A NOVAL SWITCHED CAPACITOR BASED THREE PHASE MATRIX CONVERTER

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Abstract—Matrix conversion converters have become highly popular over AC- DC-AC converters for AC to AC since they don't have a dc capacitor. Only 0-86.6 percent of input voltage can vary the gains of these converters. It limits operations in high voltage applications as well as for grid integrations. This study builds a switched boost capacitor network in the fictional dc-link in the converter to improve the boosting abundance beyond the previous one. Moreover, this converter has the benefit of a two-way power flow without extra switch demand. Simulation studies check the suggested topology.

Index Terms—Indirect Matrix Converter, Buck boost Converter, Switched Capacitor

I. INTRODUCTION

Most loads offered in the industry are motor loads in those AC motors, preferable for their robustness, lower service life, etc.The power supply required to drive the ac motor for specific applications in industrial or aerospace applications comprises a specified voltage and frequency level; to operate these motor loads with variable voltage and variable frequency needs, an AC-AC power converter is necessary. Voltage source back to back converter, Current source back to back converter, Diode Bridge cascaded voltage source inverter, Fundamental frequency front end converter, Matrix converter, and more popular and frequently used AC-AC converters are available. Recently, matrix converters have gained favor in academic research due to its benefits such as increased efficiency, reduced switching losses, operating at unity power factor, no intermediary reactive components, smaller size, longer life than rival converters, and so on.

Penetration of clean energy, mainly the wind and photovoltaic(PV) generated electrical energy,in the power grid is increasing exponentially. Both the wind and PV power plants are connected to the grid through converters, transferring the generated DC power in PV applications and ACpower in wind power (WP) applications to the AC grid. The aim of the dissertation is to propose new topologies,modulation techniques, and control of grid converters for WP applications. Throughout the various types of proposed topologies, non-grid cases are explained and then followed by grid applications.

There is some debate about who created the matrix converter [2], however without getting into the invention process, the development of the matrix converter began with Alesina and Venturini [1]. The matrix converter is characterized as having an array of two bidirectional switches.

The absence of reactive components in the converter skewed the study toward matrix converters. Indirect matrix converter is another arrangement with the same number of switches organized in a mix of rectifier and inverter form. For traditional matrix converters or Direct Matrix Converters (DMC), several modulation approaches have been devised, such as the venturini method [1], the roy method and other scalar methods [6]- [9]., In [5,] the creation of a space vector modulation approach employing space vectors with greater commutation than previous methods used to an indirect matrix converter.

The voltage gain of the converter changes as follows: 0.5 for the Venturini technique, 0.866 for the Roys method, 0.866 for the direct scalar method, and 0.866 for the space vector modulation. Despite the fact that matrix converter research is progressing, the converter voltage gain has yet to increase to the needed level. The simplest way to enhance gain is to cascade the transformer with a matrix converter, however this results in a greater cost, a large low frequency transformer that takes up a lot of space, complex control, and so on. The matrix converter converter also has drawbacks, such as the inability to function with pulsing loads, commutation issues, susceptibility to EMI, lack of internal intrinsic protection, and so on.

F. Z. Peng's [4] discovery of impedance source networks has accelerated the development of inverters that use the impedance idea. With the impedance source idea, it is feasible to overcome matrix converter drawbacks and improve matrix converter capabilities.The primary goal of this work is to improve the voltage transfer ratio of a typical indirect matrix converter [10].

To increase the dc-link voltage, the suggested architecture employs the concept of switching capacitor boost converters. The basic IMC design is modified by incorporating a switched capacitor boosting circuit [11] in the matrix converter's dc-link. While analyzing the boosting action of the converter, design equations are also investigated, indicating that more than one voltage transfer ratio may be accomplished analytically and conceptually.The results of simulations are also provided, confirming the usefulness of the suggested topology.

Matrix converter is a new generation of the direct power converter controlling the output voltage, amplitude and frequency. It has an adjustable power factor to control the input, regardless of the load. Matrix converters can perform operations at high temperature, gain reliability, control input and output current and adjust voltage sine waves with an adjustable phase shift. These are considered some advantages of this type of converters. The controlling of output voltage, amplitude and frequency represents one more advantage over the previously mentioned advantages and over other types of converters as well.

