Matrix Converter

A matrix converter is defined as a converter with a single stage of conversion. It utilizes bidirectional controlled switch to achieve automatic conversion of power from AC to AC.

The matrix converter consists of 9 bi-directional switches that allow any output phase to be connected to any input phase. The circuit scheme is shown in Fig 1. The input terminals of the converter are connected to a three phase voltage-fed system, usually the grid, while the output terminal are connected to a three phase current-fed system, like an induction motor might be.

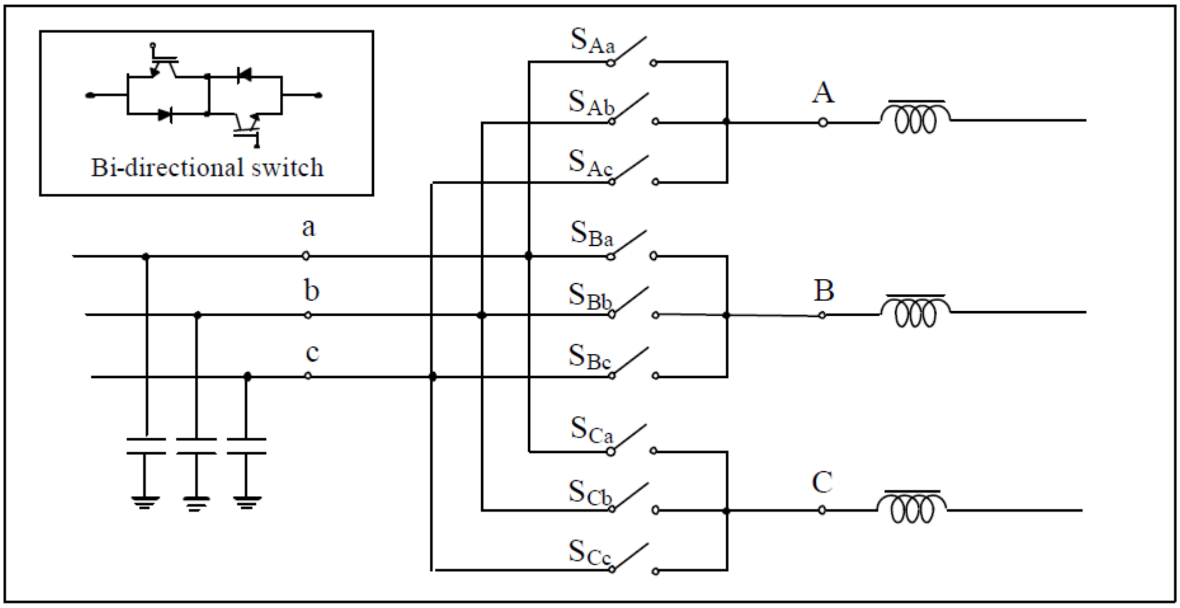


Fig.1 Circuit scheme of a three phase to three phase matrix converter.

a,b,c are at the input terminals. A,B,C are at the output terminals.

With nine bi-directional switches the matrix converter can theoretically assume 512 (2^9) different switching states combinations. But not all of them can be usefully employed. Regardless to the control method used, the choice of the matrix converter switching states combinations (from now on simply matrix converter configurations) to be used must comply with two basic rules. Taking into account that the converter is supplied by a voltage source and usually feeds an inductive load, the input phases should never be short-circuited and the output currents should not be interrupted. From a practical point of view these rules imply that one and only one bi-directional switch per output phase must be switched on at any instant. By this constraint, in a three phase to three phase matrix converter 27 are the permitted switching combinations.

Applications:

1) Renewable energy systems: Matrix converters can efficiently interface renewable energy sources, such as solar panels or wind turbines, with the electrical grid, enabling power conversion and grid integration.

2) Electric vehicles: Due to their compact size and bidirectional power flow capability, matrix converters are suitable for use in electric vehicles. They can efficiently convert energy from the battery to the motor and can also recover braking energy, increasing overall efficiency.

3) Industrial automation: Matrix converters are employed in motor drives, machine tools, and other industrial automation systems. They offer precise control of motor speed and direction, leading to improved system performance and energy efficiency.

4) Aerospace and marine systems: The compactness and high efficiency of matrix converters make them valuable in aerospace and marine applications, where space and weight considerations are critical. They can be used for power conversion in aircraft, ships, and offshore platforms.

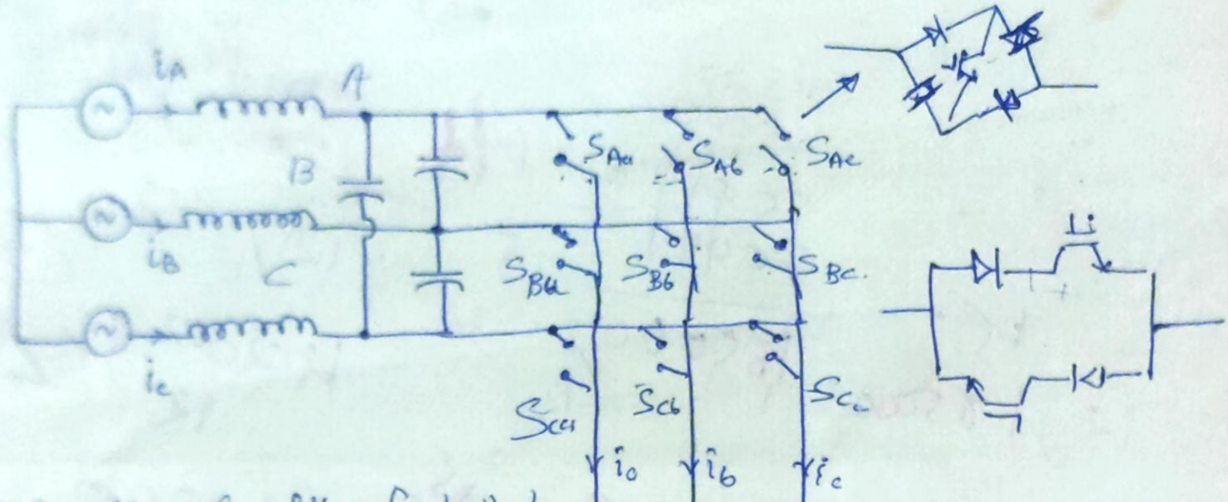
Advantages:

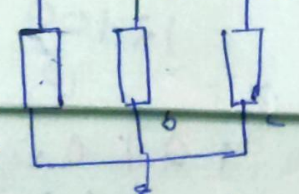
- The matrix converter has several advantages over traditional rectifier-inverter type power frequency converters. It provides sinusoidal input and output waveforms, with minimal higher order harmonics and no subharmonics;
- it has inherent bi-directional energy flow capability;
- The input power factor can be fully controlled.
- It has minimal energy storage requirements, which allows to get rid of bulky and lifetime-limited energy-storing capacitors.

Disadvantages:

- First of all it has a maximum input output voltage transfer ratio limited to = 87 % for sinusoidal input and output waveforms.
- It requires more semiconductor devices than a conventional AC-AC indirect power frequency converter.
- It is particularly sensitive to the disturbances of the input voltage system

Matrix Converter: it is Forced Commutated Cyclo-conv^r.
(Universal Conver^r)





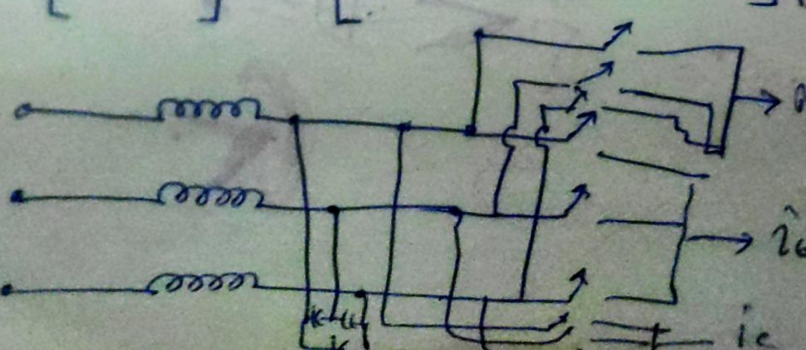
→ Bidirectional fully Controlled switches for direct conversion (No dc link) from AC to AC

→ Nine switch use for three phase to three phase Conversion are arranged that any of three input pase could be connected to any output phase.

→ At any time, one and only one of the three switches connected to an output phase must be closed to prevent short circuiting of supply line.

→ Total $2^9 = 512$ possible state, 27 combination are allowed.

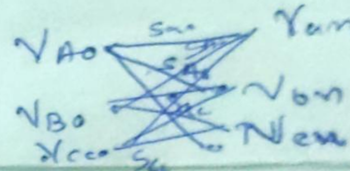
$$\begin{bmatrix} V_{an} \\ V_{bn} \\ V_{cn} \end{bmatrix} = \begin{bmatrix} S_{Aa} & S_{Ba} & S_{Ca} \\ S_{Ab} & S_{Bb} & S_{cb} \\ S_{Ac} & S_{BC} & S_{cc} \end{bmatrix} \begin{bmatrix} V_{AN} \\ V_{BN} \\ V_{CN} \end{bmatrix}$$



→ Switching pattern & communication control must avoid line to line short ckt

→ Switching pattern & communication control must avoid open ckt at the output (Inductive load)

→ Switch duty cycles are modulate so that the average output voltage follows the desire reference.



→ input phase Current are

$$\begin{bmatrix} i_A \\ i_B \\ i_C \end{bmatrix} = \begin{bmatrix} S_{Aa} & S_{Ab} & S_{Ac} \\ S_{Ba} & S_{Bb} & S_{Bc} \\ S_{Ca} & S_{Cb} & S_{Cc} \end{bmatrix} \begin{bmatrix} i_a \\ i_b \\ i_c \end{bmatrix}$$

Advantage

→ unity displacement factor (pf↑)

→ bidirectional power flow

→ Sinusoidal output waveform.

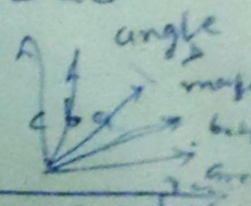
→ Absent of dc link reactive Component

→ Controllable input PF

Rotating Vector (Synchronous) : ABC seqn abc bca cab

Six State.

Rotating Vectors (inverse) : ACB seqn : acb bac



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another 18 switching states produce active vector of variable amplitude, depending on the selected line-to-line voltage, but at a stationary position

abb, baa, bcc, cbb, caa, ...

angle is remain same

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zero vector:

aaa, bbb, ccc. magnitude & angle are zero