Matrix Converter Technology

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***Abstract*- This paper presents a review of Matrix converter and its topologies, control strategies. Matrix converter is an AC-AC converter which does not require any energy storing devices components for conversion. The various topologies of converter switch and modulation techniques are discussed in this paper.**

***Index Terms*- Matrix converter, modulation techniques, SPWM, SVPWM.**

1. INTRODUCTION

Today power converters are backbone of industrial development and especially in power sector and in the field of renewable energy. Matrix converter is developed by Venturini and Alesina in 1980. Matrix converter is an AC-AC converter which is developed for variable or fixed frequency conversion.

Conventionally for frequency conversion cycloconverter are used but cycloconverter suffer from following disadvantages.

1. It introduces objectionable harmonics in the system
2. Poor line power factor.

To overcome these disadvantages a matrix converter technology has been proposed. Various configurations matrix converter (MC) have been proposed, which include three leg, four leg MC. MC is ac-ac converter which do not require any dc link physically.[1-3] It can control voltage magnitude, frequency and phase angle as well as input power factor. The desired output is obtained by various modulations techniques. The MC injects active power in grid and thus optimizes the energy utilization.[1]. Each topology has its own advantages and disadvantages. Matrix converter has many applications in drives, wind energy conversion system. Matrix converter is different from other converter in configuration and in working principle. Matrix converter offers a single stage conversion scheme. Though it is an AC-AC converter, its control scheme consists of rectification and inversion mode.

II. MATRIX CONVERTER

It is a kind of force commutated voltage source converter. This revolutionized converter came into existence due to major contribution of Venturini and Alesina. Matrix converter is an array of switches; the matrix converter requires a switch which is capable to block reverse voltage and which allows bidirectional current. But practically there is no such switch which is able to perform both the operations . Therefore switch is designed with discrete power electronic switches mainly with IGBTs and diodes. Figure 1 shows various configurations of switches. There is common emitter back to back, common collector back to back, Diode Bridge with IGBT at centre. Among the common collector is popular because it requires only six isolated gate drive supplies.[5-6]

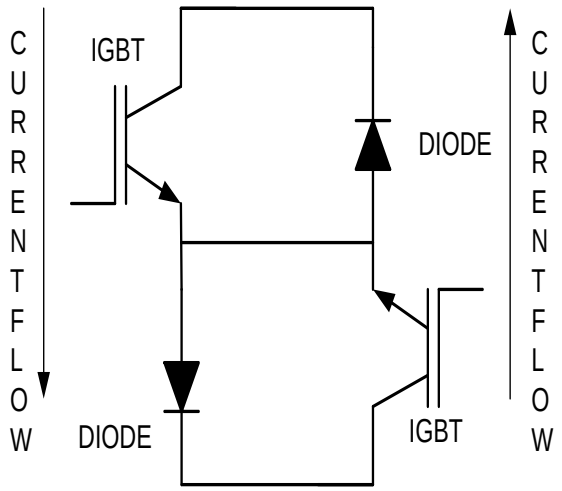


Figure 1. Common emitter back to back

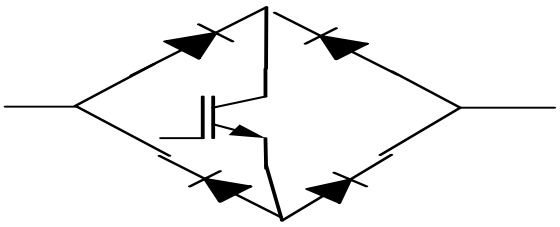


Figure 2: Diode Bridge

Matrix converter can be implemented using these configurations or it can be implemented using modules of switches. Matrix converter can be divided into two groups as

- Indirect matrix converter (based on indirect modulation techniques)
- Direct matrix converter (based on direct modulation techniques

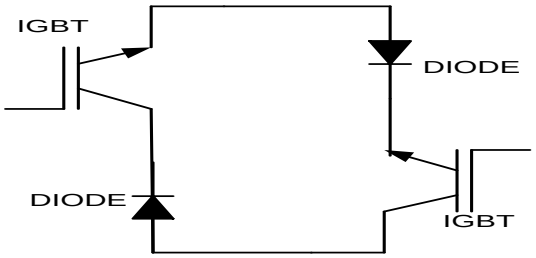


Figure 3: common collector back to back

III. MODULATION TECHNIQUES

The modulation techniques used for MC are

- State vector pulse width modulation (SVM)
- Sinusoidal pulse width modulation (SPWM)

SVM is basically indirect modulation technique while SPWM is a direct modulation technique. In indirect technique two stages of conversion are created; first stage is rectification stage and second is inversion but in this technique no DC link is required. Modulation techniques itself creates a fictitious DC link via two stage conversion modes.

