Induction Motor Drive For Smart Electric Vehicle

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Abstract

The new revolutionary age is demanding more and more vehicles that are both user and environment friendly. Smart Electric Vehicles are one of them which are taking huge attention to the public. An induction motor is used inside these vehicles which takes care of the speed and torque of the car. In this project, to control the speed and torque of the motor, a Vector control-based electric motor drive is developed. The motor current is fed to the Field Oriented Control (FOC) algorithm which generates correction voltage after comparison of the actual and desired values. The Space Vector Pulse Width Modulation (SVPWM) converts the correction voltages to the three-phase inverter gate signals. This three-phase inverter drives the motor. This whole system works in a closed-loop and maintains the output at the desired value.

Objective

1. ACIM Modeling
2. Space Vector PWM Development
3. IFOC Implementation
4. Clark and Park Transformation
5. Closed loop PI control

Methodology

1. Stator phase currents are measured.
2. Current is converted to αβ coordinate system. Rotor position is derived by integrating the speed by means of speed measurement sensor.
3. Rotor flux linkage vector is estimated by multiplying the stator current vector with magnetizing inductance Lm and low-pass filtering the result with the rotor no-load time constant Lr/Rr.
4. Current vector is converted to dq coordinate system.
5. d-axis component of the stator current vector is used to control the rotor flux linkage and the q-axis component is used to control the motor torque. PI controllers are used to control these currents.
6. PI controllers provide dq correction component voltage.
7. Voltage components are transformed from dq coordinate system to αβ coordinate system.
8. αβ voltage components are fed in Space Vector PWM (SVPWM) modulator, for signaling to the power inverter.

