EEE4123C

Project 2

BRYLIA002

21 August 2023

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1. I know that plagiarism is wrong. Plagiarism is to use another's work and pretends that it is one's own.
2. Each significant contribution to, and quotation in this assignment from the work(s) of other people has been attributed, and has been cited and referenced.
3. This assignment is my own work.
4. I have not allowed, and will not allow anyone to copy this work with the intention of passing it off as his or her own work.
5. By filling in my full names, I am formally signing this declaration and declares I have abided by the rules.

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Part 1

Using Matlab Simulink block-set in Simscape/SimPowerSystems and Simulink libraries, the practical implementation of the FOC algorithm for a surface PM motor can be set up using the machine parameters given below:

$$p \text{ (pole pairs)} = 4$$

$$r_s = 2.9\Omega$$

$$L_s = 8.5mH$$

$$\lambda_{pm} = 0.175 Wb\text{-}turns$$

$$J = 0.8 \text{x} 10^{-3} \, kg.m^2$$

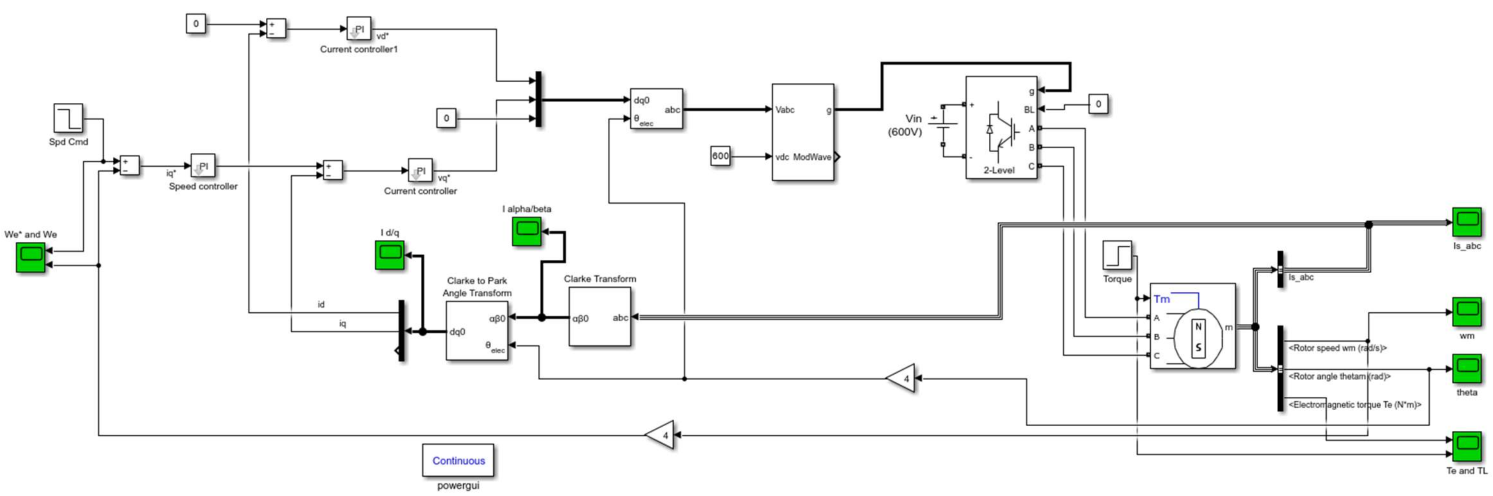
$$K_p = 50$$

$$K_i = 2.6$$

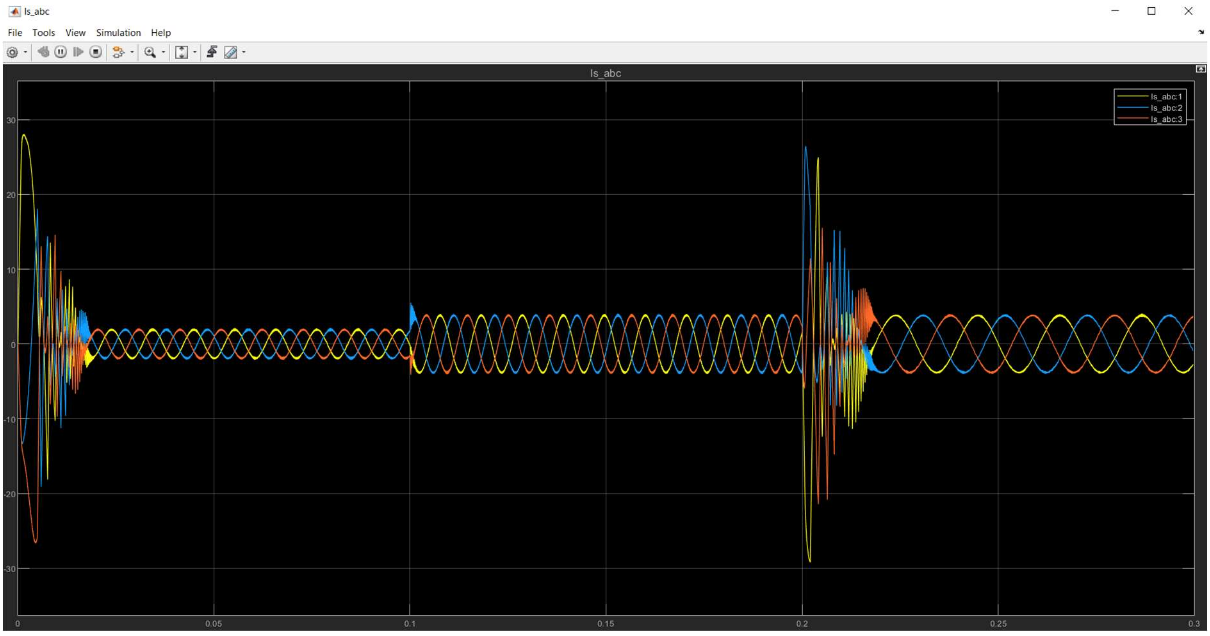
All current and speed controllers are standard PI controllers and have the same proportional and integral gain constants. The output of each current controller is limited to a minimum and maximum saturation value of -300 and +300, whereas the saturation limit for the speed controller is -30 and +30. The initial setpoint speed is set at 600rad/s and is stepped to 300rad/s at 0.2sec. The initial load torque is 2Nm and is stepped to 4Nm at 0.1sec.

i)

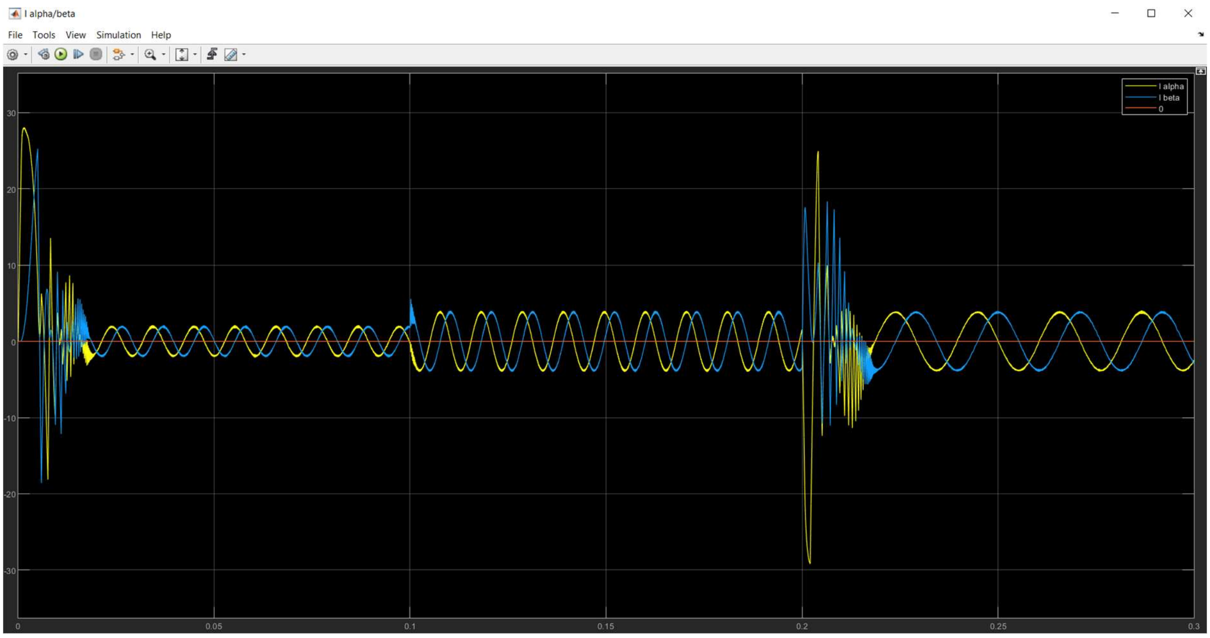
The Simulink model below is used to plot the stator currents in the abc, $\alpha\beta$ and dq reference frames.



