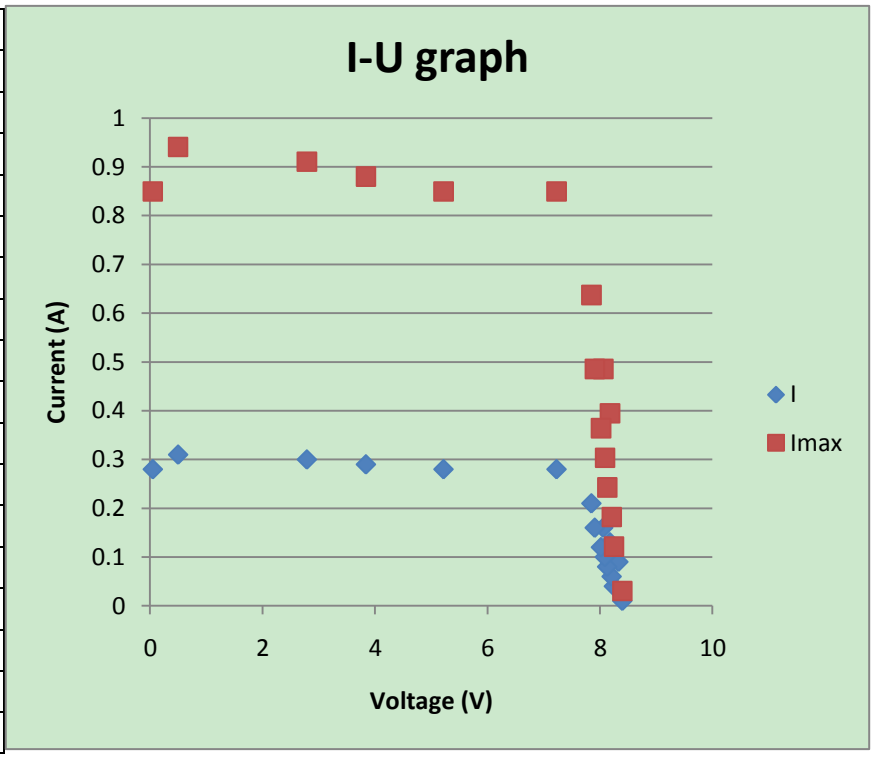
Calculations

Solar panel

$I_{max} = (0{,}88/0{,}29) * I_{measured}$

V	I	Imax
8,33	0,09	0,273103
8,18	0,13	0,394483
8,06	0,16	0,485517
7,85	0,21	0,637241
7,23	0,28	0,849655
5,22	0,28	0,849655
3,84	0,29	0,88
2,79	0,3	0,910345
0,5	0,31	0,94069
8,4	0,01	0,030345
8,25	0,04	0,121379
8,21	0,06	0,182069
8,13	0,08	0,242759
8,09	0,1	0,303448
8,02	0,12	0,364138
7,91	0,16	0,485517
0,05	0,28	0,849655



$V_{P,max} = 7{,}23$ V
$I_{P,max} = 0{,}85$ A
} Working point

$P_{meas} = V * I = 7{,}23 * 0{,}85 = 6{,}15$ W

Power of the motor

$P_{real} = V * I * \eta = 6{,}15 * 0{,}70 = 4{,}31$ W

$P_{real} = F_{wheel} * V_{A/B}$

Parameters of the motor

$U_a = R_a * I_a + E$

$E = U_a - R_a * I_a$

$= 7,23 - 3,2 * 0,85$

$= 4,51$ V

$E = C_E * \Phi * n$

$n = E / (C_E * \Phi)$

$= 5051,2$ rpm ➔ $\omega = n * (2\pi / 60) = 529$ rad/s

$T = C_T * \Phi * I_a * \eta = 8,55 * 10^{-3} * 0,85 * 0,7$

$T_{motor} = 5,09 * 10^{-3}$ Nm

Gears

i = 9

Assume: $R_{wheel} = 0,03$ m and m = 1 kg

Before point B

$T_{wheel} = 8,55 * 10^{-3} * 0,70 * 0,85 * 9$

$= 0,0458$ Nm

$T_{wheel} = F_{wheel} * R_{wheel}$

➔ $F_{wheel} = T_{wheel} / R_{wheel} = 1,53$ N

$P_{real} = F_{wheel} * V_{A/B}$

➔ $V_{A/B} = P_{real} / F_{wheel} = 4,31 / 1,53 = 2,82$ m/s

$S = 0,5 * V_{A/B} * t_{A/B}$ $S = 6m @ V_{A/B}$

➔ $t_{A/B} = 4{,}26$ s

$(F_{wheel} - F_{rolling}) * t_{A/B} = m * V_{A/B}$

$F_{rolling} = F_{wheel} – (m * V_{A/B}) / t_{A/B} = 1{,}53 – (1*2{,}82) / 4{,}26$