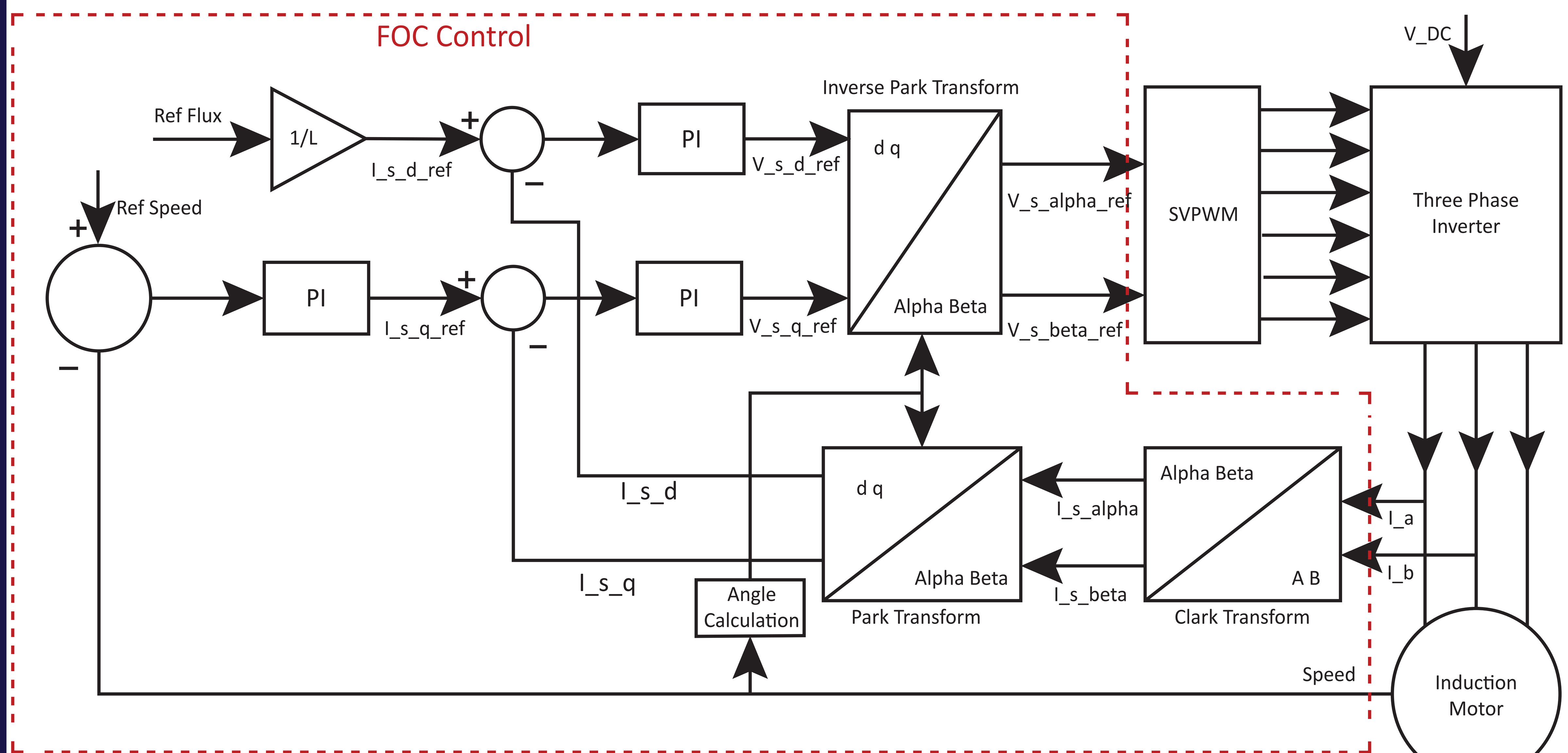

Figure 1. Block diagram of Field Oriented Control of Induction Motor

Space Vector PWM

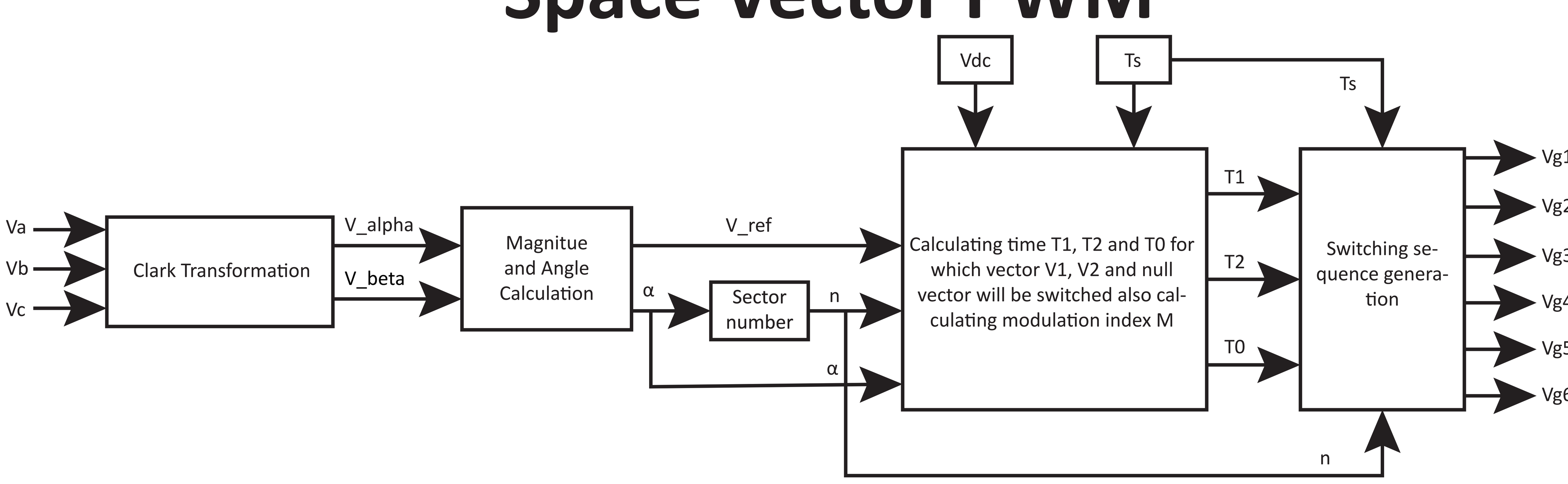

Figure 2. Block diagram of Space Vector Pulse Width Modulation (SVPWM)

References

[1] Muhammad H. Rashid, Power Electronics Devices, Circuits, and Applications, Pearson Education, 2014
[2] Stephen J. Chapman, Electric Machinery Fundamentals, McGraw-Hill, 2012
[3] Vector control (motor), https://en.wikipedia.org/wiki/Vector_control_(motor)
[4] Gunay Simsek, Sensorless DFOC of induction motor by flux and speed estimation using model reference adaptive system, 2004 (Available online)

