Design and Control Strategies for Renewable Microgrids with EV Charging and Vehicle-to-Grid Support

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ABSTRACT:

Achieving smooth synchronization with the primary electrical grid is the main obstacle. In order to prevent instability, problems with power quality, and system failures, grid synchronization makes sure that the microgrid's voltage, frequency, and phase match those of the grid. Although virtual synchronous generators (VSGs), phase-locked loops (PLLs), and droop management techniques are frequently employed for this purpose, additional improvements are needed to handle the dynamic nature of renewable energy and EV charging demands. In addition to adding a substantial load, the addition of EV charging stations to microgrids creates opportunities for more sophisticated energy management, particularly with vehicle-to-grid (V2G) technology. During times of high demand, EVs can act as mobile storage devices that return electricity to the grid or microgrid. The design, control schemes, and synchronization mechanisms required for the effective operation of microgrids powered by renewable energy sources combined with EV charging systems are examined in this research. It talks about how energy management systems help keep the grid stable by balancing generation, storage, and consumption. It also emphasizes the benefits of such integrated systems, such as reduced carbon emissions, grid resilience, peak load shaving, and increased energy efficiency. These systems have a wide range of uses, from smart campuses and rural villages to EV charging stations in homes and businesses.

Keywords :- Microgrid synchronization, Vehicle-to-Grid (V2G), Grid stability, Virtual synchronous generator (VSG)

1. INTRODUCTION

Global warming is estimated to raise the earth's surface temperature from 30C to 60C by the end of this century as a result of the greenhouse effect. The power generated by conventional systems needs to be passed on to the end-user on a long-term basic basis, requiring costly, complex infrastructure and exposing the entire system to higher energy loss and safety risks. The encouraged investments in clean-energy production through PV systems. Modern topologies of power converters have provided various positive approaches for the relation to Photovoltaic (PV) systems. In view of fossil fuel price inflation and diminishing public acceptance of these energy sources, photovoltaic technology has become a truly sensible alternative. The PV has the advantage of converting sunlight directly into electricity and is also well suited for most geographical regions. Hence it is highly preferred compared to other Renewable Energy Systems (RES). In particular, solar power has been pollution-free, easily accessible from sunlight, and at a more acceptable level for the past two decades in terms of a minimum price.

1.1 CONCEPT OF CLASSICAL INVERTER

There is a heavy competition currently between the use of conventional configurations implemented with high voltage rating switches and modern converter configurations implemented with medium voltage rating switches. Figure 1.2 illustrates a full bridge inverter. The configuration of full bridge inverter comprises of four switches (S1, S2, S3, S4) with their respective diodes and one separate voltage source, Vz. When the switch S1 and S2 are triggered, the load voltage obtained is +Vz. When the switches S3 and S4 are triggered the load voltage obtained is −Vz.

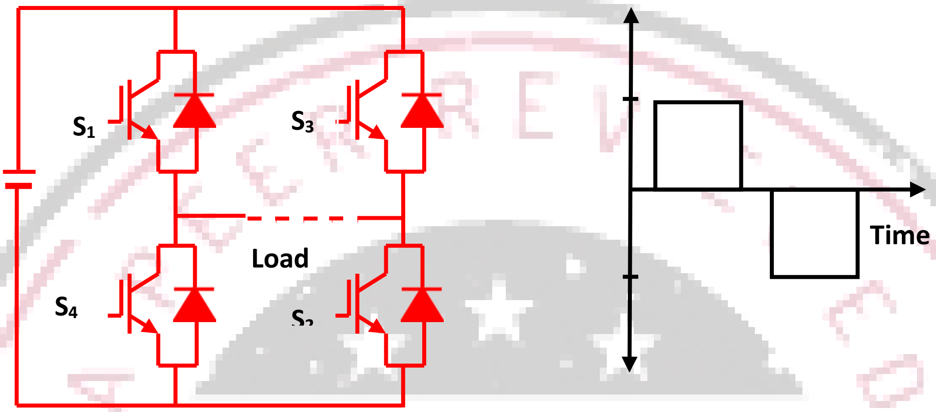

Figure 1.1: Full Bridge Inverter with its Output Waveform

A square waveform is obtained as the output from the positive and negative half cycles which are specified as two levels. The zero potential is also obtained which is also included as an additional level. Therefore, the full bridge inverter produced three levels of output voltage ($+V_Z$, $0V_Z$, $-V_Z$).

