Esté

Design a SSV

Small solar vehicle

Case Simulink

2012-2013

1. Simulate the solar panel with the resistor

In this section, the behavior of the solar panel was simulated. First, a subsystem was created where the solar panel is specified as a circuit of solar cells in series. The correct values of the parameters of the solar cells were inserted.

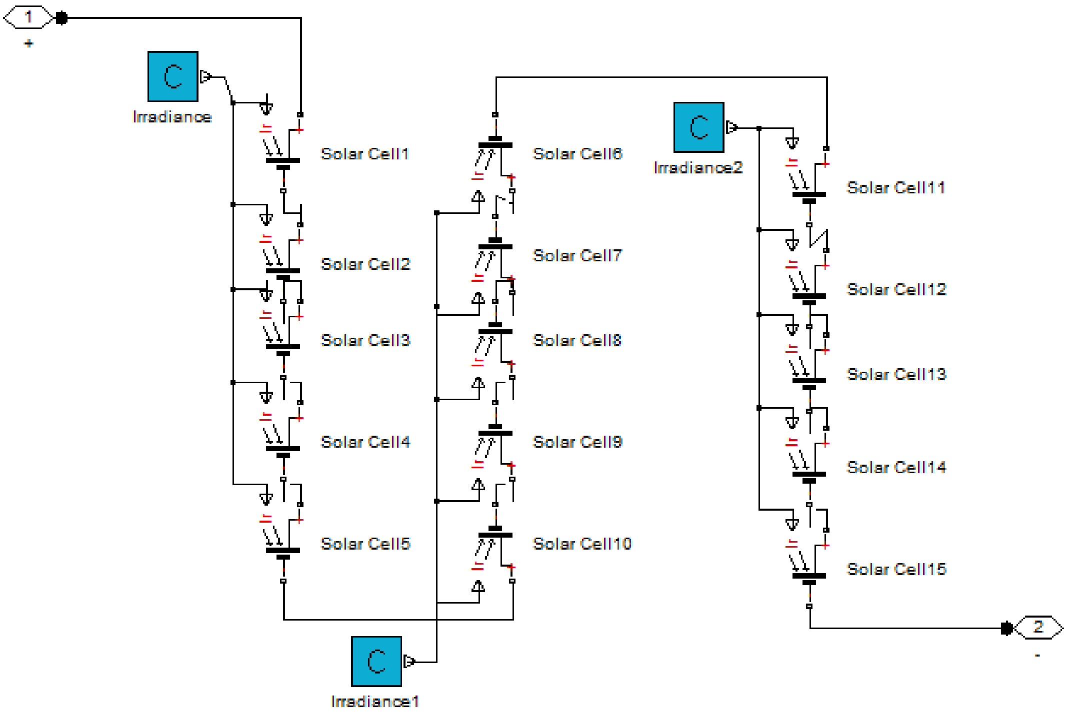


Figure 1: Simulink model- Solar panel

Next, the following circuit was designed in Simulink, where the solar panel was used as a subsystem:

