Modular Cascaded H-Bridge Multilevel PV Inverter with Distributed MPPT

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Abstract - Due to shortage of fossil fuels and environmental problems caused by conventional power generation, renewable energy, especially solar energy, has become very popular. Solar-electric-energy demand has grown consistently by 20%- 25% per annum over the past 20 years, and the growth is mostly in grid-connected applications..Power electronic inverters are widely used in industrial power conversion systems both for utility and drives applications. As the power level increases, the voltage level also increases accordingly to obtain satisfactory efficiency. Multilevel Inverters have been attracting attention in recent years due to high power quality, high voltage capability, low switching losses and low Electro Magnetic Interference (EMI) concerns; and have been proposed as the best choice in several medium and high voltage applications such as static VAR compensators and large electrical drives. Conventional inverter can switch to each input / output connection between two possible voltage (and possible current) levels. Multilevel inverter can switch their outputs between many voltage or current levels and have multiple voltage or current sources (or simply capacitors or inductors) as part of their structure.

Keywords - Multilevel, Voltage, Capability, Inverter, MPPT.

I. Introduction

A multilevel inverter can be implemented in different topology with its own advantages and limitations. The simplest technique adopted is parallel or series connection of conventional inverters to form the multilevel inverter. More complex structures involve, inserting inverter within inverter to form a multilevel inverter. Whatever approach is chosen, the subsequent voltage or current rating of the multilevel inverter becomes a multiple of the individual switches and so that the power rating of the inverter can exceed the limit imposed by the individual switching devices. Pulse Width Modulation (PWM) of multilevel inverter is typically an extension of two level inverters. The most common types of multilevel voltage source pulse width modulation are sine triangle modulation and space vector modulation. Multilevel sine triangle modulation relies on defining a number of triangle waveforms and switching rules for the intersection of these waveforms with a commanded

voltage waveform. This method is fairly straightforward and insightful for the description of multilevel systems.

Inverters

A power inverter, or inverter, is an electronic device or circuitry that changes direct current (DC) to alternating current (AC).

The input voltage, output voltage and frequency, and overall power handling depend on the design of the specific device or circuitry. The inverter does not produce any power; the power is provided by the DC source.

Hundreds of thousands of volts, where the inverter is part of a high-voltage direct current power transmission system.

An inverter can produce a square wave, modified sine wave, pulsed sine wave, pulse width modulated wave (PWM) or sine wave depending on circuit design. The two dominant commercialized waveform types of inverters as of 2007 are modified sine wave and sine wave.

There are two basic designs for producing household plug-in voltage from a lower-voltage DC source, the first of which uses a switching boost converter to produce a higher-voltage DC and then converts to AC. The second method converts DC to AC at battery level and uses a line-frequency transformer to create the output voltage.

The AC output frequency of a power inverter device is usually the same as standard power line frequency, 50 or 60 hertz.

If the output of the device or circuit is to be further conditioned (for example stepped up) then the frequency may be much higher for good transformer efficiency.

The AC output voltage of a power inverter is often regulated to be the same as the grid line voltage, typically 120 or 240 VAC at the distribution level, even when there are changes in the load that the inverter is driving. This allows the inverter to power numerous devices designed for standard line power.

A power inverter will often have an overall power rating expressed in watts or kilowatts. This describes the power that will be available to the device the inverter is driving and, indirectly, the power that will be needed from the DC source.

Smaller popular consumer and commercial devices designed to mimic line power typically range from 150 to 3000 watts.

Fig. 1. Power Inverter

A power inverter can be entirely electronic or may be a combination of mechanical effects (such as a rotary apparatus) and electronic circuitry. Static inverters do not use moving parts in the conversion process.

A typical power inverter device or circuit requires a relatively stable DC power source capable of supplying enough current for the intended power demands of the system. The input voltage depends on the design and purpose of the inverter.

12 V DC is for smaller consumer and commercial inverters that typically run from a rechargeable 12 V lead acid batteries or automotive electrical outlet.

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- 24, 36 and 48 V DC, are common standards for home energy systems.
- 200 to 400 V DC, when power is from photovoltaic solar panels.
- 300 to 450 V DC, when power is from electric vehicle battery packs in vehicle-to-grid systems.

