Assignment 6 - DC Motor

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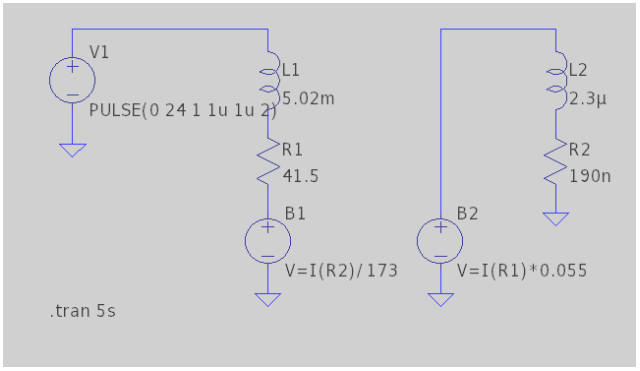
	Values at nominal voltage		
1	Nominal Voltage	24	V
2	No load speed	2990	rpm
3	No load current	14.6	mA
4	Nominal speed	2360	rpm
5	Nominal torque (max. continuous torque)	12.6	mNm
6	Nominal current (max. continuous current)	0.240	A
7	Stall torque	31.9	mNm
8	Starting current	0.578	A
9	Max. efficiency	70	%
	Characteristics		
10	Terminal resistance	41.5	Ω
11	Terminal inductance	5.02	mH
12	Torque constant	55.2	$mNm.A^{-1}$
13	Speed constant	173	$rpm.V^{-1}$
14	Speed / torque gradient	130	$rpm.mNm^{-1}$
15	Mechanical time constant	31.7	ms
16	Rotor inertia	23.2	gcm^2

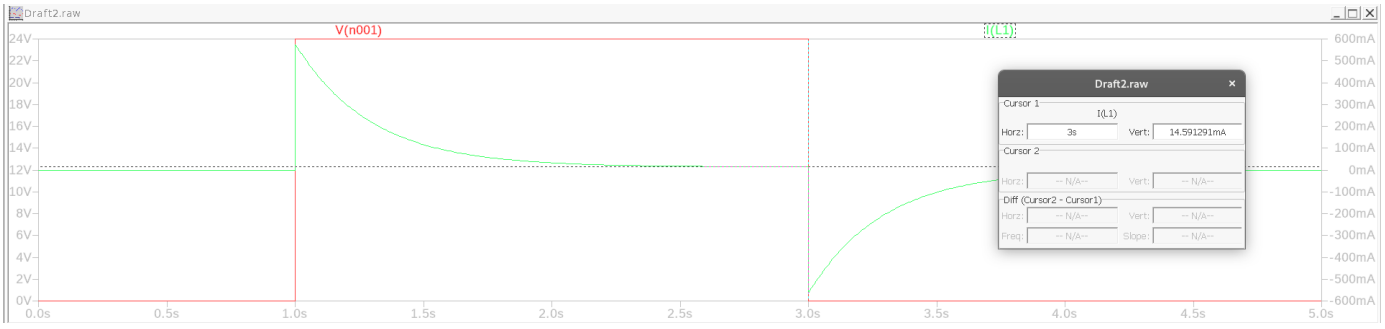
Question 1 - Inrush current



Verify the simulation model (L1, R1, B1, L2 and B2)

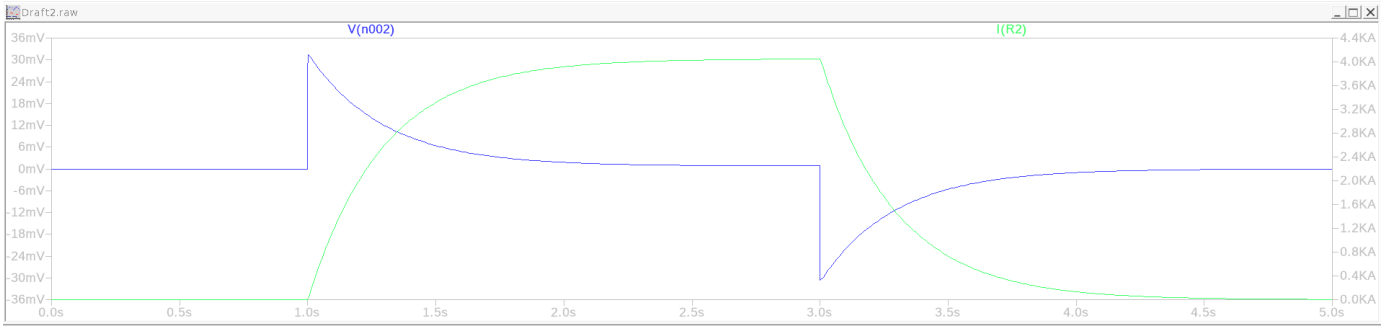
$L_1 = \text{Terminal Inductance} = 5.02mH$
$R_1 = \text{Terminal Resistance} = 41.5\Omega$
$L_2 = \text{Rotor inertia} \times 10^{-7} = 2.32\mu H$