II. . DC-DC Converters

Before demonstrating the new topology, it is necessary to first explain the basic concepts of the standard indirect matrix converter. As seen in Fig 1, the IMC has evolved to separate the traditional DMC into two stages: load and line.

The line side is a rectifier, which consists of six bidirectional switches and twelve unidirectional switches connected by an antiparallel diode. A standard inverter with six unidirectional switches is used on the load side. As a consequence, each step can have its own modulation method applied to it. The clamp circuit is also a required add-on for both the DMC and the IMC. As a consequence, each step can have its own modulation method applied to it. In addition, both the DMC and the IMC require a clamp circuit to safeguard the converter in the event of a short circuit or an over-voltage scenario.

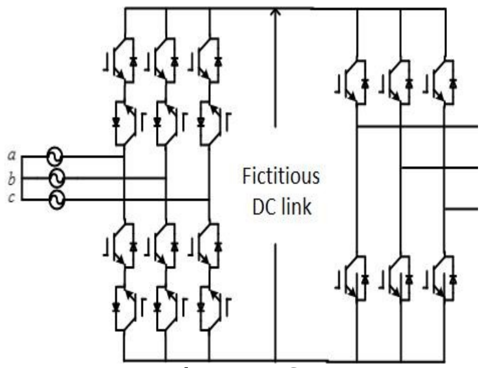

Fig.1.IndirectMatrixConverter

CONVENTIONAL MATRIX CONVERTER

DC-DC Converters are electronic devices used whenever we want to change DC electrical power efficiently from one voltage level to another. They are needed because unlike AC, DC cannot simply be stepped up or down using a transformer. In many ways, a DC-DC converter is the equivalent of a transformer.

The DC-DC converter can be viewed as dc transformer that delivers a dc voltage or current at a different level than the input source. Electronic switching performs this dc transformation as in conventional transformers and not by electromagnetic means. The DC-DC converters find wide applications in regulated switch mode dc power supplies and in dc motor drive applications.

DC-DC converters are non-linear in nature. The design of high performance control for them is a challenge for both the control engineering engineers and power electronics engineers. In general, a good control for dc-dc converter always ensures stability in arbitrary operating condition. Moreover, good response in terms of rejection of load variations, input voltage changes and even parameter uncertainties is also required for a typical control scheme.

After pioneer study of dc-dc converters, a great deal of efforts has been directed in developing the modelling and control techniques of various dc-dc converters. Classic linear approach relies on the state averaging techniques to obtain the state-space averaged equations. From the state-space averaged model. Possible perturbations are introduced into the state variables around the operating point. On the basis of the equations, transfer functions of the open-loop plant can be obtained. A linear controller is easy to be designed with these necessary transfer functions based on the transfer function.

DC-DC converters are important in portable electronic devices such as cellular phones and laptop computers, which are supplied with power from batteries primarily. Such electronic devices often contain several sub-circuits, each with its own voltage level requirement different than that supplied by the battery or an external supply.
Additionally, the battery voltage declines as its stored power is drained. Switched DC-DC converters offer a method to increase voltage from a partially lowered battery voltage thereby saving space instead of using multiple batteries to accomplish the same thing.

III. Proposed circuit

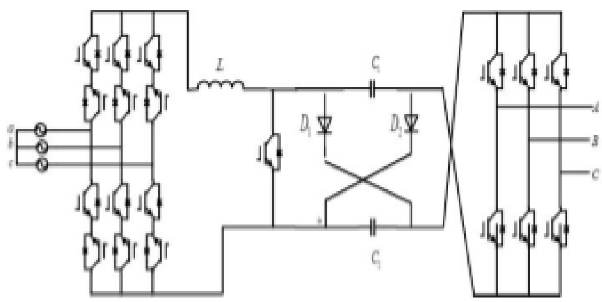

Fig.2.Proposed Circuit

In spite of extensive research over the last two decades, matrix converters have rarely been employed in commercial products due to their complex modulation techniques, low voltage gain, and high number of semiconductor switches. Recently, sparse and ultra-sparse matrix converter topologies, often categorized as indirect matrix converters, have been proposed to reduce the switch count. To increase the voltage gain, various control algorithms and topologies was developed. One of the most effective solutions is the use of the Z-source concept. As described in [6], the Z-source network has been originally proposed as the dc link for boost voltage-source inverters. In such an inverter, the dead time is not needed, which improves the quality of output power and reliability of the converter.

