

KPIT

Automatic Transmission Controller

Name: DEVISREE T (214826)



KPIT Technologies Ltd.

KPIT

Contents

Name:Devisree T.....	1
1. Introduction.....	3
2. Block Diagram of Automatic Drivetrain.....	4
3. Model Equations.....	4
4. Simulink circuit of Automatic Transmission.....	7
5. Callbacks.....	7
6. Data Inspector.....	8
7. Solver Selection Strategy.....	9
8. MATLAB Function.....	11
9. Look-up Table.....	12
10.Signal Builder	13

Figures

Figure 1 - Automatic Transmission	3
Figure 2 - Block Diagram of Typical Drivetrain	4
Figure 3 - Simulink circuit of Automatic Transmssion	7
Figure 4 - Callback Function of Automatic Transmission.....	8
Figure 5 - Data Inspector of Automatic Transmission.....	9
Figure 6 - Solver Selection Strategy	10
Figure 7 - Matlab Function of Vehicle.....	11
Figure 8 - Look-up Table of Engine.....	12
Figure 9 - Signal Builder of input signal	14

1. Introduction



Figure 1 – Automatic Transmission

Vehicles need a transmission to transfer the power from the engine to the drive shaft and the differential to let the wheels turn. The transmission varies the torque, the speed and the direction by changing the transmission ratios and enables the car to start with a high torque. An automatic gearbox, or automatic transmission system, is a gearbox which, after switching on the gear, does not require manual switching.

The Simulink design shows how to model an automotive drivetrain with Simulink. Stateflow enhances the Simulink model with its representation of the transmission control logic. Simulink provides a powerful environment for the modeling and simulation of dynamic systems and processes. In many systems, though, supervisory functions like changing modes or invoking new gain schedules must respond to events that may occur and conditions that develop over time. As a result, the environment requires a language capable of managing these multiple modes and developing conditions. In the following design, Stateflow shows its strength in this capacity by performing the function of gear selection in an automatic transmission. This function is combined with the drivetrain dynamics in a natural and intuitive manner by incorporating a Stateflow block in the Simulink block diagram.

2. Block Diagram of Automatic Drivetrain

The power flow in a typical automotive drivetrain is shown in below Figure 2. Nonlinear ordinary differential equations model the engine, four-speed automatic transmission, and vehicle. The model discussed in this example directly implements the blocks from Figure 2 as modular Simulink subsystems. On the other hand, the logic and decisions made in the Transmission Control Unit (TCU) do not lend themselves to well-formulated equations. 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.

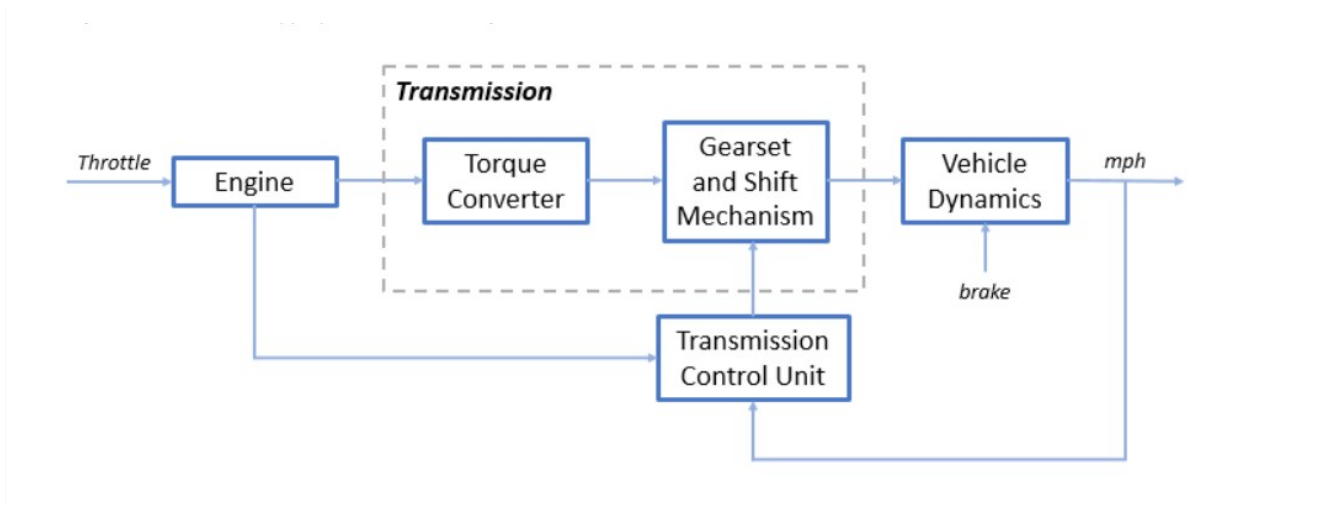


Figure 2 - Block diagram of a Typical Automatic Drivetrain.

3. Model Equations

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 (see Equation 1).

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

- **Equation 1:**

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

N_e = engine speed (RPM)

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

T_e, T_i = engine and impeller torque

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 (see Equation 2).

- **Equation 2:**

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

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

N_{in} = speed of turbine (torque converter output) = 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 (see Equation 3).

- **Equation 3:**

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

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

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

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

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

The final drive, inertia, and a dynamically varying load constitute the vehicle dynamics (see Equation 4).

- **Equation 4:**

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

$I_v =$ 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 (see Equation 5).

- **Equation 5:**

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

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

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

mph = vehicle linear velocity

4. SIMULINK circuit of Automatic Transmission Controller

The top-level diagram of the model is shown in Figure 3. To run the simulation, press the Play button on the toolbar in the model window. Note that the model logs relevant data to MATLAB Workspace in a data structure called AUTOMATIC_TRANSMISSION_CONTROLLER. Logged signals have a blue indicator (see Figure 3). After you run the simulation, you can view the components of the data structure by typing AUTOMATIC_TRANSMISSION_CONTROLLER in MATLAB Command Window. Also note that the units appear on the subsystem icons and signal lines.