R_2 is obtained by changing it's value to get a current of $\approx 14.6mA$ (No load current)



For $R_2 = 190n\Omega$, we get $I \approx 14.6$

Show in a simulation the applied voltage and motor current

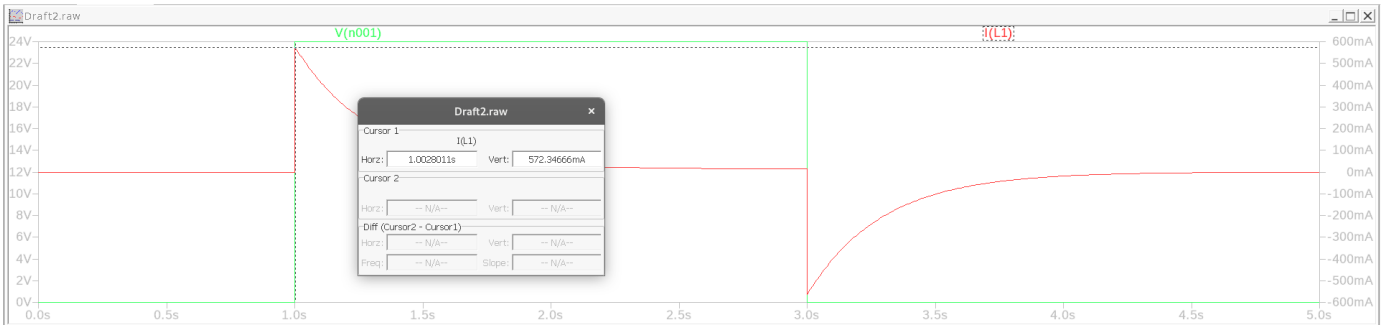


Explain the simulation

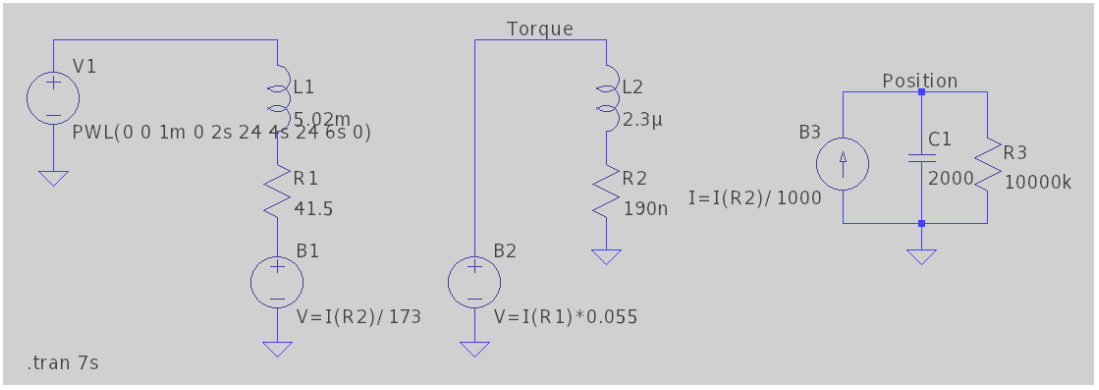
In this simulation, we are simulating a motor based on the value given in the table above.
The left part of the circuit represent the electrical circuit of the motor.
The right part is an equivalent circuit of the mechanical system of the motor.
The value of the component (inductor and resistor) can be directly obtained in the table, except R_2 which is estimated by ploting the current and making it again to the given no load current.
The no load current correspond to the current going throught the motor when no load is attached to it.