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The system integrates a generator-side three-switch buck-type rectifier and a grid-side Z-source inverter. Aforementioned topologies, often designated for renewable-energy systems, integrate a source-side buck-type rectifier and a load-side inverter. The Z-source, placed in a cascade arrangement between those the rectifier and the inverter, allows boosting the voltage two to three times. It has drawbacks. Firstly the voltage across Z-source capacitors is larger than the input voltage. This require the useof larger capacitors, which increases the overall cost and volume. Secondly, the inrush current and resonance in the Z-source network at startup are not suppressed.

We propose a three-phase/three-phase ultra-sparse matrix converter utilizing a series Z-source, quasi Z-source and switched inductor Z-source. Series Z-source, quasi Z-source and switched inductor Z-source is inserted in either rail of the indirect matrix converter. A newly developed optimal PWM technique is employed in the converters. The operating principles and comparison with the traditional topology are discussed.

The matrix converter uses nine power bi-directional switches. A bi-directional switch, shown in Fig. 2(a) must be able to block direct and reverse voltage and to conduct the current in both directions. Bi-directional power switch is one of the major challenges for the power stage design of a three-phase to three-phase matrix converter since bidirectional power switches are not available in the market. Recently some power electronics devices manufacturers have tried to produce experimental bi-directional power switch modules for matrix converter. These power modules are implemented with unidirectional switches like as IGBTs and fast diodes (DIM200WBS12-A000, SML300MAT06 and FM35R12KE3). Furthermore, some research groups have been using a specially designed power modules to build the matrix converter (Klumpner et al., 2002; Adamek et al., 2003; Simon et al., 2002). Unfortunately, these power modules are not produced in industrial scale, so their cost is very high making difficult their use in a laboratory prototype since if part of the module fails, the entire unit must be replaced. So, it is cheaper to build the bi-directional power switch using discrete components.

The gate drive circuitry transfers the information from the control circuit to the power bi-directional switches and must provide isolation between them. There are several approaches to perform the gate drive isolation: pulse transformer, with optocoupler, bootstrap circuit and photovoltaic cell.

The drawback of the pulse transformer approach is that it does not work very well for a PWM signal with wide duty cycle: the duty cycle is limited to 50%. For operation with duty cycle from 1% to 99%, it will be necessary some external circuitry to implement a DC restorer and an interface circuit with the CPLD. Other drawback is the large volume occupied in the PCB (Printed Circuit Board). The photovoltaic cell has low efficiency to transfer energy to the gate drive and the power level is not enough to support fast switching Series Z-source network, an expansion of the popular concept of Z-source dc link, was originally proposed for boosting the output voltage of power electronic inverters. In this paper, it is extended on a three-phase indirect matrix converter. The converter is based on the ultra-sparse matrix topology characterized by the minimum number of semiconductor switches. The series Z-source network is placed between the three-switch input rectifier stage and the six-switch output inverter stage in either the positive or negative rail.

The proposed converter is based on the ultra-sparse matrix topology. In the indirect-matrix topologies, the basic function of the converter is realized by splitting the ac-to-ac conversion into the ac-to-dc and dc-to-ac stages

The novel converters constitute an improvement over the cascaded Z-source matrix converter by reducing the voltage across Z-source's capacitor limiting the inrush current at startup for series Z-source and widening the boost ratio for quasi Z-source and very high boost ratio for switched inductor Z-source matrix converter. Here, experimental results of investigation of those converters are presented to verify the effectiveness of the proposed topologies and control strategies in providing a high boosting capability.