1.2 MULTILEVEL INVERTERS

MLI comprises of a set of power electronic switches and DC sources. Turning on the semiconductor switches adds up a DC voltage to provide a high voltage at the output. During the conversion process the power electronic switches of MLI experience high voltage stress. The three-level inverter generates a two-valued output voltage with a zero potential

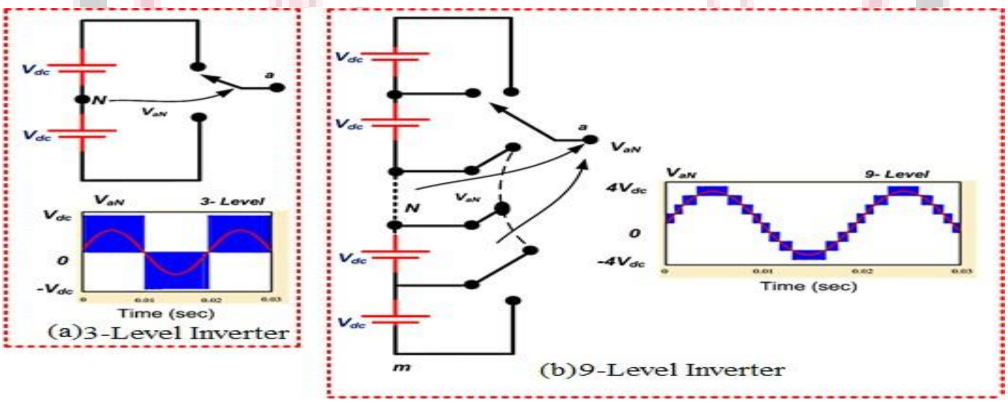

Figure 1.2 (a) 3-level Inverter (b) 9-level Inverter

A common structure of three-level, and nine-level inverter with its corresponding waveforms are shown in Figure 1.2. For all such cases, the switching elements are not organized in a sequence but they are organized in such a manner that it can produce three, and nine levels of output voltages. Here, an important thing should be noted that as the steps in the output staircase waveform increases the harmonic distortions tend to decrease. This would greatly improve the power quality of the inverters output.

2. *DC-DC CONVERTER*

A support converter (stride up converter) is a DC-to-DC power converter with a yield voltage more prominent than its data voltage. It is a class of exchanged mode control supply (SMPS) containing no less than two semiconductors (a diode and a transistor) and no less than one vitality stockpiling component, a capacitor, inductor, or the two in blend. Channels made of capacitors (now and then in mix with inductors) are regularly added to the yield of the converter to decrease yield voltage swell.

2.1 BOOST CONVERTER

A support converter (stride up converter) is a DC-to-DC power converter with a yield voltage more prominent than its info voltage. It is a class of exchanged mode control supply (SMPS) containing no less than two semiconductors (a diode and a transistor) and no less than one vitality stockpiling component, a capacitor, inductor, or the two in blend. Channels made of capacitors (now and then in mix with inductors) are regularly added to the yield of the converter to decrease yield voltage swell.