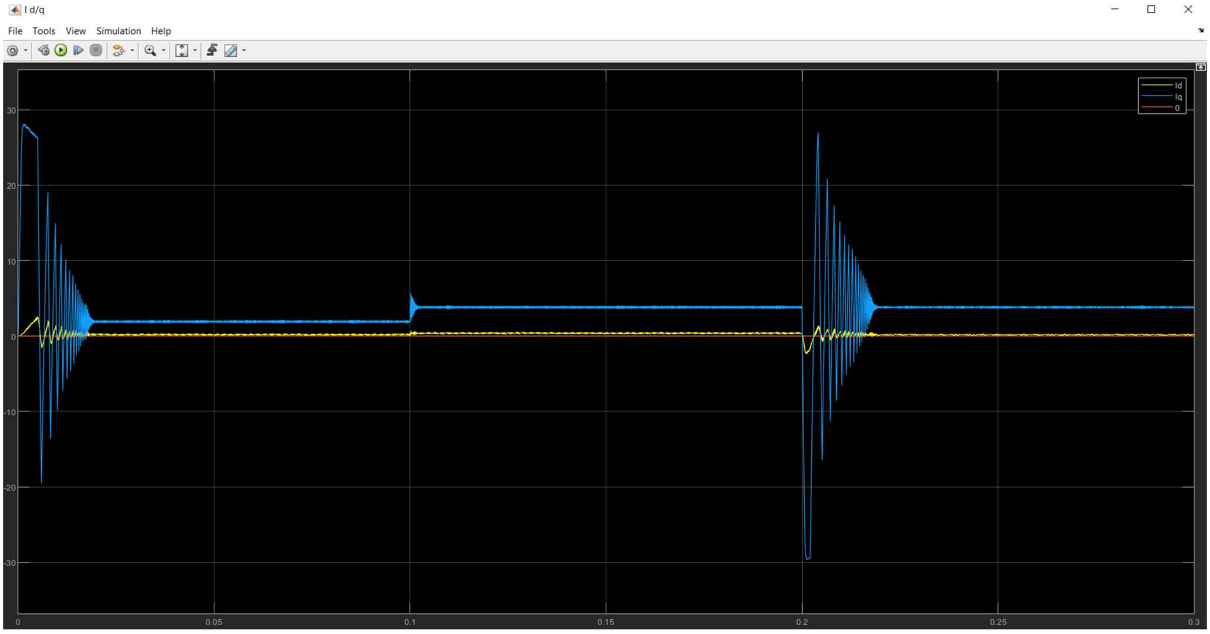
Graph 1: Stator Currents I_a , I_b and I_c over a 0.3s interval



