# Abstract

Three-phase Induction machine (IM) are extensively used in modern industry due to mechanical ruggedness, reduced size and cost, and low maintenance. Owing to high performance, field oriented control or vector control technique is very popular in industrial applications. Present-day research mainly focuses on to make these drives fault tolerant. This has motivated investigations on advanced techniques of fault diagnosis in IM drive. The source of failure may be due to the mal-operation of sensors, motor itself (such as stator inter-turn faults, broken bar in the rotor etc.) or power electronic converter (i.e. failure of the switching devices). Most of the vector controlled drives used at present employ at least two current sensors and a speed sensor. A sudden failure of these sensors decreases the system performance. Hence, graceful degradation is important else such failure may lead to severe damage of the system or loss in production/process in which the drive is used. Fault detection involves generation of residuals derived from the deviation between measurements and corresponding estimated quantities. Generation of estimated signals by using system model, or otherwise, is the key issue of all fault detection and reconfiguration techniques. Reliable estimates of currents and speed are required.

Various algorithms are reported on estimation of speed for IM. Such techniques may be broadly divided into model based and signal injection based approaches. A class of model reference adaptive system (MRAS) that belongs to the model based approach has earned enough popularity due to its simplicity, performance and ease in implementation. In the literature flux, back-emf, reactive power and a fictitious quantity termed as ‘X’ are used as the functional candidates to form the MRAS. Such methods have their merits and limitations. The present research challenge is to improve performance at low speed, make performance immune to the variation of parameters and ensure stability in all the four quadrants of operation.

Currents may also be estimated from the sensed dc-link current and also using model (observer) based methods. Presence of noise in the reconstructed current signal and dependency on switching states of the inverter are the major problems with dc-link current based technique. On the other hand, observer based methods use machine model and hence are sensitive to parameter variation.

This thesis proposes a novel speed and current estimation techniques. The speed estimator is formed using X as the functional candidate in a modified form. This modified X-MRAS has the advantage that it is independent of stator resistance variation and stable in all the four quadrant of operation. Similarly, the proposed current estimator is independent of stator resistance variation and switching states of the inverter, which eliminates the presence of noise in the estimated current.

To verify the efficacy of the proposed algorithms, the drive is made to run with only one current sensor from start i.e., speed and other current sensor being replaced by the estimated values. Performance of this single current sensor based drive is found similar to that of traditional vector controlled IM drives. Such single sensor based drives are a cheap alternative to scalar controlled (i.e. V/f) drives.

The thesis proceeds further to propose a new algorithm to implement fault tolerant drive. The drive system always checks the sensor output and in the event of sensor failure will automatically reconfigure the controller, to the estimated values. Using the actual measurement of A- and B- phase currents and the corresponding magnitude of the same in d-q reference frame, eight estimates of currents in $\alpha$-$\beta$ reference frame are thus possible. New axes transformation strategy is proposed to generate different sets of current estimations. The system can be made fault tolerant, if a mechanism can be developed to switch over from the faulty measurement to the corresponding correct estimate. An extensive study is reported to establish the effectiveness of the fault tolerant controller under different types of sensor failures.

On the other side, faults may also be developed in the motor. In case of less-critical-faults like broken rotor bar, the drive may still continue in operation, while stator-inter-turn-faults may build up rapidly and hence require an urgent attention. Normally the drive is brought to rest under such situation. A technique to identify broken rotor bar and stator inter-turn fault is proposed. All the proposed concepts are simulated in MATLAB/SIMULINK and experimentally verified in a laboratory developed prototype using dSPACE 1104.

***Key-words:-*** Induction Motor Drives, Current Estimation, Speed Estimation, Fault Detection and Isolation, Sensors, Sensorless Control, Model Reference Adaptive System (MRAS), Single Current Sensor Drives, Rotor Bar Fault, Stator Inter-Turn Fault, Frequency Estimation