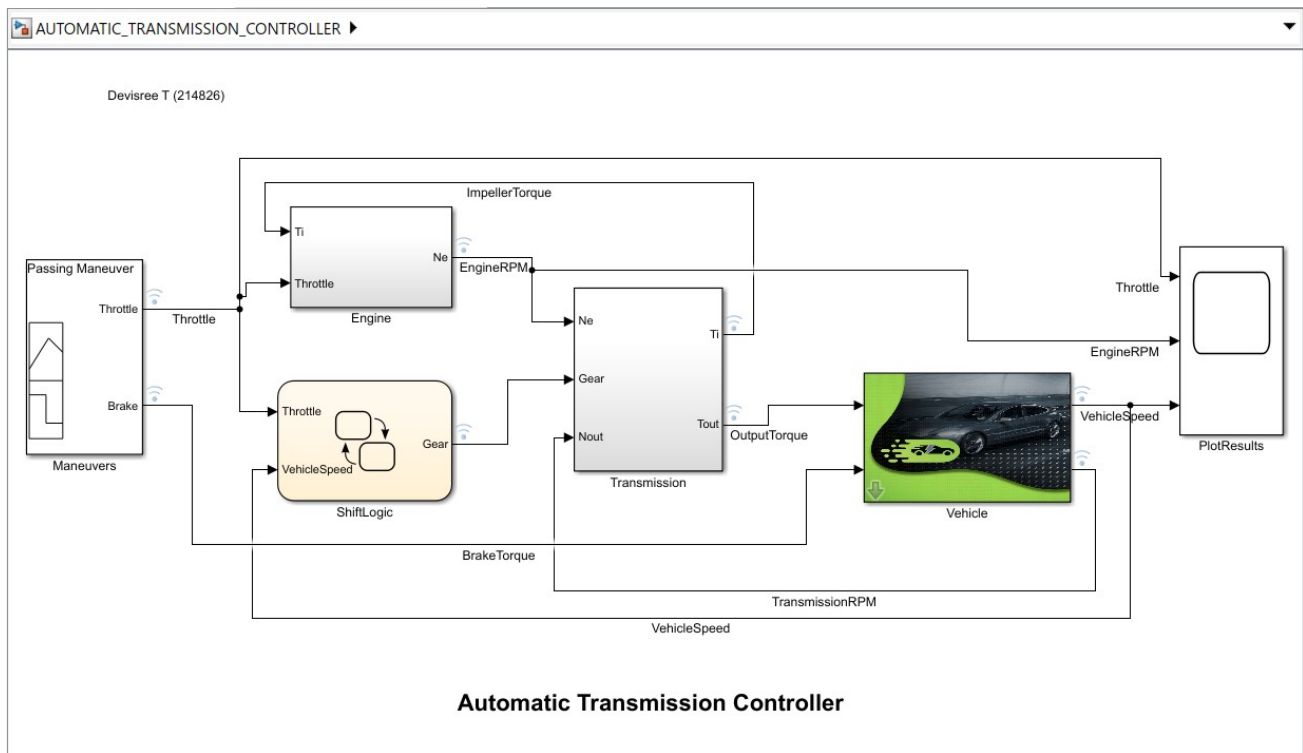


Figure 3 – SIMULINK circuit for Automatic Transmission

5. Callbacks

Model callbacks execute at specified action points, for example after you load or save the model.

You can set most of the same callbacks for libraries. Only the callbacks that can execute for a library are available to set for a library.

