Case Simulink

Nils Broes
Sander Cruysberghs
Régis de Biolley
Frederick Eskens
Seppe Verbist

Case Simulink

Simulink is used to simulate the behavior of the SSV beforehand. This will be done with three simulations. First of all we only simulate the solar panel and try to get the maximum power output by changing the resistance. Secondly we simulate the SSV rolling down the slope. Finally we simulate the race conditions

a. Determination of resistance

The simulation to determine the resistance at which the power output is the greatest, a little circuit is used that is shown in figure 1.

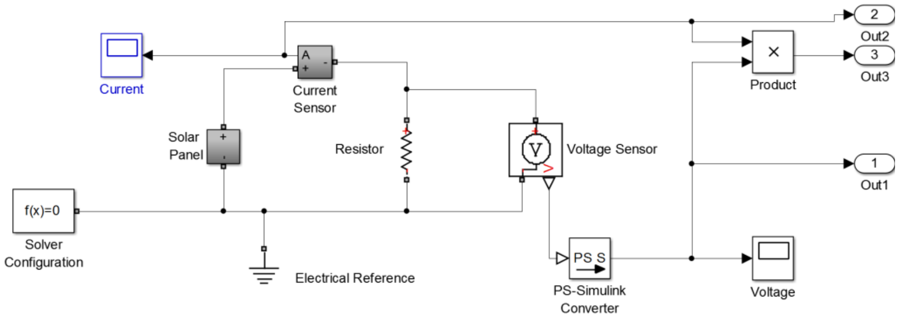

Figure 1: Solar panel circuit

The simulation was ran for different resistor values. To determine at what value the power is highest, all different power outputs were plotted per resistor in figure 2.

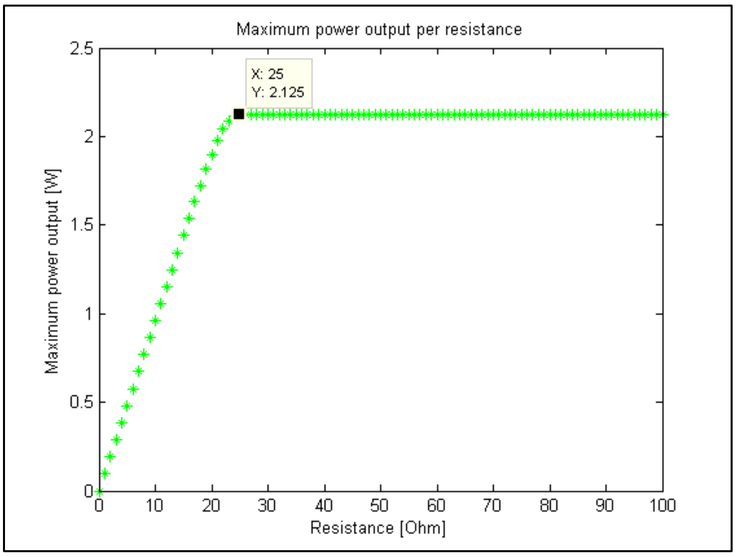

Figure 2: Maximum power output for each resistor value

The minimal resistor value that dissipates maximal power can be deduced from figure 2 by locating the point on the curve at which the resistor value is smallest and the power is largest. The power output remains the same for every resistor value greater than 25 Ω. This means the resistor dissipates maximum voltage.

To conclude, at a resistor value of 25 Ω, the power output reaches a maximum value of 2,125 W.

For this resistor value, a I-U and P-U graph can be made, as done in figure 3 and figure 5, respectively.

