A PRESENTATION ON THE DESIGN OF AN AUTOMATIC SPEED DRIVE OF A DC MOTOR USING PI CONTROLLERS FOR FOUR QUADRANT MOTOR OPERATION

By:

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2015/3947

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WHAT IS THE AIM OF THIS PROJECT ?

The Aim of this research project is to design and analyse a speed-drive for a Permanent Magnet DC (PMDC) Machine using MATLAB/SIMULINK as a simulation aid

SUMMARY OF PROJECT OBJECTIVES

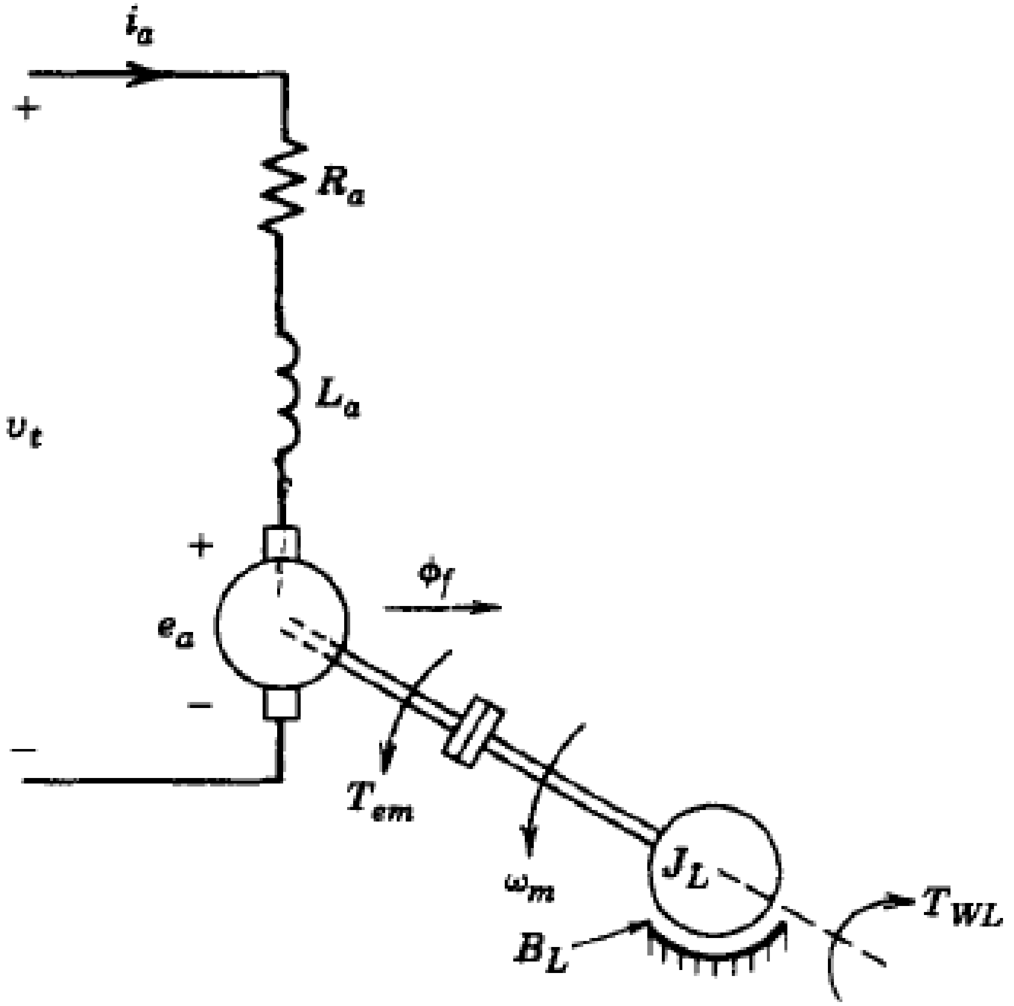
- ✓ To design and simulate a PID controller for controlling the speed of a DC motor
- ✓ To control the speed response of Brushed PMDC Motor for accurate reference speed tracking at the selected value in all four quadrant of operation.
- ✓ To ensure safe condition of the motor during operation
- ✓ To simulate and show that PID Controllers are very effective for agile load disturbance rejection while maintaining fixed set speed.

A BRIEF BACKGROUND ON PMDC MACHINES

- PMDC motors are useful in a wide range of applications
- PMDC motors offer high stating torque, compact size with energy efficiency.
- Linear speed-torque curve make them suitable for adjustable speed and servo applications
- Applications of dc motor includes: Cutting tools, Mobile traction, Mobile robots etc.
- DC motors also come in a wide range of power rating from very low to high power motors.
- DC machines play a major role in providing speed, torque and position actuation in many fields. Hence, the need for effective drive systems for them.