Graph 2: Stator Currents I_α and I_β over a 0.3s interval



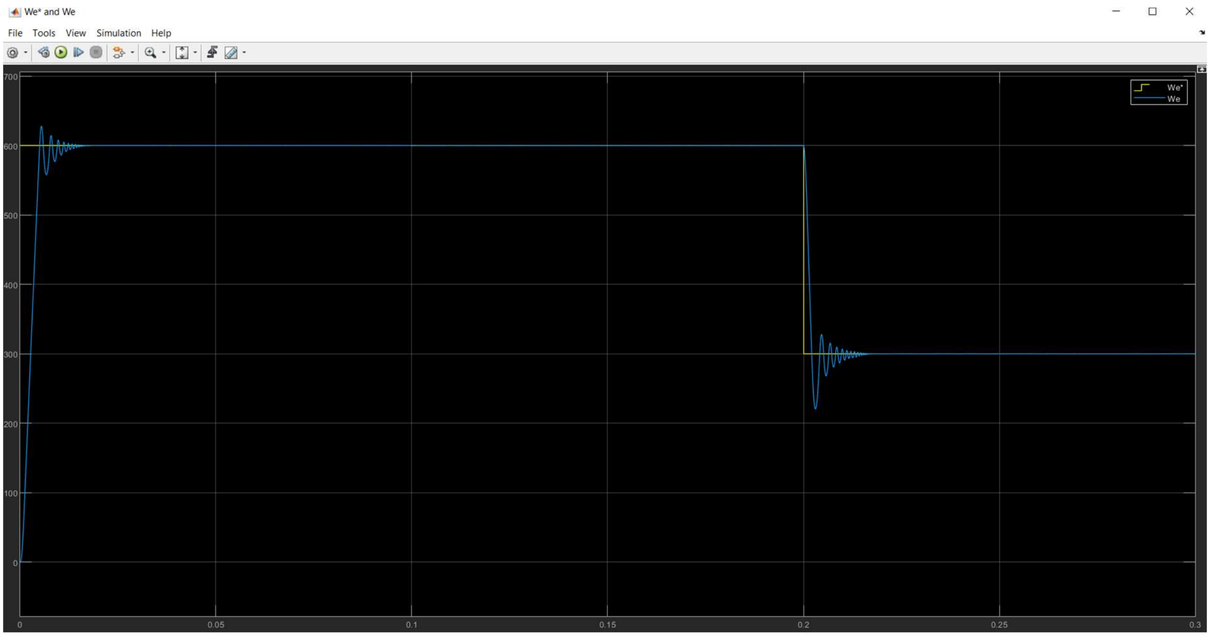
Graph 3: Stator Currents I_d and I_q over a 0.3s interval



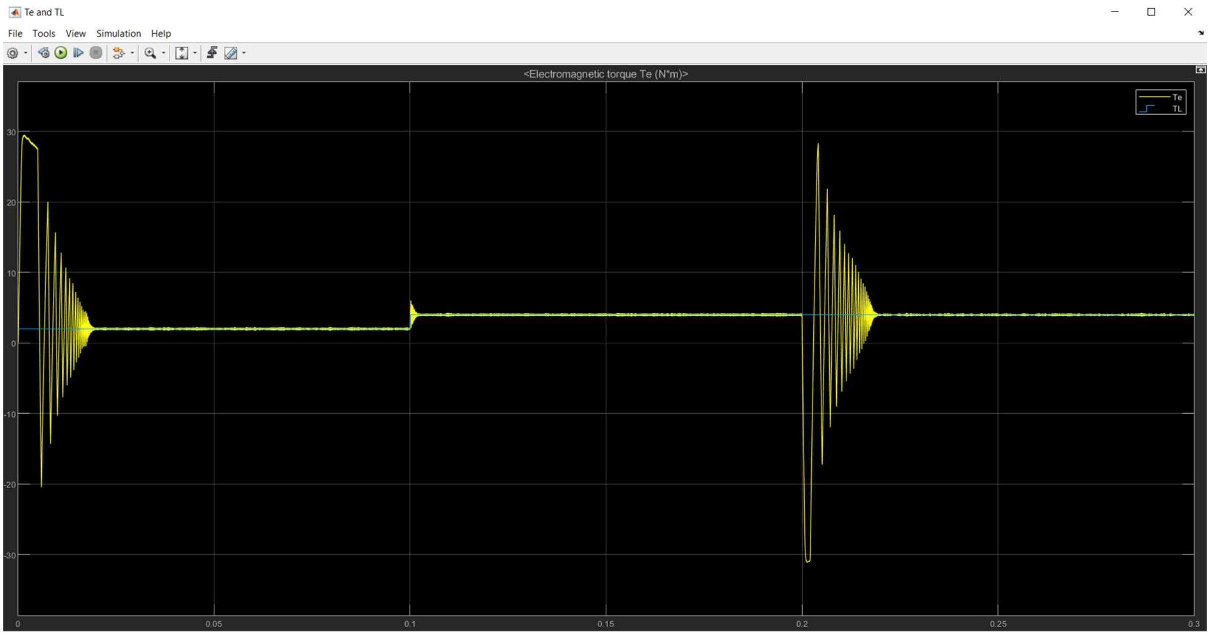
From the graphs above, the results correspond with our expectations. The stator currents in Graph 1 show 3 balanced sinusoids with an amplitude increase at 0.1s and 0.2s. This is due to the Torque decrease at 0.1s and Rotational speed decrease at 0.2s. Due to the properties of the Clarke transform we also expect I_α and I_β to also have an amplitude increase (as shown). Because I_d is maintained at 0 for max Te/Amp, we expect I_d to remain around 0, where as, I_q should Increase with the increase amplitude of the Alpha Beta reference frame.

