SSV REPORT

Part I

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1.solar panel characteristic

1.1 Solar Panel Model

The solar panel characteristic can be define as the function below.

$$I = I_{sc} - I_s \cdot (e^{\frac{U}{m \cdot N \cdot U_r}} - 1)$$

I_{sc}—short circuit current (A)

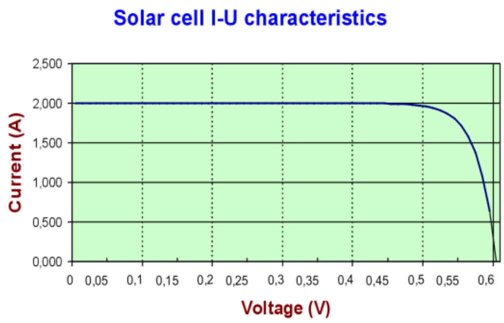
I_s—saturation current (A) (1e-8 A/m^2)

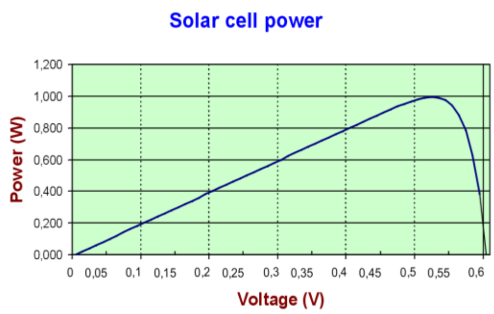
U—output voltage (V)

U_r—thermo voltage (V) ($U_r = {K \cdot T}/_{e}$, K is *Boltzmann constant which is equals to 1.38 x* 10^{-23} *J/K; T is Kelvin temperature; e is charge of electron which is equals 1.6 x* 10^{-19} *As,* U_r *is* 25.7mV at 25°C)

m—diode factor(range 1~5)
N—number of solar cells in series(N=15)

According to the above-mentioned function, we can obtain the U-I and U-P characteristic of solar cell which is shown in figure below.





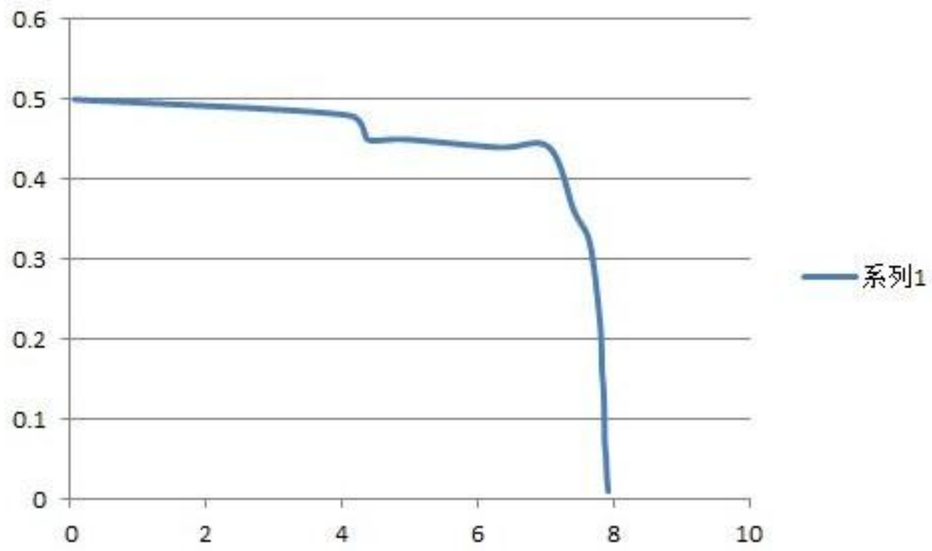
1.2 Measurement Procedure

Procedure:

1. Define the short circuit current, Isc=0.54A
2. Connect an external resistor (load), measure the working points (output current and voltage),For each working points, calculate the "m" value.