LITERATURE REVIEW AND FINDINGS

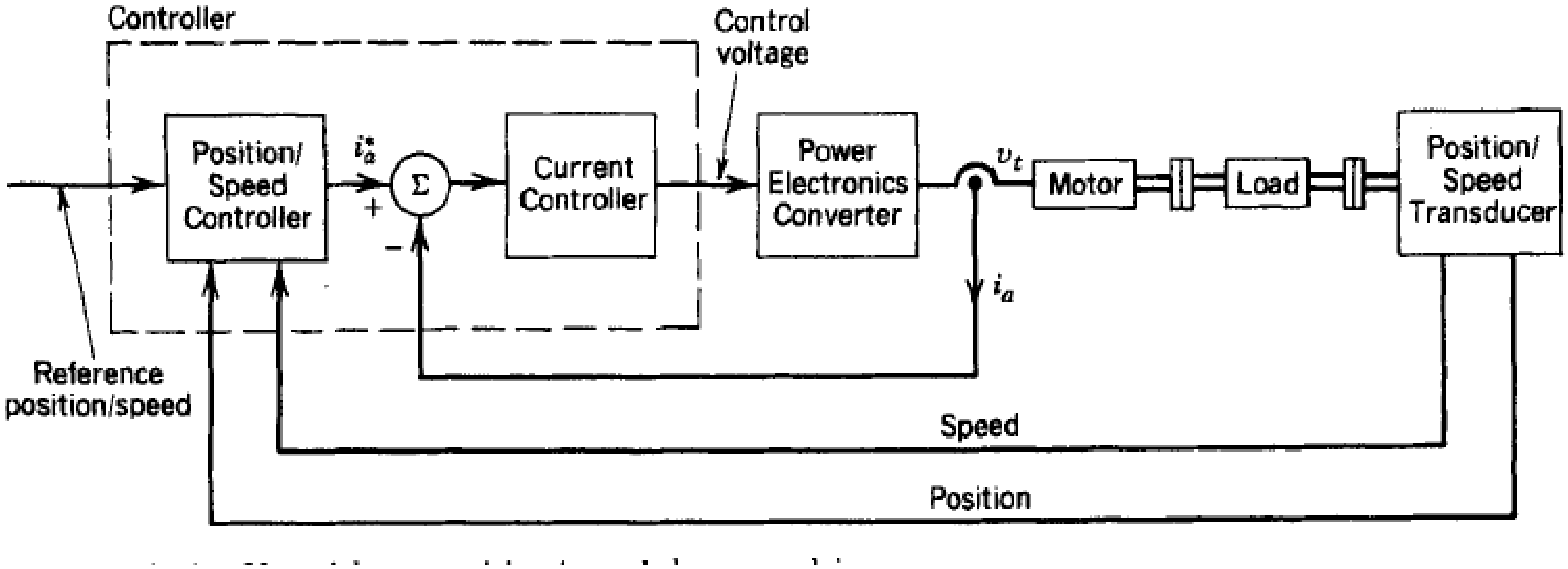
- Field flux is produced by the stator
- EM torque is produced by interaction between field flux and armature current.
- Back EMF is produced by rotation of the armature winding in a magnetic field.
- DC motors are seldom used as generators
- Except during breaking which occurs in the 2nd and 4th quadrant operation of the torque speed plane.
- Link between the electrical and mechanical part of a DC motor occurs in the conversion of armature current to shaft torque.



Source: Ned Mohan et al., Power Electronics Textbook

LITERATURE REVIEW ON MOTOR CONTROLLERS AND DRIVES

- Motor act as the plant
- Power electronics converter for processing and delivering power to motor
- Controller (current, speed and/or position)
- Transducers/sensors



Source: Ned Mohan et al., Power Electronics Textbook

LITERATURE REVIEW ON PREVIOUS WORK DONE

Prof. N. D. Mehta, Prof. A. M. Haque, Prof. M. V. Makwana 2017	Modelling and simulation of P, PI and PID controller for speed control of DC Motor Drive	Presented a DC motor drive combined with a controller for speed control under varying load condition. The PID controller was found to a more suitable control algorithm for controlling the system. And a current and speed loop was used.
Gucin, Taha Nurettin; Bibero glu, Muhammet; Fincan, Bekir; Gulbahce, Mehmet Onur 2015	Tuning Cascade PI(D) Controllers in PMDC Motor Drives: A Performance Comparison for Different Types of Tuning Methods	Discussed a classical Proportional Integral (PI) tuning technique which is model based in nature and requires just the motor parameters and the cross-over frequency or bandwidth of the controller to be specified. The gains of the controller are achieved by pole cancellation.

