MATLAB Simulink Modeling of Matrix Converter

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ABSTRACT

The indirect matrix converter needs six bidirectional switches in the rectification stage to connect with six unidirectional switches in the inversion stage. Bidirectional switches are not available on the market today and need to be constructed from semiconductor devices. Most research work about matrix converters has so far regarded the modulation and control of the matrix converter. The practical experience is still very limited. In this thesis presents an indirect matrix converter using simple commutation method base on AC/DC/AC converter. It combines the control method between the rectification stage and the inversion stage which can largely simplified modulation in rectification stage and all bidirectional switches at line side turn on and turn off at zero current.MATLAB/Simulink modeling and simulation of the matrix converter feeding an R load was carried out. The experimental results at variable frequency are presented.

Key words- AC/DC/AC converter, MATLAB/Simulink model, matrix converter

1. INTRODUCTION

This project is concerned with the design and invented of a Matrix Converter for Frequency Changing Power Supply device. Normally such units are used to convert between 50/60Hz supplies available in airports to a 400Hz one for aircraft supply when they are parked in their bays. This progress will consider the simulation of various matrix converter twitching system, A Matrix Converter is a device used for converting directly AC energy into AC energy; the main theme of this matrix converter is to convert the magnitude as well as the frequency of the feed into a required magnitude and frequency of the output with an "all-silicon" solution. Generally, a Matrix Converter consists of nine bi-directional switches, which are required to be blocked in the right way and sequence in order to reduce losses and produce the required output with a great quality input and output waveforms. After the controlled rectifiers were invented in the early 1930's, it was surprised that this provided the chance of generating alternating currents of variable frequency directly from a fixed frequency AC supply, the positive rectifier supplying the positive half cycles of current and the negative rectifier the negative half cycles. This system was called cycloconverter at its early stage and this proved to be so appropriate that nowadays it is still used in some high power applications because of high power requirements and the Matrix Converter technology is still not available widely.

2. IGBT WITH ANTI-PARALLEL DIODE TOPOLOGIES

There are so many different configurations for bi-directional switches which use IGBTs with anti-parallel diodes switch. Such systems are mentioned below.

2.1COMMON EMITTER BI-DIRECTIONAL SWITCH

This switch is constructing with the help of two diodes and two IGBTs as shown in Figure 2.1. The diodes are contained to show the opposite blocking ability. The reverse blocking capability is a poor of the early IGBT technology. There are various advantages in using this switch when compared to the diode bridge switch. The first advantage is that it is possible to self control the direction of the current. Flowing losses are also decreased as only two devices carry the current at any one time. As with the diode bridge switch every bi-directional switch cell require an insulate power supply.

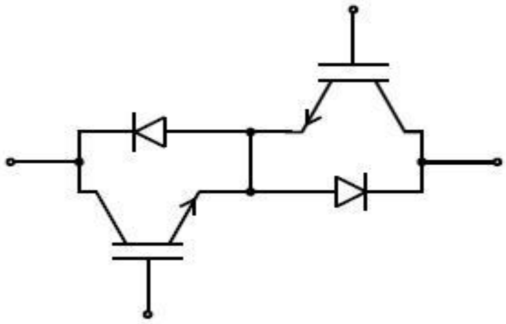

Figure 2.1 Common Emitter Bi-directional Switch

2.2 COMMON COLLECTOR BI-DIRECTIONAL SWITCH.

This switch is similar to the arrangement presented in the previous arrangement. The difference is common collector configuration is made with help of IGBTs switch as shown in Figure 2.2. The flowing losses are the similar as the common emitter configuration. One possible merit of the common collector configuration is that only six isolated power supplies are required to supply the gate drive signals.

This is possible if the inductance between the devices sharing the same isolated power supply is low. This is the case for Matrix Converter strategies where all bi-directional switches are combined in single package. However, as the power levels rise, the stray inductance of the single bi-directional switches becomes more necessary. Therefore at greater power converters it is required to package the IGBTs into single bi-directional switches or complete output . Hence the common emitter configuration is mostly preferred for higher power levels circuit.

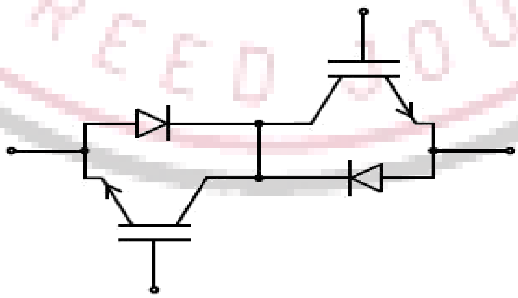

Figure 2.2 Common Collector Bidirectional Switch

3. THREE PHASE TO SINGLE PHASE MATRIX CONVERTER

A Three Phase to Single- Phase Matrix Converter is shown in Fig.3.1. The converter is combined of three bidirectional switches S_1, S_2 and S_3. Each switch inter-connect the output line to an input phase. To neglect short-circuit in the supply-side and current blocking in the load side only one switch can and must be on at any time. The switches are turned on and off in sequence one by one and cyclical way. For the jth switching period, if t^j_b t^j_2 and t^j_3 are the on-time intervals of S_1, S_2 and S_3, respectively, we have,

