Design and Control of a Matrix Converter as an AC Current Source

By

Ahmed Mostafa Maarouf Abd El-Rahman
B.Sc. in Electrical Power and Machines – Ain Shams University

A Thesis Submitted to the
Faculty of Engineering at Cairo University
In Partial Fulfillment of the
Requirements for the Degree of
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In
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Under the Supervision of

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Title of Thesis:

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Key Words:

Matrix Converter, AC-AC converters, Current Source.

Summary:

Matrix Converters are AC-AC converters that use bi-directional switches as the main components of their power circuit to create an output voltage system whose voltage and frequency can be changed. They don't need any DC-link capacitors or energy storage elements.

Increased interest in developing and enhancement of matrix converters has grown due to their advantages over convenient AC-DC-AC converters, that's because the absence of DC-link leads to cheaper and more compact converters with longer lifetime.

Abstract

Matrix Converters are AC-AC converters that use bi-directional switches as the main components of their power circuit to create an output voltage system whose voltage and frequency can be changed. They don't need any DC-link capacitors or energy storage elements.

Increased interest in developing and enhancement of matrix converters has grown due to their advantages over convenient AC-DC-AC converters, that's because the absence of DC-link leads to cheaper and more compact converters with longer lifetime.

A three phase Matrix Converter consists of 3x3 bi-directional switches arranged in matrix form. The arrangement of bi-directional switches is such that any phase of the power supply can be connected to any phase of the load. The switches are controlled such that the output voltage is sinusoidal with desired frequency and desired amplitude.

Many switching techniques have been developed to overcome common problems in practical Matrix Converters such as commutation problem. Other practical challenges include but not limited to overvoltage spikes due to fast switching, harmonics present in the input current, etc.

The control circuit of a Matrix Converter introduced in this research includes current feedback from the load as well as voltage feedback from the source in order that the controller determines the required switching pattern. Practical considerations in the design of the control circuit include but not limited to suitable design of power supply, appropriate isolation from the power circuit, etc.

In this thesis, the Hysteresis Current Control modulation of matrix converter was introduced, the Matrix Converter circuit was simulated using Matlab Simulink software for extensive validation and evaluation, and then a hardware prototype was designed and constructed to verify the theoretical results. The main goal of this research is to study the practical problems in Matrix Converter implementation and their proposed solutions.

The work in this dissertation is presented in five chapters as follows:

Chapter one provides introductory information about matrix converters and a brief comparison between the matrix converter and the well-known rectifier-inverter assembly.

Chapter two studies the theory of operation and fundamentals of matrix converter. The HCC modulation technique was selected for this research topic and discussed in details; also the major practical problems that face the practical implementation of the matrix converter were discussed in this chapter.

Chapter three discusses the simulation model and simulation results for the direct matrix converter which was developed using Matlab Simulink®.

Chapter four discusses the design of the implemented prototype for the direct matrix converter as well as the experimental results.

Chapter five concludes the thesis and identifies some areas for future researches.

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It has been fortunate for me to perform my master thesis at Cairo University, where all the teaching staff and employees always help researchers to perform their work in a supportive and friendly environment.

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