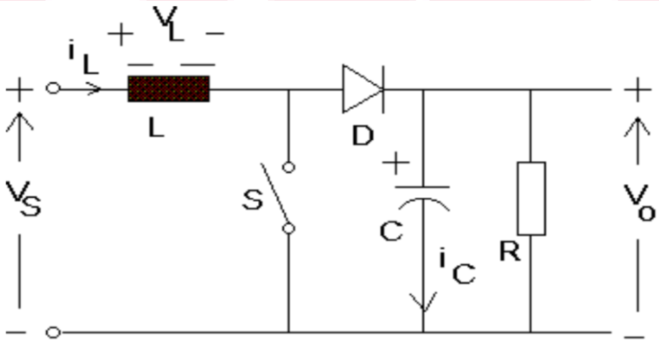

Figure 2.1: Boost Converter Circuit Diagram

When the switch is closed the inductor is charged through the battery and stocks the energy. In this mode, inductor current increases exponentially but for ease we assume that the charging and the discharging of the inductor are linear.

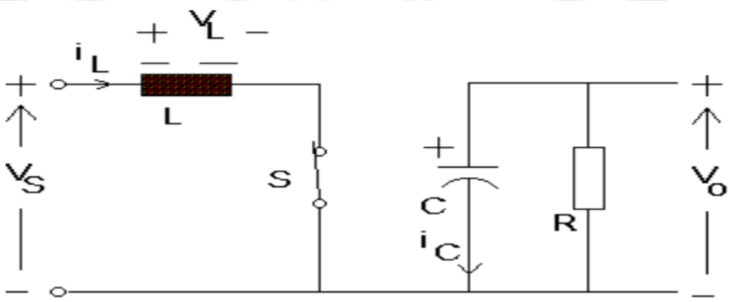

Figure 2.2: Close Loop Boost Converter Circuit Diagram

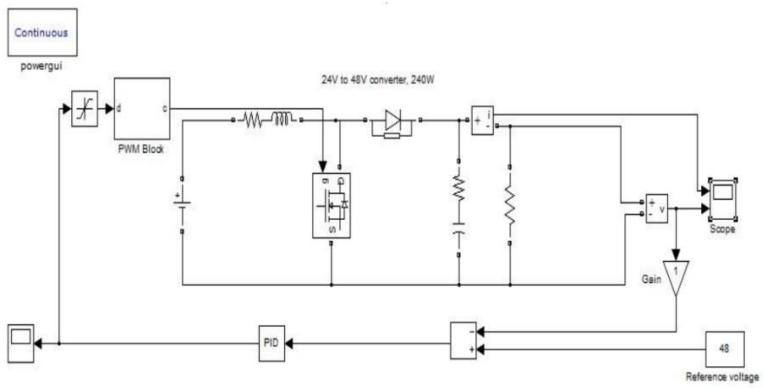

Figure 2.3: Simulation Model of Closed Loop Boost Converter

The switch is open and so the diode becomes short circuited. The energy stored in the inductor gets discharged through opposite polarities which charge the capacitor. The load current remains constant throughout the operation.

3. GENERATE PWM SIGNAL

The PWM method should be used to produce necessary switching pulses in order to provide a low and fixed switching frequency suitable for high power and industrial applications. Some switching techniques, such as hysteresis, have a variable switching frequency, which causes irritating audible noises. To modulate the measured reference signal, carriers are transferred vertically.