Verify the maximum inrush current with a calculation

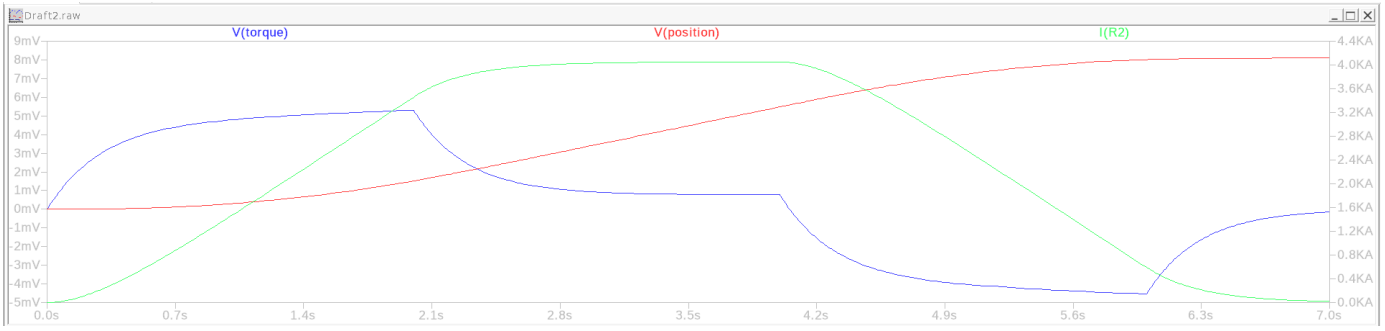
Maximum inrush current: $\frac{24}{41.5} = 0.578A$



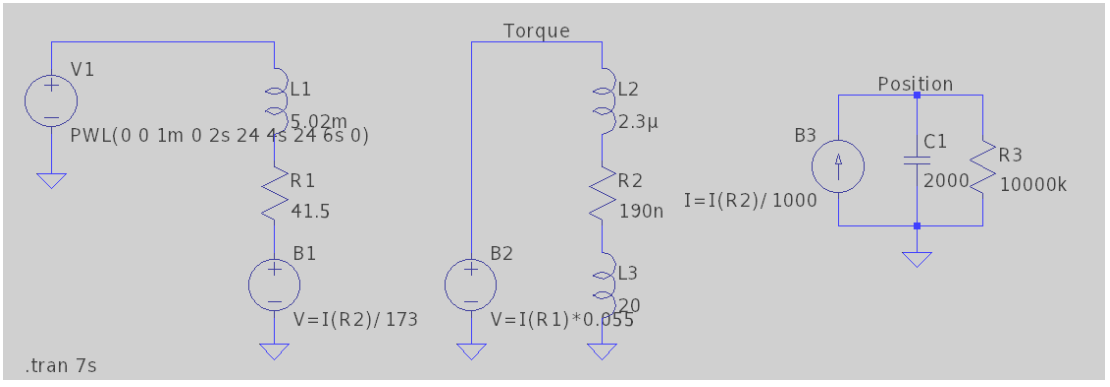
Question 2 - Simulation of a motor without load

