

## EE3014 POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS

### UNIT IV-POWER CONVERTERS FOR WIND SYSTEMS

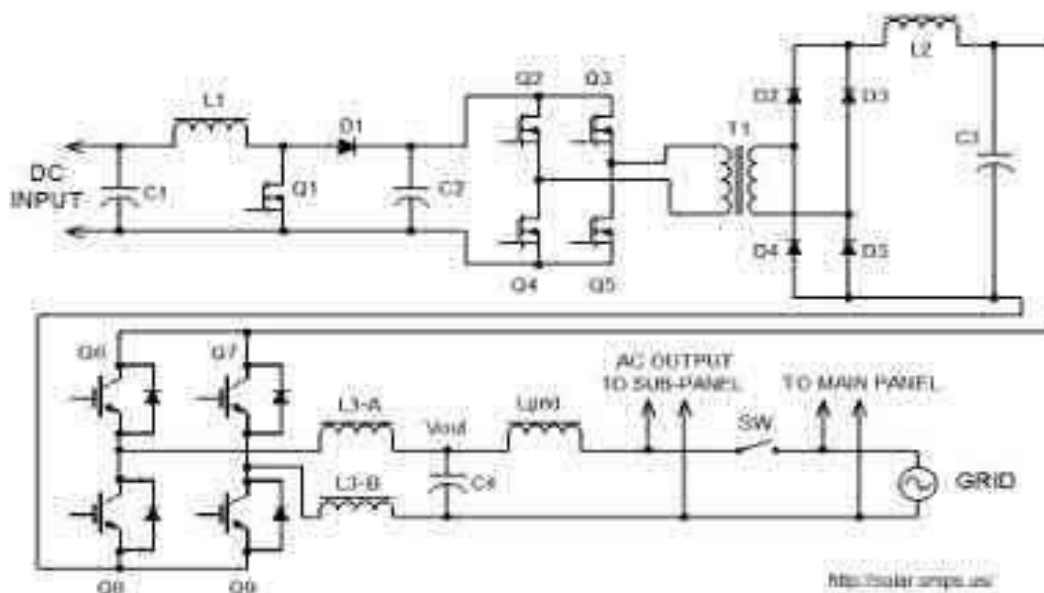
#### 4.4 - GRID-INTERACTIVE INVERTERS - MATRIX CONVERTER

##### GRID INTERACTIVE (GRID-TIE) INVERTERS

###### Introduction

A grid-tie inverter converts direct current (DC) into an alternating current (AC) suitable for injecting into an electrical power grid, normally 120V RMS at 60Hz or 240V RMS at 50 Hz. Grid-tie inverters are used between local electrical power generators: solar panel, wind turbine, hydro-electric, and the grid. In order to inject electrical power efficiently and safely into the grid, grid-tie inverters must accurately match the voltage and phase of the grid sine wave AC waveform. Some electricity companies will pay for electrical power that is injected into the grid. Payment is arranged in several ways. With net metering the electricity company pays for the net power injected into the grid, as recorded by a meter in the customer's premises. For example, a customer may consume 400 kilowatt-hours over a month and may return 500 kilowatt-hours to the grid in the same month. In this case the electricity company would pay for the 100 kilowatt hours balance of power fed back into the grid. Feed-in tariff, based on a contract with a distribution company or other power authority, is where the customer is paid for electrical power injected into the grid.

###### Operation



Grid-tie inverters convert DC electrical power into AC power suitable for injecting into the electric utility company grid. The grid tie inverter (GTI) must match the phase of the grid and maintain the output voltage slightly higher than the grid voltage at any instant. A high-quality modern grid-tie inverter has a fixed unity power factor, which means its output voltage and current are perfectly lined up, and its phase angle is within 1 degree of the AC power grid. The inverter has an on-board computer which senses the current AC grid waveform, and outputs a voltage to correspond with the grid. However, supplying reactive power to the grid might be necessary to keep the voltage in the local grid inside allowed limitations. Otherwise, in a grid segment with considerable power from renewable sources, voltage levels might rise too much at times of high production, i.e. around noon with solar panels.

Grid-tie inverters are also designed to quickly disconnect from the grid if the utility grid goes down. It ensures that in the event of a blackout, the grid tie inverter will shut down to prevent the energy it transfers from harming any line workers who are sent to fix the power grid.

Properly configured, a grid tie inverter enables a home owner to use an alternative power generation system like solar or wind power without extensive rewiring and without batteries. If the alternative power being produced is insufficient, the deficit will be sourced from the electricity grid.

