# POWER QUALITY RELATED APPROACH IN SPACE VECTOR CONVERTER

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***ABSTRACT***

*A cycloconverter is a power electronics device used to convert constant frequency AC power to adjustable voltage adjustable frequency AC power without any DC link. Cycloconverter inject significant harmonics and non-standard frequency components like inter harmonics (i.e., non integer multiples of power frequency) into power systems. The impact of cycloconverter on power quality is studied, and the relation between power quality indices and cycloconverter control strategies are developed. Control strategies based on the switching sequence SVPWM (i.e., space vector pulse width modulation). Control strategies are proposed to minimize the power quality impact of the converters. An innovative wavelet filter concepts are illustrated with the help of wavelet transform tool to recognize the power quality.*

***KEYWORDS:*** *Cycloconverter, power electronics, power quality, harmonics, wavelet.*

## I. INTRODUCTION

Cycloconverters are static frequency changers (SFCs) designed to convert constant voltage, constant frequency AC power to adjustable frequency AC power without any intermediate DC link. The basic principle of a cycloconverter was proposed and patented by Hazeltine in 1926[1]. However, practical and commercial cycloconverters were not available until thyristors were developed in the 1960s. With the invent of large rating thyristors and the development of microprocessors and microcontrollers feed gate driver circuits, cycloconverters are widely used in heavy industries like rolling mills, cement industries, ship propellers. Basic cycloconverter is naturally commutated converter capable of flowing power in either direction. The sizes of the converter depend upon the rating of the thyristors. Compared with rotary frequency changers, its losses are considerably low. Cycloconverters can deliver a nearly sinusoidal waveform resulting in minimum torque pulsations for the case of rotating loads [8]. However it produces highly distorted input currents. Highly distorted input currents can significantly decrease electrical power quality [11]. The cycloconverter input currents and output voltages contain harmonics as well as inter harmonics. In this paper a soft-switching technique is adapted to reduce these power harmonics and the power quality impact of thyristor-controlled cycloconverters is studied. Power quality impact includes; total harmonic distortion (THD), impact on distribution transformers, and impact on communication lines [14].Basic theory of cycloconverter: A cycloconverter consists of one or more back to back connected controlled rectifiers. The delay angles of those rectifiers are modulated so as to provide AC output voltage at desired frequency and amplitude. The three phase cycloconverter consists of 18 thyristors but higher pulse order systems are large and complicated and tend to be applicable for large rating load. Based on the structure of the rectifiers used in cycloconverters are classified into half wave and bridge cycloconverter. The AC-AC matrix converter, an alternative to an AC-DC-AC converter for voltage and frequency transformation,

has two major advantages, i.e., it requires no DC-link reactive component and it allows bi-direction power flow. Since its description [2], the matrix converter has been of intensive ongoing research [3-6] and an aspect which attracts much of the research effort is the pulse-width modulation control. For matrix converters used in variable-speed drive applications the ideal PWM algorithm should have;
* Provide independent control of the magnitude and frequency of the generated output voltages.
* Give sinusoidal input current with adjustable phase shift,
* Achieve the maximum possible range of output to input voltage ratio,
Satisfy the conflicting requirements of minimum low-order harmonics and minimum switching losses. Hitherto two control schemes, the Venturini method and the space vector modulation, have been used to meet the above listed requirements. However, owing to completely different design approaches, the two PWM algorithms give distinctly different performances with regard to operation in unbalanced or distorted supply voltages. The brief circuit diagram of matrix converter is given in the Fig.1. Nine bidirectional switches are so arranged that any of the three input phases can be connected to any output phase. Each of the bidirectional switches employed is constructed by connecting a pair of power devices back to back. One power diode is provided in series to protect the IGBTs from reverse voltage blocking. The switching control obeys a rule that only one of the three switches connected to an output phase can and must be ON at any one time. It provides short circuit protection as well as uninterrupted load current flow.