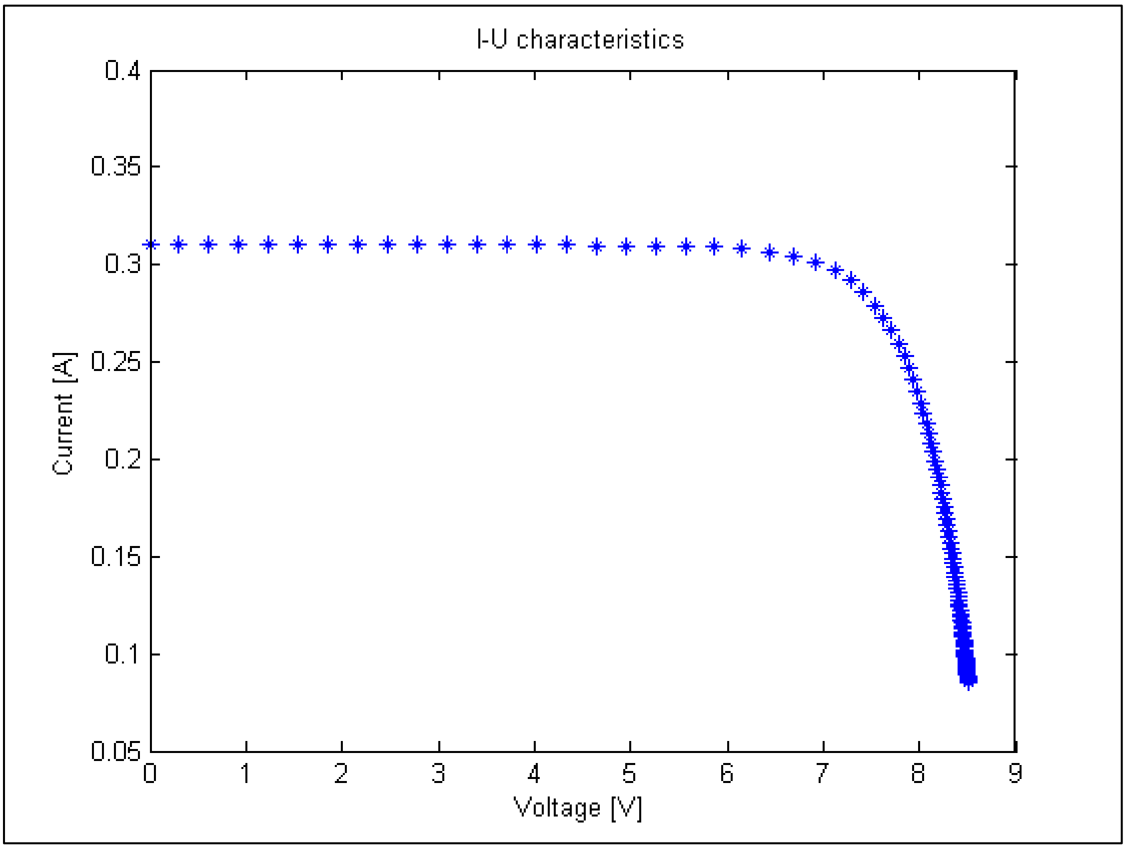

Figure 3: I-U characteristics at R = 25 Ω

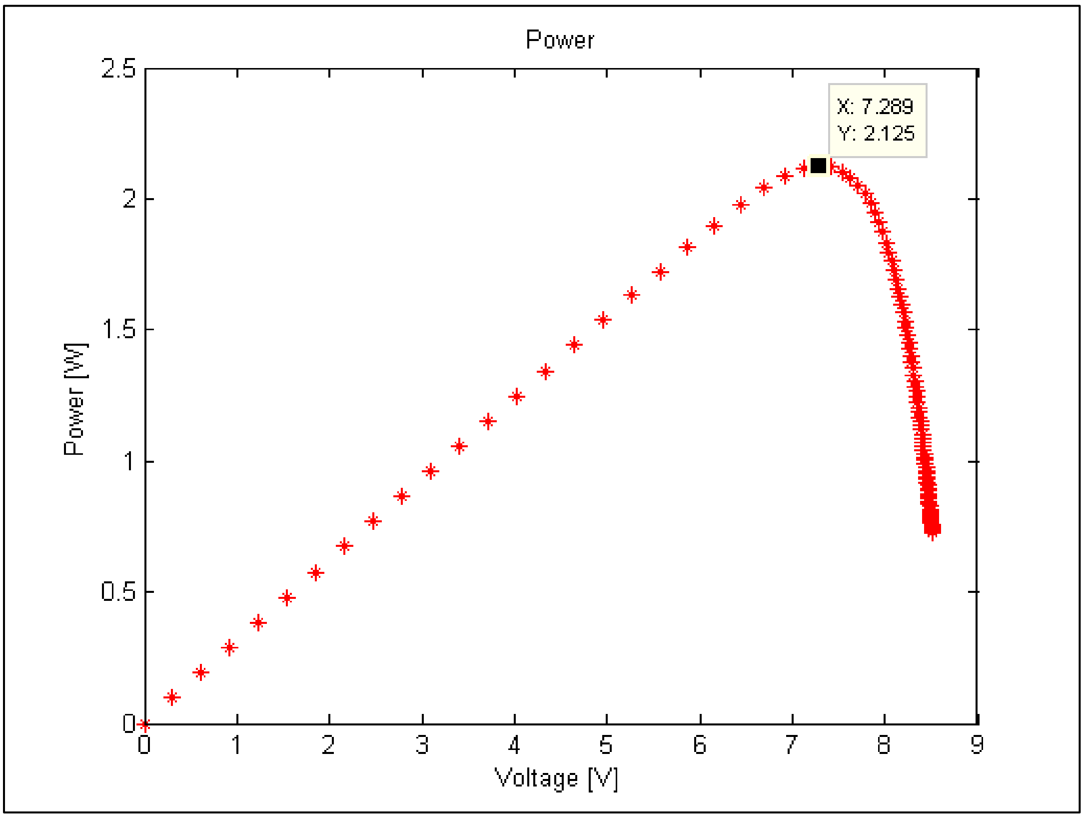

Figure 4: P-U characteristics at R = 25 Ω

These graphs look very alike to the graphs in the previous reports.

b. Behaviour without solar panel

To simulate the SSV rolling down, without the solar panel, the irradiance of the sun was set to zero. That way, the solar panel doesn't dissipate any power. Physical factors like air resistance and rolling resistance are taken into account. To determine the length the SSV rolled, the position was plotted in function of time, as shown in figure 2.