ii)

Graph 4: Angular Speed of $\omega_e{}^*$ and ω_e over a 0.3s interval



Graph 5: Torque of T_e and T_L over a 0.3s interval

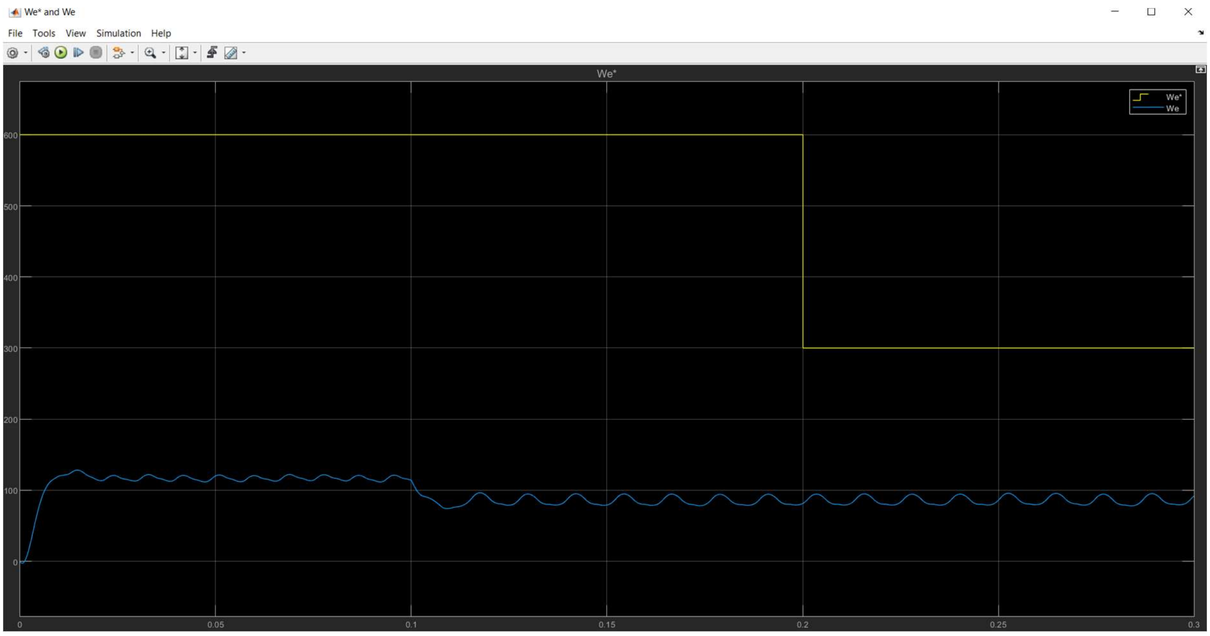


When T_L is increased at 0.1s, ω_e remains constant. This is done by the speed control loop as it serves to regulate the speed of the motor against the effect of the load torque disturbance. However, T_e Adjusts to match T_L at 0.1s because the torque developed by the motor is directly proportional to the magnitude of I_q. We can therefore see the magnitude change of I_q in Graph 3. I_d still remains at 0 for maximum output torque per Amp. When ${\omega_e}^*$ is increased at 0.2s the negative feedback system adjusts accordingly, resulting in the transient behaviour shown in Graphs 1-5 as the system tries to reach equilibrium again.