Simulation Results

Induction Motor Modeling In Simulink

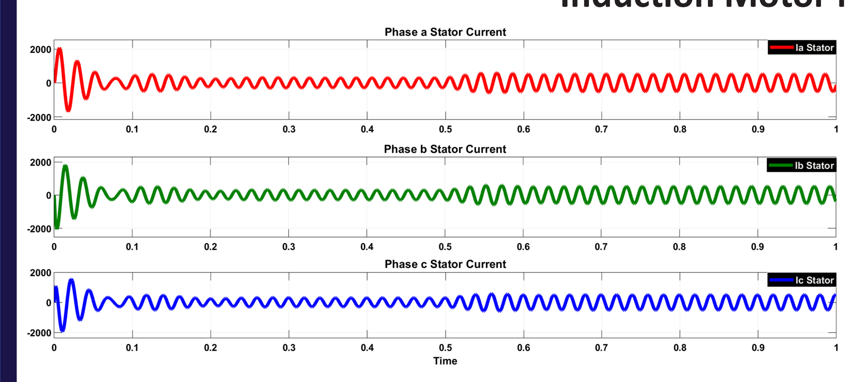

Figure 3. Three phase stator current of induction motor step change in slip from 2% to 4% at t=0.5

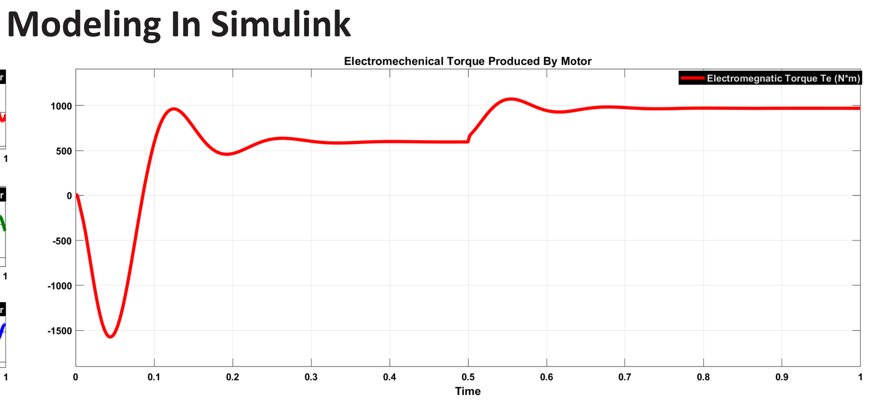

Figure 4. Electromechanical torque of induction motor step change in slip from 2% to 4% at t=0.5