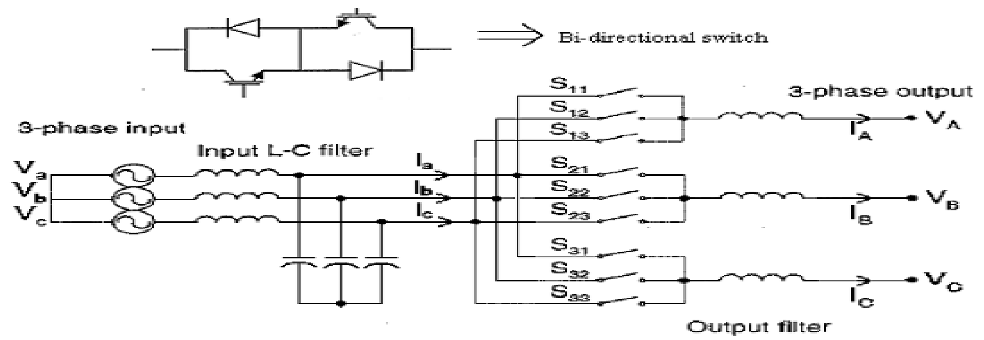


Figure 1. Matrix converter topology

# II. SVM METHOD

The SVM methods represent the three-phase input currents and output line to line voltages as space vectors. It is based on the concept of approximating a rotating reference vector with those voltages physically realizable on a matrix converter. For nine bi-direction switches there are 27 possible combination of switching status, which is also divided into five groups. The first group consists of six vectors whose angular positions vary with change of the input voltages. These groups are invalid for SVM technique. The next three groups of switch combinations have two common features; namely each of them formulates a six-sextant hexagon as shown in Fig.2. These, so named 'stationary vectors', are used to synthesis the desire output voltage vector. The remaining group comprising three zero vectors is also used in this method. The modulation process selection can be done in two ways one is vector selection and another vector on time duration calculation. At a given time instant Ts, the SVM selects four stationary vectors to approximate a desired reference voltage with the constraint of unity input power factor.

## 2.1. Switching technique of SVM

To calculate the on time duration of the chosen vectors, the four vectors selected are combined into two sets leading to two new vectors adjacent to the reference voltage vector. According to space vector modulation theory, the integral value of the reference vector over one sample time interval can be approximated by the sum of the products of the two adjacent vectors on time intervals. General formulae derived for estimating the vector on time intervals have been given as,

(1)

(2)

(3)

(4)

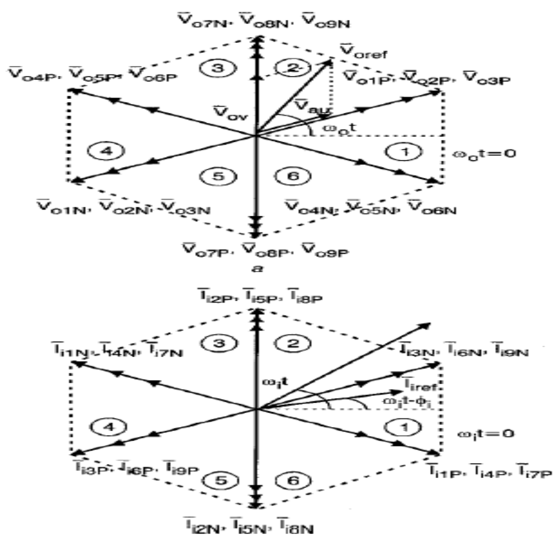


Figure 2. Output voltage and input current hexagon

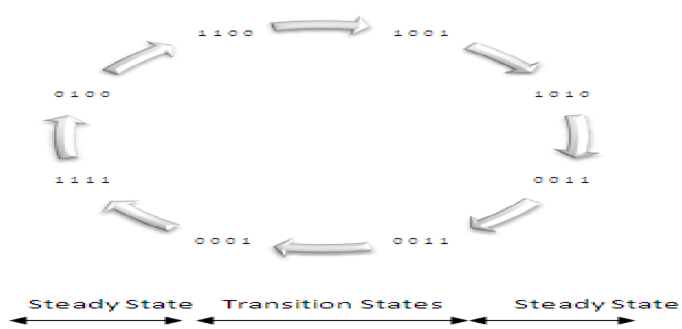


Figure 3. Switching states

Where — the voltage transfer ratio, $\theta_0$ and $\theta_i$ are the phase angles of the output voltage and input current vectors respectively. These values are limited within 0 to $60^0$ ranges. The zero vector on-time is given by,

(5)

The above procedure is performed at every sampling interval.

## 2.2. Circuit description

Matlab simulink has been applied here to simulate the matrix converter from three phase to single phase conversion. Fig.4 shows the schematic of vector converter. Reference voltage of the space vector converter can be adjusted to control the output frequency of the converter.