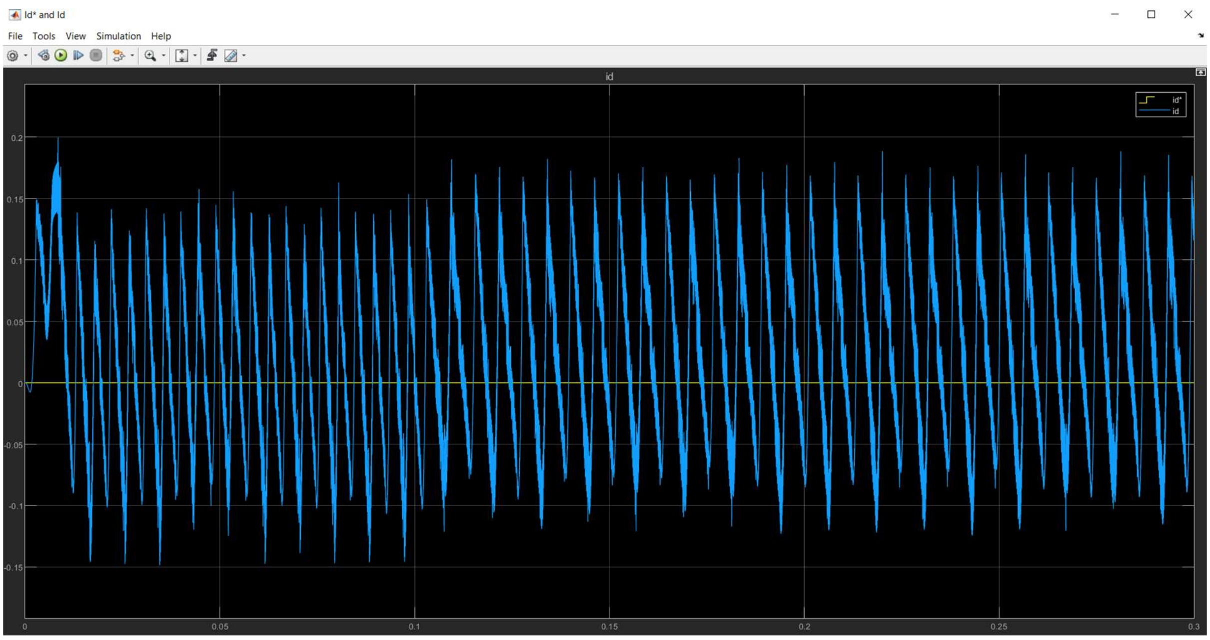
Part 2

Changing the saturation limit of each current controller to a minimum and maximum saturation value of -30 and +30 and showing $\omega_e{}^*$, ω_e and $I_d{}^*$, I_d on two separate scopes.

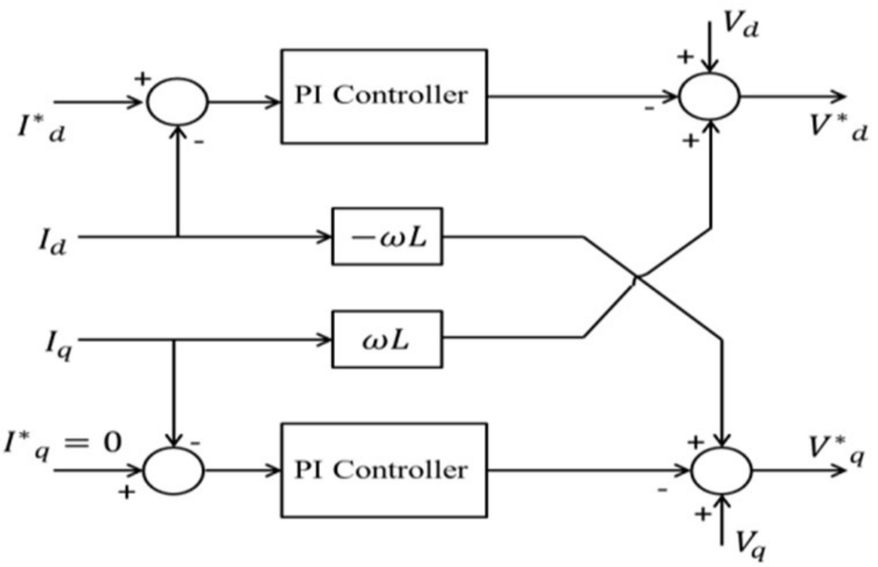
Graph 6: Angular Speed of $\omega_e{}^*$ and ω_e over a 0.3s interval