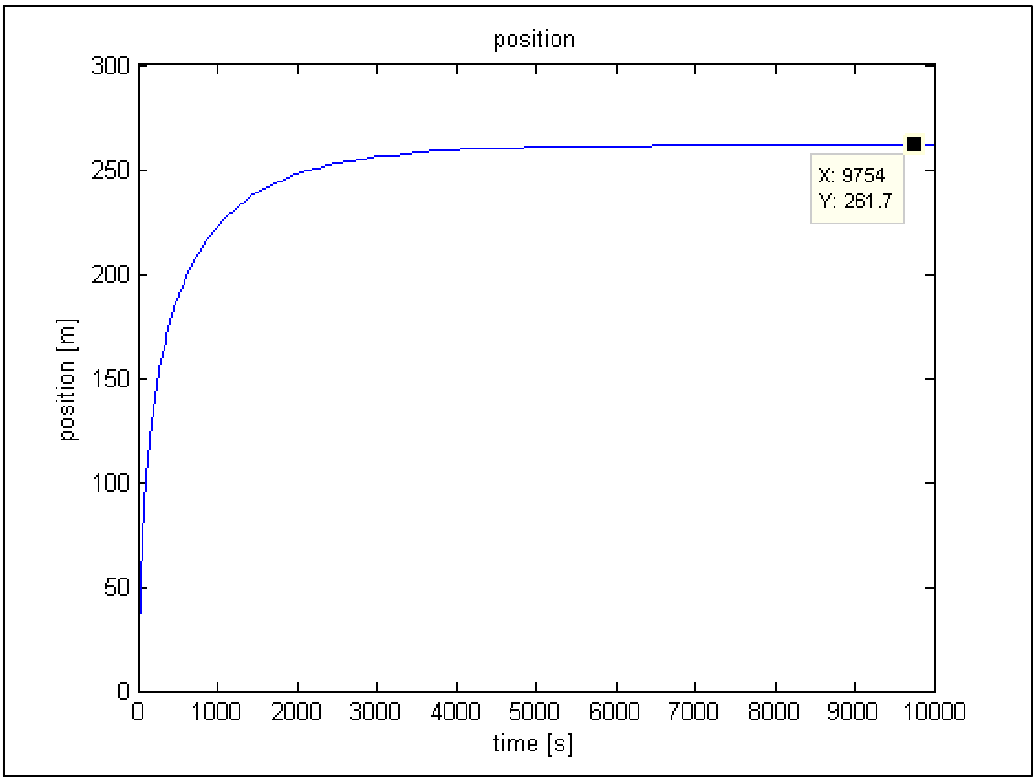

Figure 5: Position of SSV in function of time

When time goes to infinite, the graph shows the position nears one value. This value is the position where the SSV will stop rolling and stand still. In this case, the SSV will stop at approximately 261,7 meters.

c. Simulation of the race

For the final simulation, the model of the solar panel was extended with physical parameters to accurately simulate the physical SSV. The used model is shown in figure 3.

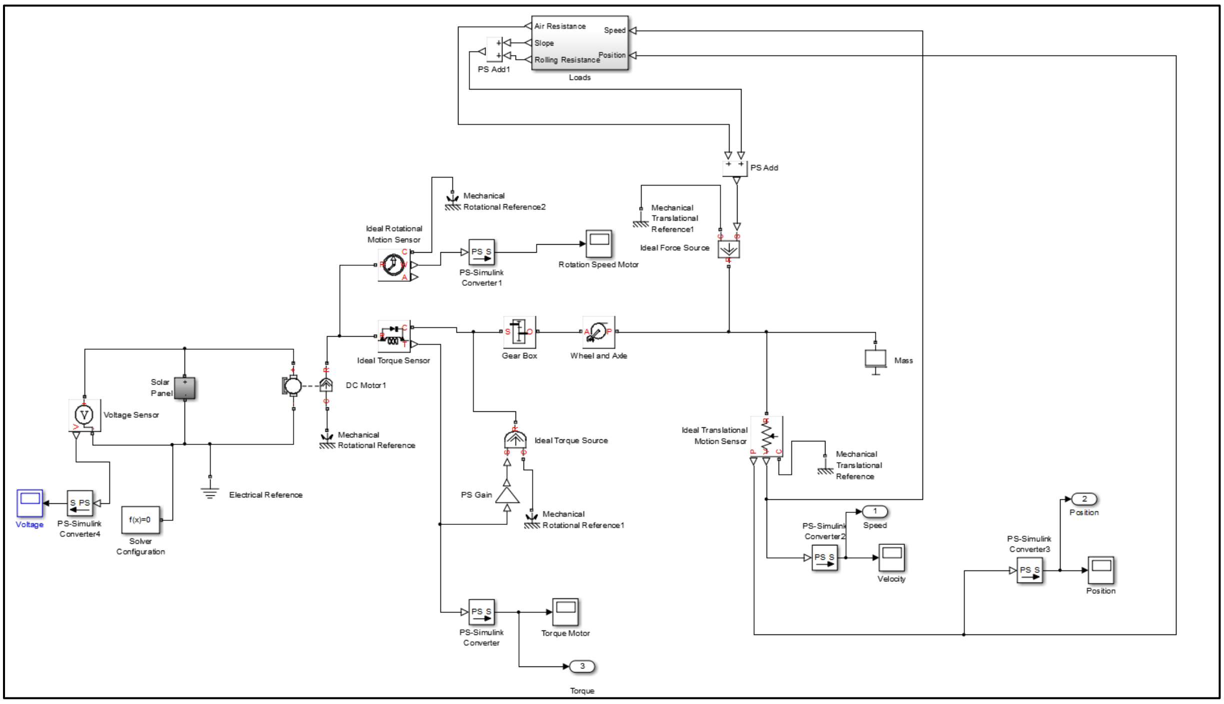

Figure 6: Simulink model

When running this model, another gear ratio graph can be made to determine the optimal gear ratio. This time, the result will be more accurate because more external factors are taken into account. The new optimal gear ratio, as seen in figure 4, is now 13,75.