	1	2	3	4	5	6	7	8	9
U(V)	0.06	4.11	4.37	4.93	6.31	7.05	7.42	7.65	7.80
I(A)	0.5	0.48	0.45	0.45	0.44	0.44	0.36	0.32	0.22
m	0.01	0.68	0.71	0.80	1.01	1.13	1.15	1.17	1.17
	10	11	12	13	14	15	16	17	18
U(V)	7.83	7.85	7.86	7.87	7.88	7.89	7.90	7.91	7.92
I(A)	0.16	0.14	0.12	0.07	0.06	0.05	0.03	0.02	0.01
m	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16

3. Taking the average of all “m” values
   $\bar{m}$=1.02;



Solar panel Characteristic

2. Optimal gear ratio

2.1 Resistance

2.1.1 Rolling resistance

The given formula is Fr = Crr * N

Crr : the rolling resistance coefficient that can be found in data table.

N : the normal force to the ground.

2 situations.

First on the flat road, N equals the mg, for our SSV it is

Fr = 0.01* 9.8 = 0.098 N

Second on the slope, N equals the mg*cos7.18

$$Fr = 0.01 * 9.8 * \cos 7.18 = 0.097N$$

2.1.2 Aerodynamic resistance

the given formula is

$$Fw = 1/2 * Cw \cdot A \cdot \rho \cdot v^2$$

Cw: drag coefficient
A: frontal surface area (m2)
ρ: density of air (kg/m3)
v: speed of the car

Cw for our SSV is found to be 0.5 which is a relative large value compare to other shapes.

$\rho = 1.29kg/m^3$

A for our SSV the frontal area is $0.01m^2$

2.1.3 F difference on the slope

When the SSV is on the slope, an extra friction force is the mg*sin7.18.

2.2 Data Calculation

2.2.1 Given energy equation for the process.

$a(t) = g(\sin(\alpha) - \cos(\alpha) \times Crr) + I(t) \times E(t)/(M \times v(t)) - Cw \times A\rho \times v2(t)/2M$

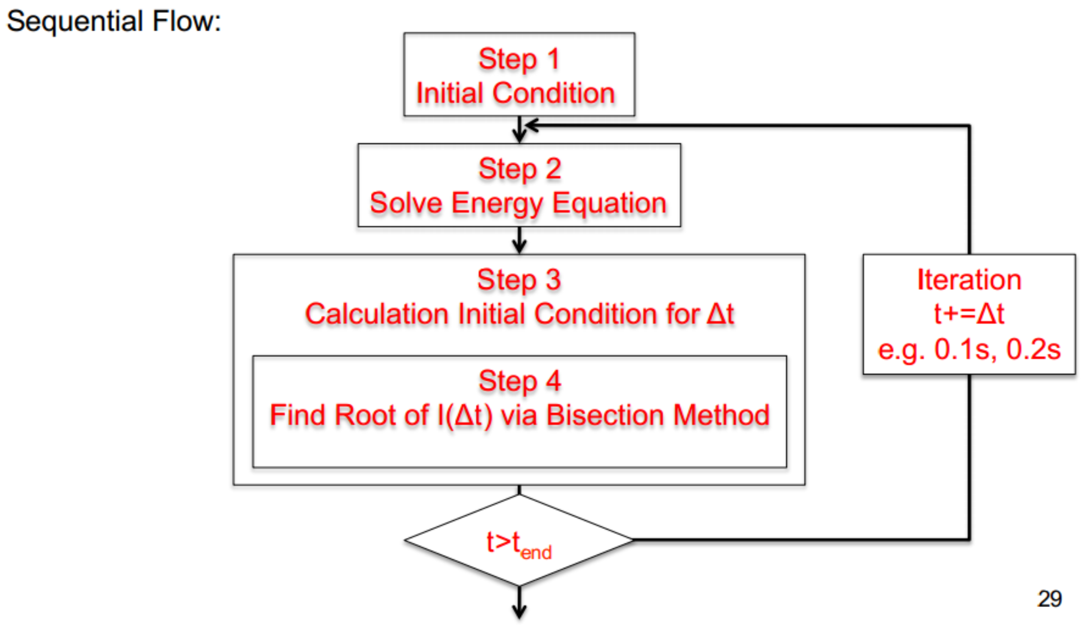
for each unknowns in the equations we have corresponding solutions