Model Properties: AUTOMATIC_TRANSMISSION_CONTROLLER

Main	Callbacks	History	Description	External Data
<p>Model callbacks</p> <ul style="list-style-type: none"> PreLoadFcn* PostLoadFcn InitFcn StartFcn PauseFcn ContinueFcn StopFcn PreSaveFcn PostSaveFcn CloseFcn 		<p>Model pre-load function:</p> <pre> EMAP=[-40 -44 -49 -53 -57 -61 -65 -70 -74 -78 -82;215; Iei=0.021991488283555904; VEHICLE_DATA=[3.23;40;0.02;1;12.094147857312473; TWAIT=2; UP_TH_BP=[0;25;35;50;90;100]; UP_TABLE=[10 30 50 1.0E+6;10 30 50 1.0E+6;15 30 50 1.0E+6; TH_VEC=[0;20;30;40;50;60;70;80;90;100]; NE_VEC=[799.9999999999999 1200 1599.9999999999999; DOWN_TH_BP=[0;5;40;50;90;100]; CONVERTER_DATA=[0 137.4652089938063 2.2319999999999999; DOWN_TABLE=[0 5 20 35;0 5 20 35;0 5 25 40;0 5 30 40;0 5 35 40;0 5 40 45;0 5 45 50;0 5 50 55;0 5 55 60;0 5 60 65;0 5 65 70;0 5 70 75;0 5 75 80;0 5 80 85;0 5 85 90;0 5 90 95;0 5 95 100;0 5 100 105;0 5 105 110;0 5 110 115;0 5 115 120;0 5 120 125;0 5 125 130;0 5 130 135;0 5 135 140;0 5 140 145;0 5 145 150;0 5 150 155;0 5 155 160;0 5 160 165;0 5 165 170;0 5 170 175;0 5 175 180;0 5 180 185;0 5 185 190;0 5 190 195;0 5 195 200;0 5 200 205;0 5 205 210;0 5 210 215;0 5 215 220;0 5 220 225;0 5 225 230;0 5 230 235;0 5 235 240;0 5 240 245;0 5 245 250;0 5 250 255;0 5 255 260;0 5 260 265;0 5 265 270;0 5 270 275;0 5 275 280;0 5 280 285;0 5 285 290;0 5 290 295;0 5 295 300;0 5 300 305;0 5 305 310;0 5 310 315;0 5 315 320;0 5 320 325;0 5 325 330;0 5 330 335;0 5 335 340;0 5 340 345;0 5 345 350;0 5 350 355;0 5 355 360;0 5 360 365;0 5 365 370;0 5 370 375;0 5 375 380;0 5 380 385;0 5 385 390;0 5 390 395;0 5 395 400;0 5 400 405;0 5 405 410;0 5 410 415;0 5 415 420;0 5 420 425;0 5 425 430;0 5 430 435;0 5 435 440;0 5 440 445;0 5 445 450;0 5 450 455;0 5 455 460;0 5 460 465;0 5 465 470;0 5 470 475;0 5 475 480;0 5 480 485;0 5 485 490;0 5 490 495;0 5 495 500;0 5 500 505;0 5 505 510;0 5 510 515;0 5 515 520;0 5 520 525;0 5 525 530;0 5 530 535;0 5 535 540;0 5 540 545;0 5 545 550;0 5 550 555;0 5 555 560;0 5 560 565;0 5 565 570;0 5 570 575;0 5 575 580;0 5 580 585;0 5 585 590;0 5 590 595;0 5 595 600;0 5 600 605;0 5 605 610;0 5 610 615;0 5 615 620;0 5 620 625;0 5 625 630;0 5 630 635;0 5 635 640;0 5 640 645;0 5 645 650;0 5 650 655;0 5 655 660;0 5 660 665;0 5 665 670;0 5 670 675;0 5 675 680;0 5 680 685;0 5 685 690;0 5 690 695;0 5 695 700;0 5 700 705;0 5 705 710;0 5 710 715;0 5 715 720;0 5 720 725;0 5 725 730;0 5 730 735;0 5 735 740;0 5 740 745;0 5 745 750;0 5 750 755;0 5 755 760;0 5 760 765;0 5 765 770;0 5 770 775;0 5 775 780;0 5 780 785;0 5 785 790;0 5 790 795;0 5 795 800;0 5 800 805;0 5 805 810;0 5 810 815;0 5 815 820;0 5 820 825;0 5 825 830;0 5 830 835;0 5 835 840;0 5 840 845;0 5 845 850;0 5 850 855;0 5 855 860;0 5 860 865;0 5 865 870;0 5 870 875;0 5 875 880;0 5 880 885;0 5 885 890;0 5 890 895;0 5 895 900;0 5 900 905;0 5 905 910;0 5 910 915;0 5 915 920;0 5 920 925;0 5 925 930;0 5 930 935;0 5 935 940;0 5 940 945;0 5 945 950;0 5 950 955;0 5 955 960;0 5 960 965;0 5 965 970;0 5 970 975;0 5 975 980;0 5 980 985;0 5 985 990;0 5 990 995;0 5 995 1000;0 5 1000 1005;0 5 1005 1010;0 5 1010 1015;0 5 1015 1020;0 5 1020 1025;0 5 1025 1030;0 5 1030 1035;0 5 1035 1040;0 5 1040 1045;0 5 1045 1050;0 5 1050 1055;0 5 1055 1060;0 5 1060 1065;0 5 1065 1070;0 5 1070 1075;0 5 1075 1080;0 5 1080 1085;0 5 1085 1090;0 5 1090 1095;0 5 1095 1100;0 5 1100 1105;0 5 1105 1110;0 5 1110 1115;0 5 1115 1120;0 5 1120 1125;0 5 1125 1130;0 5 1130 1135;0 5 1135 1140;0 5 1140 1145;0 5 1145 1150;0 5 1150 1155;0 5 1155 1160;0 5 1160 1165;0 5 1165 1170;0 5 1170 1175;0 5 1175 1180;0 5 1180 1185;0 5 1185 1190;0 5 1190 1195;0 5 1195 1200;0 5 1200 1205;0 5 1205 1210;0 5 1210 1215;0 5 1215 1220;0 5 1220 1225;0 5 1225 1230;0 5 1230 1235;0 5 1235 1240;0 5 1240 1245;0 5 1245 1250;0 5 1250 1255;0 5 1255 1260;0 5 1260 1265;0 5 1265 1270;0 5 1270 1275;0 5 1275 1280;0 5 1280 1285;0 5 1285 1290;0 5 1290 1295;0 5 1295 1300;0 5 1300 1305;0 5 1305 1310;0 5 1310 1315;0 5 1315 1320;0 5 1320 1325;0 5 1325 1330;0 5 1330 1335;0 5 1335 1340;0 5 1340 1345;0 