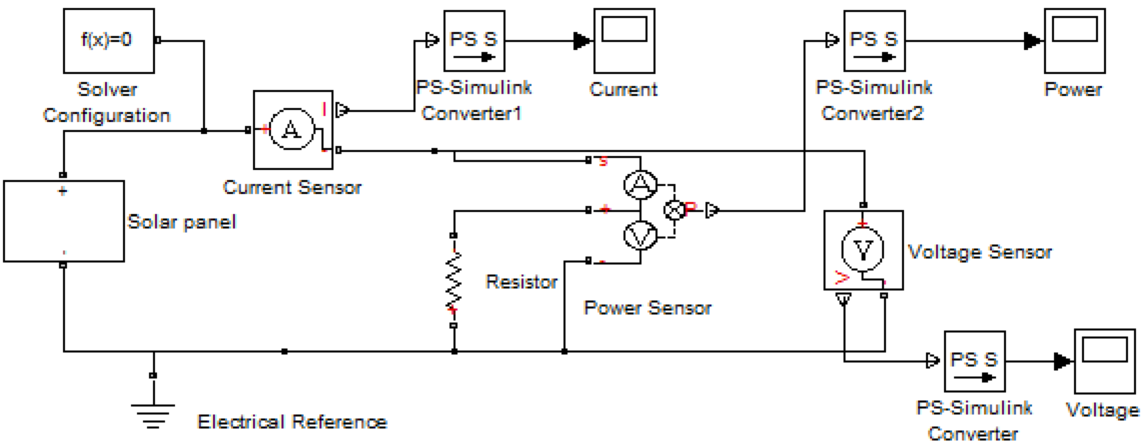


Figure 2: Simulink model

Changing the value of the resistance in the resistor, each time the exact values of the current, voltage and the power could be determined via the scopes. In the next figure, an example of the readings at the scopes has been given (at 10 Ω):

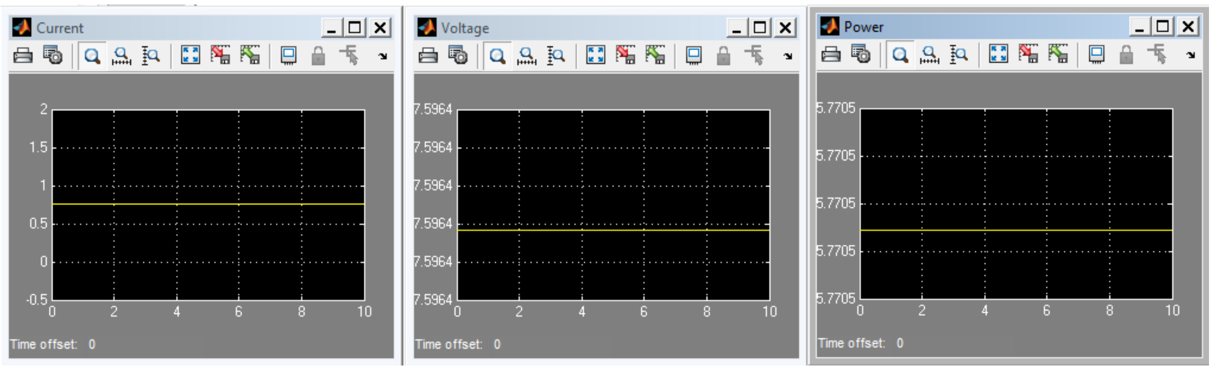


Figure 3: Readings at the scopes

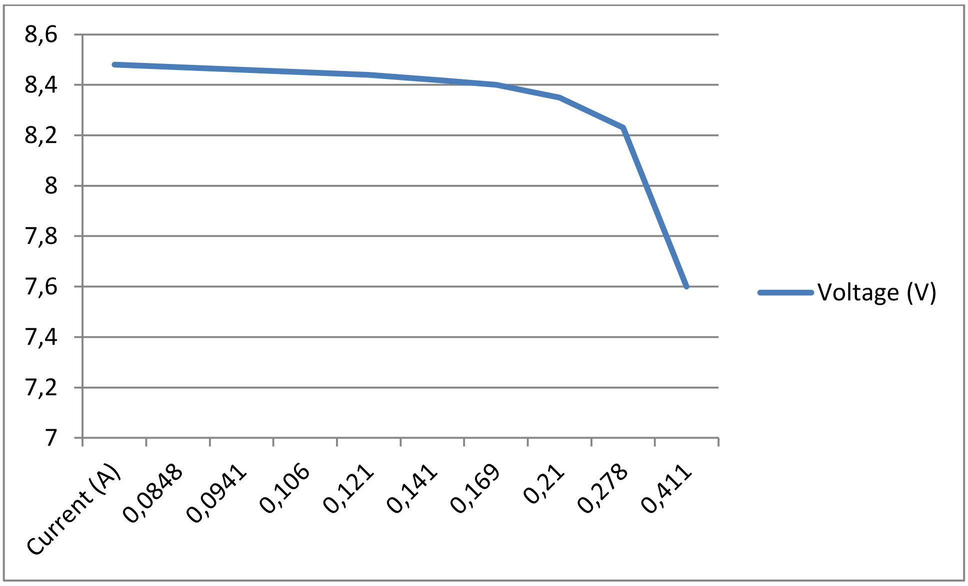
The results for the different simulations turned out to be:

Resistance (Ω)	Current (A)	Voltage (V)	Power (W)
10	0,76	7,6	5,77
20	0,411	8,23	3,39
30	0,278	8,35	2,32
40	0,21	8,4	1,76
50	0,169	8,42	1,42
60	0,141	8,44	1,19
70	0,121	8,45	1,02
80	0,106	8,46	0,895
90	0,0941	8,47	0,797
100	0,0848	8,48	0,718

Table 1: Results

From these results, the conclusion came quickly; the resistance of the resistor needs to be 10 Ω to become the greatest power so the maximum power transfer will be at 10 Ω.

Graph representing the voltage (y-axis) in function of the current (x-axis) for the different resistance values:



Graph 1: Current and voltage

2. Simulate the DC-motor

For this part, a specific model in Simulink was developed. (To be found in the addendum). This model takes into account the air resistance and the rolling resistance of the solar vehicle, where the rolling resistance has been calculated for different situations. The DC- motor is in this case connected to a voltage source with a value of 0 V.

The value of the rolling resistance changes when the position of the solar vehicle exceeds 2 meters. The following formula was used to determine the force because of the rolling resistance, with N as normal force:

$$F = Crr\ N$$

The value of the air resistance is of course proportional to the square of the velocity of the vehicle. The following formula was used to determine the force because of the air resistance:

$$F = \frac{1}{2} \rho\ A\ Cw\ v^2$$

When the simulation was at an end, these graphs were to be seen at the scopes:

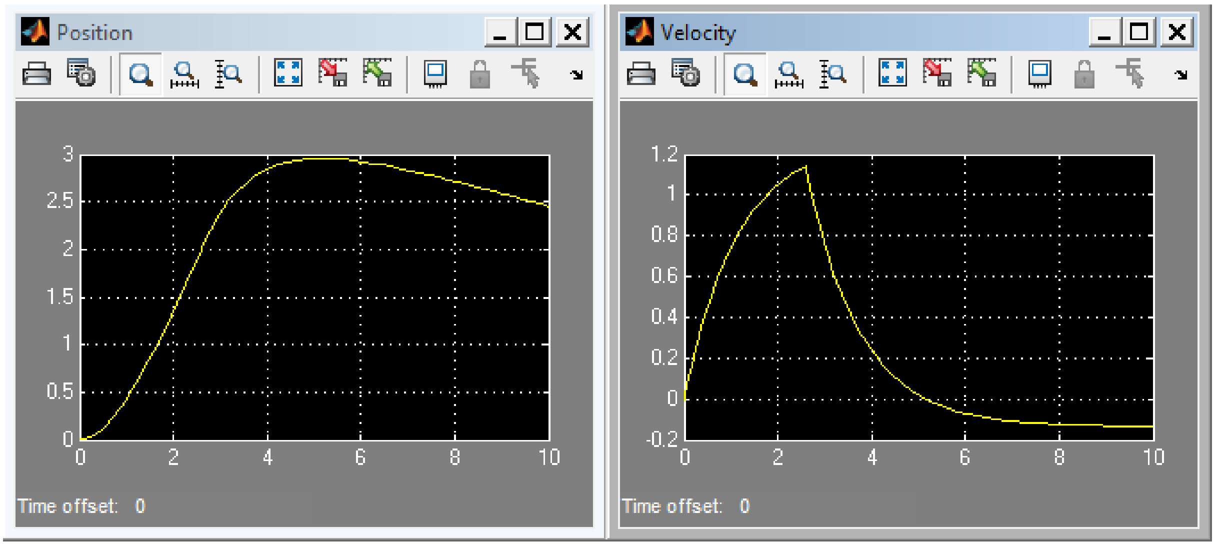


Figure 4: Position and velocity

A problem arised when seeing the results of this simulation. The solar vehicle seemed to move back in the opposite direction after a while. The explanation of this problem is that the rolling resistance was considered as a constant force working in the opposite direction. This results in a negative velocity when the vehicle should actually stand still.

