# Tire Pressure Monitoring

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## Contents

All of the matlab exercises can be run by running script.m.

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## D1

**Three Point estimates in Minutes**

| Task No. | Best Case | Likely Case | Worst Case |
|---|---|---|---|
| D1 | 10 | 25 | 40 |
| D2 | 60 | 80 | 160 |
| D3 | 80 | 150 | 200 |
| D4 | 40 | 80 | 160 |
| D5 | 30 | 70 | 150 |
| D6 | 50 | 100 | 160 |
| D7 | 40 | 70 | 120 |
| D8 | 30 | 50 | 120 |
| D9 | 40 | 60 | 100 |
| D10 | 30 | 60 | 120 |
| D11 | 40 | 60 | 100 |
| D12* | 40 | 70 | 100 |
| D13* | 20 | 40 | 60 |
| D14* | 30 | 50 | 70 |
| Sum (min) | 540 | 965 | 1660 |
| Sum (hours) | 9 | 16.08 | 27.67 |
| Result (min) | 1010 | | |
| Result (hours) | 16.83 | | |

## D2

Files: findRadius.m

Given the formulas

$$R_{RR} = W + R_{RL}$$

and

$$\frac{V_x}{V_y} = \frac{R_x}{R_y}$$

and velocities for all the wheels during the entire duration of the test data one can determine the curve radiuses easily as such:

$$R_{RL} = \frac{W}{\frac{V_{RR}}{V_{RL}} - 1}$$

$$R_{RR} = \frac{R_{RL} \cdot V_{RR}}{V_{RL}}$$

$$R_{FR} = \frac{R_{RL} \cdot V_{FR}}{V_{RL}}$$

$$R_{FL} = \frac{R_{RL} \cdot V_{FL}}{V_{RL}}$$

Another approach is the pythagoras formula which we ended up using in our final version.

$$R_{RL} = \frac{W}{\frac{V_{RR}}{V_{RL}} - 1}$$

$$R_{RR} = R_{RL} + W$$

$$R_{FR} = \sqrt{W^2 + R_{RR}^2} \cdot signum(R_{RR})$$

$$R_{FL} = \sqrt{W^2 + R_{RL}^2} \cdot signum(R_{RR})$$

In MatLab:

```
w_m=zeros(size(tv));
w_m(:,1) = w;
R_RL=(w_m./((vrr./vrl)-1));
R_RR=R_RL+w;
% sign function ensures that all signs are the same
R_FR=(sqrt(w^2 + R_RR.^2)) .*sign(R_RR);
R_FL=(sqrt(w^2 + R_RL.^2)) .*sign(R_RR);
```

