Five level CHB Using Pulse Width Modulation (PWM) Technique

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Abstract

Distributed energy resources (DER's) are emerging as new sources of electricity generation and considered as the most promising sources for expand DG due to its major benefits of higher efficiency, cleanliness, modularity, reliability and potentially competitive and most important environmental friendly. DG has some issues while interfacing with the grid and many researches are going on these issues. The thesis is addressing DC to AC conversion and equal load sharing among these issues. Multilevel inverters are the most commonly used technology for renewable energy systems. The electricity generated by distributed energy resources is in the form of DC which is converted into AC by multilevel inverters. As the number of levels is increases of multilevel inverter, it will be closer to the sine wave. Various topologies are there in multilevel inverters but CHB is most popular and desirable due to its major benefits of reduced common mode voltages, reduced dv/dt stresses, staircase waveform with better harmonic profile, capability to operate at higher voltages using traditional semiconductors etc.

1. INTRODUCTION

Conventionally electricity has been generated with so-called "centralized generation" where fossil fuels have been the sources of energy. The power at these plants is typically combustion (coal, oil, and natural) or nuclear generated. Centralized power models, like this, require distribution from the center to outlying consumers

1.1DISTRIBUTED GENERATION

Distributed energy resources (DER) are small, modular, decentralized, grid connected or off grid energy system located in or near the place where the energy is used. They are integrated system that can include effective means of power generation, energy storage and delivery.

Distributed generation takes place on two-levels: the local level and the end-point level. Local level power generation plants often include renewable energy technologies that are site specific, such as wind turbines, geothermal energy production, solar systems (photovoltaic and combustion), and some hydro-thermal plants. These plants tend to be smaller and less centralized than the traditional model plants. They also are frequently more energy and cost efficient and more reliable [3]. Since these local level DG producers often take into account the local context, the usually produce less environmentally damaging or disrupting energy than the larger central model plants.

At the end-point level the individual energy consumer can apply many of these same technologies with similar effects. One Distributed generation technology frequently employed by end-point users is the modular internal combustion engine. These modular internal combustion engines can also be used to backup homes. As many of these familiar examples show DG technologies can operate as isolated "islands" of electric energy production or they can serve as small contributors to the power grid.

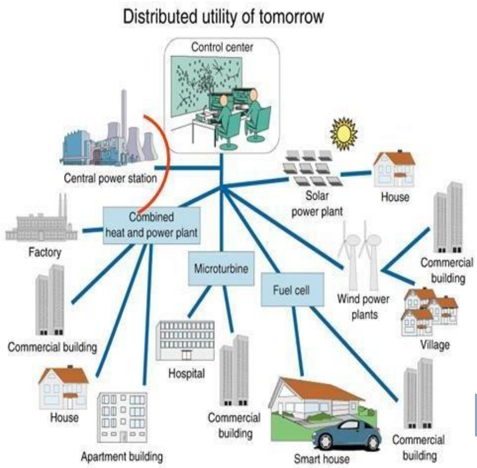


Fig.1. Futuristic Structure of the Utility [3]

1.2 TECHNICAL CONSTRAINTS

The first difficulties to overcome are related to technical improvements necessary to ensure high system reliability with distributed generation. The following section gives an overview of the technical issues caused by distributed generation [2].

Capacity: Adding distributed generators at the distribution level can significantly impact the amount of power to be handled by the equipment (cables, lines, and transformers). In order to avoid overload problems, reinforcement work will have to be undertaken. The critical piece will often be the transformers (converting medium voltage to low voltage or high voltage to medium voltage):

Voltage: Distributed generators are often connected to low voltage networks. When power is carried over long distance, voltage tends to drop due to resistance in cables. As generators connected to the distribution network tend to increase the network voltage, they may help keep the voltage within the specifications over the distance and have a positive impact on the network.

Protection: While using distributed generation, additional protection systems are required to avoid internal faults, defective distributed network and islanding. Islanding occurs when part of the network is still operating with the distributed generators delivery electricity to customers while the rest of the network has been disconnected.

Voltage and current transients: Short term abnormal voltage or current oscillation may occur as distributed generators are switched on or off. The result of these oscillations can have a destabilizing effect on the network.

Transmission and distribution losses: One of the key advantages of distributed generation is that it helps reduce transmission and distribution losses as distributed generators are not connected to the transmission grid and some of them might even choose to operate as captive plant for a client with thus limited use of the distribution grid [2], [3].

