ELG3336: Celebrating the Confederation Line (O-Train), 2019

History: The first electric passenger train was presented by Werner von Siemens at Berlin in 1879. The locomotive was driven by a 2.2 kW, series DC motor, and the train consisting of the locomotive and three cars, reached a speed of 13 km/h.



Question 1: Design a solar farm and a storage facility that provides enough energy to the entire overhead power line of the train system. Use solar panels (? V, ? W, per unit). Feel free to use suitable converters. Estimate the harvested power in kW and kWh.

Question 2: Design a suitable DC to DC converter to supply $i_0 = ?$ A to the locomotive DC series motor from the overhead power line (1500 V). Assume: $E_a = ? n$, $R_a = ?$ Ohm, $f_s = ?$ Hz. Assume ?% ripple current, 10% ripple voltage, and efficiency of ?%.

Question 3: Consider the following step-down and step-up chopper (two quadrant chopper). The circuit can provide both motoring forward operation (S_1 and D_1) and regenerating braking operation (S_2 and D_2).



For the motoring mode (I), chopper circuit (S_1 and D_1), determine the duty cycle and turn-on time in the motoring mode if n = ? r/min, and $i_0 = ?$ A. Assume $V_s = 1500$ V, $E_a = ?$ n, $R_a = ?$ Ohm, $f_s = ?$ Hz. Calculate the absorbed power in the motor armature winding and the power delivered by the voltage supply. What is the role of the diode (D_1)? Draw the voltage waveform first with D_1 and second without D_1 .

Question 4: Consider the following step-down and step-up chopper (two quadrant chopper). The circuit can provide both motoring forward operation (S_1 and D_1) and regenerating braking operation (S_2 and D_2).



For the forward breaking mode (IV), chopper circuit (S_2 and D_2), determine the duty cycle and turn-on time in the motoring mode if n = ? r/min, and $i_0 = -?$ A. Assume $V_s = ?$ V, $E_a = ?$ n, $R_a = ?$ Ohm, $f_s = ?$ Hz. Calculate the absorbed power in the motor armature winding and the power delivered by the voltage supply. What is the role of the diode (D_2)? Draw the voltage waveform first with D_2 and second without D_2 .