Motor: $E(t) = Ke \times \omega = CE.\Phi \times 60 \times v(t) \times$ gear ratio $/(2\pi r)$

Solar panel: $I(t) = Isc - Is(eU(t)/(mNUr) - 1) = Isc - Is$
$(e(E(t)+I(t)R)/(mNUr) - 1)$

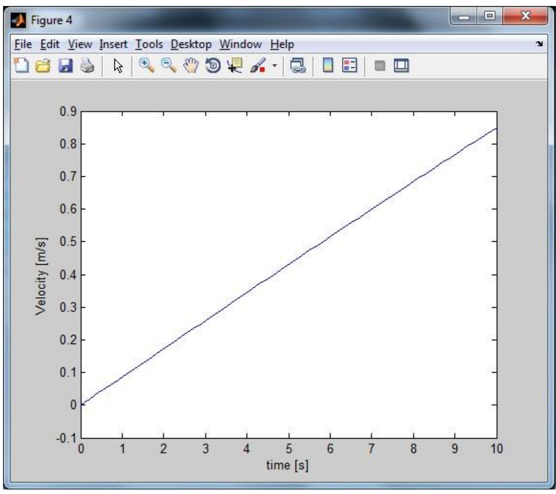
2.2.2 Steps

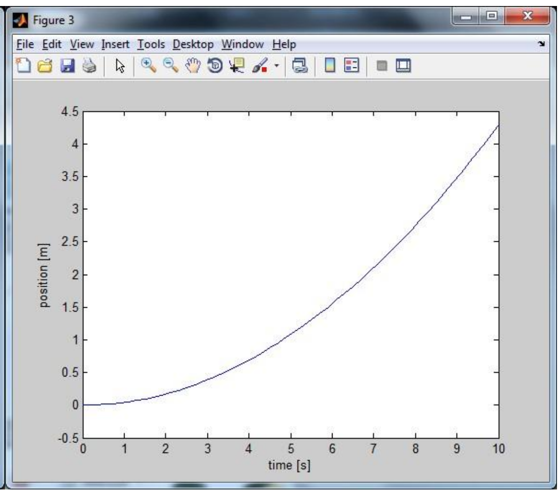
Calculate the initial values for I and E through the formula.
And the repeat until t>tend



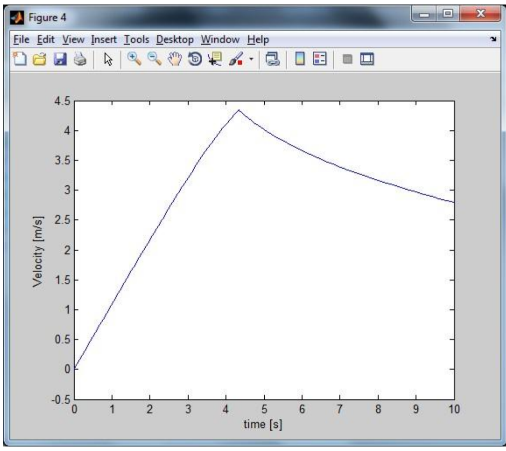
2.3 Choice of gear ratio

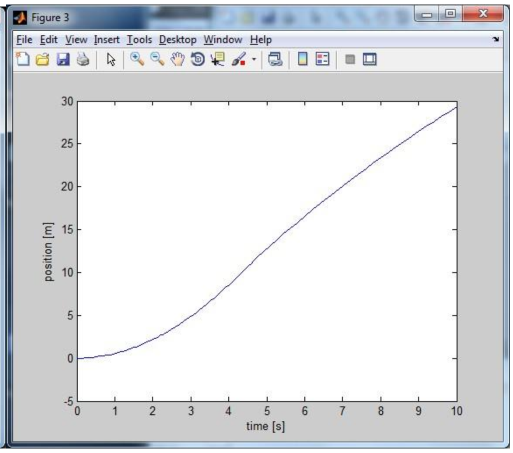
For this portion, we use matlab to simulate the displacement and the speed graph.
For gear ratio is 1