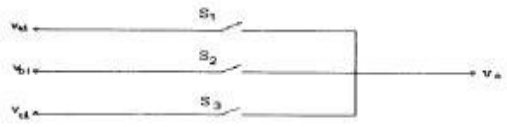

Figure 3.1 Representation of a Three Phase to Single Phase Matrix Converter

The load line is connected to supply side an input voltage for a particular period of time. Thus, the output voltage is a concentrated on the segments of the three input supply voltages. Therefore, the output voltage waveform $v_o(t)$ is a function of the three input voltages $V_{ai}(t)$, $V_{bi}(t)$ and $V_{ei}(t)$ squencilly. In general, the output voltage harmonic components depend also on the supply input frequency and the time of different switching strategy.

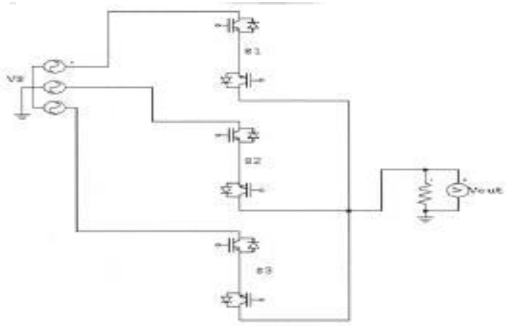

Figure3.2 Simulation Circuit of a Three Phase to Single Phase Matrix Converter

The simulation circuit of a Three Phase is Single Phase Matrix Converter is shown in Fig. 3.2. The analysis is assuming that S_1 is initially ON state when S_2 and S_3 have been off state. The Circuit complete operation is analyzed for a complete switching sequence assuming that S_1 is on followed by commutation to S_2, then to S_3 and finally back to S_1.

4. THREE PHASE TO THREE PHASE MATRIX CONVERTER

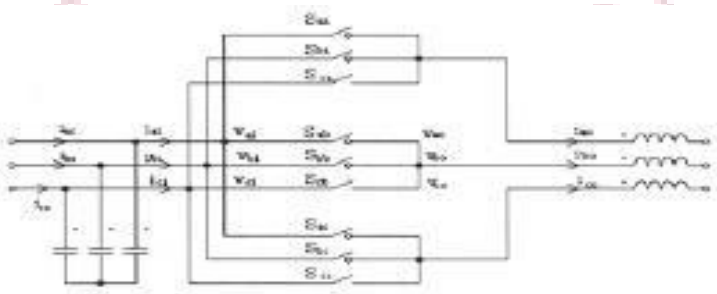

Figure 4.1 Representation of a Three Phase to Three Phase Matrix Converter

A Three-Phase to Three-Phase Matrix Converter structure similar in some part based on the Three-Phase to Single-Phase Matrix Converter. The structure of a three-phase to three-phase Matrix Converter is shown in Fig. 4.1 The converter consists of nine bidirectional switches (S_{aa}, S_{ba}, and S_{ee}) whose operations are according by a number of switching system.

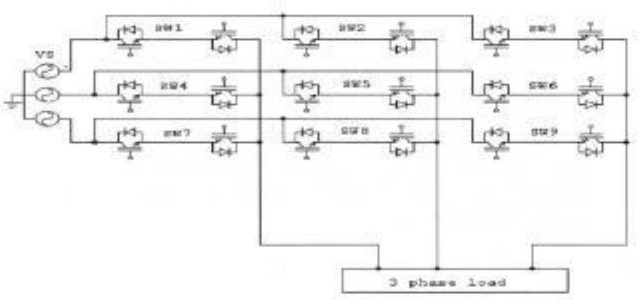

Figure4.2 Simulation Circuit of a Three Phase to Three Phase Matrix Converter

The Matrix Converter may be present a identical electrical system, if a proper switching system is used. The simulation circuit of a Three Phase Matrix Converter is shown in Fig. 5.13 S_{aa}, S_{ba}, and S_{ee} must be switched ON and OFF state with a phase delay sequence of 120' with respect to S_{aa}, S_{ba}, and S_{ee}.. Also, a 240" phase delay sequence must be considered for the switches S_{aa}, S_{ba}, and S_{ee} to get a three phase to three phase output

5. OUTPUT FILTER

The power converter requires a LC filter at the output side to reduce the harmonics generated by the pulsating modulation of voltage waveform. A power converter with higher switching frequency will result in smaller LC filter size. However, switching frequency is generally limited in high power applications. For the design of the LC low-pass filter, the cut-off frequency is considered to be able to eliminate the most low order harmonics of the output voltage waveform. The output impedance of the power converter must be keep close to zero to operate as an ideal voltage source. Ideal voltage source have no additional voltage distortion even though under the load variation or a nonlinear load. To satisfy this requirement the capacitance value should be maximized and the inductance value should be minimized at the selected cut-off frequency of the low-pass filter. When the value of the capacitor is increased the power rating of the matrix Converter is increased as well. This is due to the increment of the filter reactive power. The capacitor value is limited to some value and the value of the inductor is increased as much as the decrement of the capacitor value. It is difficult to obtain zero output impedance when the LC filter is used.