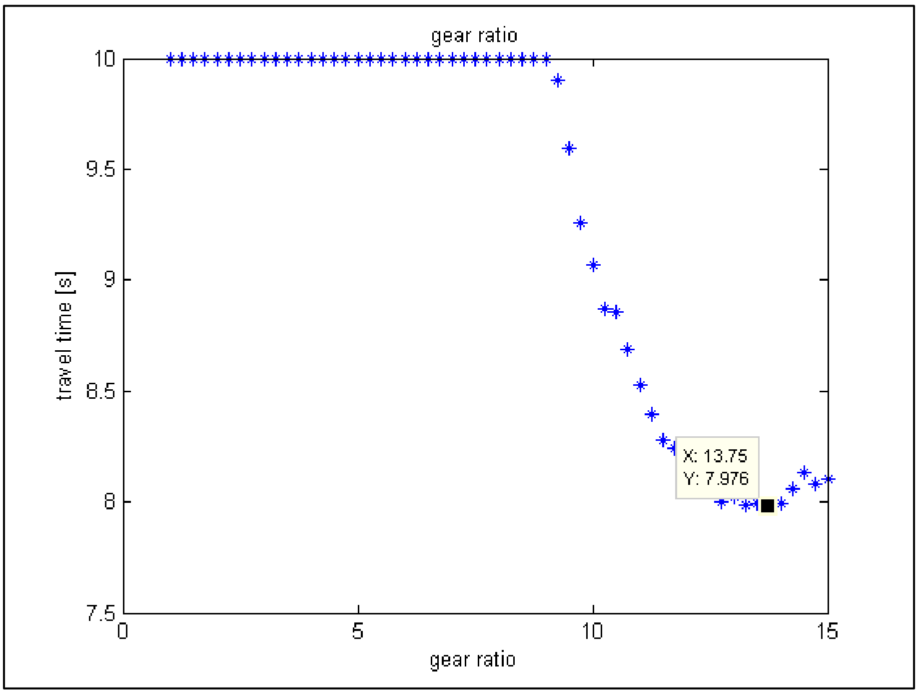

Figure 7: Travel time for each gear ratio

Figure 3 show great similarity to the graph we saw in the previous report. Also this time the first gear ratios are all at 10 seconds (the length the simulation ran) because they don't reach 14 meters. The curve begins to drop at about gear ratio 9 and reaches a minimum of 8 seconds at gear ratio 13,75.

Since the optimal gear ratio is now known, new graphs can be made for the position and speed. These are shown in figure 5 and 6, respectively.

