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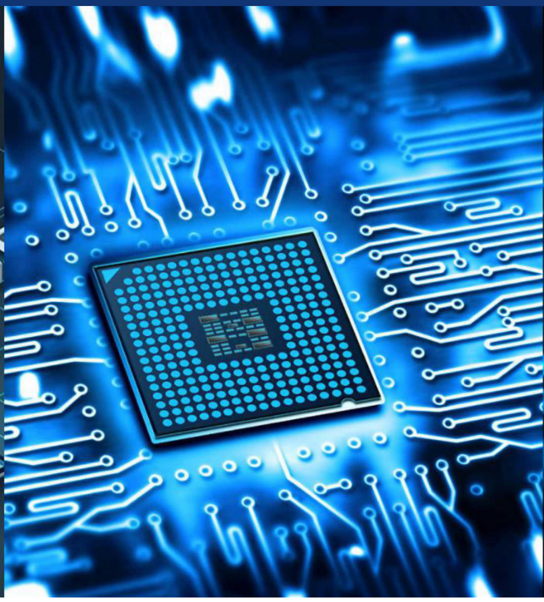

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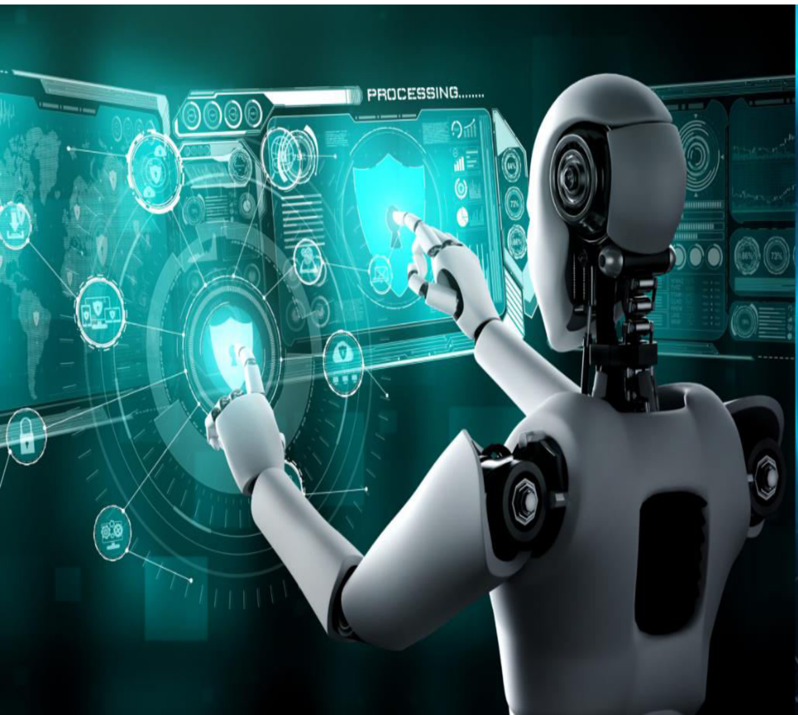

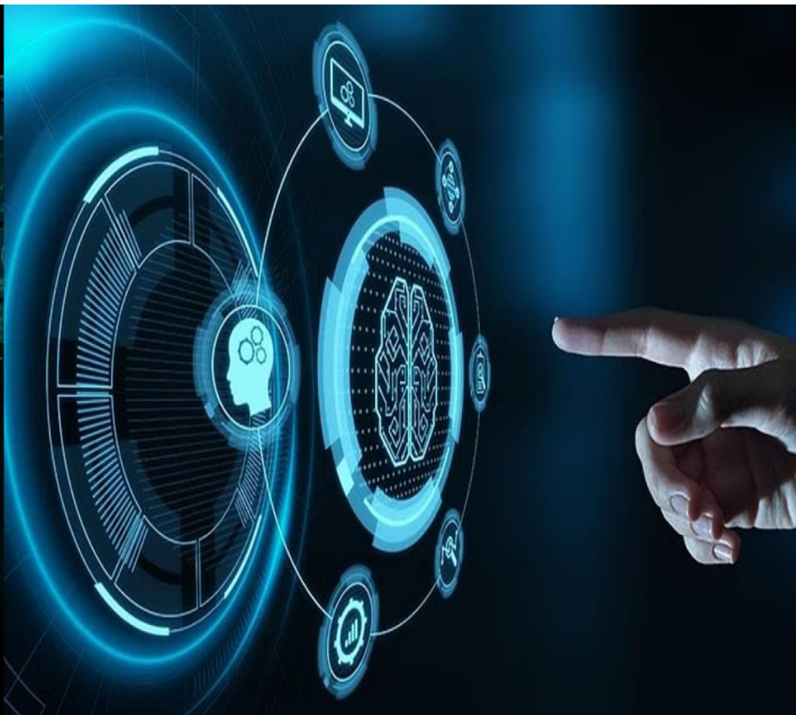

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Solar Bidirectional Smart Grid to Electric Vehicle Integration System: A Study

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ABSTRACT: As the demand for electric vehicles (EVs) rises, the need for sustainable and efficient charging solutions has become increasingly important. A PV (Photovoltaic) system-based EV charger powered by renewable solar energy is an attractive solution. Integrating multi-level inverters into these systems can enhance energy conversion efficiency, minimize power loss, and ensure high-quality power delivery. This review discusses the critical aspects of PV system-based EV chargers using multi-level inverters, including system components, technology, and challenges. This review explores the key components of a PV-based EV charger, the working principles and advantages of MLIs, and the challenges involved in their implementation. Various types of MLIs, including diode-clamped, flying capacitor, and cascaded H-bridge inverters, are discussed in terms of their efficiency, control strategies, and power quality improvements. Additionally, the review highlights the challenges posed by solar intermittency, system complexity, and grid synchronization. It also explores recent developments, such as hybrid inverters and vehicle-to-grid (V2G) technologies, which could further enhance the performance and flexibility of these systems.