METHODOLOGY

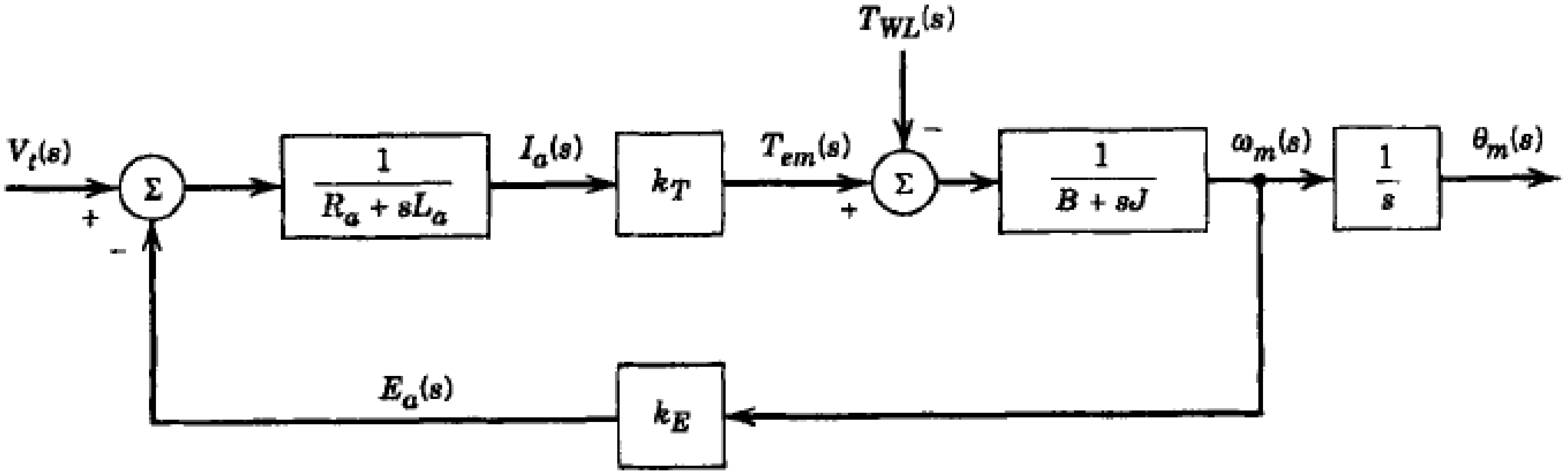
1. MATHEMATICAL MODELLING

$$V_t = e_a + R_a i_a + L_a \frac{di_a}{dt}$$

Electrical Relation

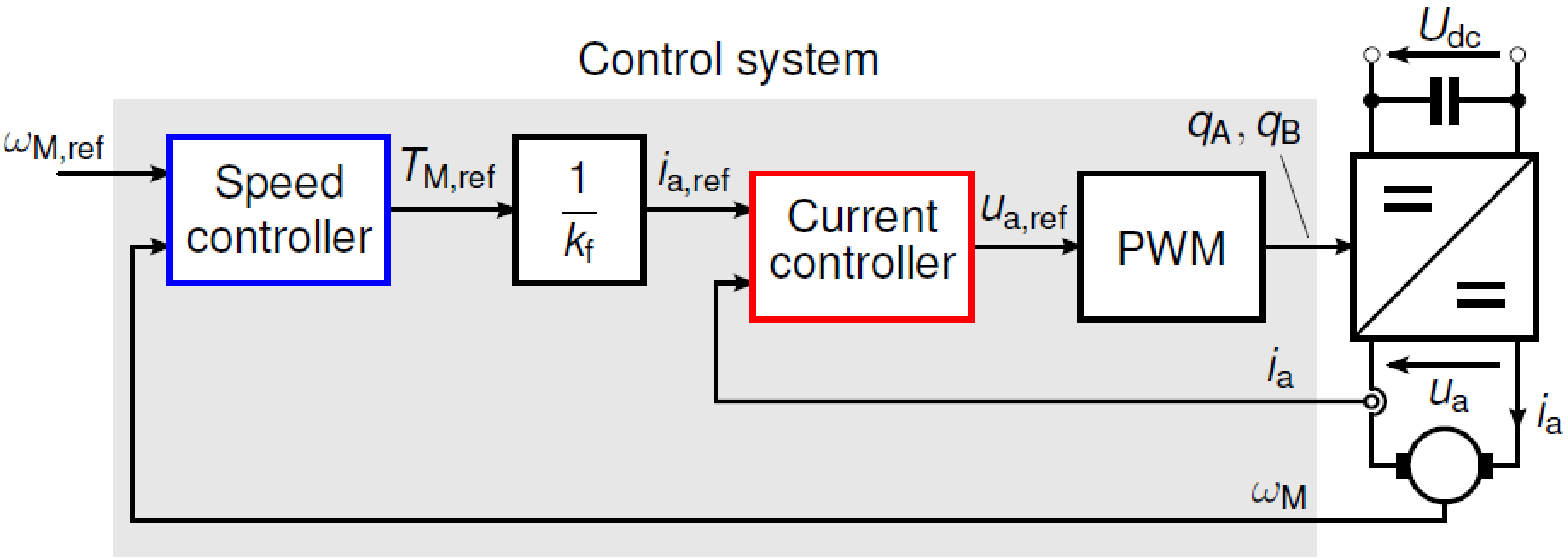
$$T_{em} = J \frac{d\omega_m}{dt} + B\omega_m + T_{wl}$$