Ancillary Services: As of today all the ancillary services positively impacting the quality of electricity delivered are provided by centralized generators. For example, centralized generators are requested to keep capacities in excess of peak load to adjust production in case of demand surge, to hold voltage control devices. As the share of distributed generation increases, distributed generators will have to provide a larger share of these services.

2 MULTILEVEL VOLTAGE SOURCE INVERTER

A multilevel inverter utilizes multiple DC sources to synthesize a stepped waveform. The multilevel voltage source inverter is recently applied in many industrial applications such as power supplies, static VAR compensators, drive systems, etc. One of the significant advantages of multilevel configuration is the harmonic reduction in the output waveform without increasing switching frequency or decreasing the inverter power output. The output voltage waveform of a multilevel inverter is composed of the number of levels of voltages, typically obtained from capacitor voltage sources. The multilevel inverter starts from three levels. As the number of levels reach infinity, the output THD approaches zero. The number of the achievable voltage levels, however, is limited by voltage unbalance problems, voltage clamping requirement, circuit layout, and packaging constraints.
Conventionally there are three types of multilevel inverters.

1) Diode-Clamped Multilevel Inverter
2) Flying-Capacitor Multilevel Inverter
3) Cascaded H-bridge multilevel Inverters

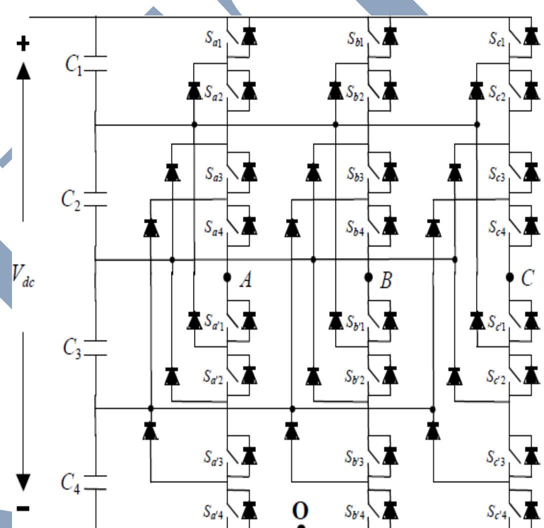
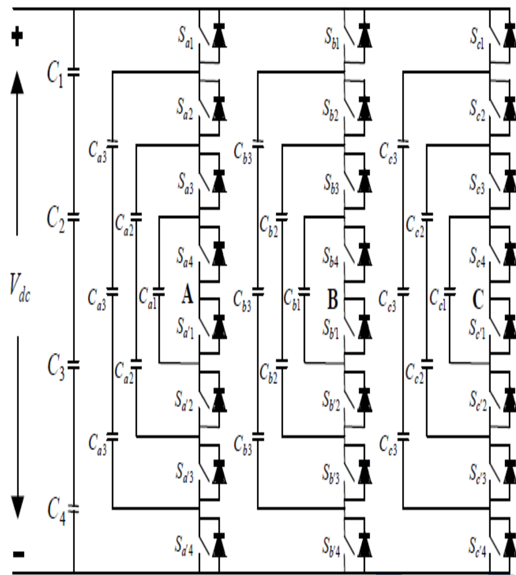


Figure 2 A three-phase five-level diode-clamped inverter

2.1 FLYING-CAPACITOR MULTILEVEL INVERTER

A FCMI shown in Fig. 3 uses a ladder structure of dc side capacitors where the voltage on each capacitor differs from that of the next capacitor. To generate *m*-level staircase output voltage, *m*-1 capacitors in the dc bus are needed. Each phase-leg has an identical structure. The size of the voltage increment between two capacitors determines the size of the voltage levels in the output waveform.



2.2 CASCADED H-BRIDGE MULTILEVEL INVERTERS

The last structure introduced in this thesis is a multilevel inverter, which uses cascaded inverters with separate dc sources (SDCSs). The general function of this multilevel inverter is the same as that of the other two previous inverters. The multilevel inverter using cascaded-inverter with SDCSs synthesizes a desired voltage from several independent sources of dc voltages, which may be obtained from batteries, fuel cells, or solar cells [20].