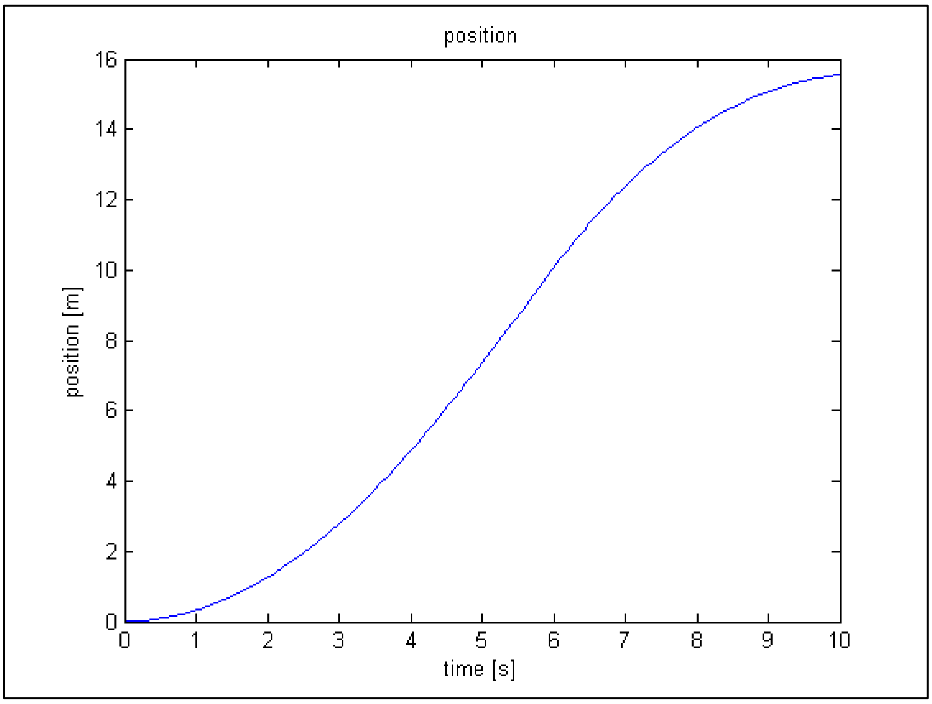

Figure 8: Position in function of time at gear ratio 13,75

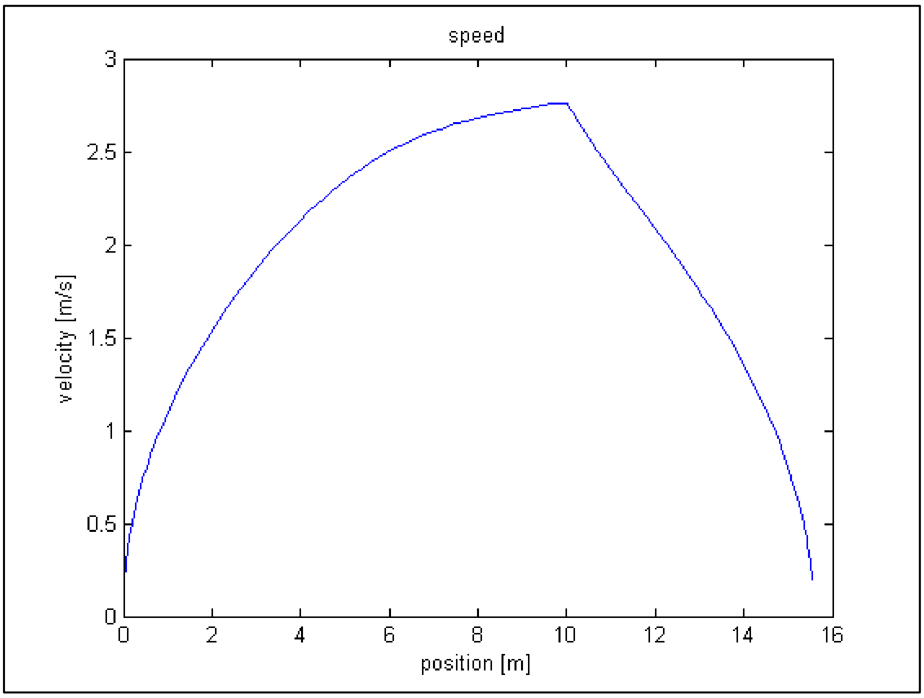

Figure 9: Speed in function of position at gear ratio 13,75

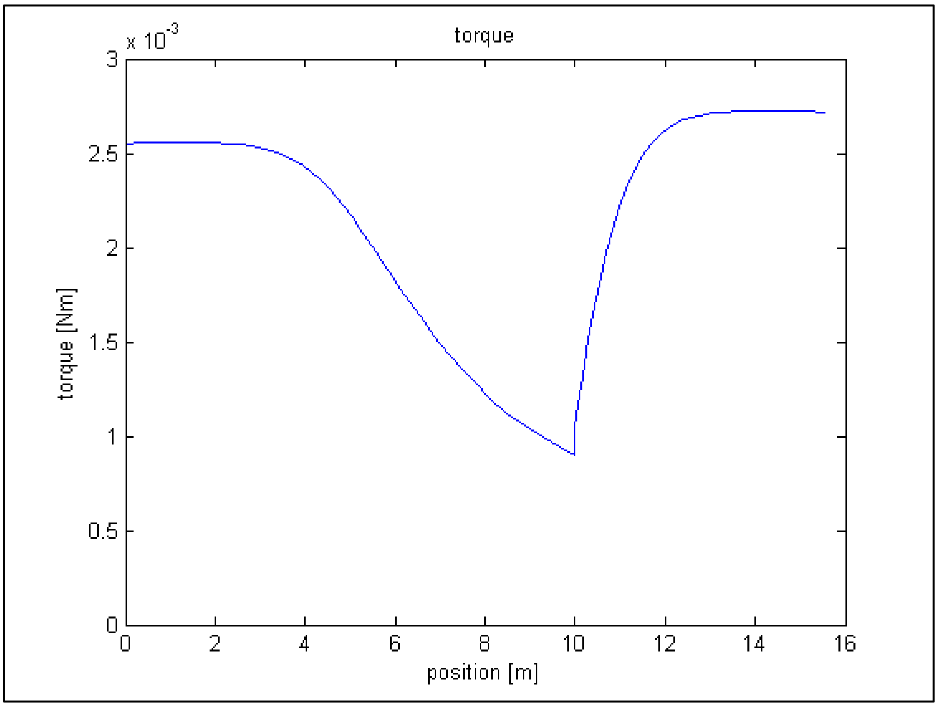

Figure 10: Torque in function of position at gear ratio 13,75

In figure 5, the position rises quite quickly until the acceleration is constant. Next, it rises linearly. At the end, starting at the 10 meter mark, it slowly decreases as it's riding on the slope.

In figure 6, it is clear that the speed drops drastically at 10 meters, the place where the slope starts.

d. Reason of simulation

The simulations were ran so the optimal gear ratio could be determined. That way no physical test were required. This makes it a lot cheaper and faster because no parts are needed in advance.

The simulations also allow us to know how the SSV will run in real life without building a prototype. That why different parameters can be altered so maximum efficiency can be achieved.

e. Attachements

Attachment A

This is the script that is ran in MatLab, to simulate the race for different gear ratios.

```
%%% Solar Power
Ir = 700 ;    % solar irradiance [W/m^2]
Is = 1e-8;    % saturation current [A]
Isc = 0.31;   % short circuit current [A]
Voc = 8.67/15;   % Open circuit voltage [V]
Ir0 = 700;   % irradiance used for measurements [W/m^2]
m = 1.27;     % diode quality factor

%%% Motor parameters
Ra = 3.32;     % Terminal Resistance [ohm]
