used. Computes the model's state at the next time step using an explicit Runge-Kutta (4,5) formula (the Dormand-Prince pair) for numerical integration. ode45 is a one-step solver, and therefore only needs the solution at the preceding time point

The Automatic Transmission model has various difference equations for vehicle dynamics and also use statesflow simultaneously. It is a non-stiff and medium accuracy is required, hence ode 45 is used.

# Reference

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