V. MATLAB/Simulation Results

Sim Power Systems software is a modern design tool that allows scientists and engineers to rapidly and easily build models that simulate power systems. It uses the Simulink environment, allowing you to build a model using simple *click and drag* procedures. Not only can you draw the circuit topology rapidly, but your analysis of the circuit can include its interactions with mechanical, thermal, control, and other disciplines. This is possible because all the electrical parts of the simulation interact with the extensive Simulink modelling library. Since Simulink uses the MATLAB computational engine, designers can also use MATLAB toolboxes and Simulink block sets. Sim Power Systems software belongs to the Physical Modelling product family and uses similar block and connection line interface. The Matlab /Simulink diagram is shown in below figure

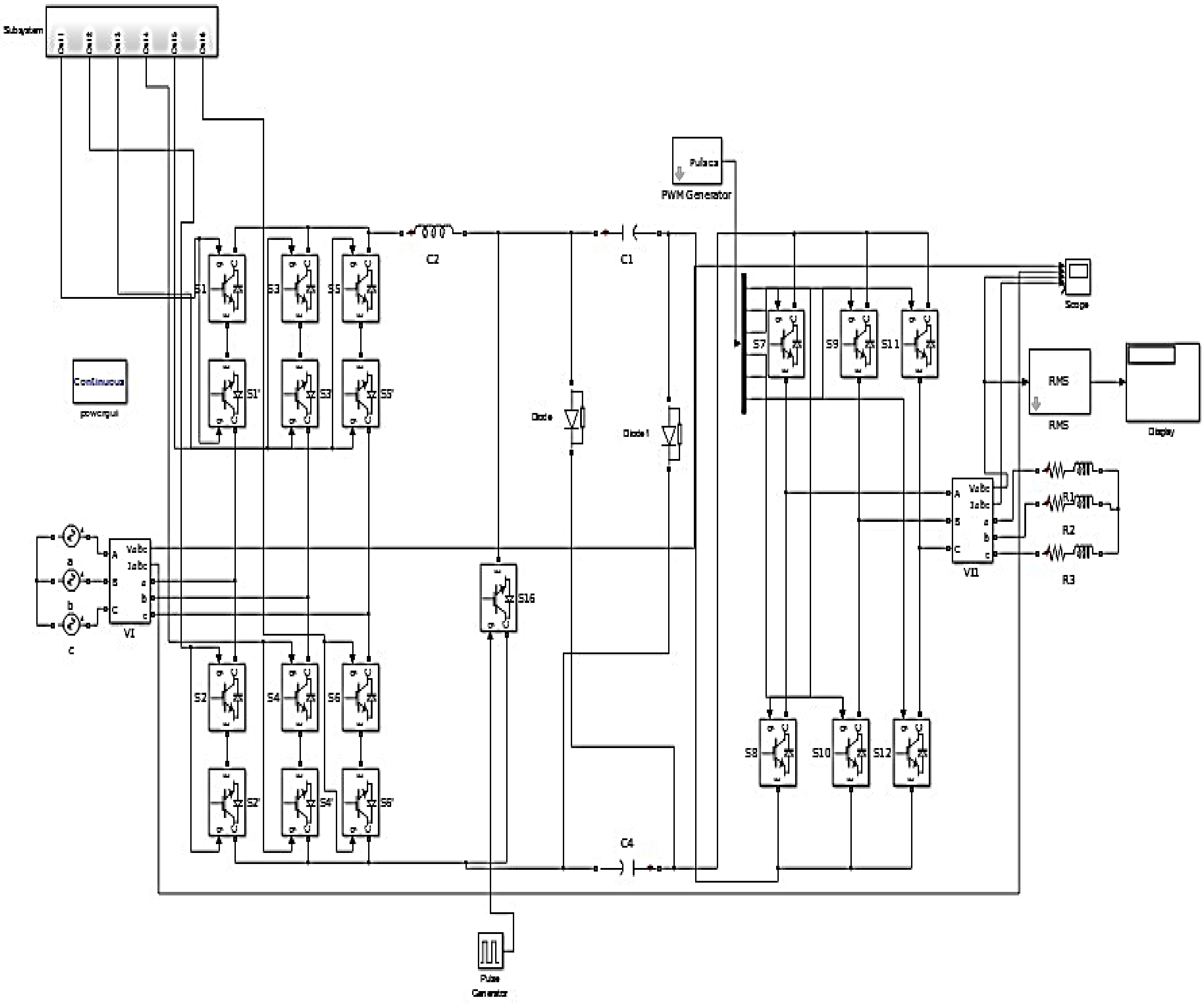

Fig.3.Simulink Diagram

