Performance Comparison of Single-Phase Cycloconverters with SiC Transistor and IGBT with Different Control Strategies

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***Abstract*—Silicon Carbide (SiC) MOSFET devices exhibiting several advantages, including high blocking voltage, lower conduction losses, and lower switching losses, when compared to silicon-based devices have become commercially available, enabling their adoption into power supply products. This paper presents a novel approach to designing a cycloconverter using SiC MOSFETs as opposed to the conventional usage of IGBT. A comparative study is attempted between the two with respect to power loss, system efficiency, leakage current etc. Furthermore, different closed loop control strategies are used to control the speed of an induction motor using the SiC cycloconverter model designed in this paper. MATLAB/Simulink models and simulations are used to analyze the results for the above.**

***Keywords—*Cycloconverters, IGBT, Silicon carbide MOSFET, PID controller.**

# **INTRODUCTION**

## **CYCLOCONVERTER**

A Cycloconverter refers to a frequency changer that can change AC power from one frequency to AC power at another frequency. A Cycloconverter is a device that converts constant voltage and frequency AC waveform to another AC waveform of lower frequency without using DC link in the conversion process thus making it highly efficient . Cycloconverters are extensively used for driving large motors like Rolling mills, water pumps, variable frequency speed control for machines such as Induction motor, Industries etc. Blocking mode type and Circulating mode type are the two main types of Cycloconverters. In Blocking mode, depending on the polarity of the load current, either the positive or negative converters are enabled. The blocking mode operation has some advantages over circulating mode operation as they don’t need any integroup reactors (IGR) reactors hence size and cost is less. The speed control of induction motor plays Important role in industries, there are various ways to control the speed of motor but considering it’s efficiency, this paper proposes a Silicon carbide based Cycloconverter for the single phase induction motor speed control. A single-phase to single-phase Cycloconverter consists of two full wave converters that are linked back to back.

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*a**b* 

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1. G. Eason, B. Noble, and I. N. Sneddon, “On certain integrals of Lipschitz-Hankel type involving products of Bessel functions,” Phil. Trans. Roy. Soc. London, vol. A247, pp. 529–551, April 1955. *(references)*
2. J. Clerk Maxwell, A Treatise on Electricity and Magnetism, 3rd ed., vol. 2. Oxford: Clarendon, 1892, pp.68–73.
3. I. S. Jacobs and C. P. Bean, “Fine particles, thin films and exchange anisotropy,” in Magnetism, vol. III, G. T. Rado and H. Suhl, Eds. New York: Academic, 1963, pp. 271–350.
4. K. Elissa, “Title of paper if known,” unpublished.
5. R. Nicole, “Title of paper with only first word capitalized,” J. Name Stand. Abbrev., in press.
6. Y. Yorozu, M. Hirano, K. Oka, and Y. Tagawa, “Electron spectroscopy studies on magneto-optical media and plastic substrate interface,” IEEE Transl. J. Magn. Japan, vol. 2, pp. 740–741, August 1987 [Digests 9th Annual Conf. Magnetics Japan, p. 301, 1982].
7. M. Young, The Technical Writer’s Handbook. Mill Valley, CA: University Science, 1989.

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