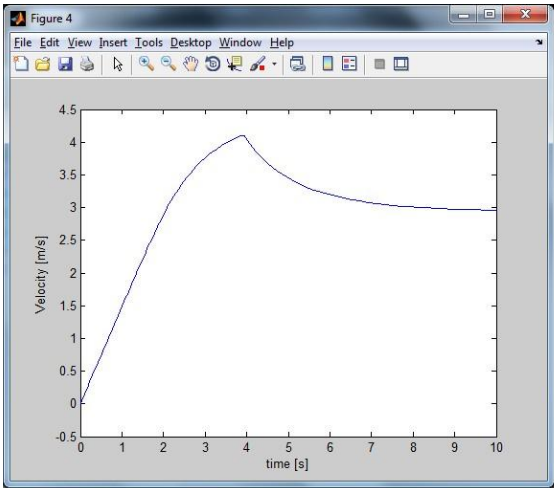
We can see from the displacement graph that it takes more 10 seconds to run 4 meters away, so this one definitely can not be used. Actually the SSV cannot even reach the end . when it meets the slope, the speed will decrease to 0.
So we tested other gear ratio and here is result.
Gear ratio 6

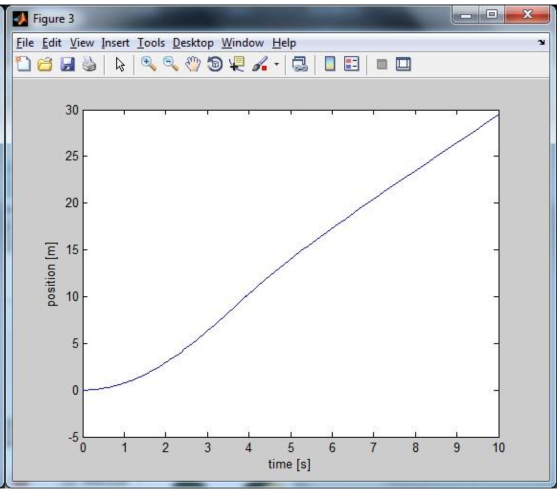




The speed graph tells that at 4.5s the speed slowed down abruptly because of the slope. And it takes about 5.5s to finish.

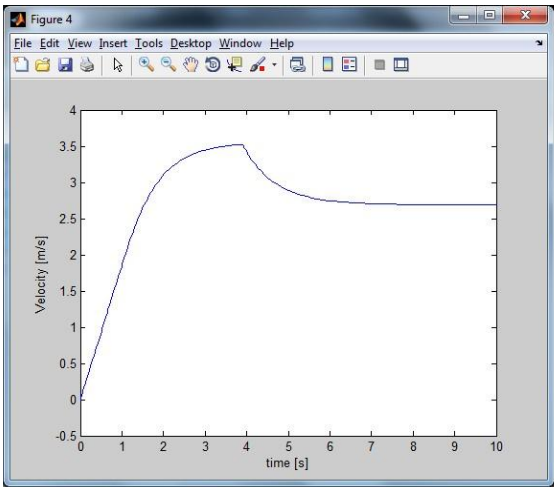
Gear ratio 8

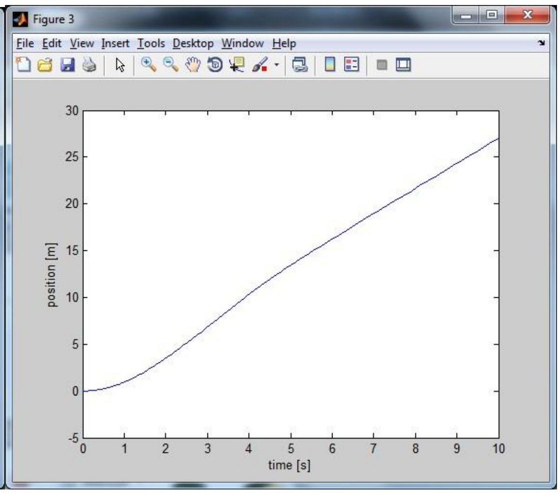




for this gear ratio, the speed reaches its maximum earlier that that of 6, it is about 3.9s. thus this one is faster than previous one.

