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VVVF INDUCTION MOTOR DRIVE TO TEST SPEED SENSOR

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ABSTRACT

Speed sensor is an important component in industries, electric locomotives etc. Here a strategy is proposed in which a speed sensor can be tested to check it's health. For that the sensor is made a part of a field oriented controlled induction motor drive and made to sense speeds up to the rated speed of motor .Field oriented control can provide better dynamic response which leads to a reduction in manufacturing cost of drive.

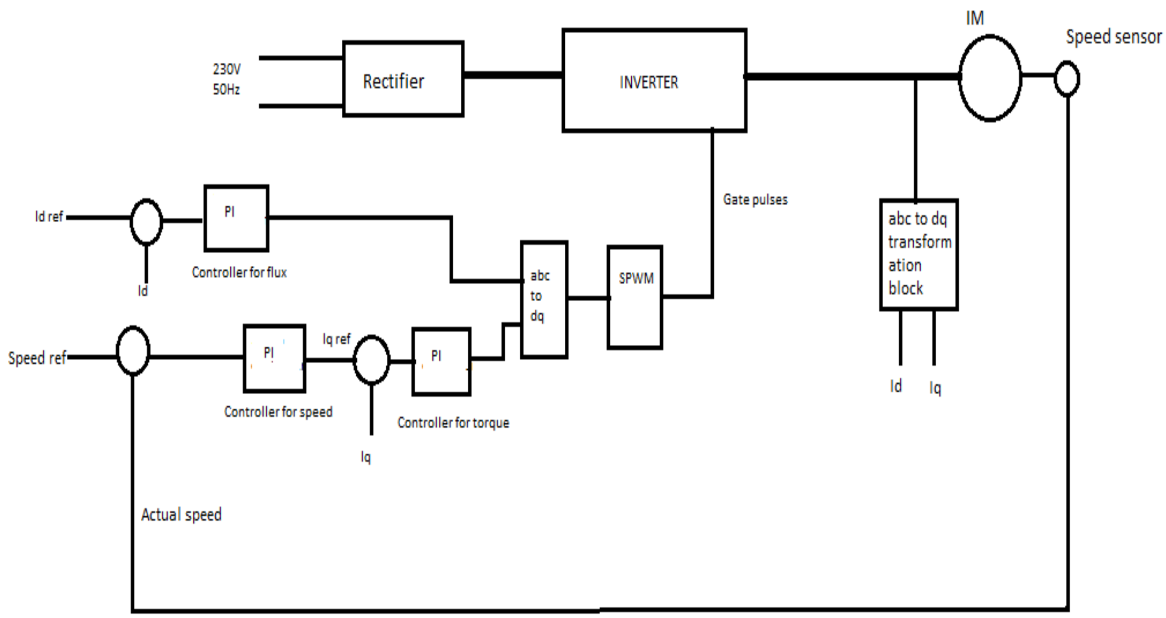
Keywords: Field Oriented Control, Dynamic, Drive.

1. INTRODUCTION

Speed sensors are very essential in an electric locomotive or any industry to monitor various speeds accurately.In case of electric loco it can be used in fields of traction control, train control etc.So it is essential to test the health of speed sensor and a VVVF induction motor drive with field oriented control can be effectively used for that.In this control flux and torque can be controlled independently.This provides good dynamic response and reduced flux variations,which leads to a reduction in large excursions of stator current avoiding large peak converter and inverter ratings.The objective of this project is to design a vector controlled induction motor drive to test whether the speed sensor is healthy.The software used for simulation is PSIM.Using this control method motor is made to run at different speeds up to its rated speed. The motor is made to rotate in different speed values same as given reference speeds given, using field oriented control.To make the motor run at different speeds field oriented control is used.The sensor to be tested which is used in the control loop for the function of sensing the actual speed of the rotor,which is to be fed back and compared with reference speed to get the error signal corresponding to compensation speed.The output speed obtained after compensation is checked.If it is obtained same as reference speed,we can conclude that the sensor is healthy.Otherwise it is sensing a wrong speed and it is having a fault.Vector control allows induction motor to be driven with high dynamic performance that is comparable to the characteristics of dc motor.In an induction motor stator current and rotor current are coupled.There is no independent variables for field current and rotor current.Here stator currents are transformed to two independent current components Id and Iq.Id controls flux and Iq controls torque.So flux and torque can be controlled independently and thus we are obtaining wide speed range with good dynamic response.

