DC CHOPPER IN THE FIRST AND THIRD QUADRANT OPERATION USING SINGLE-PHASE MATRIX CONVERTER TOPOLOGY

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ABSTRACT

This report presents the successful implementation of single-phase matrix converter (SPMC) as a DC Chopper, which is a variable dc voltage from a fix dc voltage. Simulation models were developed using MATLAB/Simulink and PSpice to study the behavior of the proposed Pulse Width Modulation (PWM) technique.

The results of simulation were then compared with those obtained from an experimental test-rig that was constructed in the laboratory.

Due to its pioneering work a resistive load without the introduction of inductance was used to reduce the complexities of the circuit. This could later be extended in the future incorporating other types of load to study the behavior of the SPMC as a DC Chopper.

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CHAPTER 1
INTRODUCTION

1.1 Static Energy Conversion

Static energy conversion uses power electronic converters to transform and control the waveshape of the output from a given input. The basic forms include;

i. AC Voltage Controller (AC to AC).

ii. Controlled Rectifier (AC to DC).

iii. Chopper (DC to DC).

iv. Inverter (DC to AC).

1.2 DC Chopper

Choppers are widely used for traction motor control in electric automobiles and other electric transportation system. In those applications, control of dc motor's speed is required where the supply is dc or an ac voltage that has been rectified. Other applications of dc chopper also include high-current DC applications in industries [2] which have many operational benefits over conventional diode or thyristor rectifiers.

1.3 Matrix Converter

Matrix converter is a fairly new converter topology. In it's basic form matrix converter is a special class of cyclo-converter that was develop in the early 1930s. This was later used by Alesina et al [1] to develop a generalized high frequency switching providing several attractive features and described as a generalized transformer synthesis.

Since matrix converter was originally introduced, it has received considerable attention because it is expected to offer many advantages over traditional topologies, such as the ability to regenerate energy back to the utility. The size of the converter also is reduced since there are no large reactive components for energy storage [1].

The most important element of matrix converter is the switching strategy for the four quadrant switches. The switching strategy will result in the input source being converted to the desired output through matrix converter. PWM was used as the switching technique for the four-quadrant switches. The switching technique will result in the selective four-quadrant switches on and off only at appropriate time. Applying the switching strategy and switching technique will produce the desired output that is synthesized from the input source of the matrix converter.

The Matrix Converter (MC) is an advanced circuit topology that offers many advantages such as the ability to regenerate energy back to the utility, sinusoidal input and output current and controllable input current displacement factor [3]. MC has the potential of affording an "all silicon" solution for AC-AC conversion, removing the need for reactive energy storage components used in conventional rectifier-inverter based system. Its topology was first proposed by Gyugyi [4] in 1976. Obviously all published studies dealt with mainly the three-phase circuit topologies [5-7].

The Single-phase matrix converter denoted as SPMC was first realised by Zuckerberger [8]. Other works includes those by Hossieni [9], Abdollah Khoei [10] and Saiful [11].

1.4 DC Chopper Using SPMC

In this work, DC chopper also known as dc-to-dc converters were presented to operate as a variable dc voltage from a fix dc voltage using SPMC topology that has been used to operate direct AC-AC converter. Main focus will be the operational dc chopper functions in the first and third quadrant, nevertheless the operation of the second and fourth quadrant are also briefly described in this work. To ascertain its feasibility, simulation models were developed using MATLAB/Simulink and PSpice to study the behaviour of the proposed technique.

Successful results presented are mainly due to the use of resistive load without the introduction of inductances to reduce complexities. The DC Chopper is based on four-quadrant operation with the output being synthesized using Pulse Width Modulation (PWM) technique. The result of this work has indicated that the same SPMC topology [8, 10, 11] maybe used as a DC chopper. This versatility is a desirable feature in the future as increases in costs for skilled manpower maybe overcame by having a versatile technology.