Gear ratio 10





When the gear ratio is 10 the speed change at the slope is rather gently that others because the larger the ratio, the larger the torque, so it enables the SSV to have a higher ability to climb the slope. But the problem is it takes longer to finish compared to 8.

With all this calculation and the simulation, we finally determined that our gear ratio is 8 to obtain a best performance of our SSV.

3.Calculate with Numerical Method

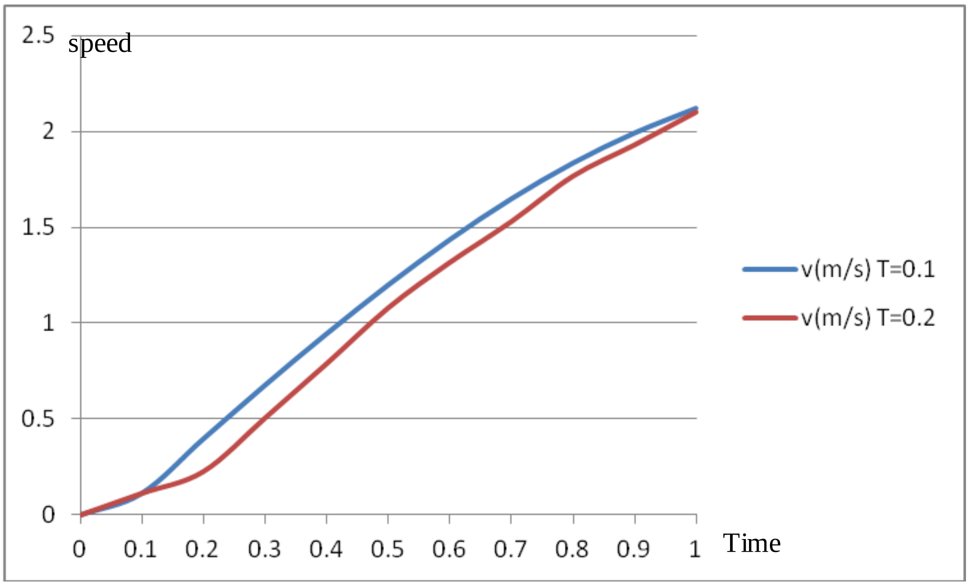
3.1Data

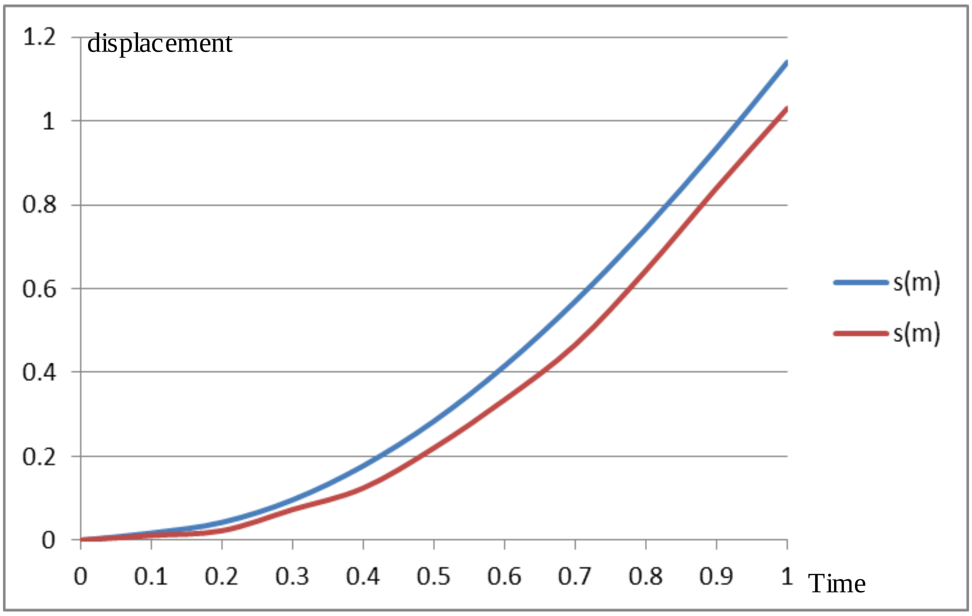
T(s)	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
a(m/s2)	1.135	2.84	2.79	2.69	2.54	2.36	2.13	1.86	1.57	1.29	1.019
v(m/s)	0	0.1135	0.3975	0.6765	0.9445	1.1985	1.4345	1.6475	1.8335	1.99	2.119
s(m)	0	0.017	0.0425	0.0962	0.1773	0.284	0.41565	0.56975	0.7438	0.935	1.14
E(J)	0	0.22	0.775	1.318	1.84	2.335	2.79	3.21	3.57	3.87	4.12
I(A)	0.88	0.879	0.879	0.879	0.877	0.872	0.857	0.828	0.786	0.74	0.69