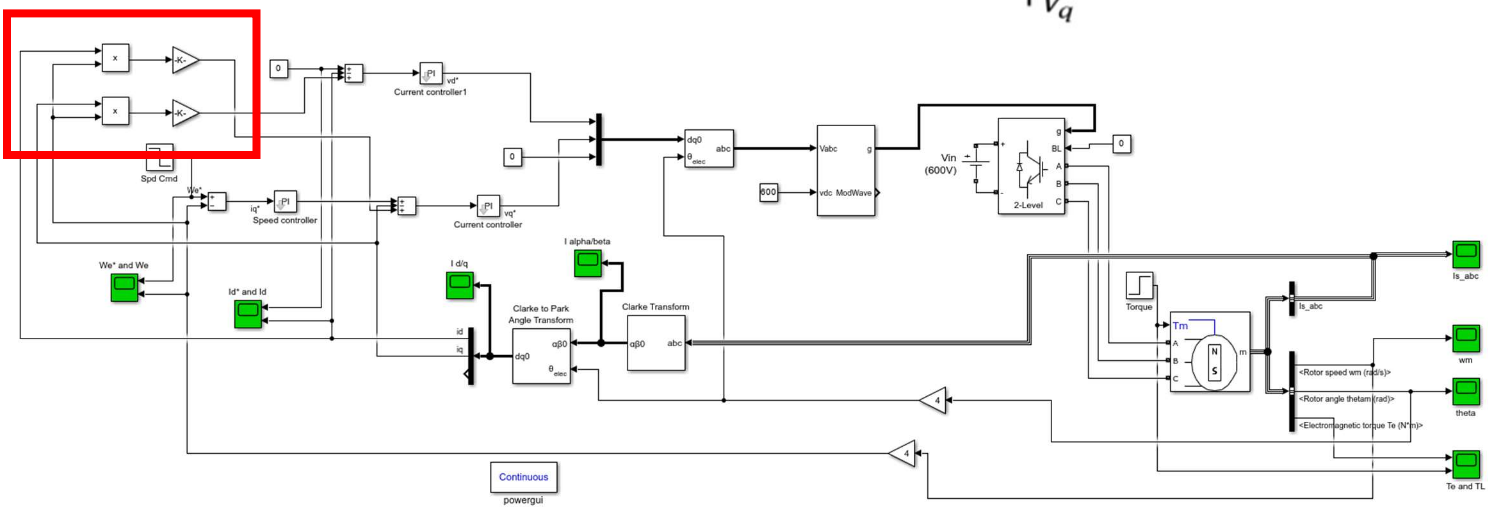


Graph 7: Stator Currents I_d and $I_d{}^*$ over a 0.3s interval



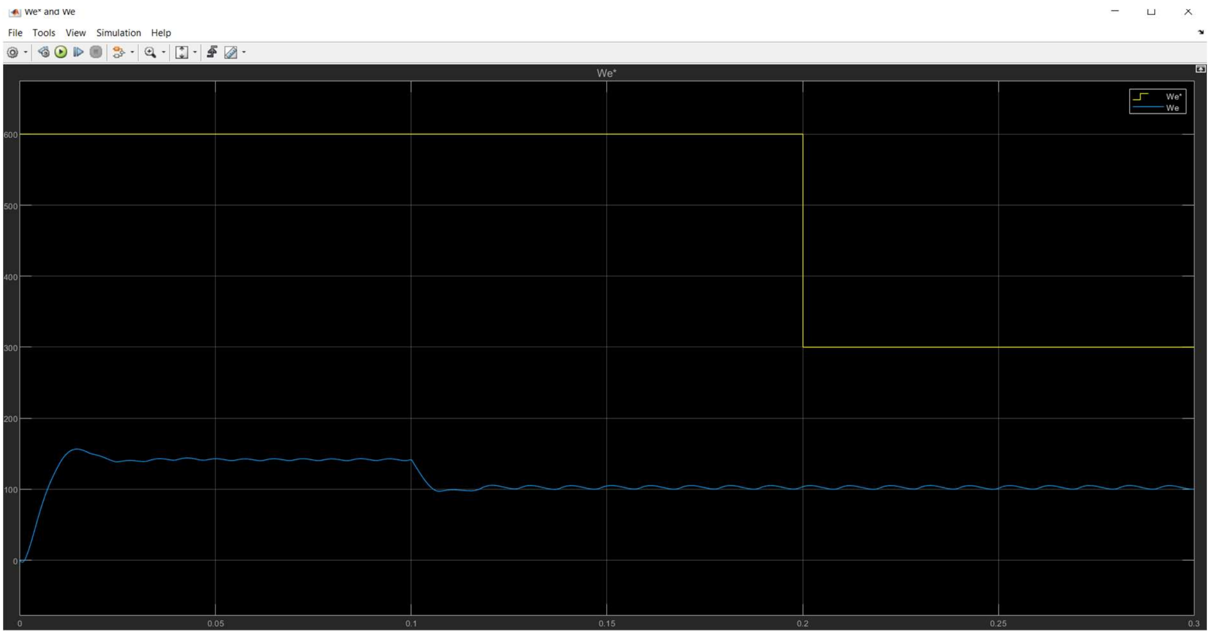
The output values do not correspond with the reference values. These cross coupling effects lead to vibration and noise as well as the motor having undesired behaviours. This can be seen in Graphs 6 and 7. To compensate for the cross-coupling effect between the d and q axes, this method can be used.



