Abstract

The present research work is directed towards design, digital computer simulation, and practical implementation of a high performance vector controlled cycloconverter-fed synchronous motor (SM) drive system for possible application in reversing rolling mills, gearless cement kilns, mine hoists, ice breakers in ship drives. Initially a 6-pulse noncirculating current cycloconverter-fed self-controlled SM (known as ac commutator-less motor or AC-CLM) drive is developed with scalar control having a closed-loop speed feedback. This drive, which can be used for applications where transient response is not very critical, serves as a prelude to the development of a vector controlled SM drive. The digital simulation of the AC-CLM drive system is achieved in two ways. The first way of simulation is an iterative one, simulating both the transient and the steady state behaviour of the drive. A simple but effective way of accounting for current discontinuities in the stator phases due to noncirculating current cycloconverter is suggested. The second method of simulation uses state variable technique to directly arrive at the steady state solution of the drive without having to proceed through the transient.

A flux-feedback type stator flux oriented vector control scheme as applicable to the 6-pulse noncirculating current cycloconverter-fed SM drive is designed and digitally simulated. The flux is estimated using a Gopinath type reduced order stator flux observer robust to speed variation. A simple stator current regulator is designed and implemented. The PI controllers are used for the speed loop, the flux loop and the excitation current loops, and the gains are selected based on *modulus optimum* and *symmetric optimum* methods.

A working model of the cycloconverter-fed vector controlled SM drive is developed in the laboratory using indigenous components. An 80386DX PC (40 MHz) with 80387DX coprocessor support is used in conjunction with analog control circuits to develop a hybrid controller. The functions such as group selection, blanking between P and N groups of cycloconverter, triggering signal generation, 3-phase/2-phase conversion are implemented by analog hardware, releasing the main digital processor for more sophisticated control

aspects like PI controller simulation for speed, flux and field current loops, flux estimation using observer, vector rotation, speed and position estimation. Real time control software is written in assembly language of 80386-387, and the software is optimised to achieve an overall sampling time of 350 μs.

The practical drive thus developed is subjected to rigorous tests. The response of the drive to step speed change, speed reversal, rectangular load torque change, ramp speed reversal is studied experimentally, and typical experimental results as obtained are compared with the simulated results.

Key words: Synchronous Motor, Cycloconverter, Transvektor control, Vector control, Scalar control, AC-CLM drive, Digital simulation, State variable technique, Harmonic spectrum, Sinusoidal mode, Trapezoidal mode, Stator flux orientation, Flux-feedback control, Robust observer, PI controller, Modulus hugging, PC, Hybrid control, Incremental encoder, Auto-start-up, Assembly language program