Table 1 ΔT=0.1

T(s)	0	0.2	0.4	0.6	0.8	1
a(m/s2)	1.135	2.81	2.64	2.23	1.67	1.06
v(m/s)	0	0.227	0.789	1.317	1.767	2.101
s(m)	0	0.0227	0.1243	0.3349	0.6433	1.03
E(J)	0	0.44	1.537	2.56	1.4435	4.09
I(A)	0.88	0.879	0.8798	0.866	0.8	0.7

Table 2 ΔT=0.2





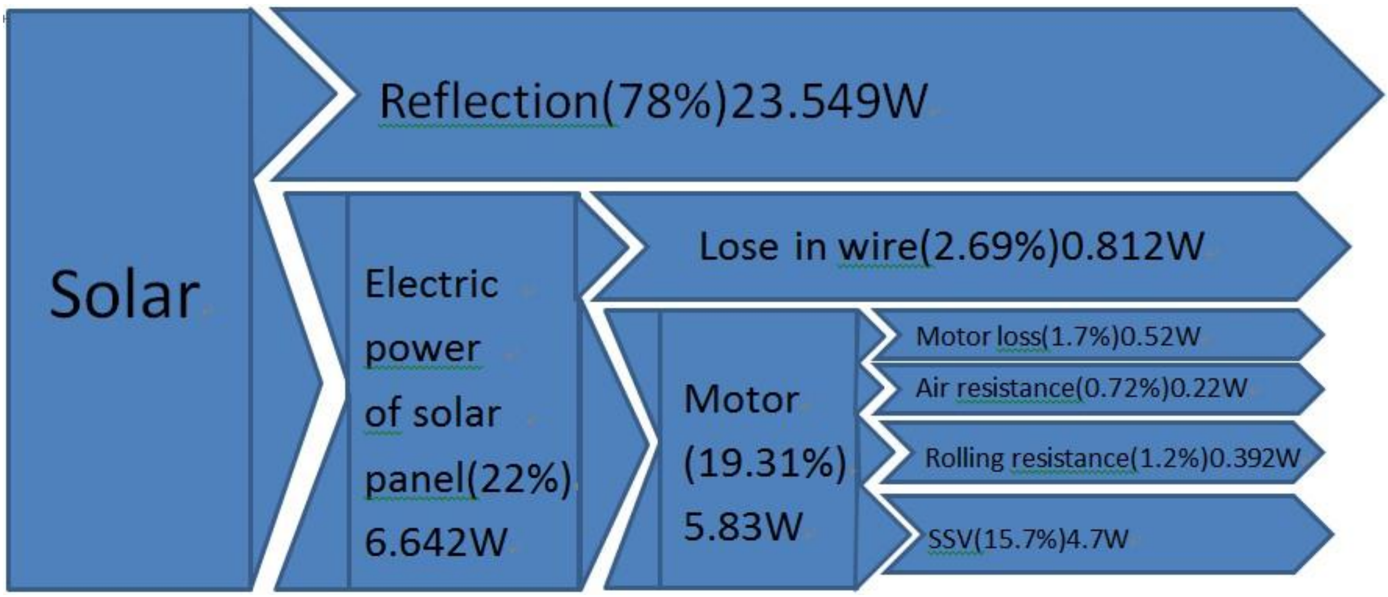
3.2 Compare

The displacement-time curve and speed-time curve are shown below. From the two curves, we can see that the displacement which calculated by time interval of 0.2s is larger than the displacement which calculated by time interval of 0.1s. The reason is that we assume the acceleration is constant in each time interval.