Mechanical Relation

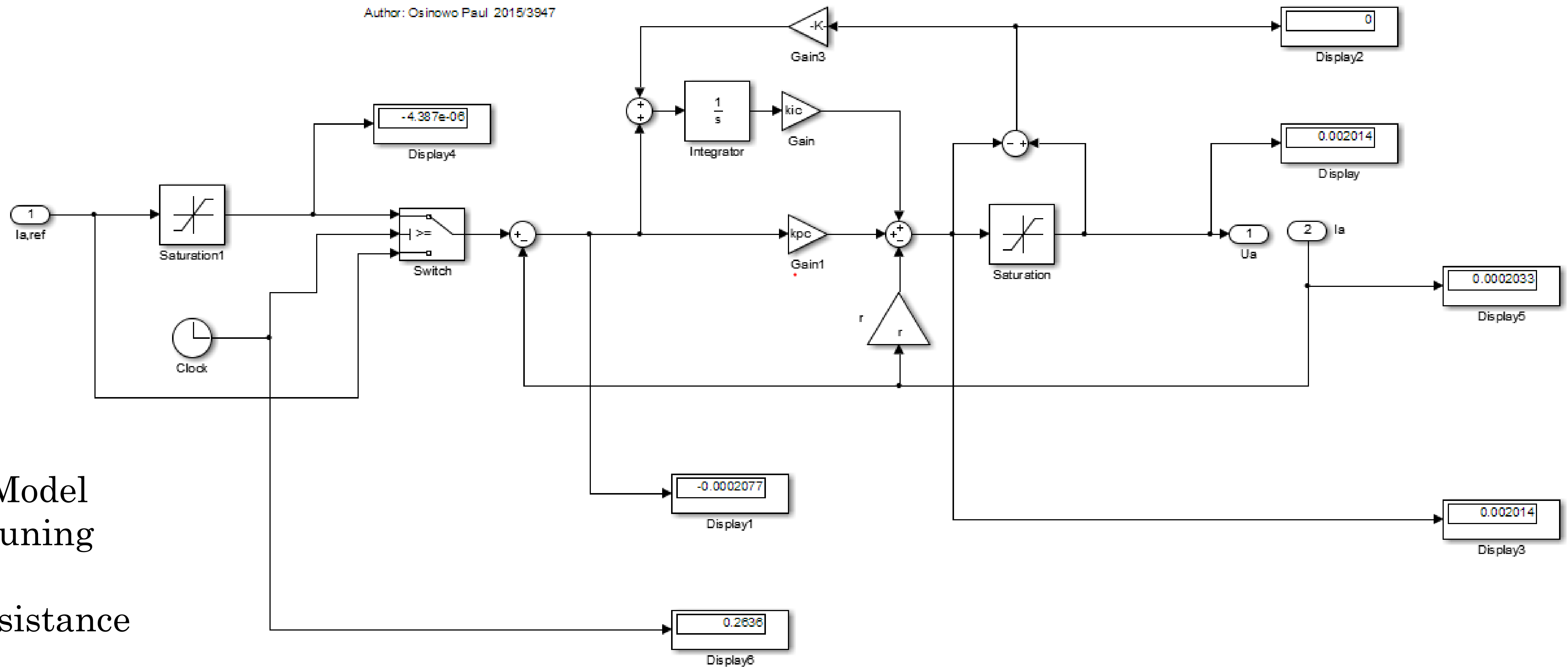


METHODOLOGY

2. CONTROL STRATEGY

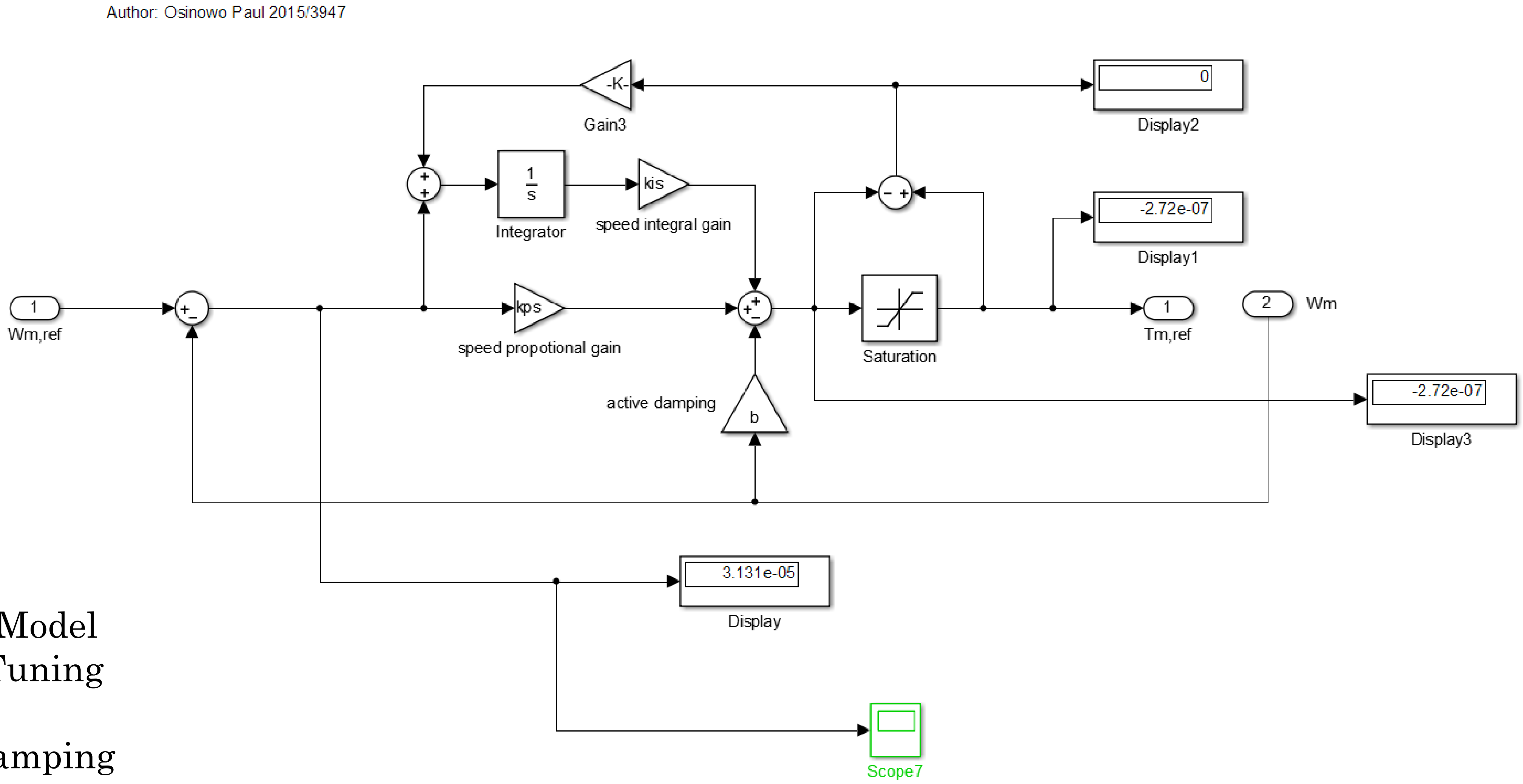


Current Controller



- Internal Model Control Tuning
- Active Resistance
- Current Limiting
- Integral Windup