5 1345 1350;0 5 1350 1355;0 5 1355 1360;0 5 1360 1365;0 5 1365 1370;0 5 1370 1375;0 5 1375 1380;0 5 1380 1385;0 5 1385 1390;0 5 1390 1395;0 5 1395 1400;0 5 1400 1405;0 5 1405 1410;0 5 1410 1415;0 5 1415 1420;0 5 1420 1425;0 5 1425 1430;0 5 1430 1435;0 5 1435 1440;0 5 1440 1445;0 5 1445 1450;0 5 1450 1455;0 5 1455 1460;0 5 1460 1465;0 5 1465 1470;0 5 1470 1475;0 5 1475 1480;0 5 1480 1485;0 5 1485 1490;0 5 1490 1495;0 5 1495 1500;0 5 1500 1505;0 5 1505 1510;0 5 1510 1515;0 5 1515 1520;0 5 1520 1525;0 5 1525 1530;0 5 1530 1535;0 5 1535 1540;0 5 1540 1545;0 5 1545 1550;0 5 1550 1555;0 5 1555 1560;0 5 1560 1565;0 5 1565 1570;0 5 1570 1575;0 5 1575 1580;0 5 1580 1585;0 5 1585 1590;0 5 1590 1595;0 5 1595 1600;0 5 1600 1605;0 5 1605 1610;0 5 1610 1615;0 5 1615 1620;0 5 1620 1625;0 5 1625 1630;0 5 1630 1635;0 5 1635 1640;0 5 1640 1645;0 5 1645 1650;0 5 1650 1655;0 5 1655 1660;0 5 1660 1665;0 5 1665 1670;0 5 1670 1675;0 5 1675 1680;0 5 1680 1685;0 5 1685 1690;0 5 1690 1695;0 5 1695 1700;0 5 1700 1705;0 5 1705 1710;0 5 1710 1715;0 5 1715 1720;0 5 1720 1725;0 5 1725 1730;0 5 1730 1735;0 5 1735 1740;0 5 1740 1745;0 5 1745 1750;0 5 1750 1755;0 5 1755 1760;0 5 1760 1765;0 5 1765 1770;0 5 1770 1775;0 5 1775 1780;0 5 1780 1785;0 5 1785 1790;0 5 1790 1795;0 5 1795 1800;0 5 1800 1805;0 5 1805 1810;0 5 1810 1815;0 5 1815 1820;0 5 1820 1825;0 5 1825 1830;0 5 1830 1835;0 5 1835 1840;0 5 1840 1845;0 5 1845 1850;0 5 1850 1855;0 5 1855 1860;0 5 1860 1865;0 5 1865 1870;0 5 1870 1875;0 5 1875 1880;0 5 1880 1885;0 5 1885 1890;0 5 1890 1895;0 5 1895 1900;0 5 1900 1905;0 5 1905 1910;0 5 1910 1915;0 5 1915 1920;0 5 1920 1925;0 5 1925 1930;0 5 1930 1935;0 5 1935 1940;0 5 1940 1945;0 5 1945 1950;0 5 1950 1955;0 5 1955 1960;0 5 1960 1965;0 5 1965 1970;0 5 1970 1975;0 5 1975 1980;0 5 1980 1985;0 5 1985 1990;0 5 1990 1995;0 5 1995 2000;0 5 2000 2005;0 5 2005 2010;0 5 2010 2015;0 5 2015 2020;0 5 2020 2025;0 5 2025 2030;0 5 2030 2035;0 5 2035 2040;0 5 2040 2045;0 5 2045 2050;0 5 2050 2055;0 5 2055 2060;0 5 2060 2065;0 5 2065 2070;0 5 2070 2075;0 5 2075 2080;0 5 2080 2085;0 5 2085 2090;0 5 2090 2095;0 5 2095 2100;0 5 2100 2105;0 5 2105 2110;0 5 2110 2115;0 5 2115 2120;0 5 2120 2125;0 5 2125 2130;0 5 2130 2135;0 5 2135 2140;0 5 2140 2145;0 5 2145 2150;0 5 2150 2155;0 5 2155 2160;0 5 2160 2165;0 5 2165 2170;0 5 2170 2175;0 5 2175 2180;0 5 2180 2185;0 5 2185 2190;0 5 2190 2195;0 5 2195 2200;0 5 2200 2205;0 5 2205 2210;0 5 2210 2215;0 5 2215 2220;0 5 2220 2225;0 5 2225 2230;0 5 2230 2235;0 5 2235 2240;0 5 2240 2245;0 5 2245 2250;0 5 2250 2255;0 5 2255 2260;0 5 2260 2265;0 5 2265 2270;0 5 2270 2275;0 5 2275 2280;0 5 2280 2285;0 5 2285 2290;0 5 2290 2295;0 5 2295 2300;0 5 2300 2305;0 5 2305 2310;0 5 2310 2315;0 5 2315 2320;0 5 2320 2325;0 5 2325 2330;0 5 2330 2335;0 5 2335 2340;0 5 2340 2345;0 5 2345 2350;0 5 2350 2355;0 5 2355 2360;0 5 2360 2365;0 5 2365 2370;0 5 2370 2375;0 5 2375 2380;0 5 2380 2385;0 5 2385 2390;0 5 2390 2395;0 5 2395 2400;0 5 2400 2405;0 5 2405 2410;0 5 2410 2415;0 5 2415 2420;0 5 2420 2425;0 5 2425 2430;0 5 2430 2435;0 5 2435 2440;0 5 2440 2445;0 5 2445 2450;0 5 2450 2455;0 5 2455 2460;0 5 2460 2465;0 5 2465 2470;0 5 2470 2475;0 5 2475 2480;0 5 2480 2485;0 5 2485 2490;0 5 2490 2495;0 5 2495 2500;0 5 2500 2505;0 5 2505 2510;0 5 2510 2515;0 5 2515 2520;0 5 2520 2525;0 5 2525 2530;0 5 2530 2535;0 5 2535 2540;0 5 2540 2545;0 5 2545 2550;0 5 2550 2555;0 5 2555 2560;0 5 2560 2565;0 5 2565 2570;0 5 2570 2575;0 5 2575 2580;0 5 2580 2585;0 5 2585 2590;0 5 2590 2595;0 5 2595 2600;0 5 2600 2605;0 5 2605 2610;0 5 2610 2615;0 5 2615 2620;0 5 2620 2625;0 5 2625 2630;0 5 2630 2635;0 5 2635 2640;0 5 2640 2645;0 5 2645 2650;0 5 2650 2655;0 5 2655 2660;0 5 2660 2665;0 5 2665 2670;0 5 2670 2675;0 5 2675 2680;0 5 2680 2685;0 5 2685 2690;0 5 2690 2695;0 5 2695 2700;0 5 2700 2705;0 5 2705 2710;0 5 2710 2715;0 5 2715 2720;0 5 2720 2725;0 5 2725 2730;0 5 2730 2735;0 5 2735 2740;0 5 2740 2745;0 5 2745 2750;0 5 2750 2755;0 5 2755 2760;0 5 2760 2765;0 5 2765 2770;0 5 2770 2775;0 5 2775 2780;0 