$= 0{,}86$ N

After point B

$F_r = F_{rolling} + mg * \sin(3°) = 0{,}86 + 1 * 9{,}81 * \sin(3°) = 1{,}38$ N

➔ $F_{wheel} > F_r$

$F_{wheel} = F_r = 1{,}38$ N

$T_{wheel} = F_{wheel} * R_{wheel}$

$= 1{,}38 * 0{,}03$

$= 0{,}0414$ Nm

$T_{wheel} = T_c * I * \eta * i$

➔ $I = T_{wheel} / (T_c * \eta * i)$

$= 0{,}0414 / (8{,}55 * 10^{-3} * 0{,}7 * 9)$

$= 0{,}77$ A

U(I) graph: $U(0{,}77) = 7{,}6$ V

$P_{new} = I * U * \eta$

$= 0{,}77 * 7{,}6 * 0{,}7$

$= 4{,}10$ W

$P_{new} = F_{wheel} * V_{slope}$

➔ $V_{slope} = P_{new} / F_{wheel} = 4{,}10 / 1{,}38 = 2{,}97$ m/s

$t_{slope} = slope / V_{slope} = 8 / 2{,}97 = 2{,}69$ s

$t_{total} = t_{A/B} + t_{slope} = 4,26 + 2,69 = 6,95$ s

i = 8

Assume: $R_{wheel} = 0,03$ m and $m = 1$ kg

Before point B

$T_{wheel} = 8,55 * 10^{-3} * 0,70 * 0,85 * 8$

$= 0,0407$ Nm

$T_{wheel} = F_{wheel} * R_{wheel}$

➔ $F_{wheel} = T_{wheel} / R_{wheel} = 1,36$ N

$P_{real} = F_{wheel} * V_{A/B}$

➔ $V_{A/B} = P_{real} / F_{wheel} = 4,31 / 1,36 = 3,17$ m/s

$S = 0,5 * V_{A/B} * t_{A/B}$ $S = 6m @ V_{A/B}$

➔ $t_{A/B} = 3,78$ s

$(F_{wheel} - F_{rolling}) * t_{A/B} = m * V_{A/B}$

$F_{rolling} = F_{wheel} – (m * V_{A/B}) / t_{A/B} = 1,36 – (1 * 3,17) / 3,78$

$= 0,52$ N

After point B

$F_r = F_{rolling} + mg * \sin(3°) = 0,52 + 1 * 9,81 * \sin(3°) = 1,03$ N

➔ $F_{wheel} > F_r$

$F_{wheel} = F_r = 1,03$ N

$T_{wheel} = F_{wheel} * R_{wheel}$

$= 1,03 * 0,03$

$= 0,0309$ Nm

$T_{wheel} = T_c * I * \eta * i$

➔ $I = T_{wheel} / (T_c * \eta * i)$

$= 0,0309 / (8,55 * 10^{-3} * 0,7 * 8)$

$= 0,65$ A

U(I) graph: U(0,65) = 7,85 V

$P_{new} = I * U * \eta$

$= 0,65 * 7,85 * 0,7$

$= 3,60$ W

$P_{new} = F_{wheel} * V_{slope}$

➔ $V_{slope} = P_{new} / F_{wheel} = 3,60 / 1,03 = 3,50$ m/s

$t_{slope} = slope / V_{slope} = 8 / 3,50 = 2,29$ s

$t_{total} = t_{A/B} + t_{slope} = 3,78 + 2,29 = 6,07$ s

i = 10

Assume: $R_{wheel} = 0,03$ m and m = 1 kg

Before point B

$T_{wheel} = 8,55 * 10^{-3} * 0,70 * 0,85 * 10$

$= 0,0509$ Nm

$T_{wheel} = F_{wheel} * R_{wheel}$

➔ $F_{wheel} = T_{wheel} / R_{wheel} = 1{,}70$ N

$P_{real} = F_{wheel} * V_{A/B}$

➔ $V_{A/B} = P_{real} / F_{wheel} = 4{,}31 / 1{,}70 = 2{,}54$ m/s

$S = 0{,}5 * V_{A/B} * t_{A/B}$ $S = 6m @ V_{A/B}$

➔ $t_{A/B} = 4{,}73$ s

$(F_{wheel} - F_{rolling}) * t_{A/B} = m * V_{A/B}$

$F_{rolling} = F_{wheel} – (m * V_{A/B}) / t_{A/B} = 1{,}70 – (1 * 2{,}54) / 4{,}73$

$= 1{,}16$ N

After point B

$F_r = F_{rolling} + mg * \sin(3°) = 1{,}16 + 1 * 9{,}81 * \sin(3°) = 1{,}67$ N

➔ $F_{wheel} > F_r$

$F_{wheel} = F_r = 1{,}67$ N

$T_{wheel} = F_{wheel} * R_{wheel}$

$= 1{,}67 * 0{,}03$

$= 0{,}0501$ Nm

$T_{wheel} = T_c * I * \eta * i$

➔ $I = T_{wheel} / (T_c * \eta * i)$

$= 0{,}0501 / (8{,}55 * 10^{-3} * 0{,}7 * 10)$

$= 0{,}84$ A

U(I) graph: U(0,84) = 7,23 V

$P_{new} = I * U * \eta$

= 0,84 * 7,23 * 0,7

= 4,25 W

$P_{new} = F_{wheel} * V_{slope}$

➔ $V_{slope} = P_{new} / F_{wheel} = 4,25 / 1,67 = 2,55$ m/s

t_{slope} = slope / V_{slope} = 8 / 2,55 = 3,14 s

$t_{total} = t_{A/B} + t_{slope} = 4,73 + 3,14 = 7,87$ s