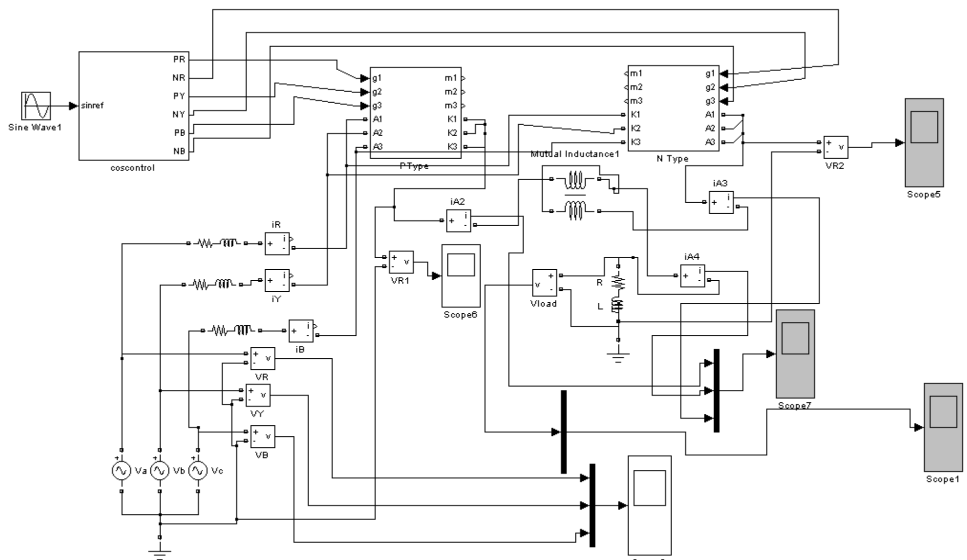


Figure 4. Space vector cycloconverter technique

## 2.3. Results

Three phase single phase vector simulation Fig.5 and power quality of that output phase has been measured through Matlab. Three phase 230V supply voltage, applied to the converter and the output voltage power quality is measured through power GUI tool. Total harmonic distortions for different angles have been studied and compared with the conventional converter. Total control strategy has been performed with the help of field programming gate array embedded system.

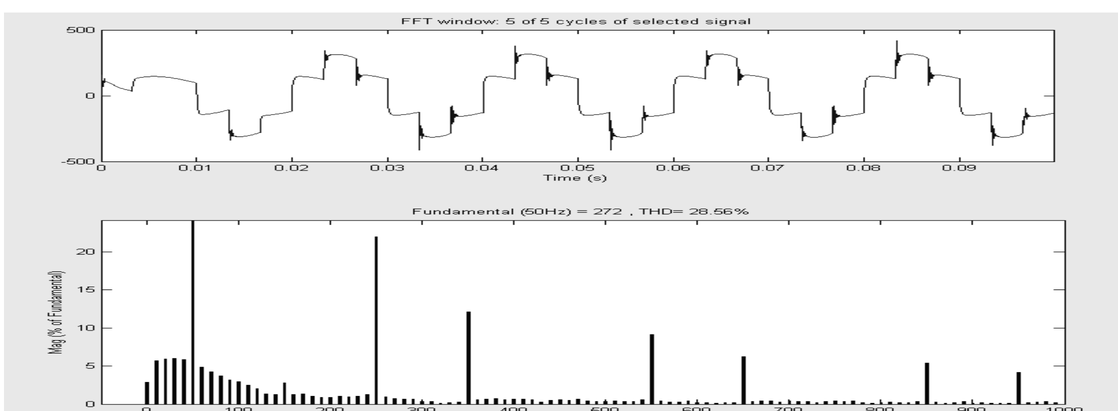


Figure 5. Spectrum analysis

**Sampling time = 3.25521e-005 sec, samples per cycle = 614.4, fundamental = 272 peak (192.4 RMS), Total Harmonic Distortion (THD) = 28.56%**

**Table 1 Harmonic order**

| Harmonics Hz | Order | Amplitude Volt |
|---|---|---|
| 0 | | 7.86 |
| 10 | | 15.47 |
| 20 | | 16.19 |
| 30 | | 16.31 |
| 40 | | 15.95 |
| 50 | Fundamental | 272.05 |
| 60 | | 13.14 |
| 70 | | 11.43 |
| 80 | | 10.08 |
| 90 | | 8.54 |
| 100 | H2 | 7.98 |
| 110 | | 6.78 |
| 120 | | 5.48 |
| 130 | | 3.73 |
| 140 | | 3.35 |
| 150 | H3 | 7.49 |
| 160 | | 3.47 |
| 170 | | 3.56 |
| 180 | | 2.78 |
| 190 | | 2.47 |
| 200 | H4 | 2.47 |
| 220 | | 2.55 |
| 230 | | 2.78 |
| 240 | | 3.42 |
| 250 | H5 | 59.70 |
| 260 | | 2.70 |
| 270 | | 2.01 |
| 280 | | 1.70 |
| 290 | | 1.82 |
| 300 | H6 | 0.87 |
| 310 | | 0.84 |
| 320 | | 0.32 |
| 330 | | 0.59 |
| 340 | | 0.69 |
| 350 | H7 | 32.93 |
| 360 | | 1.55 |
| 370 | | 1.77 |
| 380 | | 2.00 |
| 390 | | 1.49 |
| 400 | H8 | 1.86 |

$10^{th}$ harmonics of this system has been studied through GUI system and voltage vs. magnitude data has been generated and shown in table 1.

## III. CONCLUSION

In this article a new ride-through module for a matrix converter has been proposed. The ride through capability has been achieved by the minimal addition of hardware and software into the matrix converter. A method for harmonic analysis of the converter waveforms is presented which can accurately predict the harmonic performances of either control method. Modelling of matrix converter losses is described, resulting in a meaningful tool for power circuit design and device optimization. The main advantage of the SVM method lies in lowering switching losses compared to the Venturini method, however, exhibits superior performance in terms of input current and output voltage harmonics. Natural sampling avoids baseband distortion, where PWM requires more computational effort than UPWM because of calculation of the crossing times.

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