5 2780 2785;0 5 2785 2790;0 5 2790 2795;0 5 2795 2800;0 5 2800 2805;0 5 2805 2810;0 5 2810 2815;0 5 2815 2820;0 5 2820 2825;0 5 2825 2830;0 5 2830 2835;0 5 2835 2840;0 5 2840 2845;0 5 2845 2850;0 5 2850 2855;0 5 2855 2860;0 5 2860 2865;0 5 2865 2870;0 5 2870 2875;0 5 2875 2880;0 5 2880 2885;0 5 2885 2890;0 5 2890 2895;0 5 2895 2900;0 5 2900 2905;0 5 2905 2910;0 5 2910 2915;0 5 2915 2920;0 5 2920 2925;0 5 2925 2930;0 5 2930 2935;0 5 2935 2940;0 5 2940 2945;0 5 2945 2950;0 5 2950 2955;0 5 2955 2960;0 5 2960 2965;0 5 2965 2970;0 5 2970 2975;0 5 2975 2980;0 5 2980 2985;0 5 2985 2990;0 5 2990 2995;0 5 2995 3000;0 5 3000 3005;0 5 3005 3010;0 5 3010 3015;0 5 3015 3020;0 5 3020 3025;0 5 3025 3030;0 5 3030 3035;0 5 3035 3040;0 5 3040 3045;0 5 3045 3050;0 5 3050 3055;0 5 3055 3060;0 5 3060 3065;0 5 3065 3070;0 5 3070 3075;0 5 3075 3080;0 5 3080 3085;0 5 3085 3090;0 5 3090 3095;0 5 3095 3100;0 5 3100 3105;0 5 3105 3110;0 5 3110 3115;0 5 3115 3120;0 5 3120 3125;0 5 3125 3130;0 5 3130 3135;0 5 3135 3140;0 5 3140 3145;0 5 3145 3150;0 5 3150 3155;0 5 3155 3160;0 5 3160 3165;0 5 3165 3170;0 5 3170 3175;0 5 3175 3180;0 5 3180 3185;0 5 3185 3190;0 5 3190 3195;0 5 3195 3200;0 5 3200 3205;0 5 3205 3210;0 5 3210 3215;0 5 3215 3220;0 5 3220 3225;0 5 3225 3230;0 5 3230 3235;0 5 3235 3240;0 5 3240 3245;0 5 3245 3250;0 5 3250 3255;0 5 3255 3260;0 5 3260 3265;0 5 3265 3270;0 5 3270 3275;0 5 3275 3280;0 5 3280 3285;0 5 3285 3290;0 5 3290 3295;0 5 3295 3300;0 5 3300 3305;0 5 3305 3310;0 5 3310 3315;0 5 3315 3320;0 5 3320 3325;0 5 3325 3330;0 5 3330 3335;0 5 3335 3340;0 5 3340 3345;0 5 3345 3350;0 5 3350 3355;0 5 3355 3360;0 5 3360 3365;0 5 3365 3370;0 5 3370 3375;0 5 3375 3380;0 5 3380 3385;0 5 3385 3390;0 5 3390 3395;0 5 3395 3400;0 5 3400 3405;0 5 3405 3410;0 5 3410 3415;0 5 3415 3420;0 5 3420 3425;0 5 3425 3430;0 5 3430 3435;0 5 3435 3440;0 5 3440 3445;0 5 3445 3450;0 5 3450 3455;0 5 3455 3460;0 5 3460 3465;0 5 3465 3470;0 5 3470 3475;0 5 3475 3480;0 5 3480 3485;0 5 3485 3490;0 5 3490 3495;0 5 3495 3500;0 5 3500 3505;0 5 3505 3510;0 5 3510 3515;0 5 3515 3520;0 5 3520 3525;0 5 3525 3530;0 5 3530 3535;0 5 3535 3540;0 5 3540 3545;0 5 3545 3550;0 5 3550 3555;0 5 3555 3560;0 5 3560 3565;0 5 3565 3570;0 5 3570 3575;0 5 3575 3580;0 5 3580 3585;0 5 3585 3590;0 5 3590 3595;0 5 3595 3600;0 5 3600 3605;0 5 3605 3610;0 5 3610 3615;0 5 3615 3620;0 5 3620 3625;0 5 3625 3630;0 5 3630 3635;0 5 3635 3640;0 5 3640 3645;0 5 3645 3650;0 5 3650 3655;0 5 3655 3660;0 5 3660 3665;0 5 3665 3670;0 5 3670 3675;0 5 3675 3680;0 5 3680 3685;0 5 3685 3690;0 5 3690 3695;0 5 3695 3700;0 5 3700 3705;0 5 3705 3710;0 5 3710 3715;0 5 3715 3720;0 5 3720 3725;0 5 3725 3730;0 5 3730 3735;0 5 3735 3740;0 5 3740 3745;0 5 3745 3750;0 5 3750 3755;0 5 3755 3760;0 5 3760 3765;0 5 3765 3770;0 5 3770 3775;0 5 3775 3780;0 5 3780 3785;0 5 3785 3790;0 5 3790 3795;0 5 3795 3800;0 5 3800 3805;0 5 3805 3810;0 5 3810 3815;0 5 3815 3820;0 5 3820 3825;0 5 3825 3830;0 5 3830 3835;0 5 3835 3840;0 5 3840 3845;0 5 3845 3850;0 5 3850 3855;0 5 3855 3860;0 5 3860 3865;0 5 3865 3870;0 5 3870 3875;0 5 3875 3880;0 5 3880 3885;0 5 3885 3890;0 5 3890 3895;0 5 3895 3900;0 5 3900 3905;0 5 3905 3910;0 5 3910 3915;0 5 3915 3920;0 5 3920 3925;0 5 3925 3930;0 5 3930 3935;0 5 3935 3940;0 5 3940 3945;0 5 3945 3950;0 5 3950 3955;0 5 3955 3960;0 5 3960 3965;0 5 3965 3970;0 5 3970 3975;0 5 3975 3980;0 5 3980 3985;0 5 3985 3990;0 5 3990 3995;0 5 3995 4000;0 5 4000 4005;0 5 4005 4010;0 5 4010 4015;0 5 4015 4020;0 5 4020 4025;0 5 4025 4030;0 5 4030 4035;0 5 4035 4040;0 5 4040 4045;0 5 4045 4050;0 5 4050 4055;0 5 4055 4060;0 5 4060 4065;0 5 4065 4070;0 5 4070 4075;0 5 4075 4080;0 5 4080 4085;0 5 4085 4090;0 5 4090 4095;0 5 4095 4100;0 5 4100 4105;0 5 4105 4110;0 5 4110 4115;0 5 4115 4120;0 5 4120 4125;0 5 4125 4130;0 5 4130 4135;0 5 4135 4140;0 5 4140 4145;0 5 4145 4150;0 5 4150 4155;0 5 4155 4160;0 5 4160 4165;0 5 4165 4170;0 5 4170 4175;0 5 4175 4180;0 5 4180 4185;0 5 4185 4190;0 5 4190 4195;0 5 4195 4200;0 5 4200 4205;0 5 4205 4210;0 5 4</pre>		

