ABSTRACT

Three-phase squirrel-cage Induction Motors (IM) is widely used as industrial drives because they are rugged, highly reliable, and economical. Although these IMs are traditionally used for fixed-speed applications, they are currently being increasingly used with Variable-Frequency Drives (VFDs) in variable-speed applications. VFDs provide important energy-saving opportunities to existing and prospective IMs in variable-torque centrifugal fans, pumps, and compressor load applications. Squirrel cage IMs are widely used in both fixed-speed and VFD applications. Direct Current (DC) motors, particularly separately excited types, were widely used in the past because of their easy speed and torque controllability. An IM has a rugged structure because it is brushless and has few internal parts that should be maintained or replaced. This characteristic makes IMs cheaper compared with other motors, such as DC motors. Pulse-Width Modulation (PWM) with a Voltage Source Inverter (VSI) is typically used in variable-speed electric motor applications with low to moderate power. However, the switched voltages produce high voltage slopes over stator windings, which stress insulations and cause bearing current problems. A possible solution is to use PWM with a Current Source Inverter (CSI). Here both stator current and voltage waveforms are close to the sinusoidal waveform; this condition reduces the occurrence of the aforementioned problems. A CSI can also be used for high-power applications. However a CSI fed induction motor drive has some drawbacks such as slower dynamic response and bulky, overall size due to the requirement of large smoothing inductor at its dc source end, and also a CSI

drive system with on-line control strategy is more complex compared to a VSI drive due to the CSI gating requirements. But depending on some particular applications, its advantages can at times outweigh its disadvantages, hence rendering it as a suitable choice for certain applications.

For the recent years Current Source Inverter Fed Variable speed drives has its dominant approach in the Industrial applications due to its high performance and High Power handling capabilities. There are so many control methods available in which vector control techniques are quiet dominant and easily adaptable for drives used in Industrial applications. Some of the important Vector control methods are Vector based V/F control, Input-Output Linearization Control (IOL), Indirect Field Oriented Control (IFOC) and Direct Torque Control (DTC). All the above said control techniques have their own highlights and advantages when applied for different Industrial applications. In which V/F control is the simplest drive since it requires no knowledge on parameters also it is an Open Loop Control. IOL control uses a nonlinear feedback control which has decoupled Input-Output even in transients. IFOC provides dynamic torque control performance similar to that of DC motors, and provides fast, near-step changes in machine torque. DTC has simpler control architecture than that of IFOC but with a similar dynamic performance.

In this research work a new approach in Mathematical Modeling of a 3-phase induction motor drive fed by a Current Source Inverter (CSI) is developed and simulated using Matlab/Simulink software. Mathematical concepts are used in developing the simulation and implementation of Vector based V/F, Input-Output Linearization Control (IOL), Indirect Field Oriented Control (IFOC) and Direct Torque Control (DTC) techniques for CSI fed IM drives. In this work Synchronous Reference Frame is used to model the IM in V/F, IOL control technique, Rotor Flux Orientation (RFO) control is used in IFOC technique, Stator Flux Orientation (SFO) is used in DTC technique.

The V/f control methods are used to study and verify the system performance which is related to scalar control concept; but in addition, this method is useful for real time control applications. The vector based V/f control is valid for both steady and transient states. In this work the IOL control uses an optimal control law designed to achieve pre-assigned Eigen values with minimum possible magnitudes for the feedback gain elements and better control performance. In Indirect FOC, a new Rotor Flux Oriented control system is implemented for CSI fed IM drive, whereas DTC offers simple control architecture with a similar dynamic performance as that of FOC. Also a modular Simulink implementation of IM model is developed and the DTC concept is applied on the developed IM model. Similar studies of Vector controlled Inverter fed drives are discussed mostly with the Voltage Source Inverters and very few literatures are available with the study of Vector Controlled Current source Inverters. Also in literature comparison is only available for FOC, DTC and IOL for VSI fed drives based on steady-state torque ripple, current peak, and switching frequency. In this work, V/f, IOL, IFOC and DTC are compared for CSI fed IM drives based on the dynamic states of change in speed as well as the torque references in a single simulation cycle and the dynamic performances of the proposed drives are individually analyzed using the sensitivity tests and the results are presented in graphical form, tabular form and verified experimentally for better understanding of dynamic performance of the drive.

The results show that the IFOC drive obviously shows the best speed response, trailed by the IOL and DTC drives. The DTC drive also exhibits the best rapid torque response, trailed narrowly by the IFOC drive. The IOL and vector-based V/f drives are slightly substandard to the others. The IOL drive clearly exhibits the best speed response, trailed by the DTC and IFOC drives. The DTC drive also presents the best prompt torque response, followed by the IFOC and IOL. Thus, the DTC method is the most efficient technique for Industrial drives with Torque control applications to achieve the desired operation of the drive in handling a particular load. IOL is the most efficient method with respect to changes in speed reference for speed control applications, whereas IFOC is the most efficient method with respect to changes in torque reference.