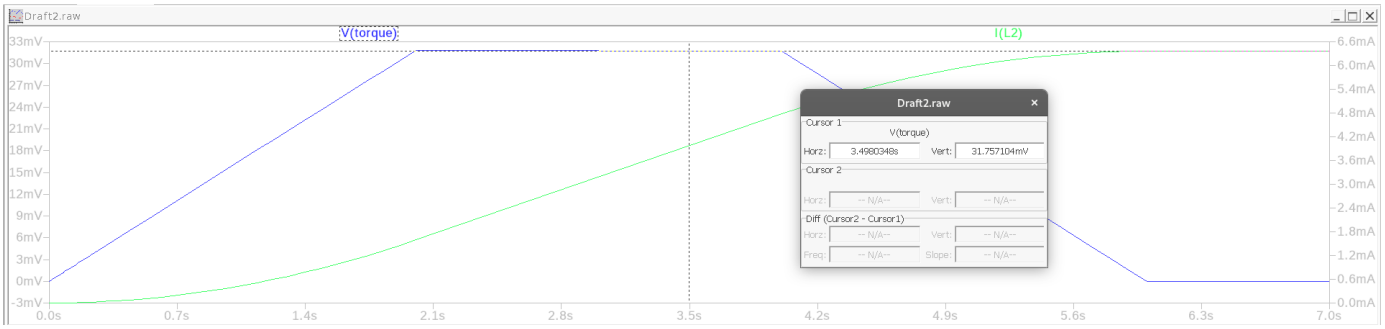


Show in a simulation the torque, speed and position



Verify the stall torque by comparing the simulation results with the motor data

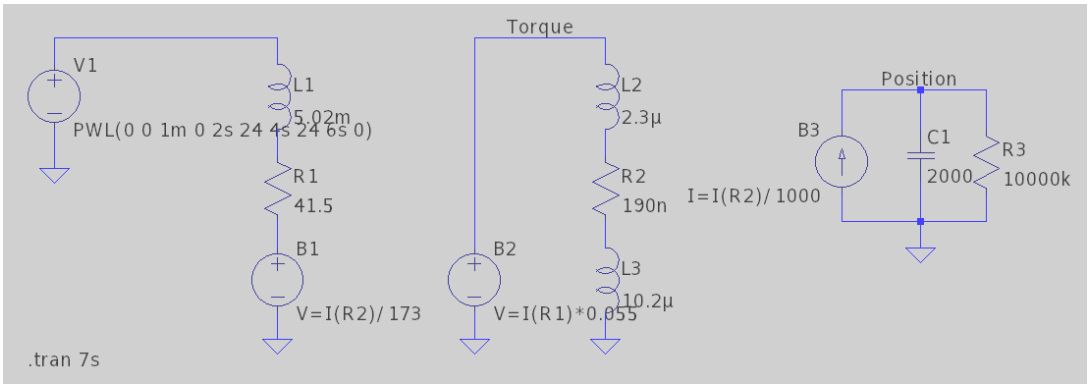




With a really big load, the stall torque doesn't exceed $31.9\ \mathrm{mNm}$

Question 3 - Simulation of a motor with load

$m = 51.1448g$

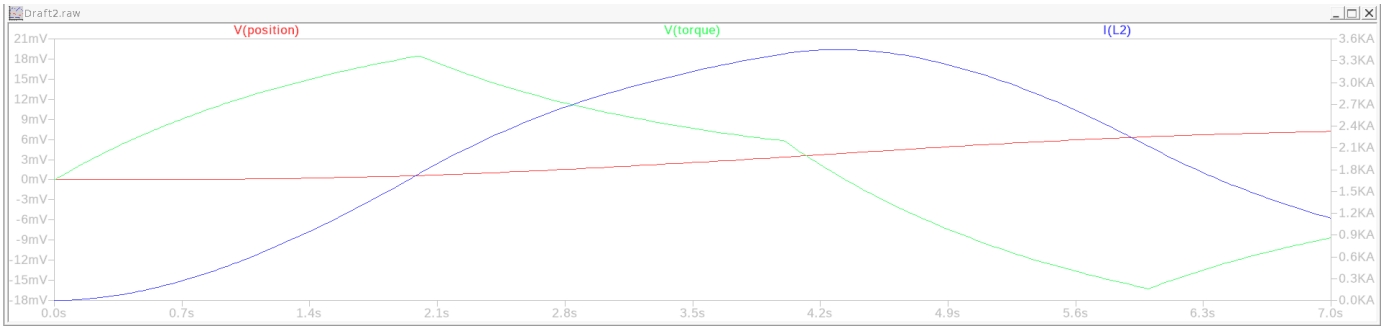


The Serie resistance of L3 has been set to 0, otherwise the motor would stall.

Calculate the inertia of the load in $kg.m^2$

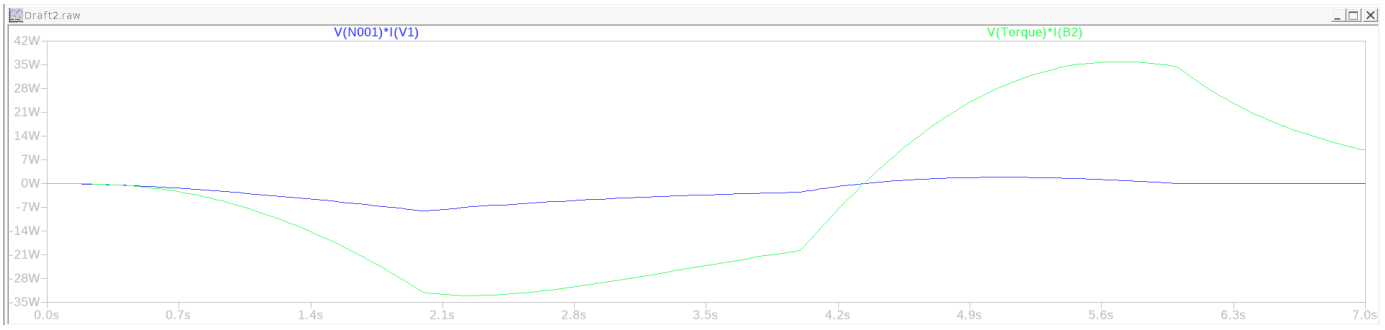
$I = \frac{1}{2}MR^2 = \frac{1}{2} \times 51.1448 \cdot 10^{-3} \times (2 \cdot 10^{-2})^2 = 1.02 \cdot 10^{-5} kg.m^2$