The solution of higher voltage transfer ratio is done such that the advantage of conventional indirect matrix converter is still maintained. By incorporating the idea of switched capacitor boost converters, a modification is made to the conventional IMC topology by adding a switched capacitor boosting circuit in the dc-link of the matrix converter. Moreover, the integrated switched boost converter has the capability to provide the bidirectional flow of power, making the proposed converter operated in all four quadrant. While analyzing the boosting operation of converter, design equations are explored so that more than unity voltage gain can be theoretically achieved. Besides this, variable frequency operation is also ensured by testing the converter at 80 Hz frequency. These feature of the proposed converter makes it potential for future AC - AC converter aspect.

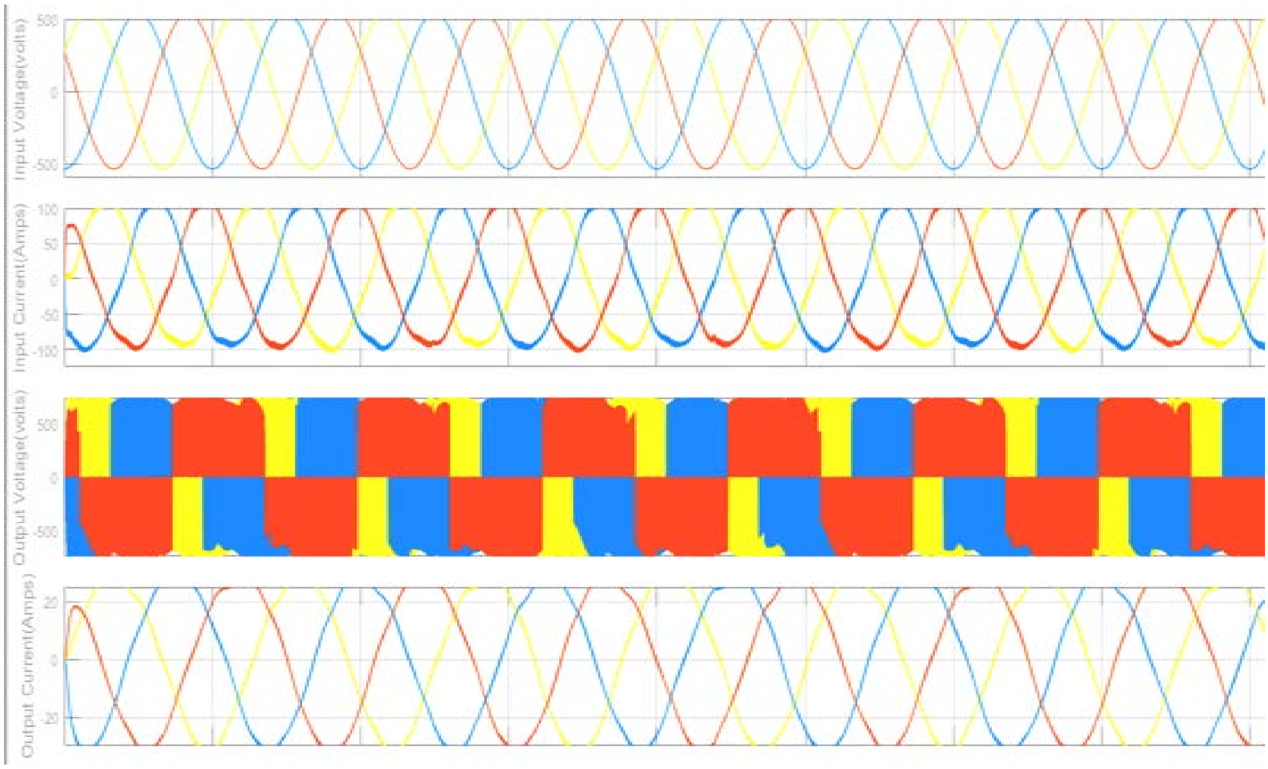

Fig.4.Simulink results

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