For the simulink simulation and to prevent errors, bad values like inf an NaN are replaced with 0.

```
% Filter bad values
R_RR(isnan(R_RR)|isinf(R_RR)) = 0.0;
R_RL(isnan(R_RL)|isinf(R_RL)) = 0.0;
R_FR(isnan(R_FR)|isinf(R_FR)) = 0.0;
R_FL(isnan(R_FL)|isinf(R_FL)) = 0.0;
```
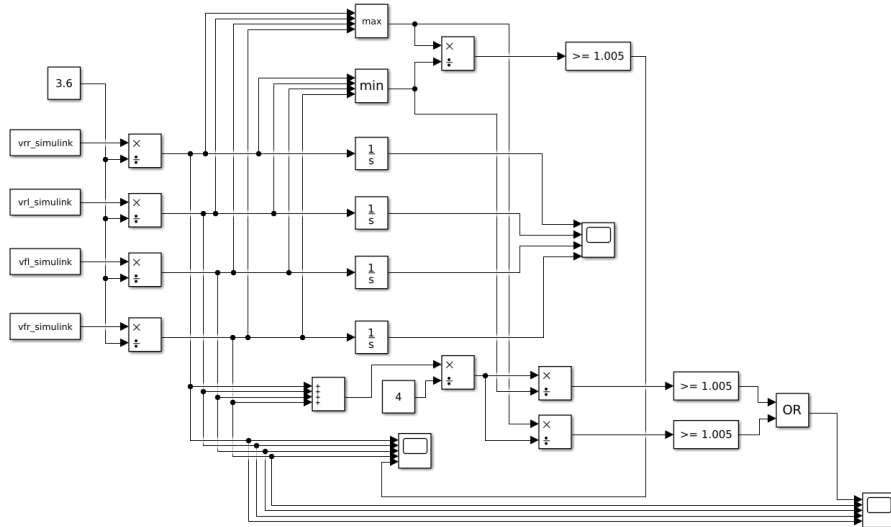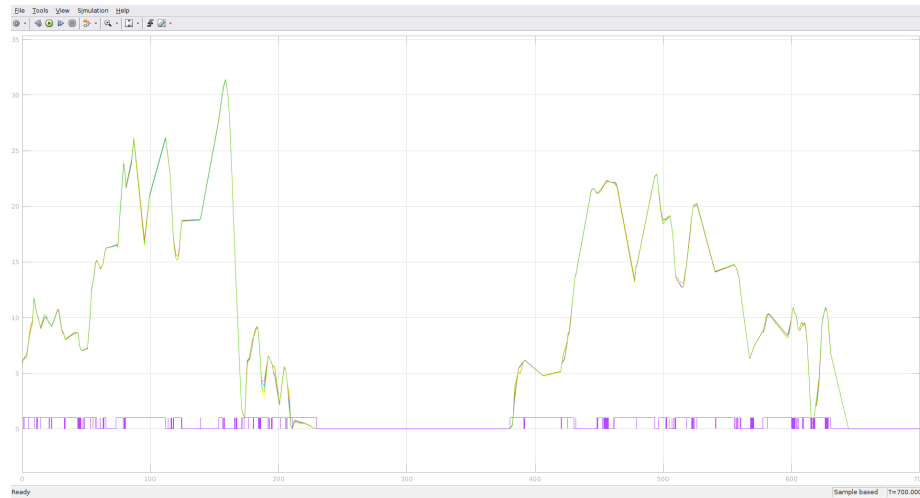
Result:
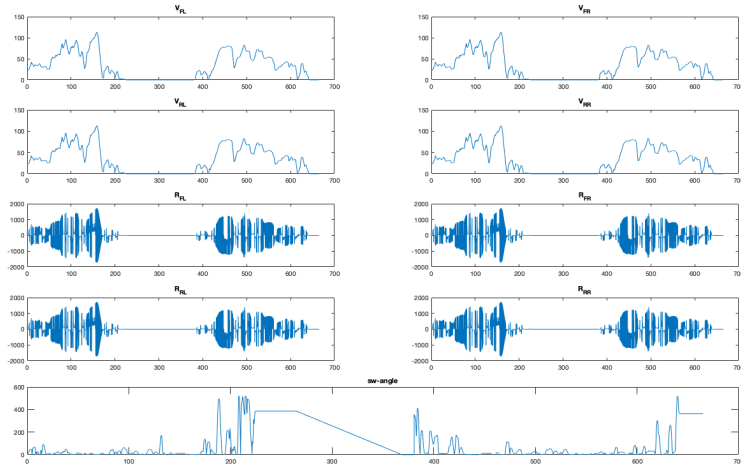


## D3

Files: D3.slx

The simulink model for D3 is provided with the velocities of the respective wheels of the vehicle. It converts the values that are given in $\frac{km}{h}$ into $\frac{m}{s}$ by dividing by 3.6. As to the Requirement R2, we think there are at least two interpretations of the word "imbalance". Both are present in the simulink model.

## First Interpretation

If any two tires differ by 0.5% in their velocities, a drop is detected. This method is implemented by taking minimum and maximum values of the four velocities at any time and dividing them to see if the two most exteme wheels differ by 0.5%. This produces the following result:



## Second Interpretation

The maximum and minimum velocities are compared to the average of all velocities. If either the minimum or maximum velocity differs by 0.5% an imbalance is detected. This produces the following result:
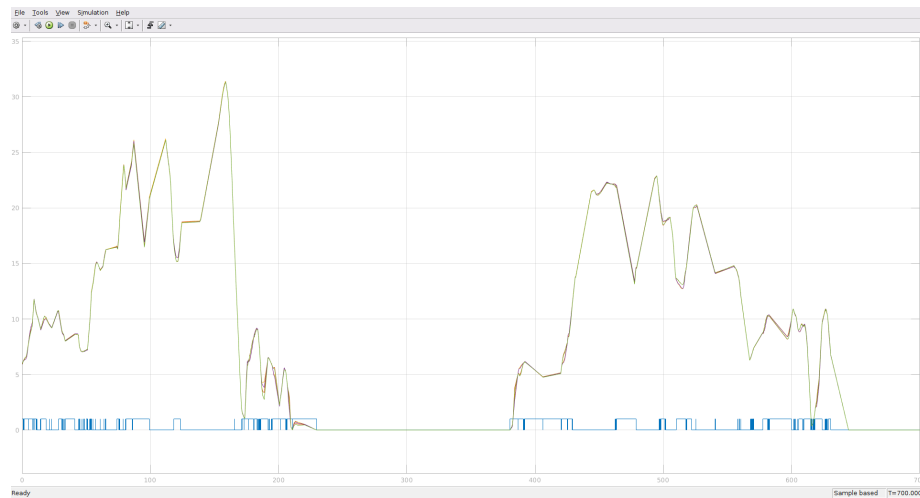
## D4

If the difference between the maximum distance and the minimum distance is greater then 0.5% the system will detect tire pressure drop. This is essentially the same as D3 but with the travelled distance of the wheels instead of their velocities. A delay block is used to get a $\delta S = S(t) - S(t-10)$ which is the traveled speed in the last 10 time units. As in D3 there are two approaches to detecting an "imbalance" both of which can be seen below.
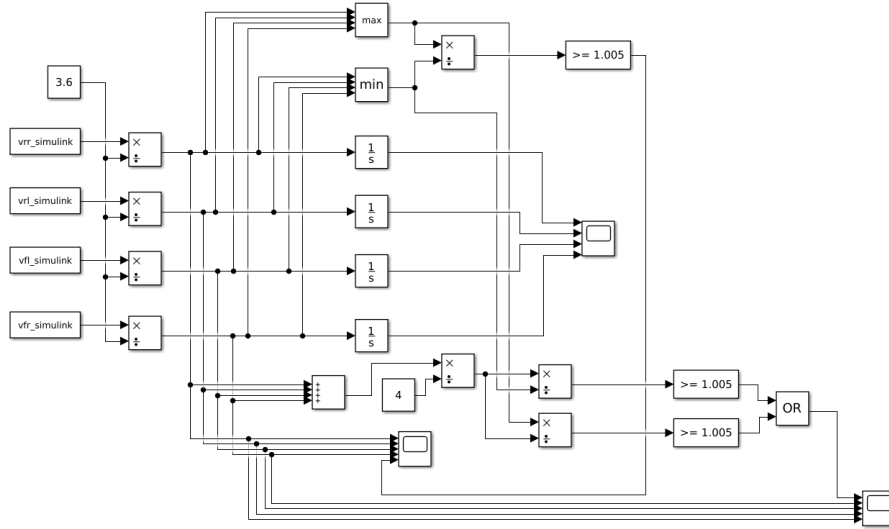


## D5

The m and c parameters of the given random number generator are the upper and lower limit for the values generated. An initial value has to be chosen and functions as seed.

---

```matlab
%randomNumberGenerator.m

function [dataset] = randomNumberGenerator(a, min, max, seed, n)
% Generater random test data for D5
% seed = X(0)
% n = length
% a,c,m according to formula of task D5

% Preallocate return array
dataset = zeros(1, n);
% Set seed
dataset(1) = seed;
```

```
for i = 2:1:n
    dataset(i) = mod(round((a * dataset(i-1) + min)), round(max))
    %fprintf('(%d * %d + %d) mod %d\n',a,dataset(i-1),c,round(max))
end
```

---

By varying this seed, random data for the wheel velocities can be generated by
only varying the seed.

---

```
% Generate own tire velocity data for testing using randomNumberGenerator()
% Will generate data up to 80 km/h per wheel

vrl_rand = randomNumberGenerator(5, 3, 80, 1, 56093)
vrr_rand = randomNumberGenerator(5, 3, 80, 2, 56093)
vfl_rand = randomNumberGenerator(5, 3, 80, 3, 56093)
vfr_rand = randomNumberGenerator(5, 3, 80, 4, 56093)
```

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