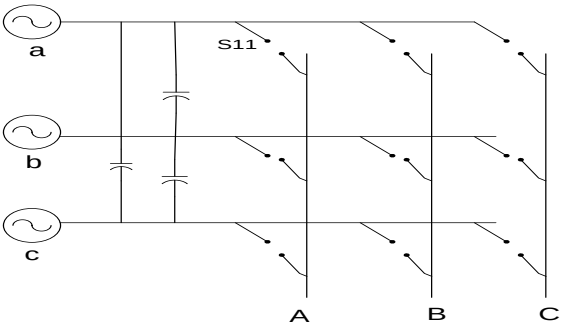


Figure 4: Matrix Converter

1. State vector pulse width modulation

In this technique various sectors of input voltages and currents are formed. Each sector is 60^0 apart from each other and total sectors contribute to 360^0 as shown in figure 5. As MC is a voltage source converter its output terminal must not be opened and input terminals should not be short circuited. Considering this there are only 27 possible switching states. They are divided into

- Active states
- Zero states

Zero vectors all switches of one phase are turned on and connected to same output phase; this can lead to damage.

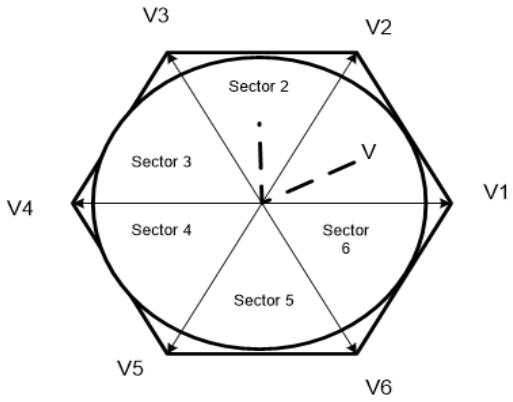


Figure 5: state of voltages

2. Sinusoidal Pulse Width Modulation (SPWM)

Sinusoidal pulse width modulation (SPWM) is a direct modulation method. In this scheme modulation time sequence of switches divide the input voltage into pieces which gives the output voltages at desired frequency.

$$S_{Mj} = \begin{cases} 1 & switch\ is\ closed \\ 0 & switch\ is\ open \end{cases}$$

Where M= {A, B, C} and j= {a, b, c}.

The output voltage equation for three legs MC is given by,

$$\begin{bmatrix} v_a \\ v_b \\ v_c \end{bmatrix} = \begin{bmatrix} S_{Aa} & S_{Ab} & S_{Ac} \\ S_{Ba} & S_{Bb} & S_{Bc} \\ S_{Ca} & S_{Cb} & S_{Cc} \end{bmatrix} \begin{bmatrix} v_A \\ v_B \\ v_C \end{bmatrix}$$

Where $\begin{bmatrix} v_a \\ v_b \\ v_c \end{bmatrix}$ is output voltage matrix, $\begin{bmatrix} v_A \\ v_B \\ v_C \end{bmatrix}$ is input voltage matrix. Thus

$v_o = T\, v_i$, where T is transfer matrix. By choosing proper modulation index and transfer matrix desired frequency can be achieved.

IV. SIMULATION OF MATRIX CONVERTER

Matrix converter can be simulated using various softwares like PSIM, MATLAB. Figure 6 shows MATLAB model of MC. This model is simulated for 50Hz output frequency. The input frequency is 30 Hz and SVM is applied to the converter. With load R= 10 ohm.

V. CONCLUSIONS

It has been observed that MC with SVM gives modulation index of 86.6% while with SPWM it gives modulation index of 70%-80%. This converter is feasible for single phase applications as for three phase applications it requires number of switches which leads to cost addition. MC can be used in drives, wind energy conversion system and uninterruptible power supplies.

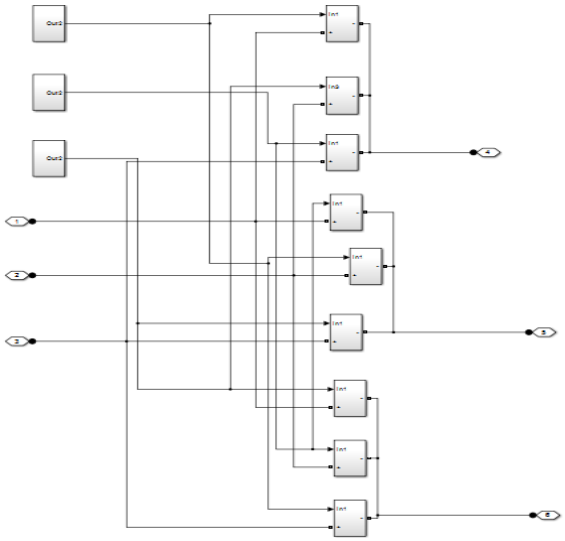
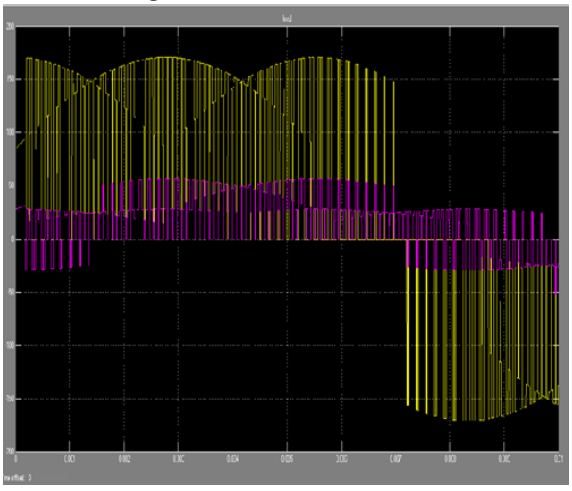


Figure 7. Matlab model of MC



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