The distortion of the output voltage waveform can be mitigated with an additional voltage feedback controller. The performance of the controller is limited by the power converter switching frequency and the sampling frequency of the digital signal processor.

The trial and error method is used to modified the filter design values to reduce the distortion of the output voltage waveform. Figure 5.1 shows the schematic of the output filter. In this figure *r* represents the internal resistance of the inductor. The transfer function of the output filter can be calculated from this figure. The resonance and cut-off frequencies are determined according to the values of the capacitor and the inductor. Bode plots are employed to find such frequencies.

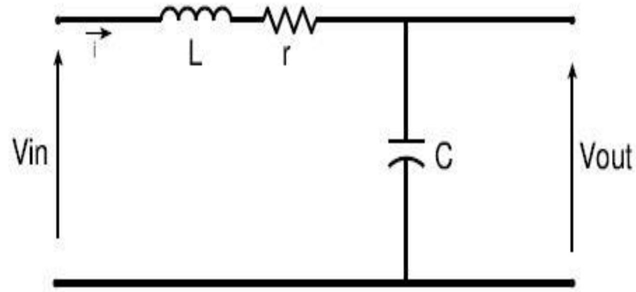

Figure 5.1 Diagram to calculate transfer function of output FILTER

6. RESULTS

6.1 BASIC SIMULATION CIRCUIT OF THREE PHASE TO THREE PHASE

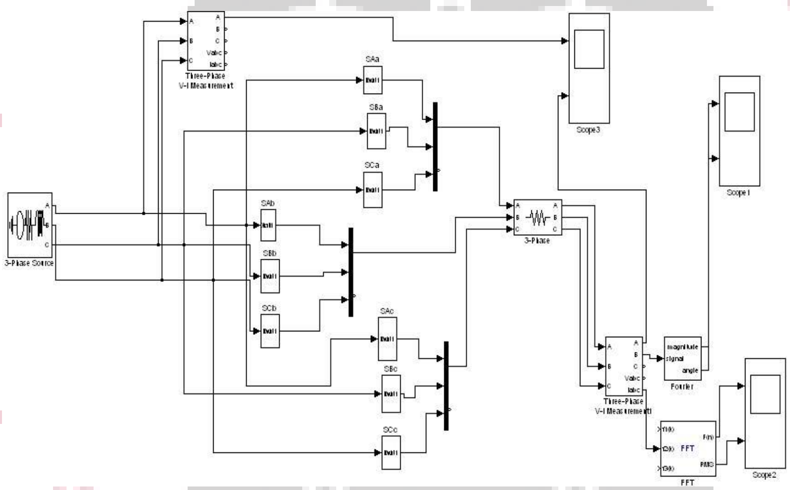

Fig 6.1 Basic simulation circuit for 3 phases to 3 phases

6.2 SIMULATION RESULT OF 100HZ

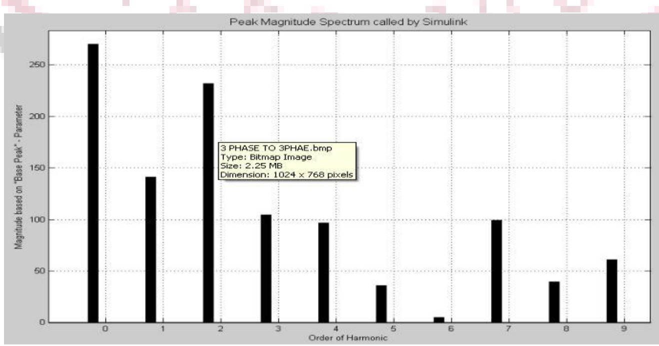

Fig 6.2 Harmonics graph of 100Hz

6.3 *OUTPUT WAVEFORM OF 100HZ*

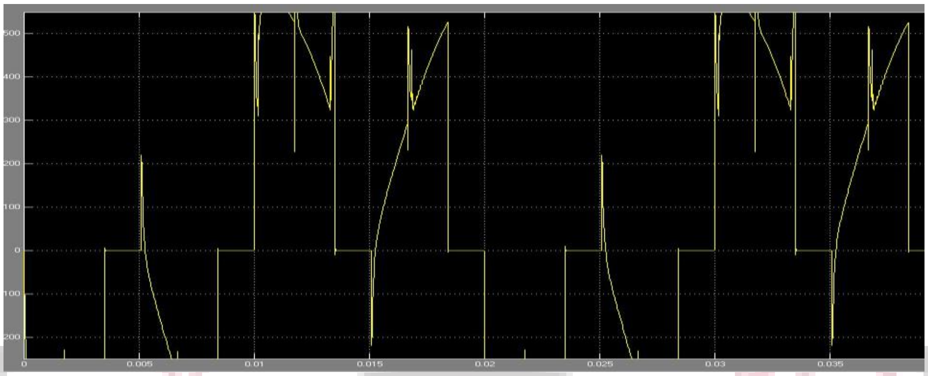

Fig 6.3 Output waveform of 100Hz

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