6. Data Inspector

Inspect and compare data and simulation results to validate and iterate model designs.

The Simulation Data Inspector visualizes and compares multiple kinds of data.

Using the Simulation Data Inspector, you can inspect and compare time series data at multiple stages of your workflow.

This model workflow the Simulation Data Inspector supports all stages of the design cycle:

- **View Data in the Simulation Data Inspector.**
Run a simulation in a model configured to log data to the Simulation Data Inspector, or import data from the workspace or a MAT-file. You can view and verify model input data or inspect logged simulation data while iteratively modifying your model diagram, parameter values, or model configuration.
- **Inspect Simulation Data.**
Plot signals on multiple subplots, zoom in and out on specified plot axes, and use data cursors to understand and evaluate the data. Create Plots Using the Simulation Data Inspector to tell your story.
- **Compare Simulation Data**
Compare individual signals or simulation runs and analyse your comparison results with relative, absolute, and time tolerances. The compare tools in the Simulation Data Inspector facilitate iterative design and allow you to highlight signals that do not meet your tolerance requirements. For more information about the comparison operation, see [How the Simulation Data Inspector Compares Data](#).
- **Save and Share Simulation Data Inspector Data and Views.**
Share your findings with others by saving Simulation Data Inspector data and views.

You can also harness the capabilities of the Simulation Data Inspector from the command line.

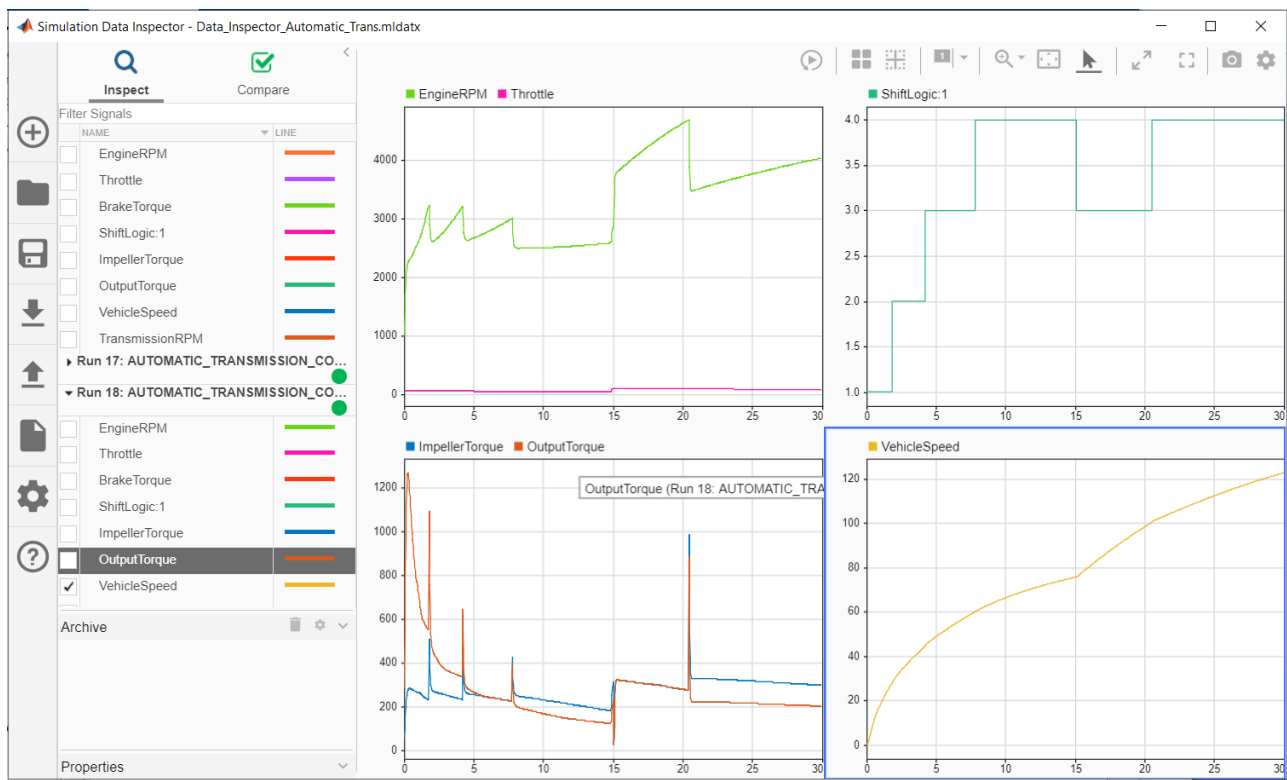


Figure 5 – Data Inspector of Automatic Transmission

7. Solver Selection Strategy

Simulink selects a solver for simulating the model, and it selects an auto solver. Auto solver chooses a suitable solver and sets the maximum step size of the simulation.

For this Simulink model Fixed-step type is used. *Fixed-step solvers* solve the model at regular time intervals from the beginning to the end of the simulation. The size of the interval is known as the step size. You can specify the step size or let the solver choose the step size. Generally, a smaller the step size increases the accuracy of the results but also increases the time required to simulate the system.

And the Solver used is ode5 (Dormand-Prince).

ODE45 Uses the fifth-order Dormand-Prince formula to compute the model state at the next time step as an explicit function of the current value of the state and the state derivatives approximated at intermediate points.