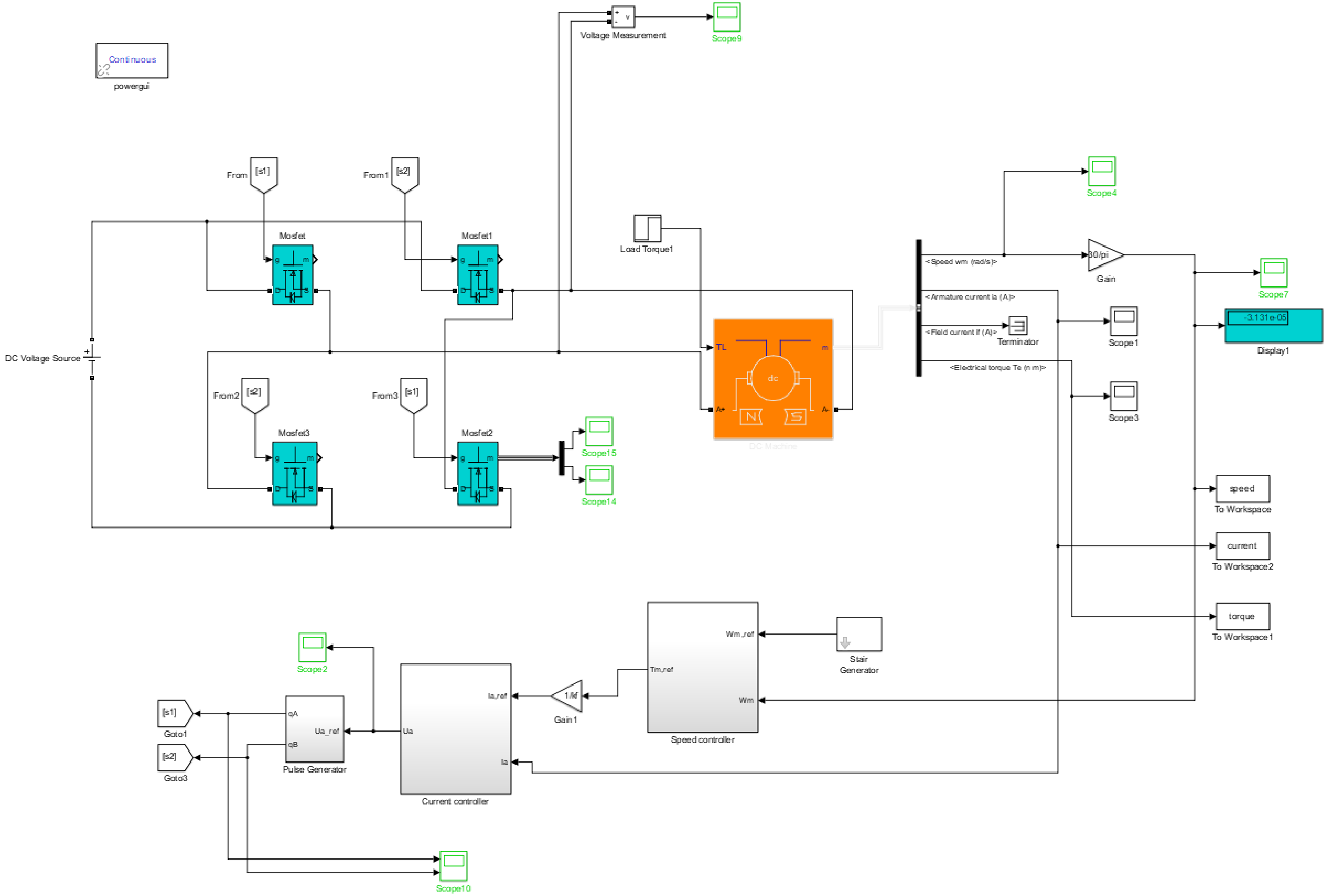
Speed Controller



- Internal Model Control Tuning
- Active Damping

Overall Simulation On Simulink

- Pulse Width Modulation
- Full Bridge DC-DC Converter
- Permanent Magnet DC Machine
- Four Quadrant Operation