The system is designed and tested using PSIM software.The PI controllers are designed using Ziegeler Zichols method.

2. BLOCK DIAGRAM



AC supply is rectified using a bridge rectifier and the dc output obtained is given to a 3 phase inverter.The phase difference between two consecutively conducting switches will be 60 degree and that of between switches on common leg is 180 degree.Currents of three phases are sensed and given to abc to dq converter.Speed is sensed using speed sensor which is to be tested. Id reference is compared with actual Id and the error is provided to PI controller which provides compensation signal for Id which corresponds to flux.Reference speed is compared with actual speed to produce speed error when given to PI controller ,provides Iq reference signal which corresponds to torque.This signal is compared with actual Iq and the error is given to PI controller which provides compensation signal which corresponds to torque.

3. DESIGN REQUIREMENTS

Specifications :

Element	Rating
Induction motor	.75Kw,2890rpm
Capacitor	.66F
Input	230V,50Hz
Carrier wave frequency	10Kz

Designed Kp and Ki values for PI controllers:

PI for speed error signal	Kp=.0339,Ki=0.26
PI for torque error signal	Kp=1.12,Ki=.0008
PI for flux error signal	Kp=1.125,Ki=.00023

Capacitor value is selected so as to get ripple free dc voltage for inverter input.Carrier frequency is taken in kilo hertz range so as to increase number of pulses per cycle, which reduces harmonics.

Kp and Ki values are designed using Ziegler Nicholes method.Its values are designed such as to reduce settling time,oscillatons, overshoot etc. Because of reduced oscillations inverters of higher ratings can be avoided and thus cost can be reduced.

4. DESIGN OF PI CONTROLLERS (Ziegler Nicholes Method 1):

PI for speed error :

Open loop circuit

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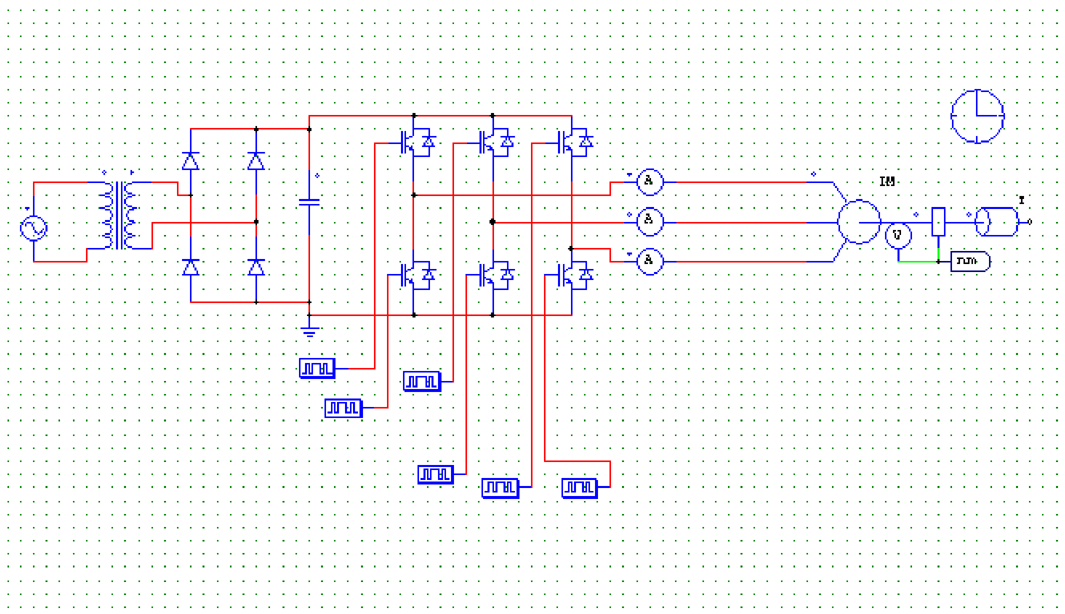
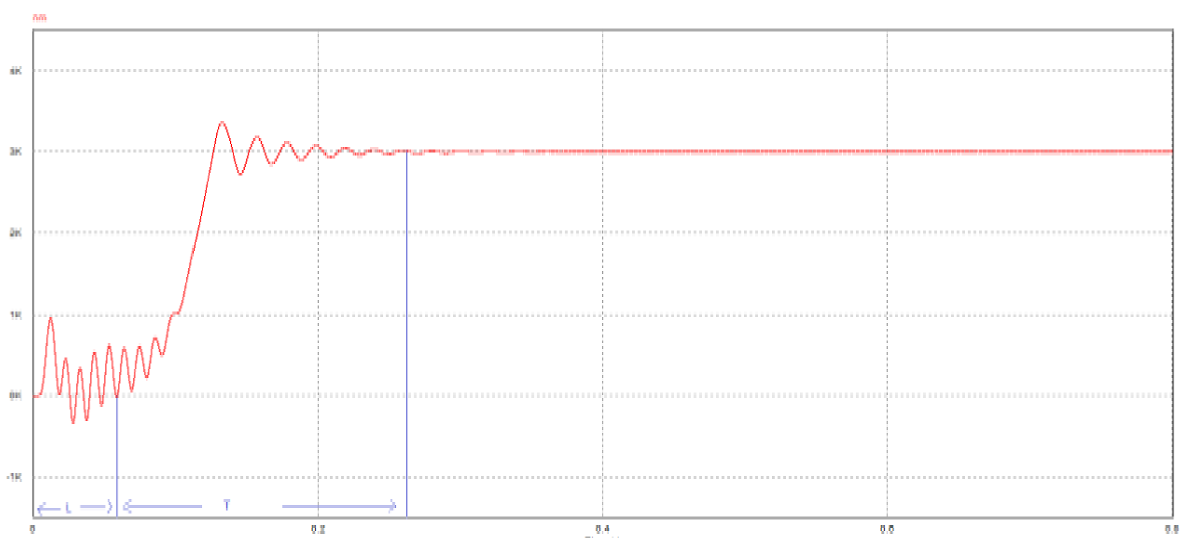