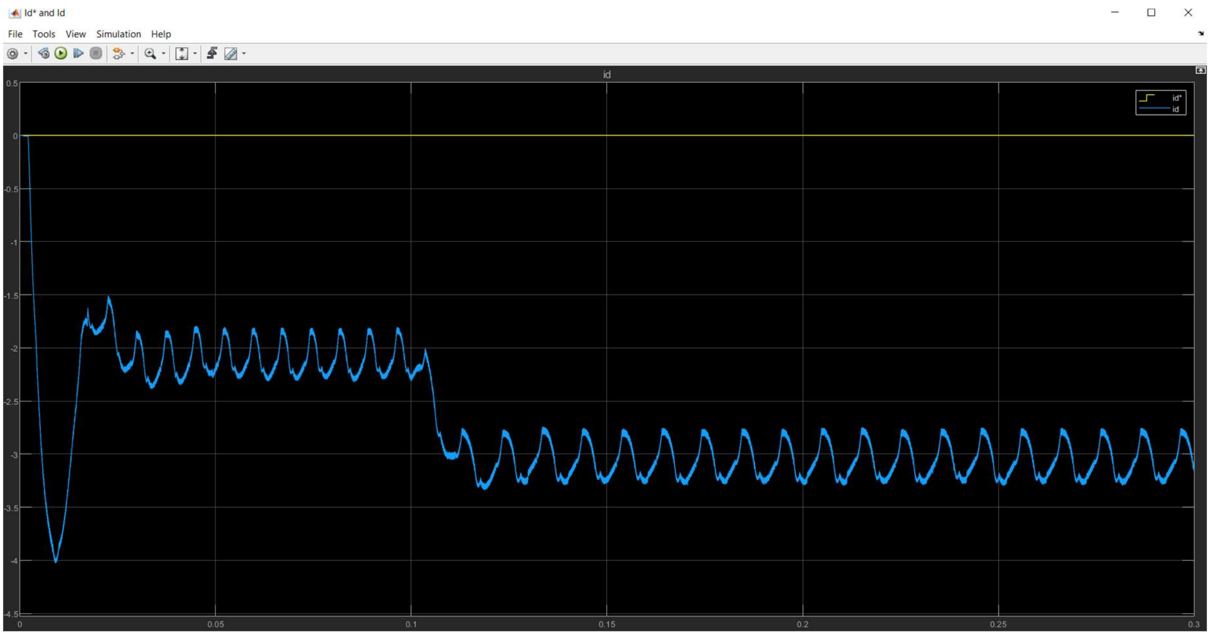


Using the proposed method for compensation, the following graphs were obtained.

Graph 8: Angular Speed of $\omega_e{}^*$ and ω_e over a 0.3s interval



Graph 9: Stator Currents I_d and $I_d{}^*$ over a 0.3s interval



From the results it can be seen that the cross coupling effect has been reduced. Noise has been reduced in both Graphs 8 and 9, comparing them to Graphs 6 and 7 where the cross-coupling effect was present.

Bibliography

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