Km = 8.55e-3;     % Torque constant [Nm/A]
L  = 0.22e-3;     % Terminal inductance [H]
Im = 4.10;     % Rotor inertia [g*cm^2]
Cm = 2.42e-4;     % [N*m/(rad/s)]
Sc = 1/1120;    % Back emf constant [V/rpm]

%%% SSV parameter
mass = 1;   % kg
Cw   = 0.5;
A    = 0.0485;    % m^2
rho = 1.17;    % kg/m^3
Crr = 0.0055 ;

%%% Wheel radius
r = 0.04 ; % m

%%% Track

% put parameters track here %

result=[];
tn=[];
for ratio=1:0.25:15
    ratio
    tn=[tn ratio];    % Extend vector with current ratio
    sim('SSV_model',10);    % Simulate Simulink model for 10 s
    [i,j]=find(yout(:,2)>14);    % find when position of 14 m is achieved
    if isempty(i)
        result = [result 10];  % if not achieved take time = 10 s
    else
        result = [result tout(i(1))];    % put travel time in vector
    end

end

figure(1)
plot(tn,result,'*') % plot gear ratio versus travel time
xlabel('gear ratio')
ylabel('travel time [s]')
title(['gear ratio'])

[opt,i]=min(result); % find minimal travel time
```

```
ratio=tn(i); % select gear ratio corresponding to the minimal travel time

% simulate once more with best gear ratio and make a few plots
sim('SSV_model',10);

figure(2)
plot(yout(:,2),yout(:,1))
xlabel('position [m]')
ylabel('velocity [m/s]')
title(['speed'])
figure(3)
plot(tout,yout(:,2))
xlabel('time [s]')
ylabel('position [m]')
title(['position'])
figure(4)
plot(yout(:,2),yout(:,3))
xlabel('position [m]')
ylabel('torque [Nm]')
title(['torque'])
```