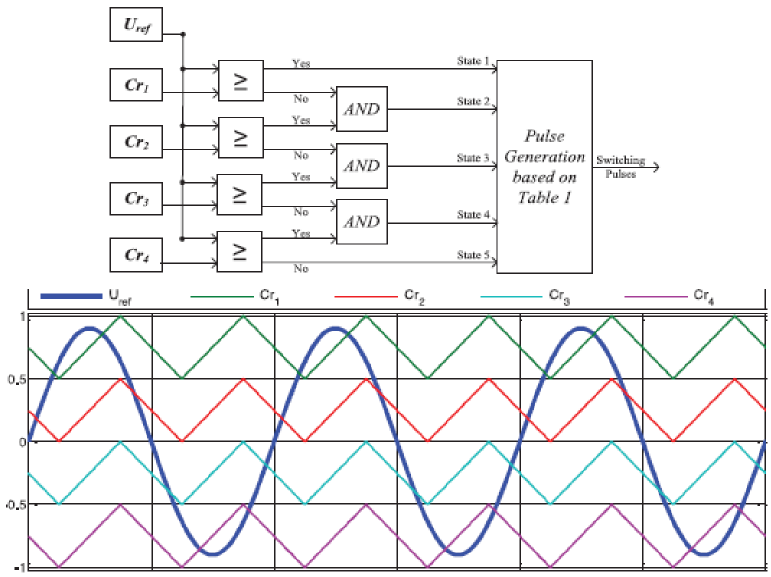

Figure 3.1: Level shifted PWM technique

Level shifted high frequency PWM technique use to generates switching pulses. As shown by logic blocks, each carrier is responsible for generating pulses for associated voltage levels and switching states. Furthermore, the corresponding switching pulses for three cycles of the modulated waveform have been shown as fixed switching frequencies in each cycle. In comparison to other topologies, the proposed method ensures low and fixed switching frequency functionality of the proposed converter, resulting in low switching losses and high performance. Generation of PWM signal for the proposed converter described in Table 3.1.

TABLE 3.1: Switching States of the Converter

State	Voltage Level	S1	S2	S3	S4	S5
1	+Vdc	0	1	0	0	1
2	+Vdc/2	1	0	0	0	1
3	0	0	1	0	1	0
4	0	0	0	1	0	1
5	-Vdc/2	1	0	0	1	0
6	-Vdc	0	0	1	1	0

4. *SIMULATION RESULTS*

In this work PV simulates at a 2 KW power rating and use a PV module as 1 parallel and 6 series connected string at specific module. Also, specified 290 maximum dc output voltage. Graph plot of current and power with respect to voltage shown in figure 4.1.

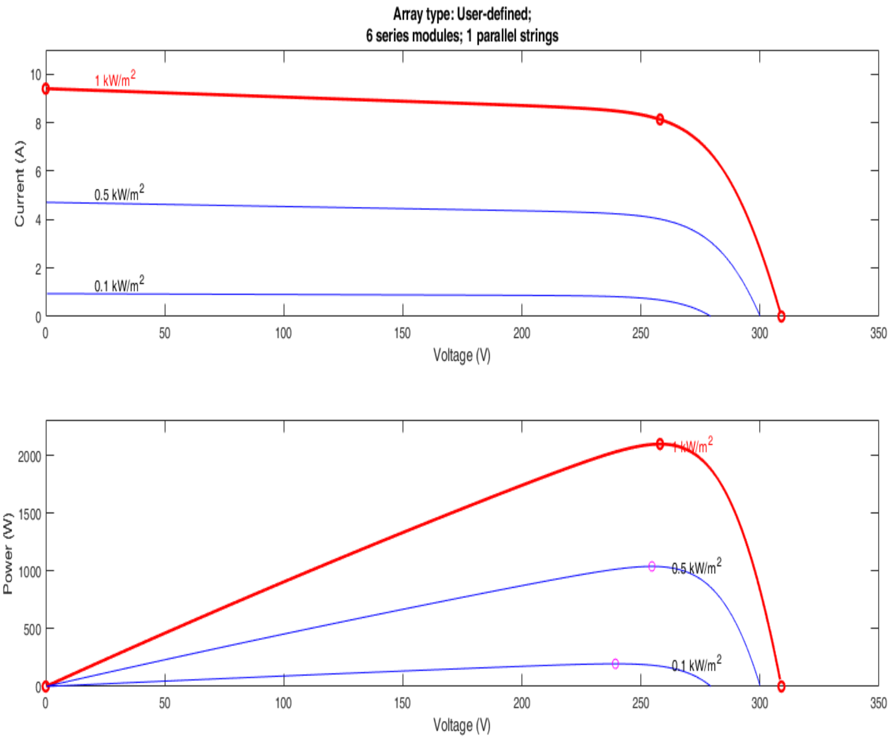

Figure 4.1: PV power and current with respect to voltage

Maximum PV output voltage is set to 290 according to the PV module and this voltage has approximately 50V peak to peak ripple. This high voltage ripple can damage a system and reduces the efficiency also increases the losses of the system. DC voltage of the PV output shown in figure 4.2