II. Classification of Inverters

The classification of inverter is done as follows: According to semiconductor devices:

- SCR
- BJT
- MOSFET
- IGBT
- MCT

According to commutation methods:

- Line commutation inverter
- Forced commutation inverter According to output phases:
- Single phase
- Three phase According to supply sources:
- Voltage source inverter
- Current source inverter According to voltage waveforms:
- Sinusoidal inverter
- Non-sinusoidal inverter

According to connection of semiconductor devices:

- Half bridge inverter
- Full bridge inverter
- Series inverter
- Parallel inverter
- Classification based on the mode of operation, inverters can be classified into three broad categories:
- Stand-alone inverters
- Grid-connected inverters
- Bimodal inverters

III. Principle Of Operation Of Inverter

The process of conversion of the DC current into AC current is based on the phenomenon of electromagnetic induction. Electromagnetic induction is generation of electric potential difference in a conductor when it is exposed to varying magnetic field. For example, if you place a coil (spool of wire) near a rotating magnet, electric current will be induced in the coil.

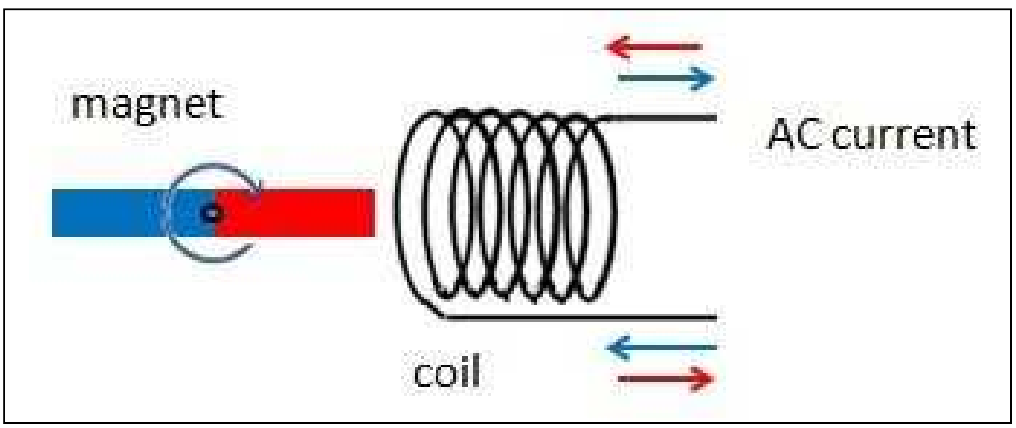

Fig. 2. Principle of operation of inverter

Next, if we consider a system with two coils and pass DC current through one of them (primary coil), that coil with DC current can act analogously to the magnet (since electric current produces magnetic field). If the direction of the current is reversed frequently (e.g., via a switch device), the alternating magnetic field will induce AC current in the secondary coil.