4. Sankey Diagram

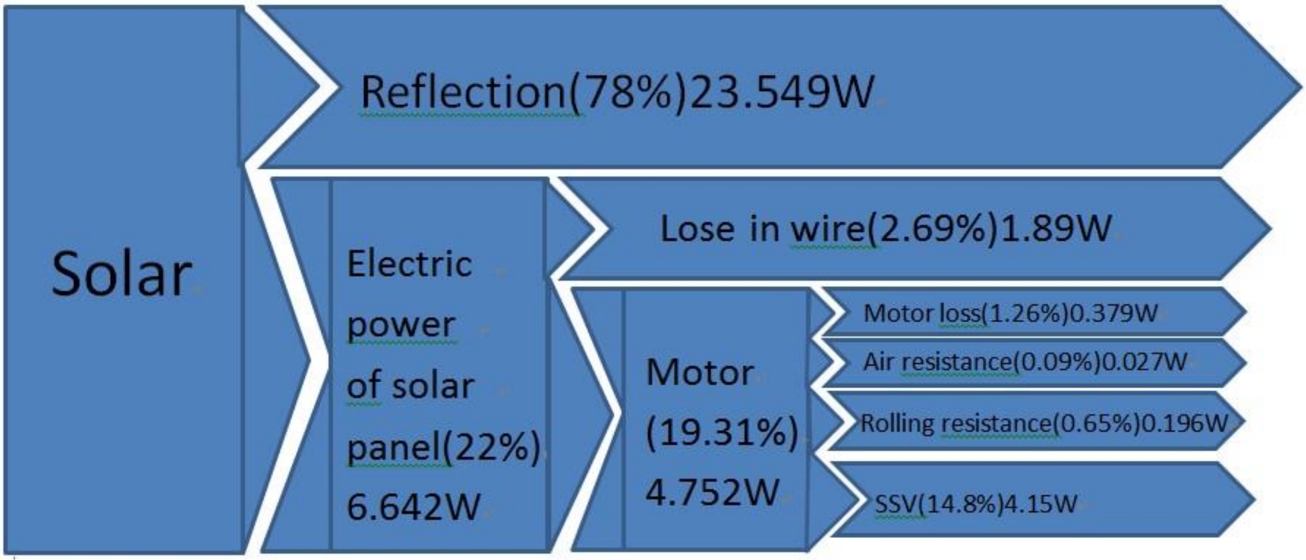
4.1 Situation 1:

At the moment when the SSV reaches its maximum speed, under the assumption that the SSV is driving on an infinitely long, flat track.



4.2 Situation 2

When the SSV drives half of the prior found maximum speed, but on the slope, in case of the race track as described in the competition rules



4.3 Detailed calculations

We choose the parameter of our solar panel to be
The intensity of sunshine is 800 W/m²
The area of our solar panel 0.06*0.04=.0024m^2
These values are changing with various speed of car since the v is related to E and I according to the formula mentioned in the Calculation part.

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At Vmax
The power generated by the solar panel is U*I=6.57W
The energy loss in the wire is I^2*R=0.738W
The kinetic energy transferred by the motor is E*I=5.83W
For the aerodynamic loss
P=F*v=Fw *v= ½·Cw·A·ρ·v^3=0.5*0.5*0.01*1.29*4.1^3=0.22W
For the rolling resistance loss
P=Crr*N*v=0.1*9.8*4.1=0.392W
The kinetic energy of SSV
P=Fwheel*v
Since (Fwheel-f)*t=m*Vmax we can get t from the speed diagram then Fwheel =1.15N
P=1.15*4.1=4.7W
So the motor loss due to friction is the rest energy 0.52W

At 1/2Vmax

The power generated by the solar panel is6.642W
The energy loss in the wire is1.8W
The kinetic energy transferred by the motor is4.752W
For the aerodynamic loss
P=0.027W
For the rolling resistance loss
P=0.196W
The kinetic energy of SSV
P=2.35W
So the motor loss is 0.379W
Hence the efficiency is shown on the Sankey Diagram.