Space Vector PWM Development In Simulink

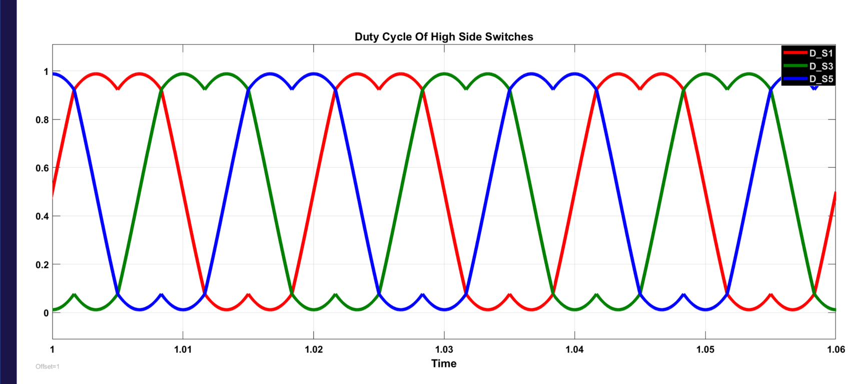

Figure 5. Duty cycle of high side switches

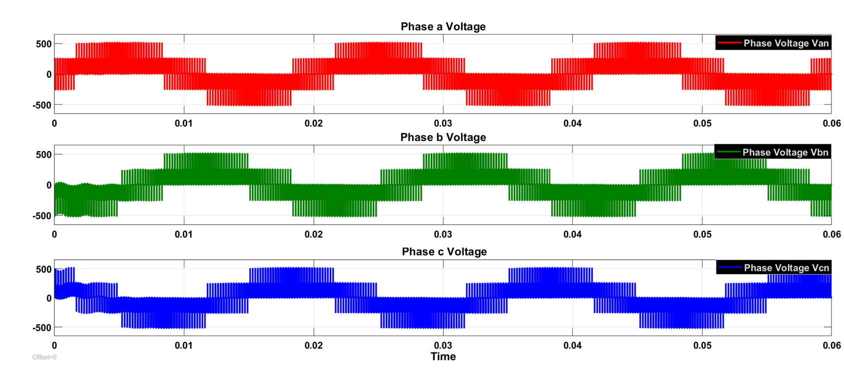

Figure 6. Three phase voltage from inverter with SVPWM gating signal

Clark and Park transformation

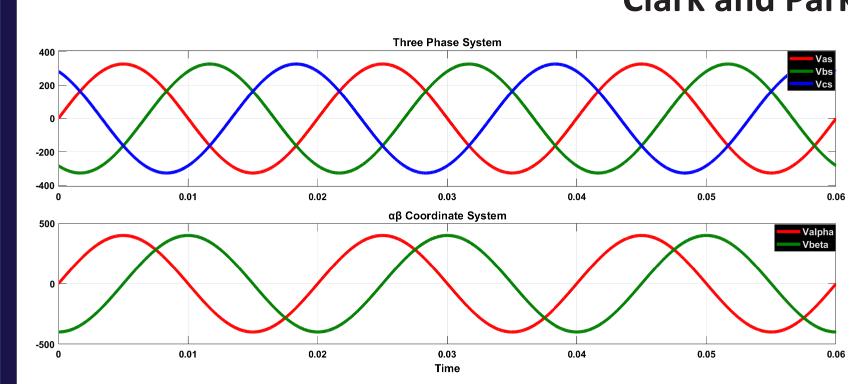

Figure 7. Clark Transformation

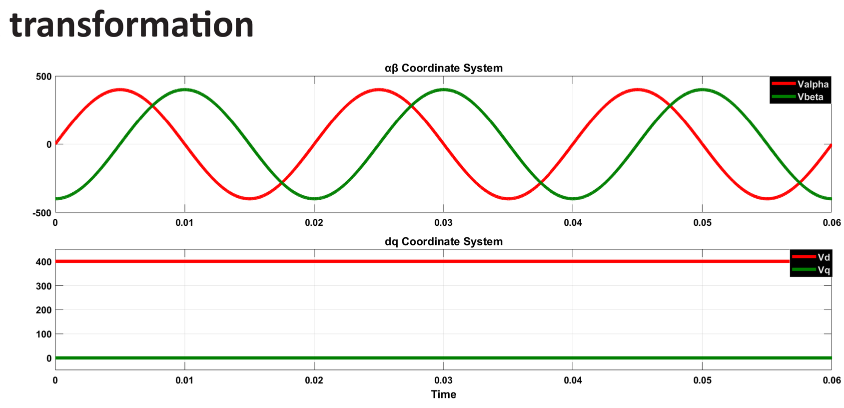

Figure 8. Park Transformation

Field Oriented Control of IM In Simulink

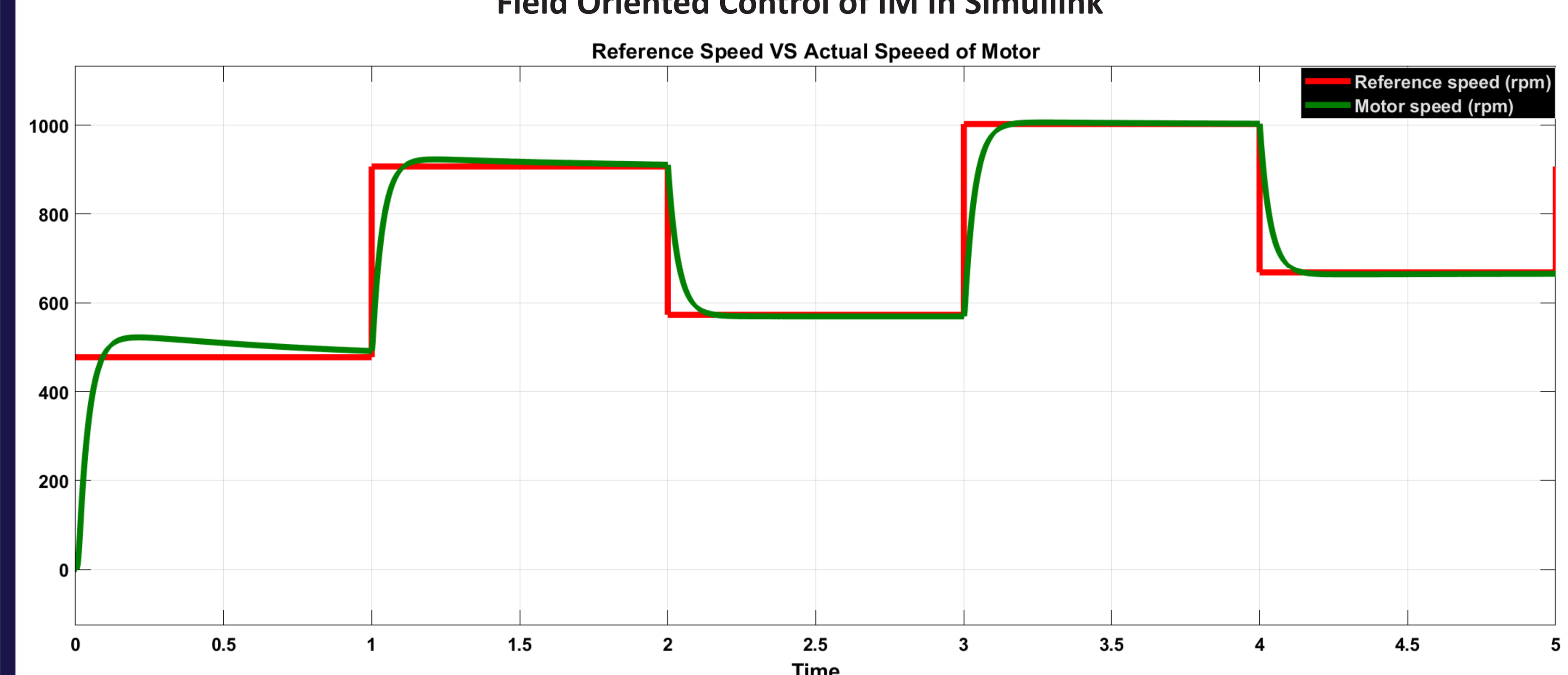

Figure 9. Reference speed VS actual speed of motor, FOC implemented

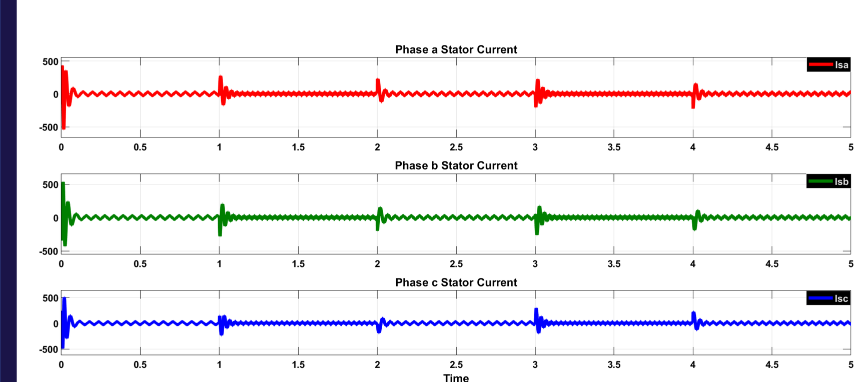

Figure 10. Three phase stator currents of motor at no-load, FOC implement-

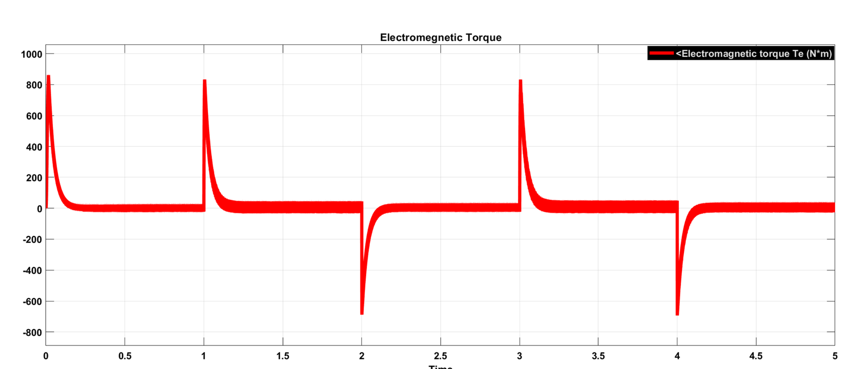

Figure 11. Electromechanical torque of motor at no-load, FOC implemented

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Summary

This project endeavors to the improvision of both sensored and sensorless field-oriented control (FOC) for the induction motor. PI feedback controllers are used to maintain the parameters at desired values. We implemented Space Vector PWM Technique to generate a gate signal for the inverter from the correction voltages generated by the PI controller. This project likely to be expanded further to implement other controllers and feedback techniques like fuzzy logic or Particle Swarm Optimization (PSO).

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