### Types

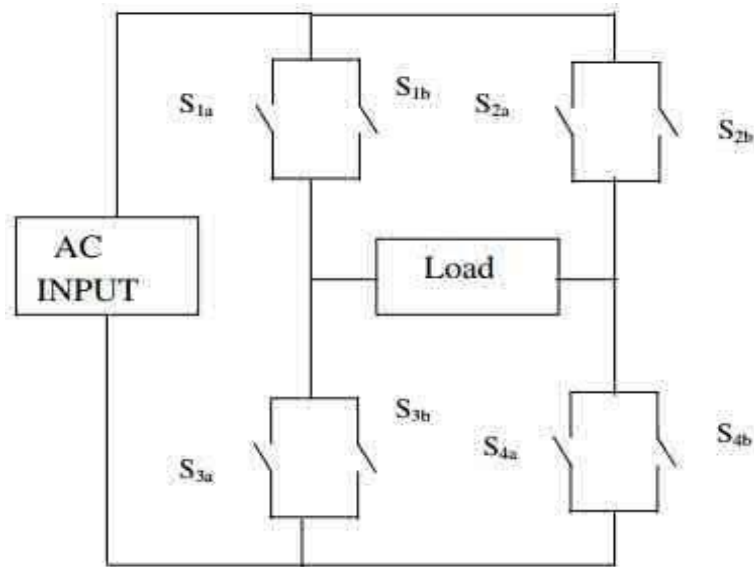
Grid-tie inverters include conventional low-frequency types with transformer coupling, newer high-frequency types, also with transformer coupling, and transformer-less types. Instead of converting direct current directly into AC suitable for the grid, high-frequency transformers types use a computer process to convert the power to a high-frequency and then back to DC and then to the final AC output voltage suitable for the grid. Transformer-less inverters are lighter, smaller, and more efficient than inverters with transformers. But transformer-less inverters have been slow to enter the market because of concerns that transformer-less inverters, which do not have galvanic isolation between the DC side and grid, could inject dangerous DC voltages and currents into the grid under fault conditions.

## MATRIX CONVERTERS

### Introduction

The main advantage of matrix converter is elimination of dc link filter. Zero switching loss devices can transfer input power to output power without any power loss. But practically it does not exist. The switching frequency of the device decides the THD of the converter. Maximum power transfer to the load is decided by nature of the control algorithm. Matrix converter has a maximum input output voltage transfer ratio limited to 87 % for sinusoidal input and output waveforms, which can be improved. Further, matrix converter requires more semiconductor devices than a conventional AC-AC indirect power frequency converter. Since monolithic bi-directional switches are available they are used for switching purpose. Matrix converter is particularly sensitive to the disturbances of the input voltage to the system. The instantaneous power flow does not have to equal power output. The difference between the input and output power must be absorbed or delivered by an energy storage element within the converter. The matrix converter replaces the multiple conversion stages and the intermediate energy storage element by a single power conversion stage, and uses a matrix of semiconductor bidirectional switches connecting input and output terminals. With this general arrangement of switches, the power flow through the converter can reverse. Because of the absence of any energy storage element, the instantaneous power input must be equal to the power output, assuming idealized zero-loss switches.

### Single Phase Matrix Converter



### Single Phase Matrix Converter

The AC/AC converter is commonly classified as an indirect converter which utilizes a dc link between the two ac systems and converter that provides direct conversion. This converter consists of two converter stages and energy storage element, which convert input ac to dc and then reconverting dc back to output ac with variable amplitude and frequency. The operation of this converter stages is decoupled on an instantaneous basis by the energy storage elements and controlled independently, so long as the average energy flow is equal. Figure shows the single phase matrix converter switching arrangement.

### Three Phase Matrix Converter

Three phase matrix converter consists of nine bidirectional switches. It has been arranged into three groups of three switches. Each group is connected to each phase of the output. These arrangements of switches can connect any input phase. These 3x3 arrangements can have 512 switching states. Among them only 27 switching states are permitted to operate this converter. Here A, B and C are input phase voltage connected to the output phase. Figure shows synchronous operating state vectors of three matrix converter. It shows that the converter switches are switched on rotational basis. In this case no two switches in a leg are switched on simultaneously. These states will not generate gate pulse when one phase of the supply is switched off.

### Circuit scheme of a three phase to three phase matrix converter

The matrix converter consists of 9 bi-directional switches that allow any output phase to be connected to any input phase. 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. The capacitive filter on the voltage- fed side and the inductive filter on the current-fed side represented in the scheme are intrinsically necessary. Their size is inversely proportional to the matrix converter switching frequency. It is worth noting that due to its inherent bi-directionality and symmetry a dual connection might be also feasible for the matrix converter: a current-fed system at the input and a voltage-fed system at the output. 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.