Attachment B

This is the script that is ran in MatLab, to find the final position of the SSV after rolling down a slope.

```
%%% Solar Power
Ir = 0 ;   % solar irradiance [W/m^2]
Is = 1e-8;   % saturation current [A]
Isc = 0.31;  % short circuit current [A]
Voc = 8.67/15;  % Open circuit voltage [V]
Ir0 = 700;  % irradiance used for measurements [W/m^2]
m = 1.27;    % diode quality factor

%%% Motor parameters
Ra = 3.32;    % Terminal Resistance [ohm]
Km = 8.55e-3;    % Torque constant [Nm/A]
L  = 0.22e-3;    % Terminal inductance [H]
Im = 4.10;    % Rotor inertia [g*cm^2]
Cm = 2.42e-4;    % [N*m/(rad/s)]
Sc = 1/1120;   % Back emf constant [V/rpm]

%%% SSV parameter
mass = 1;  % kg
Cw   = 0.5;
A    = 0.0485;   % m^2
rho = 1.17;   % kg/m^3
Crr = 0.0055 ;
ratio=13.75; % gear ratio

%%% Wheel radius
r = 0.04 ; % m

%%% Track

% put parameters track here %



sim('SSV_model_downhill',10000);   % Simulate Simulink model for 10 s

figure
plot(tout,yout(:,2))
xlabel('time [s]')
ylabel('position [m]')
title(['position'])
```

Attachment C

This is the script that is ran in MatLab, to determine the maximum power output of the solar panel, when different resistances are connected.

```
clear all;
close all;

%%% Solar Power
Ir = 700      ;   % solar irradiance [W/m^2]
Is = 1e-8 ;   % saturation current [A]
Isc = 0.31     ;   % short circuit current [A]
Voc = 8.67/15     ;   % Open circuit voltage [V]
Ir0 = 700 ;   % irradiance used for measurements [W/m^2]
m = 1.27       ;   % diode quality factor

Rr=[];
V=[];
I=[];
P=[];
Pmax=[];
M=0;

for R=0:1:100

    sim('Solar_panel_model',10); % Simulate Simulink model
"Solar_panel_model.mdl" for 10 sec.

    Rr=[Rr R];
    V = [V yout(end,1)];
    I = [I yout(end,2)];
    P = [P yout(end,3)];
    Pmax = [Pmax max(P)]
    if (max(P)>M)
        M = max(P);
        Rmax=R;
    end
end

R=Rmax
sim('Solar_panel_model',10)

figure(1)
plot(V,I,'b*');
xlabel('Voltage [V]');
ylabel('Current [A]');
title('I-U characteristics')

figure(2)
plot(V,P,'r*');
ylabel('Power [W]');
xlabel('Voltage [V]');
title('Power')

figure (3)
plot(Rr,Pmax,'g*');
xlabel('Resistance [Ohm]');
ylabel('Maximum power output [W]')
title('Maximum power output per resistance')
```