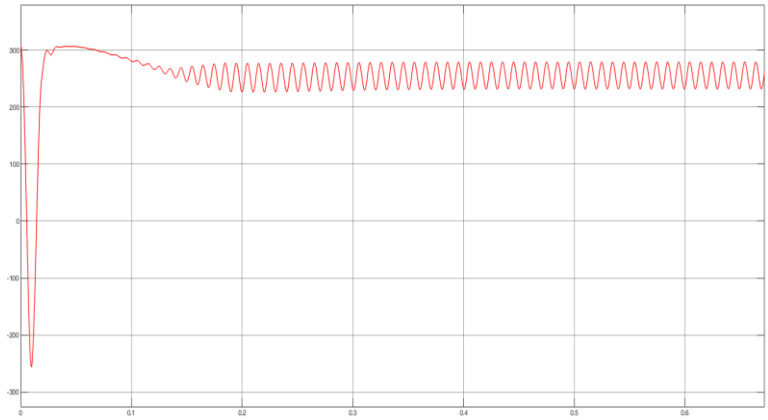

Figure 4.2: PV output DC voltage with 50V ripple

For reduction of this ripple and increase the dc voltage required a DC-DC boost converter. Output voltage of DC-DC boost converter is ripple free and high voltage as 400V so it can be easily connected to the single-phase grid by using inverter. This DC-DC boost converter also useful for MPPT (Maximum Power point tracking) which is performed by perturb and observe method. This converter worked as a first stage of our system and work on a 5KHz Switching frequency. Output voltage of the first stage as a DC-DC boost converter is shown in figure 4.3

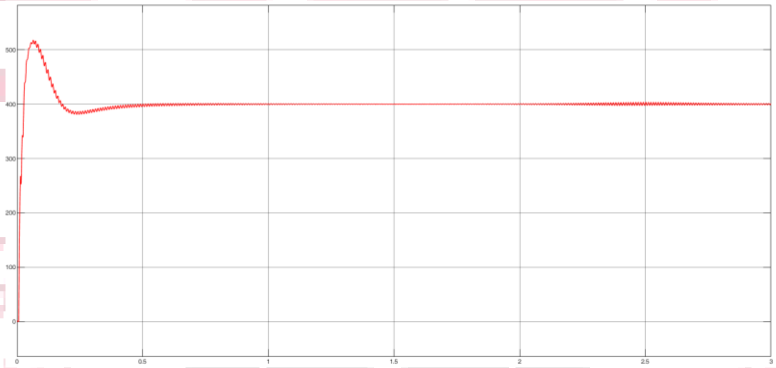

Figure 4.3: DC-DC boost converter output voltage

5. *CONCLUSION*

In this work PV simulates at a 2 KW power rating and use a PV module as 1 parallel and 6 series connected string at specific module. Also, specified 290 maximum dc output voltage. Maximum PV output voltage is set to 290 according to the PV module and this voltage has approximately 50V peak to peak ripple. This high voltage ripple can damage a system and reduces the efficiency also increases the losses of the system. DC voltage of the PV output. For reduction of this ripple and increase the dc voltage required a DC-DC boost converter. Output voltage of DC-DC boost converter is ripple free and high voltage as 400V so it can be easily connected to the single-phase grid by using inverter. This DC-DC boost converter also useful for MPPT (Maximum Power point tracking) which is performed by perturb and observe method. This converter worked as a first stage of our system and work on a 5KHz Switching frequency.

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