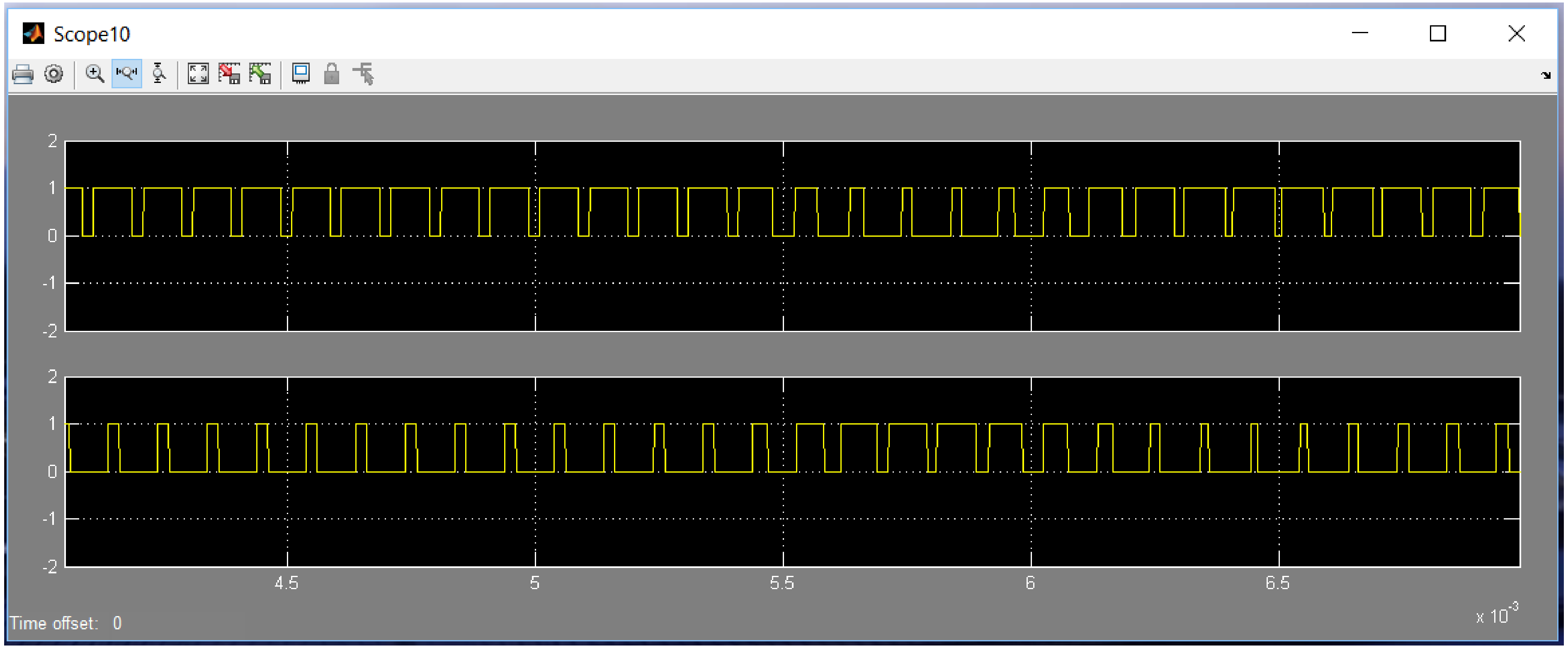


METHODOLOGY

3. Unipolar Pulse Width Modulation

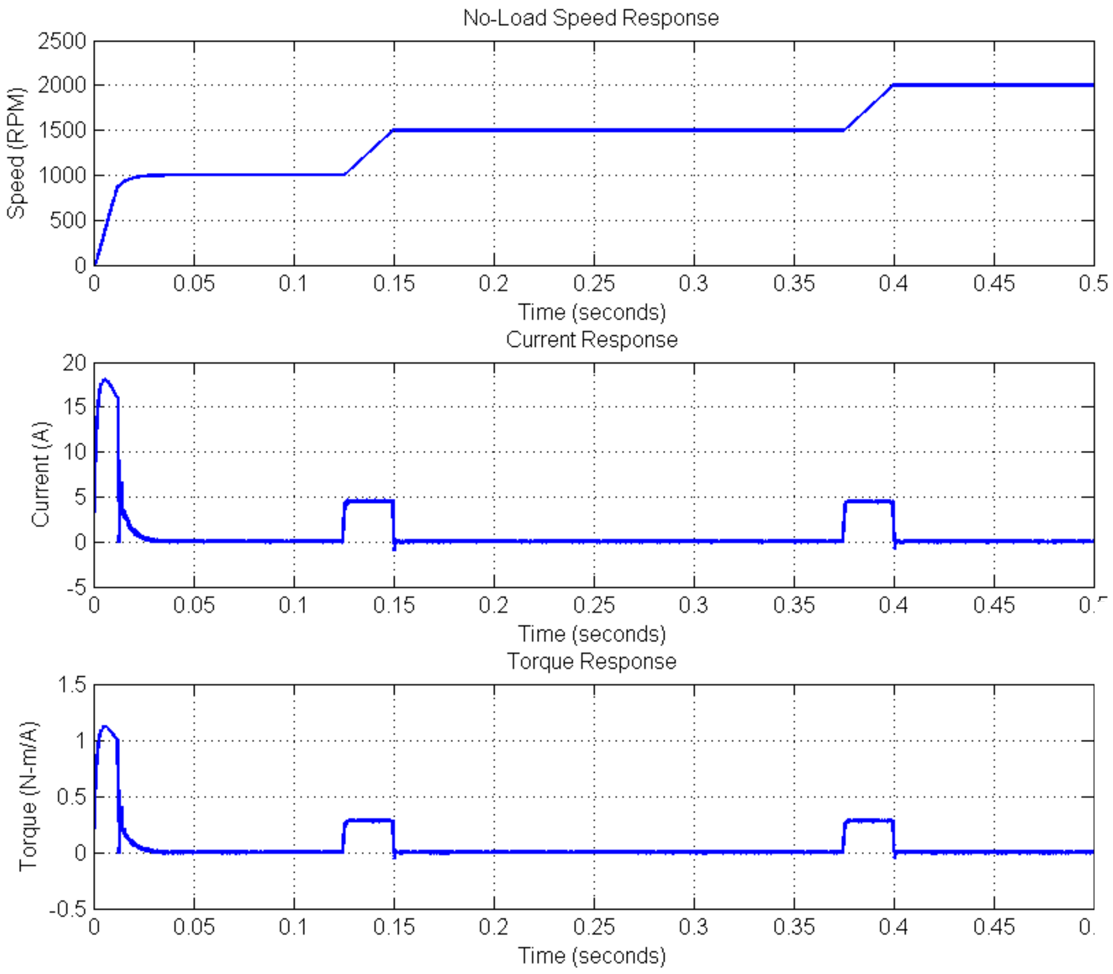
$$d_A = \frac{1}{2}\left(1 + \frac{u_{a,ref}}{U_{dc}}\right)$$