In this method the open loop response of the circuit is obtained.If the response of the parameter is as in the form of the wave form given below ie; slowly raising in a linear manner from zero and then settling to a steady state value ,we can continue with the calculation as follows. Speed response is of that form and we are considering that waveform here.

Open loop response



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$$Kp = 0.9*\frac{L}{T}$$

$$= 0.9*\frac{.008}{.212}$$

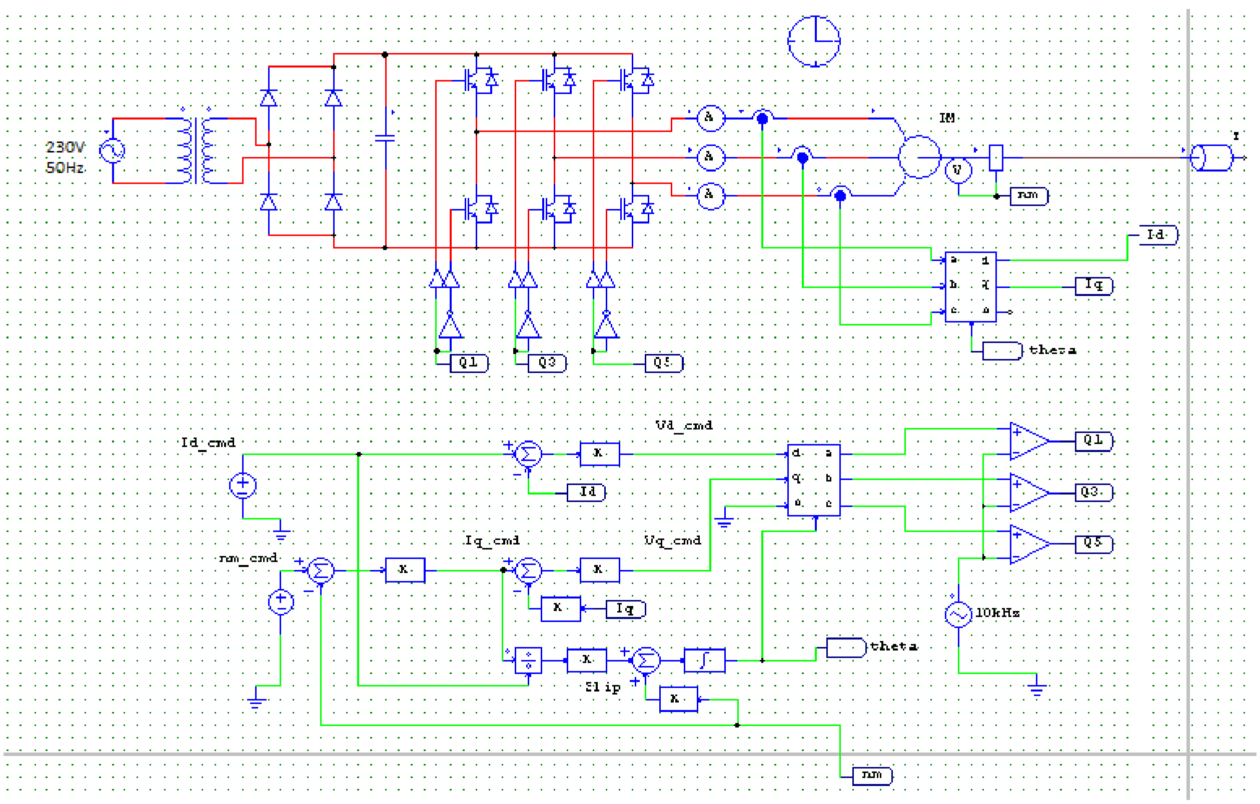
$$= .0339$$

$$Ki = \frac{L}{.3}$$

$$= \frac{.008}{.3}$$

$$= 0.26$$

PI for Torque and flux error(Ziegler Nicholes method2) :



If the response is in an oscillating form with reducing amplitude we follow this method.Id and Iq wave forms are like that and those are considered here.

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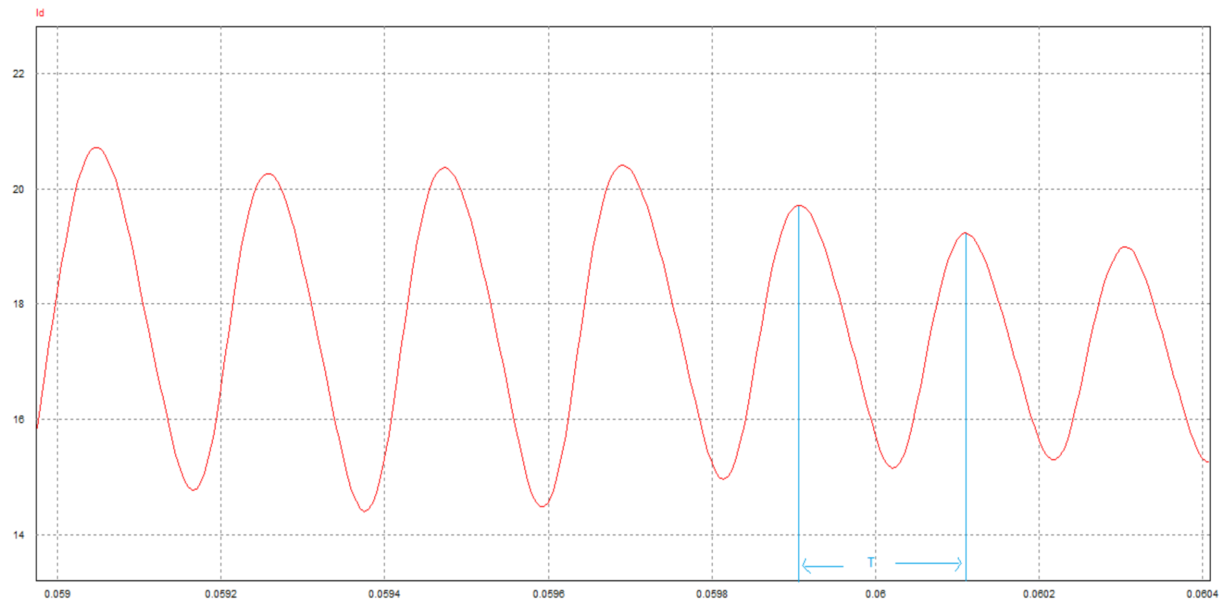
PI for flux error:

Response of Id



$$Kcr = 2.5$$

$$T = .0011$$

$$Kp = Kcr*.45$$

$$= 2.5*.45$$

$$=1.12$$

$$Ki = \frac{T}{1.3}$$

$$= \frac{.0011}{1.3}$$

$$= .0008$$

PI for torque :

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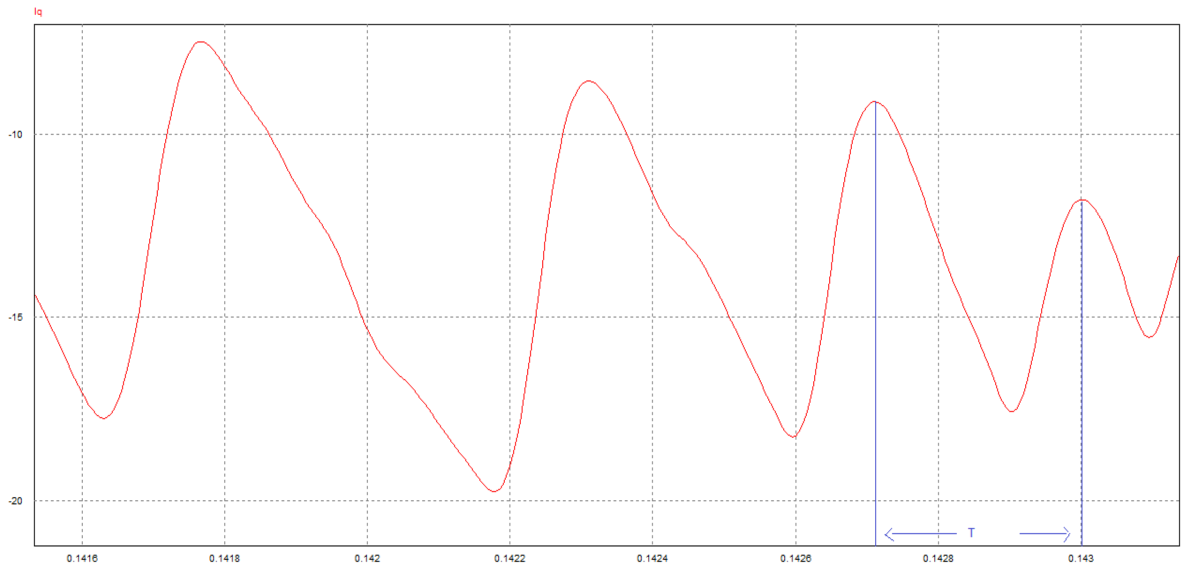
Response of Iq



Kcr = 2.5

T = .0003

Kp = 2.5*.45

= 1.125

$$Ki = \frac{T}{1.3}$$

= .00023

Constraints of alternate solutions: Speed control methods of induction motor drives which are scalar controls like voltage control, frequency control,rotor resistance control,v/f control,flux control,slip control have inferior dynamic response than separately excited dc motor.Time taken for the speed to reach steadystate for various control methods are 0.1 to 0.15 Sec and oscillations of speed will be there.Even is steady state response is good,dynamic responses are oscillating.

Benefits of proposed system: Scalar control methods have good steady state response but poor dynamic response.If the air gap flux linkages get varied from set value in magnitude or phase,there will be oscillations in torque and speed.In scalar control method only magnitude and frequency of stator current is controlled to keep it in set value.In vector control along with that phase is also controlled to set value.So oscillations are reduced and good dynamic performance is achieved.