Show in a simulation the torque, speed and position

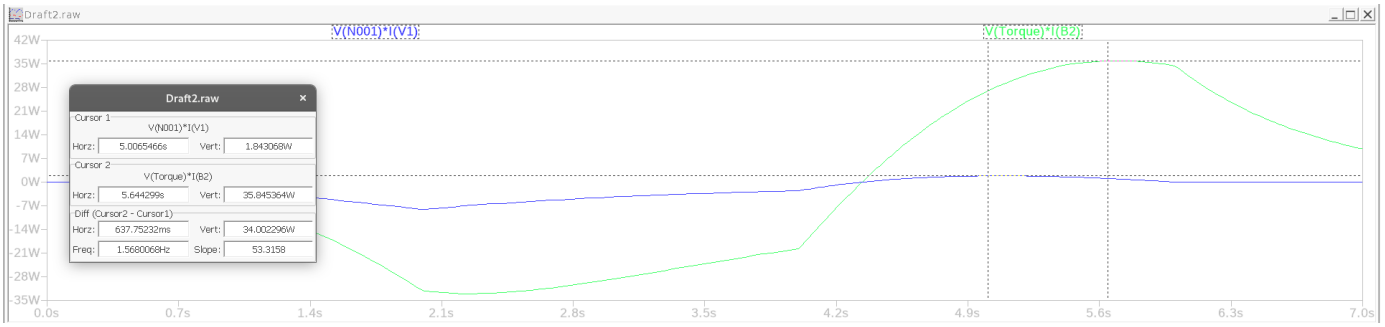


Perform a power analysis

Show in a simulation the electrical source power P_e and the mechanical load P_w



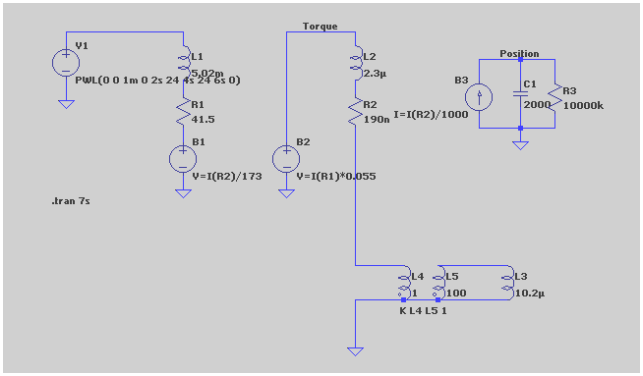
What si the maximum of P_e and P_w



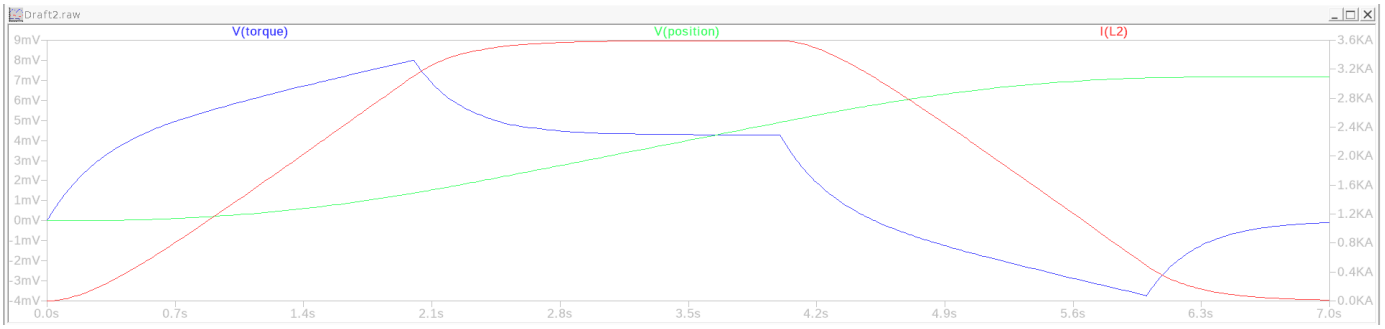
Explain the difference between the source power and the load power

The difference between the source power and the load power is due to losses.