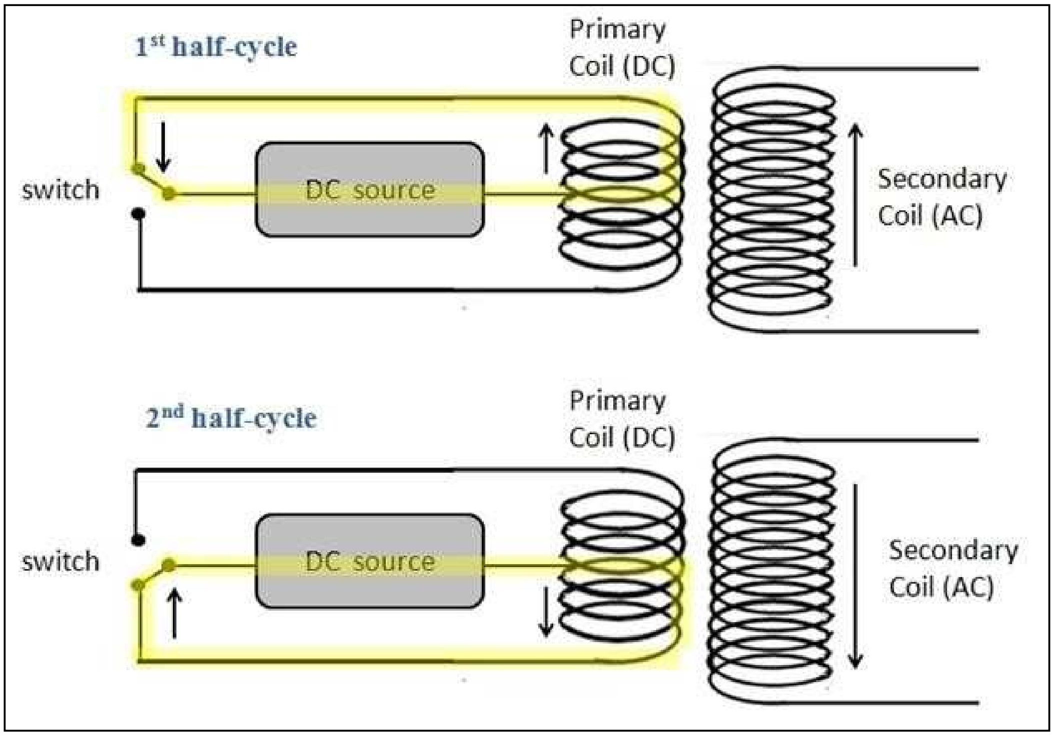

Fig. 3. Operation of inverter

The simple two-cycle scheme shown in above produces a square wave AC signal. This is the simplest case, and if the inverter performs only this step, it is a square-wave inverter. This type of output is not very efficient and can be even detrimental to some loads. So, the square wave can be modified further using more sophisticated inverters to produce a modified square wave or sine wave.

To produce a modified square wave output, low frequency waveform control can be used in the inverter. This feature allows adjusting the duration of the alternating square pulses. Also, transformers are used here to vary the output voltage. Combination of pulses of different length and voltage results in multi-stepped modified square wave, which closely matches the sine wave shape. The low frequency inverters typically operate at ~60 Hz frequency.

To produce a sine wave output, high-frequency inverters are used. These inverters use the pulse-width modification method: switching currents at high frequency, and for variable periods of time. For example, very narrow (short) pulses simulate a low voltage situation, and wide (long pulses) simulate high voltage. Also, this method allows spacing the pulses to be varied: spacing narrow pulses farther apart models low voltage.

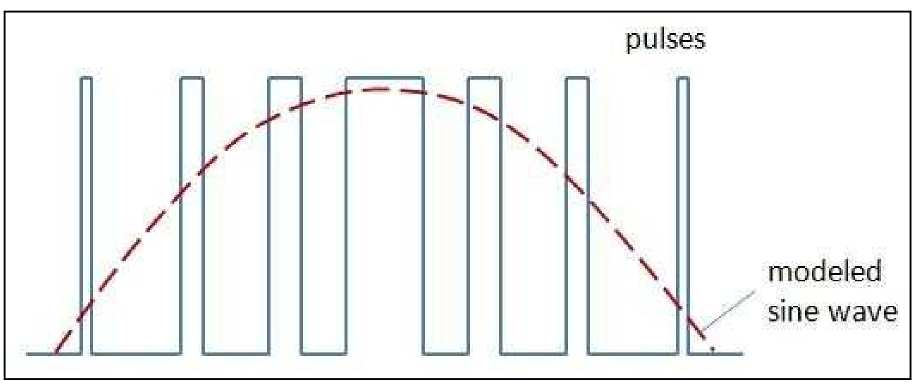

Fig. 4.Wave forms

In the image above, the continuous line shows the square wave varied by the length of the pulse and timing between pulses; the dotted curve shows how those alternating signals are modeled by a sine wave. Using very high frequency helps create very gradual changes in pulse width and thus models a true sine signal. The pulse-width modulation method and novel digital controllers have resulted in very efficient inverters.

IV. Conclusion

In this Project, a modular cascaded H-bridge multilevel inverter for grid-connected PV applications has been presented. The multilevel inverter topology will help to improve the utilization of connected PV modules if the voltages of the separate DC links are controlled independently. Thus, a distributed MPPT control scheme for both single-phase and three-phase PV systems has been applied to increase the overall efficiency of PV systems. The proposed techniques was Simulated using MATLAB-Simulink software and obtained expected results successfully.

V. Future Scope

The cascaded multilevel inverters are mainly used as drive for induction motors, STATCOM. shunt active power filters, aero space and solar powered applications. Application of SVPWM technique, incorporating Neuro-Fuzzy controller for performance improvement in closed loop control and hardware implementation of closed loop control are some of the important future scope of the present work.

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