$$d_A = \frac{1}{2}\left(1 - \frac{u_{a,ref}}{U_{dc}}\right)$$

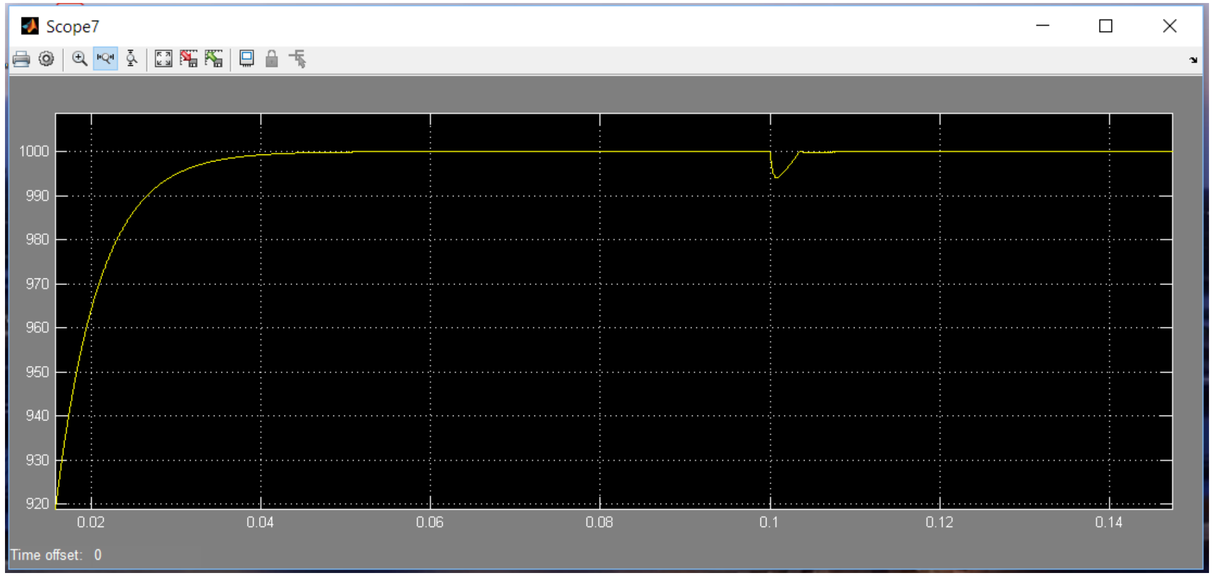


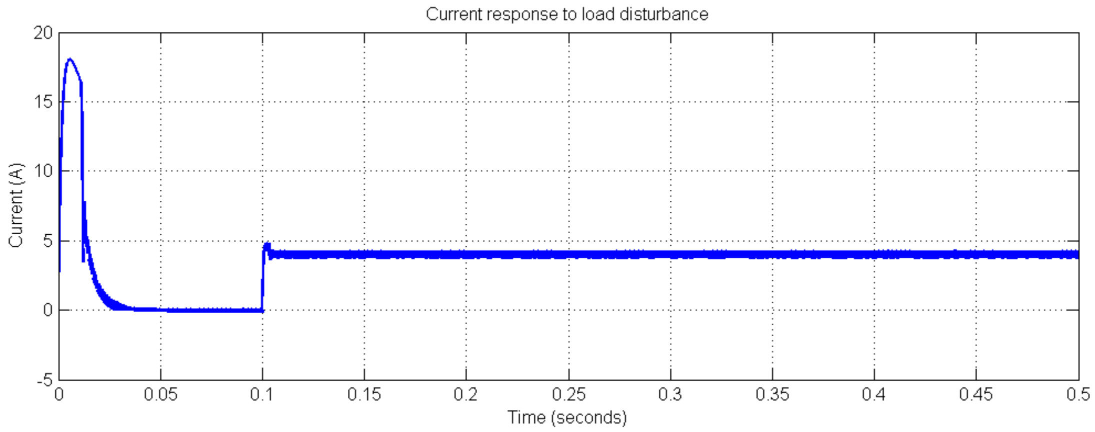
RESULTS

1. Reference Tracking



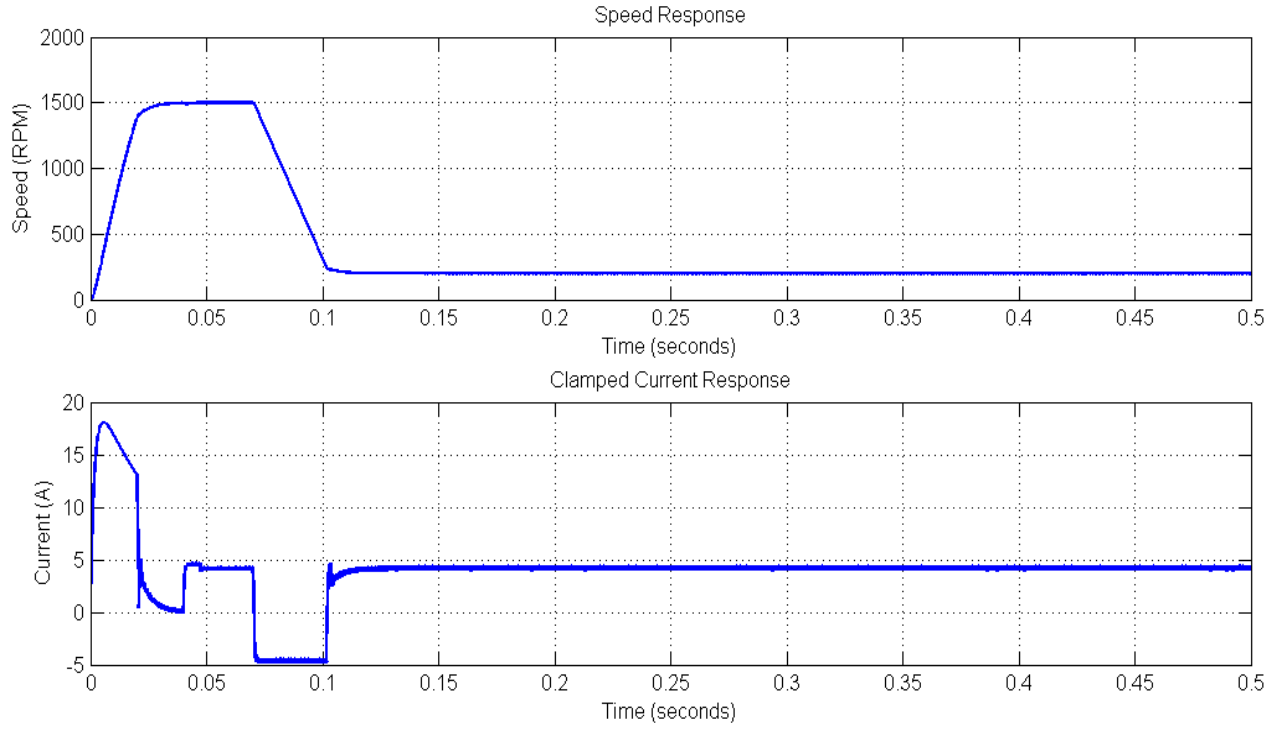
2. Load Disturbance Rejection