Question 4 - Simulation with motor, gearbox and load

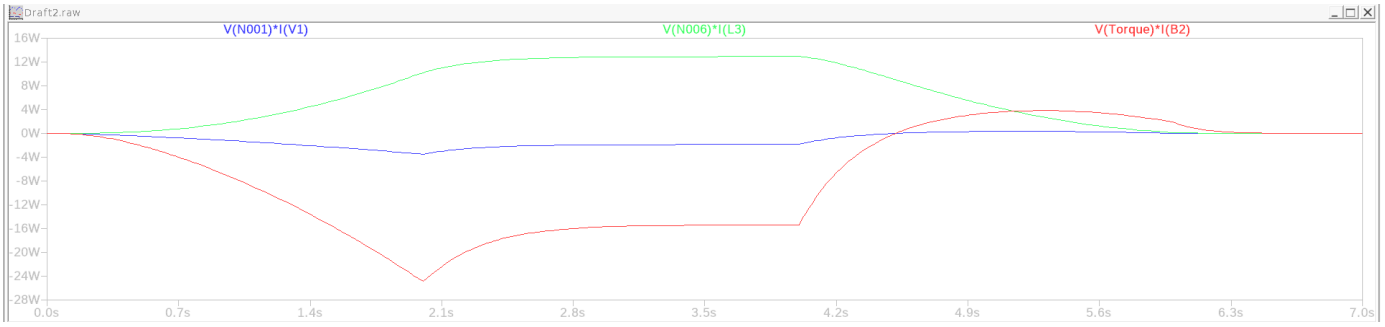


Show in a simulation the torque, speed and position

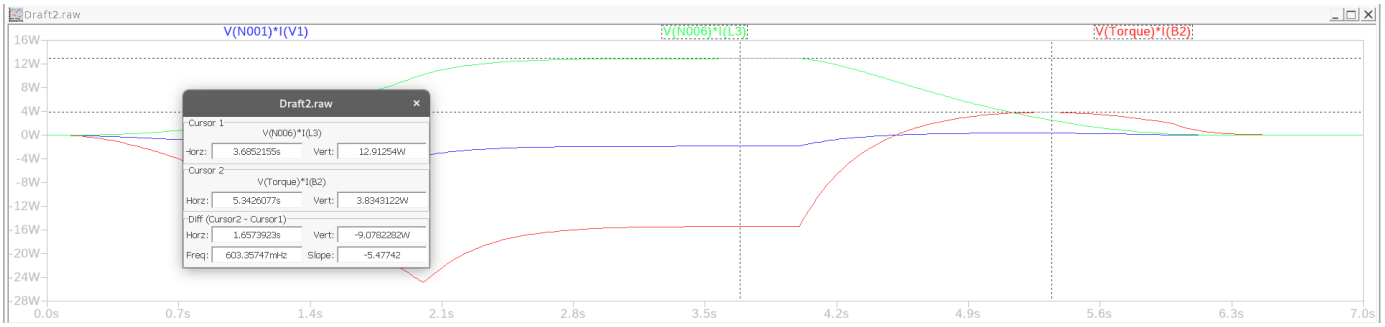


Perform a power analysis

Show in a simulation the electrical source power P_e and the mechanical power at the motor axis and the load $P_{M.motor}$ and $P_{M.load}$

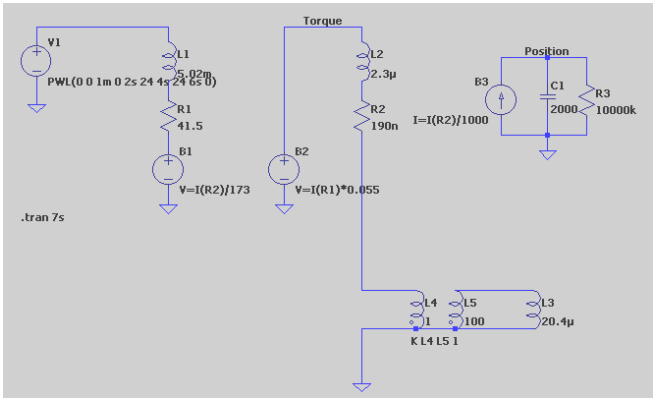


What is the maximum of P_e and P_M



Explain the difference between the source power and the load power

Increase the inertia of the load to a value which will result in the same power of the motor $P_{M.motor}$ as in simulation 6.3



Show in a simulation the electrical source power P_e and the mechanical power at the motor axis and the load $P_{M.motor}$ and $P_{M.load}$ and compare the results with simulation 6.3