Nevertheless, the conclusion of these graphs is that the solar vehicle reaches a state of 0 m/s where it will fall still. This occurs at approximately 5 seconds and the vehicle reaches approximately 3 meters, where the first 2 meters were downhill.

3. Simulate the race

For this simulation almost the same model as for part 2 was used (also to be found in the addendum). The differences are that the model for the vehicle is now connected to the solar panel and the values for the rolling resistance were changed and they change at 10 meters. This is because the vehicle now runs 10 meters at a flat surface and then runs up a hill for 4 meters.

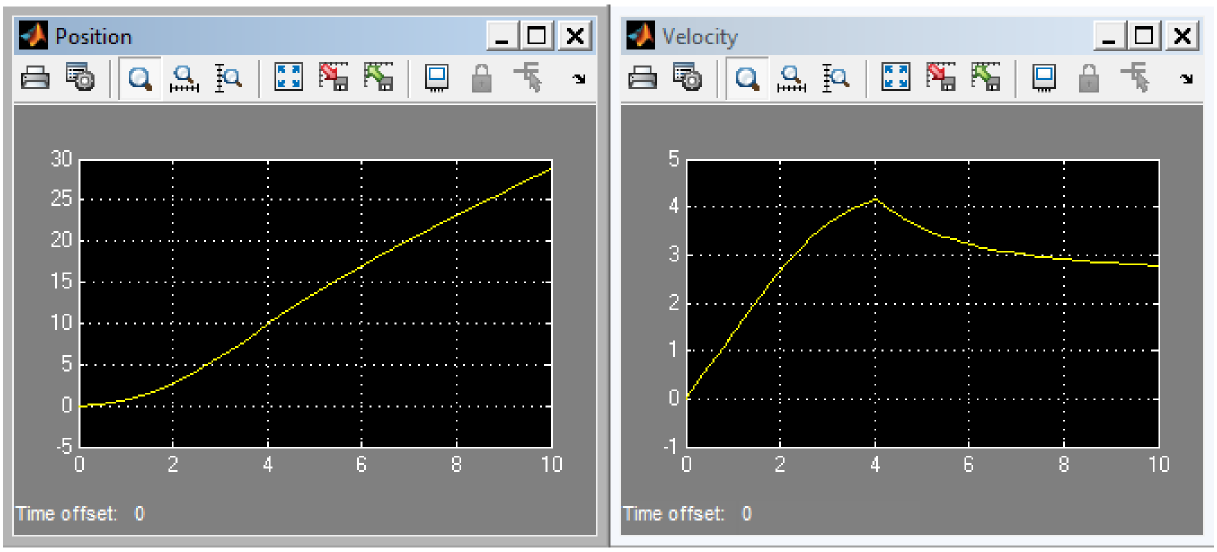


Figure 5: Results for simulation 3

From the graph of the velocity there can be concluded that the velocity will decrease immense when the vehicle starts to ascend the hill. This will be at exactly 4 seconds.

From the graph of the position there can be concluded that the finish of the race at 14 meters will be reached at approximately 5 seconds. This will be the expected race time.

When changing the gear ratio of the used gear box in the Simulink model, the conclusion was that the velocity of the solar vehicle would parabolically increase and decrease where the peak of the velocity would be reached at a gear ratio of 8:1. As a consequence of the velocity, the position of 14 meters would never be reached as quickly as with a gear ratio of 8:1.

4. Why are these simulations necessary?

These simulations can be used for a lot of purposes.

The optimal gear ratio can be determined by changing the gear ratio of the gear box and looking at the direct results of position and velocity.

The influence of the air and rolling resistance can easily be visualized in these graphs. By changing the forces, following from air resistance and rolling resistance, that influence the movement of the vehicle, we can determine the optimal shape of the vehicle.

By changing the value of the wheel diameter and looking at the direct results, the optimal wheel diameter can also be determined.