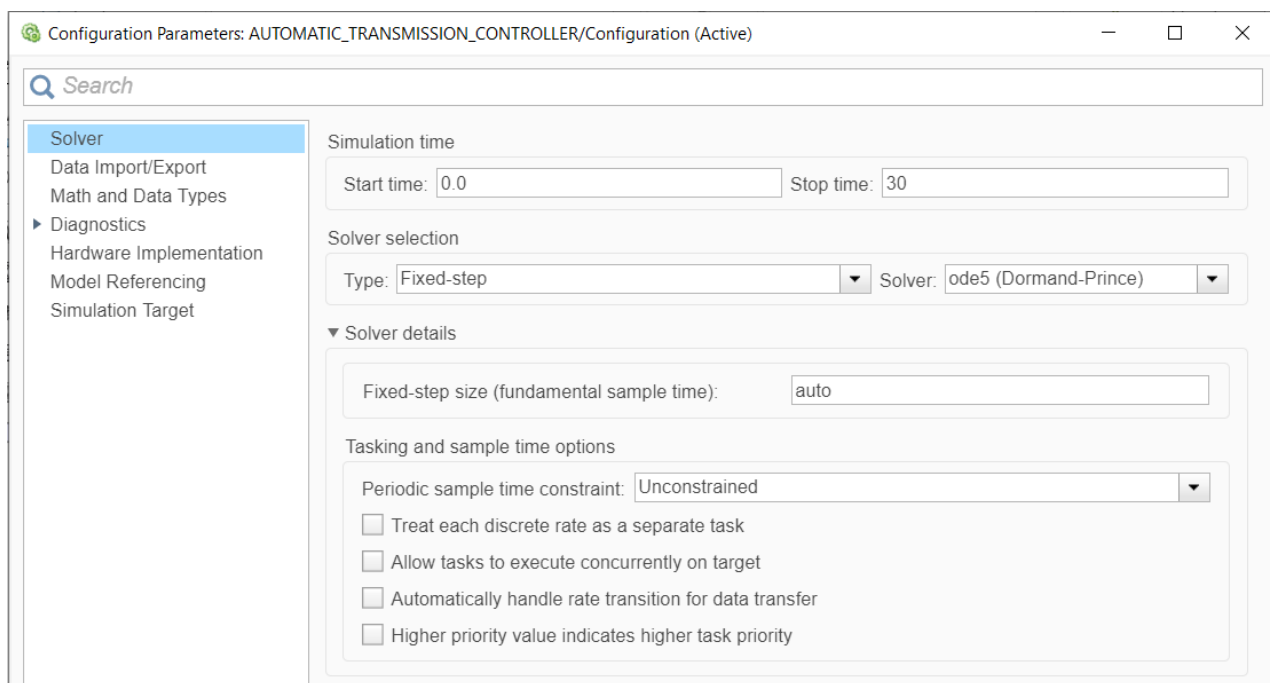


Figure 6 – Solver selection strategy

8. MATLAB Function Block

MATLAB Function blocks enable you to define custom functionality in Simulink models by using the MATLAB language.

MATLAB Function block to implement MATLAB functions to Simulink models to deploy code and embed code in processors. Using MATLAB Function block, you can generate readable, efficient, and compact C/C++ code for deployment to desktop and embedded applications.

In this model we used a MATLAB function block for defined equation. For this block there were three inputs in our model with single output.

With the help of input values of rload0 and rload2 we calculated the output of y using the equation.

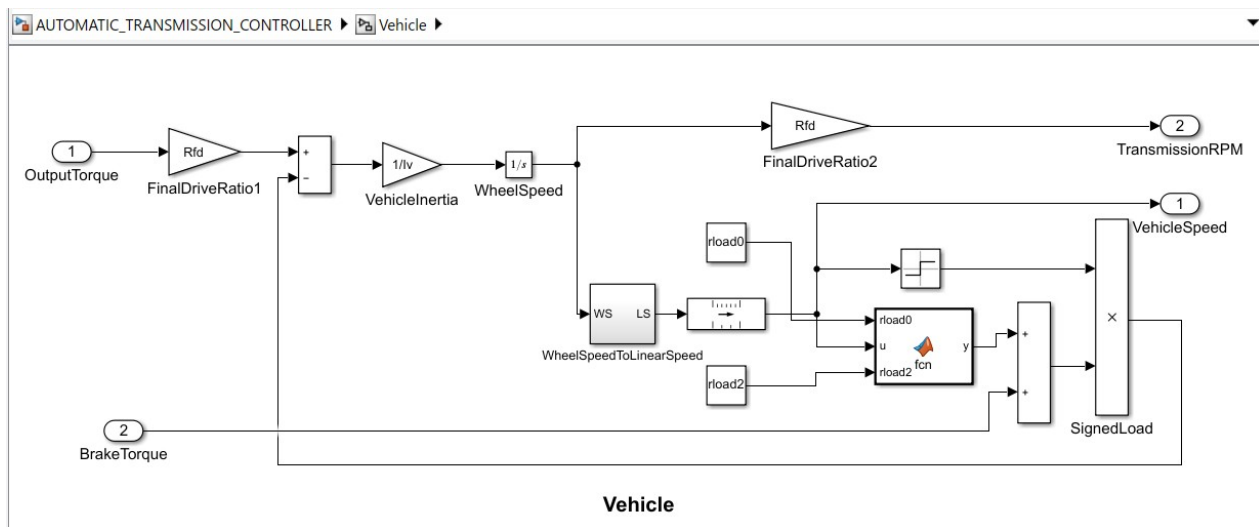


Figure 7 - MATLAB Function Block of Vehicle

9. Look-up Table

A *lookup table* is an array of data that maps input values to output values, thereby approximating a mathematical function. Given a set of input values, a lookup operation retrieves the corresponding output values from the table. If the lookup table does not explicitly define the input values, Simulink can estimate an output value using interpolation, extrapolation, or rounding, where:

- An interpolation is a process for estimating values that lie between known data points.
- An extrapolation is a process for estimating values that lie beyond the range of known data points.
- A rounding is a process for approximating a value by altering its digits according to a known rule.

In this Simulink model there three look-up tables. Look-up tables are used in engine and transmission.

An interpolation is a process for estimating values that lie between known data points.