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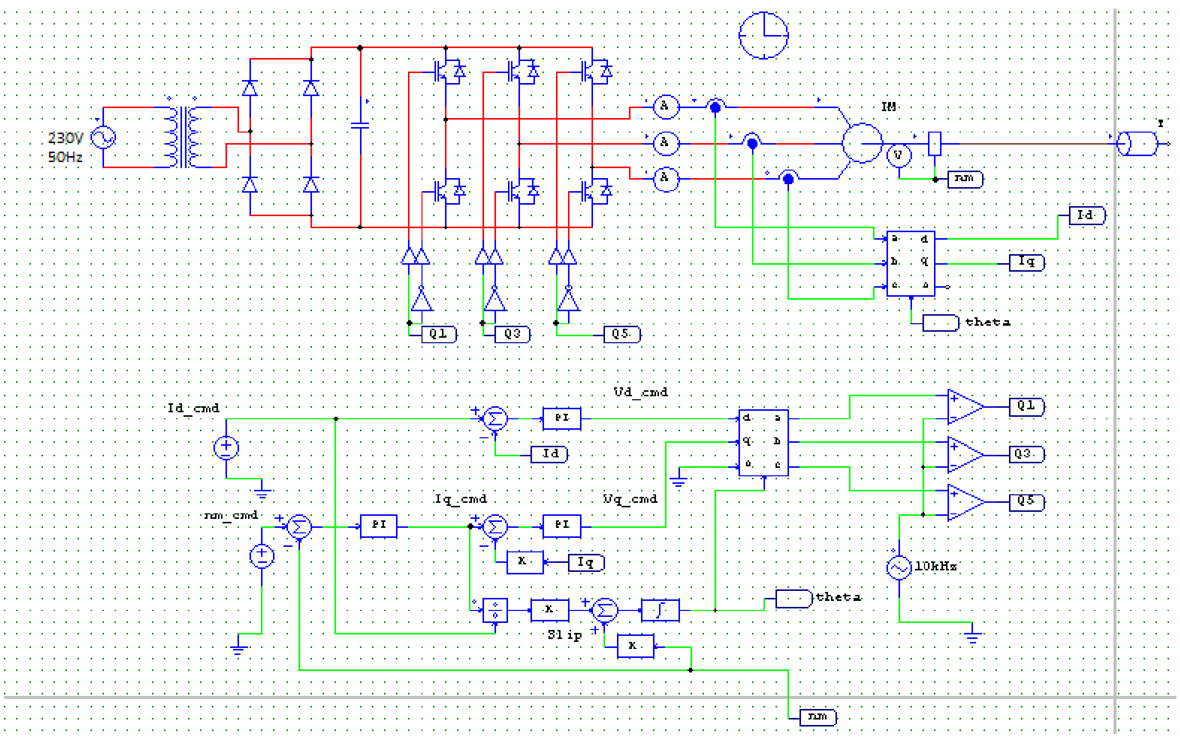
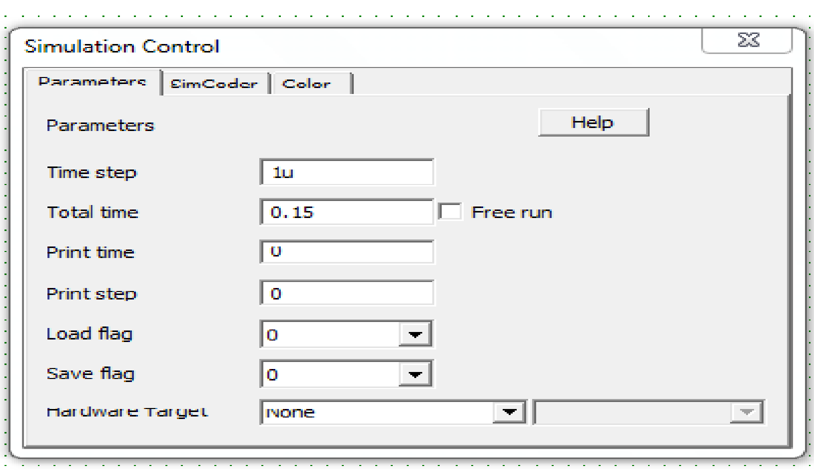
SIMULATION CIRCUIT



