

Simulation of Active Front End Converter Based VFD for Induction Motors

Aswathi G¹, S Nalini², R.Sudeep Kumar³

ABSTRACT : Insulated Gate Bipolar Transistor based active front-end converters are widely utilized by industries due to the advantages of bi-directional power flow, unity power factor, low harmonic distortion of the line current, and smaller filter size. In this paper, the MATLAB Simulink model and control of the active front end converter system based VFD for induction motors are presented .

KEYWORDS: Variable frequency drive(VFD),Space vector pulse width modulation(SVPWM),Active front end converter

I. INTRODUCTION

Solid State Variable Frequency Drive is an adjustable speed drive used in electromechanical drive systems to control AC motor speed and torque by varying input frequency and voltage. Over the last four decades power electronics technology have improved performances in the field of VFD's through advances in semiconductor switching devices, drive topologies, simulations and control techniques and control hardware and software. They have already become an integral part of many process plants and their usage is on the rise in industrial, commercial and residential applications. The high dynamic performance, increased flexibility and possible energy savings are among the most important features driving the VFD market. They are also economical, reliable, highly flexible in their use and are rapidly becoming an important segment of the overall industrial and commercial loads seen by most distribution networks. While these new loads do contribute to the overall load growth of the electric utility industry, it does also create potentially severe problems in terms of the "electrical pollution". In addition, these loads are often rather sensitive to voltage dips and short supply interruptions. The effects of these events may include the total disconnection of the particular VFD load thereby causing loss of revenue for the particular user. It will cause a lot of production and may also incur significant restart costs depending on the particular industrial process in which the VFD is used. Hence reliable operation of these VFD's have to be guaranteed in order to avoid malfunctioning or interruption of the process. Also VFD's consume about one third of world's electrical energy and thus its global market penetration is still relatively small. This highlights the need for energy efficiency improvement in new VFD installation.

The standard solution for industrial controlled drives typically have an ac-dc conversion stage followed by dc-ac conversion feeding an induction machine. Traditionally diode rectifiers are used for ac-dc conversion. These rectifiers can only produce a constant DC voltage, which is a function of the system voltage. A thyristor rectifier can be used to produce variable dc output voltage. But, both these

rectifiers behave as nonlinear loads. The currents drawn by the rectifiers include a fundamental (or line frequency) component and harmonic components. The voltage drop across the line inductance due to the harmonic currents distorts the mains voltage. Consequently, the other loads connected to the mains are also fed with a distorted voltage. A pulse width modulated (PWM) rectifier draws near sinusoidal currents from the ac mains. Also, the dc output voltage can be regulated, and the input power factor is adjustable. Replacing the diode bridge by an IGBT bridge allows to address regenerative or recuperative operation, reduction of harmonic currents and control of reactive power. For such a converter, the power can also flow in either direction, which is required in many motor drive applications. Since the converter is typically connected in the line-side of a motor drive, this is called a line-side converter or front-end converter (FEC). Active front end converters are becoming an interesting solution for power factor correction and low frequency current harmonic elimination in static power conversion systems. Due to current harmonic restrictions in power distribution systems, active front end rectifiers offer a viable alternative to replace traditional six pulse diode rectifiers in frequency changers. Active front end (AFE) rectifiers have been investigated for the last decade and provide a good solution for the rectifying stage in frequency changers. The main characteristics of AFE rectifiers are the generation of reduced low frequency line current harmonics, due to the use of pulse-width modulation (PWM), a better overall power factor, substantially smaller filter requirements, and inherent regeneration capabilities. Moreover, with the development of new high voltage and current gate controlled semiconductor, such as Insulated Gate Bipolar Transistors (IGBTs) and Integrated Gate Controlled Thyristors (IGCTs), and with the implementation of multilevel structures, PWM-AFEs rectifiers are becoming the standard solution for large-power medium-voltage VFDs and are responsible of the drastic increment in the market share of PWM voltage-source controlled converters.

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Vijayakumar Belaguli,1995 High performance ac to dc converters are required to meet the regulation standards to suit wide variety of applications This thesis presents the steady state analysis design and operation of high frequency HF transformer isolated resonant converters on the single phase utility line as a low harmonic controlled rectifier Two resonant converter configurations of third order have been studied namely the LCC type parallel resonant converter also popularly known as series parallel resonant converter SPRC and the hybrid parallel series resonant converter bridge HPSRCB These converters are operated at HF using variable frequency as well as fixed frequency control and they operate in different modes depending on the choice of switching frequency and load The variable frequency SPRC is operated in discontinuous current mode DCM to obtain low line current total harmonic distortion T H D and high power factor pf without using active control State space analysis has been presented for one of the predominant circuit modes encountered during its operation in DCM The various design constraints for operating the resonant converter on the utility line for high pf operation have been stated for different control schemes In addition steady state analysis design optimization carried out for dc dc converter have been presented The effect of resonant capacitor ratio on the converter performance characteristics have been studied SPICE3 simulations and experimental results obtained from a 150 W converter are presented to verify the theory Continuous current mode CCM operation of the SPRC and its effect on the line current T H D and pf are studied Both fixed and variable frequency control schemes have been used to control the SPRC Complex ac circuit analysis method has been considered as the design tool to get the design curves and design of the SPRC operating on the utility line SPICE3 simulation results for open loop operation and experimental results for both open as well as closed loop operations active control for two capacitance ratio s have been presented to verify the converter performance It is shown that nearly sinusoidal line current operation at unity pf can be obtained with closed loop operation A HPSRCB has been proposed and operated at very high pf on the utility line as a controlled rectifier Some of the predominant operating modes of the fixed and variable frequency HPSRCB have been identified The steady state analysis using state space modeling presented for a dc to dc converter has been extended to analyze the ac to dc converter Using the large signal discrete time domain model the time variation of line current and line pf have been predicted using PROMATLAB for both fixed and variable frequency operations of HPSRCB on the utility line SPICE3 simulation results without active control and experimental results obtained from the bread board model for both open as well as closed loop fixed and variable frequency operations have been presented to verify the theory and design performance

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