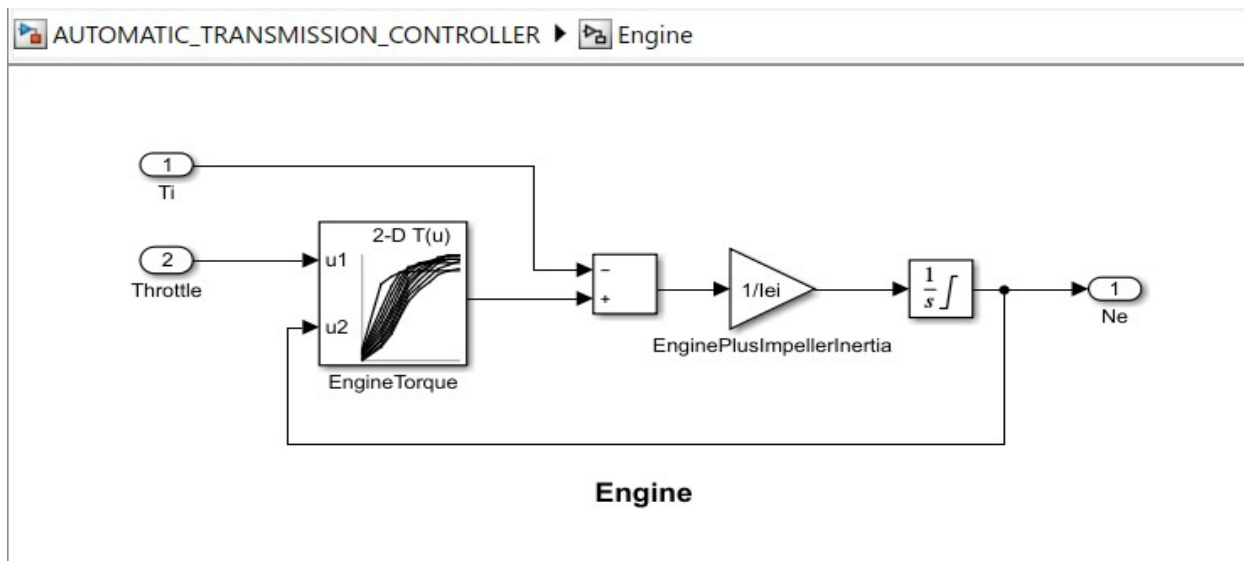


Figure 8 - Look-up Table of Engine

10. Signal Builder

Signal builder create and generate interchangeable groups of signals whose waveforms are piecewise linear.

You can quickly switch the signal groups into and out of a model to facilitate testing. In the Signal Builder window, create signals and define the output waveforms.

A Signal Builder also allows you to construct different kinds of test cases so that you are running all of them to study your model's behaviour. If you click on the "Start simulation" icon inside the Signal Builder, you will run the simulation with this signal as an output of the signal builder. You can modify the signal by clicking on one line or one point and moving it around. As you can see, this only modifies the location of the straight lines delimited by points or the location of the points.

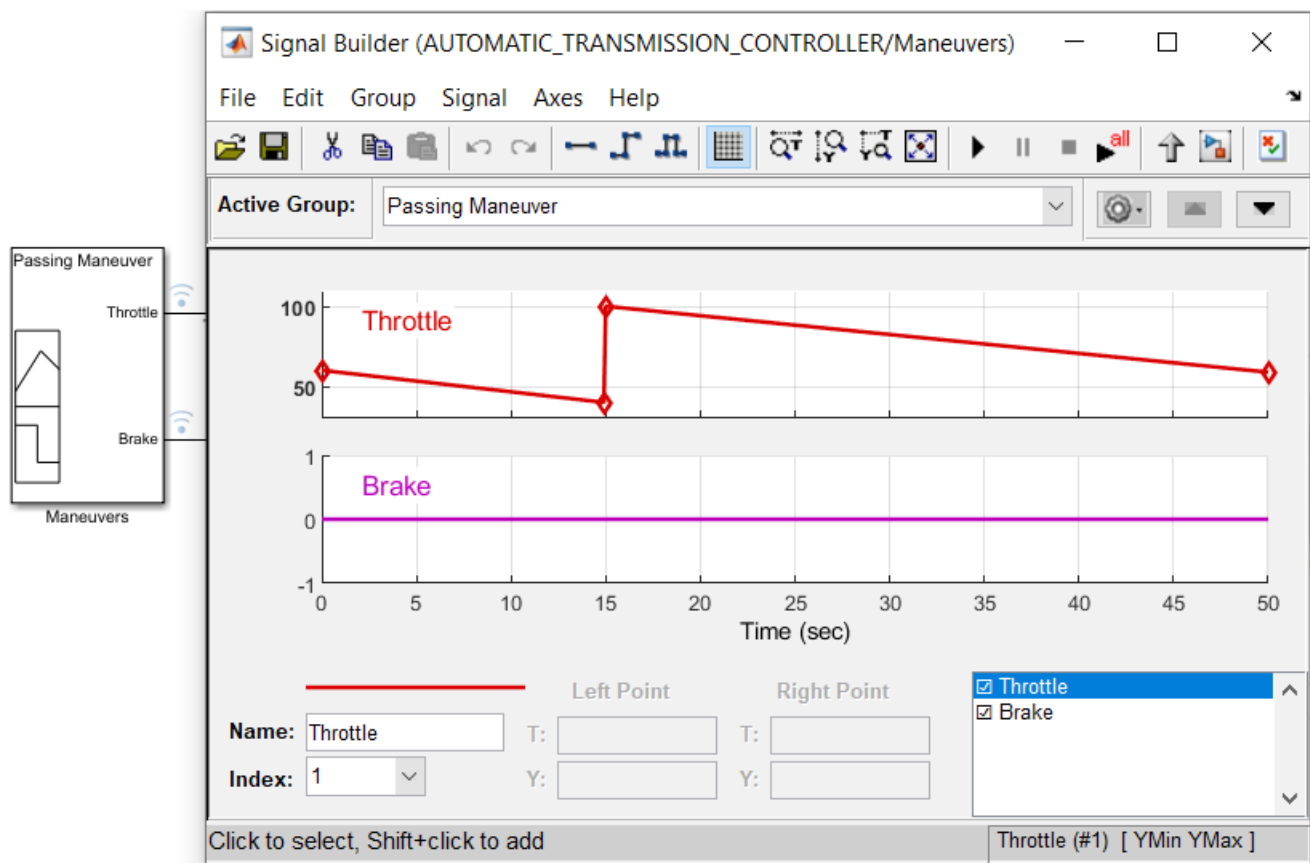


Figure 9 – Signal Builder of Input