SIMULATION CONTROL



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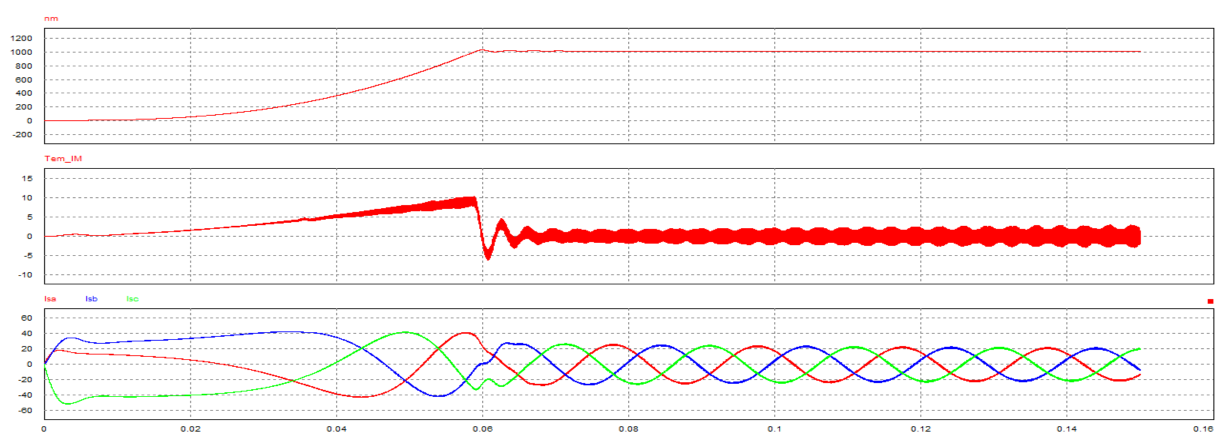
Id and Iq compensation signals are given to dq to abc transformation block.The current signals Ia,Ib and Ic which were obtained sinusoidal is compared with triangular carrier wave of 10kHz by SPWM technique to produce suitable switching pulses for inverter to produce output proportional to Ia,Ib and Ic signals.

SIMULATION RESULTS

Below are the waveforms of generated torque three phase currents and speed. The generated torque increases as the motor accelerates to the reference speed and we can see the phase currents decrease as steady state speed is reached.Corresponding to provided reference commands inverter output frequency is obtained and thus the required output speed.Rise time is drastically reduced when compared to scalar control and oscillations are eliminated.Dynamic response is thus improved.Output speed is tested till 3000rpm to check weather the sensor is healthy. Speed,Torque and current wave forms when reference speed given is 1000rpm:



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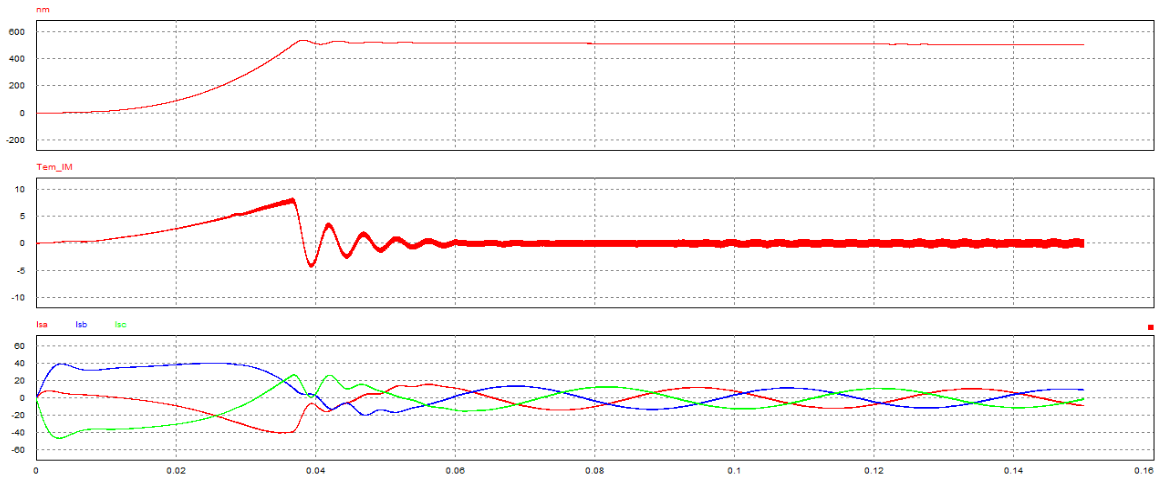
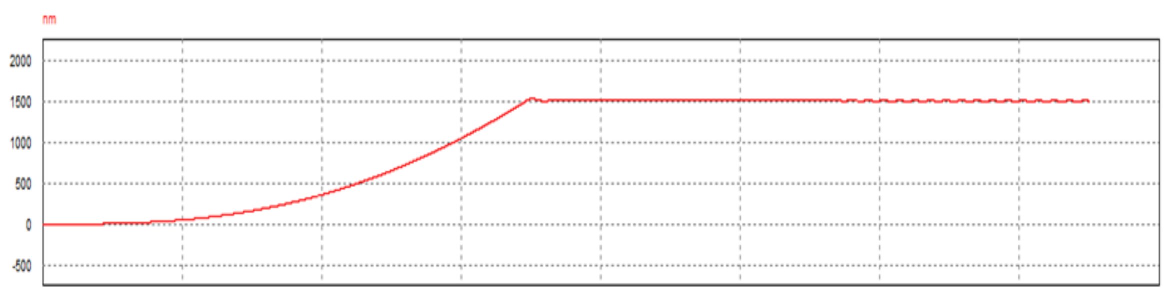
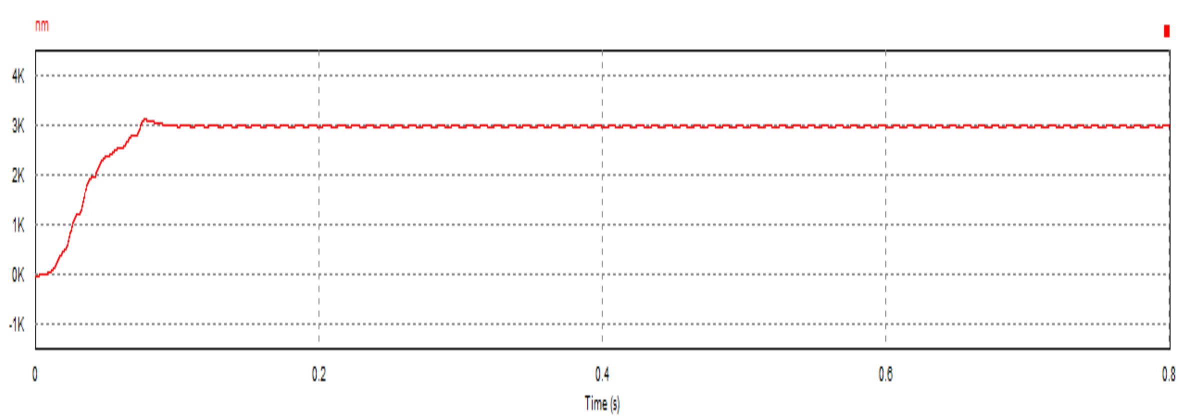
When reference speed given is 500rpm



When reference speed given is 1500rpm



When reference speed given is 3000rpm(rated speed)



CONCLUSION

A field oriented controlled induction motor drive was designed to test a speed sensor.The improved dynamic response and thus a reduced oscillation in speed and flux linkage provided by this type of control helped to reduce large excursions of stator current avoiding large peak converter and inverter ratings leading to a reduced manufacturing cost.

Reference materials

[1] Saroj Kumar Sahoo ,Tanmoy Bhattacharya, Field Weakening Strategy for a Vector-Controlled Induction Motor Drive Near the Six-Step Mode of Operation, IEEE Transactions on Power Electronics,Vol. 31, no.4,April 2016

[2] Suneel Kumar Agrawal, Sumit Ghatak Choudhuri, Simulation of Vector Controlled Induction Motor Drive in Matlab for Various Applications: A Comparative Study, Michael Faraday IET International Summit: MFIIS-2015,2015

[3] Domenico Casadei , FOC and DTC: Two Viable Schemes for Induction Motors Torque Control , IEEE Transactions on Power Electronics, vol. 17, no. 5, september 2015

[4] Kamil Klimkowski, Mateusz Dybkowski, A Comparative Analysis of The Chosen Speed Sensor Faults Detectors for Induction Motor Drives,International Conference on Electrical Drives and Power Electronics (EDPE),2015

[5] Ambrish Devanshu, Madhusudan Singh and Narendra Kumar,DSP based Feedback Linearization Control of Vector Controlled Induction Motor Drive1st IEEE International Conference on Power Electronics. Intelligent Control and Energy Systems (ICPEICES-2016),2016

[6] Chandan Chakraborty, Speed and Current Sensor Fault Detection and Isolation Technique for Induction Motor Drive Using Axes Transformation, IEEE Transactions on Industrial Electronics,Vol. 62, no. 3,March 2015.