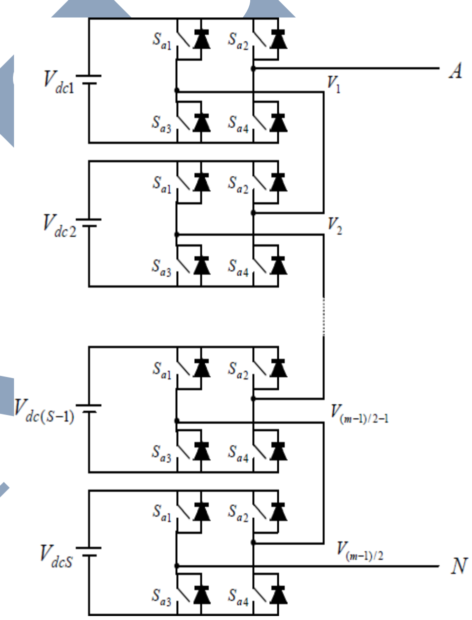


Figure 4 1ϕ structure of a multilevel cascaded inverter.

3. SIMULATION RESULTS OF FIVE-LEVEL CHB USING PULSE WIDTH MODULATION (PWM) TECHNIQUE

To examine the performance of the proposed modulation technique of multilevel inverter, a simulation model of single-phase five-level inverter is developed in MATLAB/Simulink environment. Two DC sources with V_{DC1}= 100 V and V_{DC2}=100 V are used to obtain an output voltage of 200 V. The load is considered to be RL load (R=0.2 Ω, L=8 mH) so as to observe the charge and discharge patterns of the DC sources. Frequency of reference wave is 50 Hz and carrier wave is 800 Hz. The output voltage waveform along with its harmonic spectrum

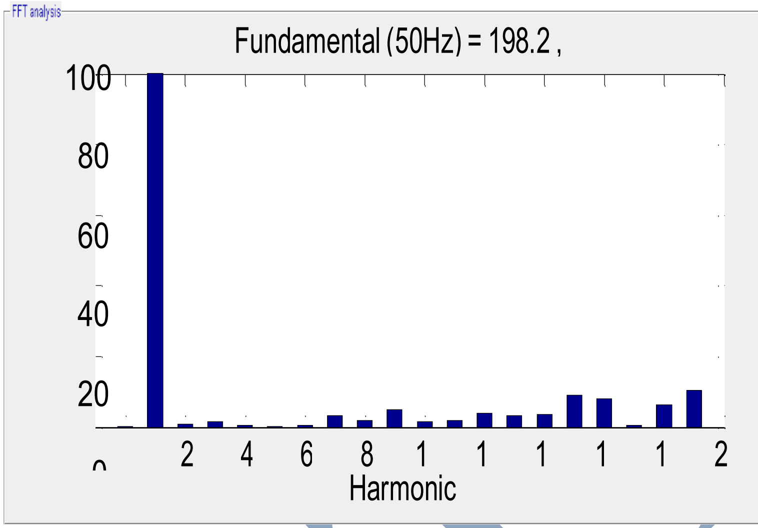


Fig 5 Harmonic spectrum of 5-level voltage output

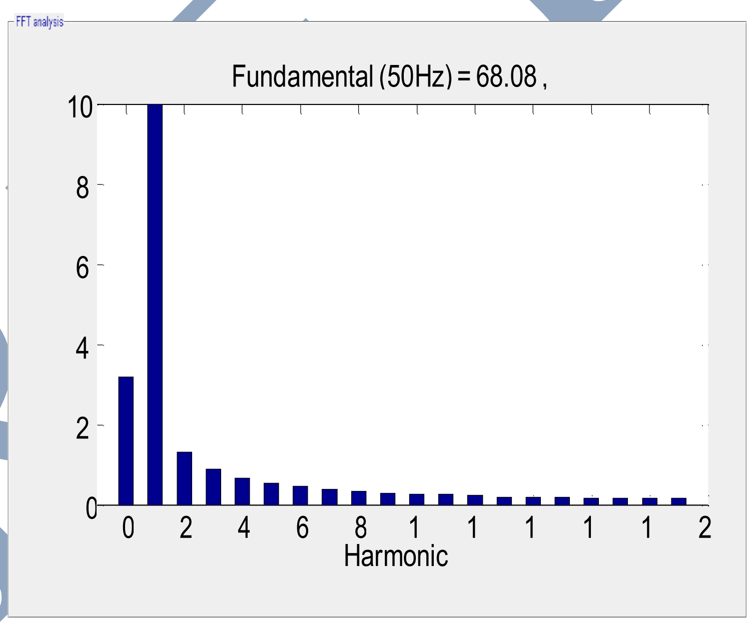


Fig 6 Harmonic spectrum of 5-level load current

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