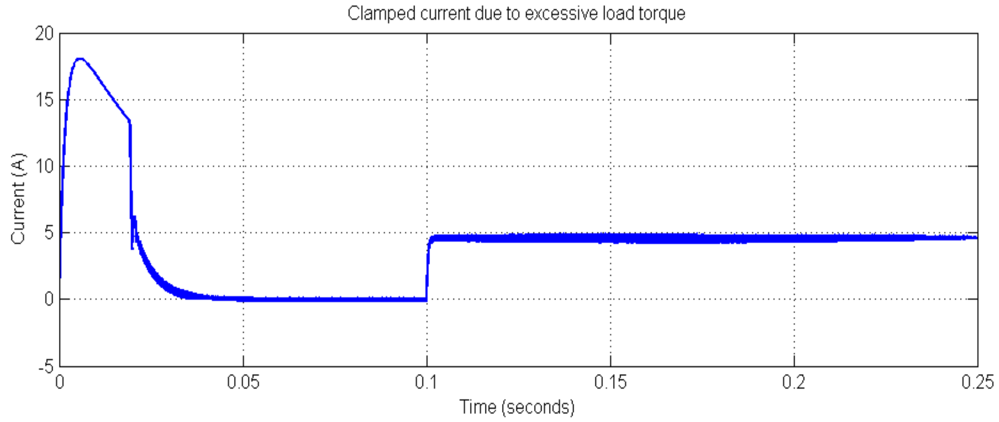


RESULTS

3. Speed Dropping During Full-Load

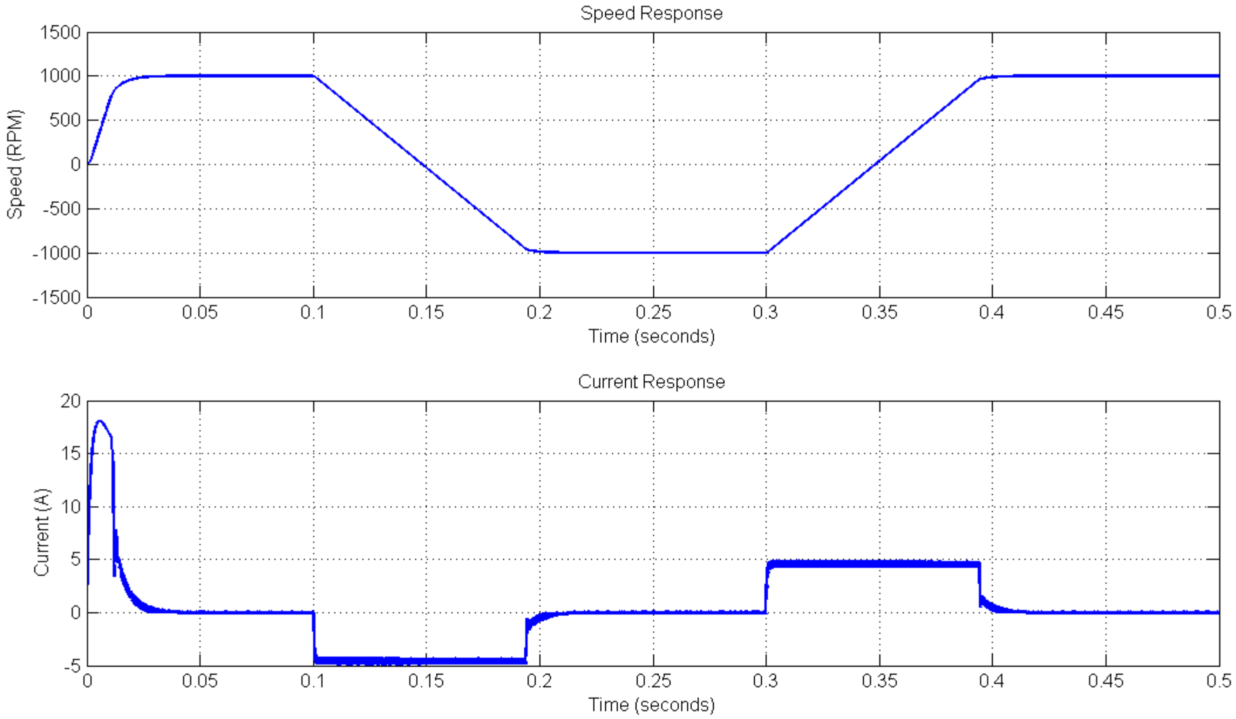


4. Current Limiting



RESULTS

5. Bi-Directional Operation



6. Damped Speed Response with Minimal Overshoot