KEYWORDS: Electrical Vehicles, PV System, Multilevel Inverter

I. INTRODUCTION

With the interest for an expansion in the necessities of high power quality in modern applications and solar PV frameworks, the regular inverters in gathering the ideal circumstances like an unadulterated sine-wave yield and less symphonious twists is a difficult undertaking. The staggered inverters get more consideration in arriving at the ideal necessities and goes about as an option in conveying a nature of force. It gives a few benefits, for example, decreased gadget count, works in low exchanging recurrence, diminished dv/dt stress, less consonant twists, and so on [1]. The new staggered inverter geographies contain fewer parts utilized in the circuit contrasted and the customary inverters like flying capacitor type (FC) [2], cascade H-bridge type (CHB) [3], also, the neutral point clamped type (NPC) [4]. The number of parts in the circuit is straightforwardly relative to the number of levels in MLI, which inflates cost and complex structure [5]. Capacitor voltage balancing is a difficult task in both the FC MLI and the NPC MLI because these are limited to five levels and cannot cascade. This brings down the yield voltage to half of the info voltage, giving a high exchanging recurrence with additional misfortunes [6]. The components of MLI are being reduced by a variety of studies, and a number of topologies based on the various levels that face difficulties have been proposed.

In the new past, different MLI geographies without relationship with the customary three sorts of arrangement are accounted for in [7]. The proposed sub multilevel converter configurations in are significant. In, an essential level geography is accounted for, where numerous dc voltages are required. These models are basic yet stretching out to more elevated levels is a difficult errand. Clever MLI geographies in view of switched capacitor (SC) with help methods are introduced. The usage of a few switches and gadgets builds the cost and size of the framework. Concerning the SC method, a new MLI geography with a staggered converter and a full extension is addressed in [8]. Two diodes make up a five-level single phase inverter with a full bridge shows a single switch with a five-level output and circuitry that restricts the expansion of higher levels. The SC-based MLI geography detailed in makes up a frontend SC, and full-span backend, the control intricacy, also, more gadget count limit the application. As the transporter recurrence gives the exchanging recurrence, a high exchanging misfortune is powerful for giving the high-recurrence yield. A lift MLI with a fractional charging procedure of SC hypothetically can ready to expand the quantity of result voltage levels. The control intricacy is high in executing halfway charging [9]. Subsequently, planning a SC-based MLI

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with high frequency yield, less sounds, and high proficiency is a difficult undertaking. Because the system is smaller and lighter, high-frequency output can be used to implement circuits in electric vehicles (EVs).

The photovoltaic power age includes sun oriented PV boards, where the result of a sunlight powered charger is taken care of two DC connect through a DC converter. The voltage from a DC connect is taken care of to the DC-AC inverter and to stack. The result of sun based PV isn't steady, and it changes as per the sun powered light and temperature. In this way, for an effective activity of PV boards considerably under different climatic changes, extricating most extreme power from the PV module is fundamental, conceded to being MPPT. Whenever the MPPT exists in a framework, a DC converter assumes a critical part in taking care of most extreme power as it works with the obligation cycle change [10]. For a PV took care of inverter, in delivering a steady DC voltage, there is a requirement for a control procedure. It isn't alluring to have command over the DC converter with the MPPT method; also, thus different geographies are proposed to address this issue for the independent planetary group. The choice of the MPPT method for a reasonable application is a surprising errand where each strategy has its own benefits and faults. MPPT reliably changes the energy of the sunlight based charger to work at the greatest mark of the power, which relies upon temperature, load, and sunlight based irradiance. Both sun oriented irradiance and temperature change during day time for climatic circumstances and contingent upon the season. Along these lines, it is essential to follow this large number of boundaries and get most extreme power point.

II. KEY POWER CONVERTER FEATURES FOR EV CHARGING SYSTEMS

In order to effectively accomodate the specifications/battery voltages of the commercially available EVs and available power source (single- and/or three-phase), while efficiently charging the EV battery and supporting the utility grid, some essential features of the power converters are summarized herewith:

1. Power factor: A high power factor near unity is essential for EV charging to maximize energy efficiency, minimize power losses, optimize power grid utilization, and reduce overall electricity consumption and cost.
2. Single and three-phase power converters: Single-phase PFC rectifiers are commonly used for onboard EV charging due to their compactness and lightweight design, making them suitable for charging from a standard household outlet. On the other hand, three-phase PFC rectifiers are used for off-board EV charging, as they provide higher power output, making them suitable for fast charging stations with high charging demands.
3. Bidirectional power flow: A bidirectional power converter is crucial for both G2V charges and V2G discharging processes in EVs. It includes components such as an AC-to-DC converter, DC-to-DC converter, and DC-to-AC inverter. It efficiently manages the bidirectional flow of electricity, complies with safety standards, and incorporates advanced control algorithms for seamless communication between the EV, the grid, and the converter.
4. Wide voltage range: EV chargers must provide a wide range of output DC voltage to accommodate different nominal battery voltage levels. To meet this requirement, EV chargers must be designed with efficient and reliable voltage regulation and current control mechanisms, ensuring safe and optimal charging performance for different EVs and batteries.

III. LITERATURE REVIEW

Allu Bhargav et al. [1], an analysis of a PV-based isolated-bidirectional electric vehicle charger (IBEVC) for household use is presented in this work to charge EV batteries while simultaneously improving power quality. When adequate PV power is free, the electrical power produced by PV is utilized to charge EV batteries, private loads, and feed capacity to the utility framework in this IBEVC framework. The EV battery and IBEVC provide reactive power when PV power is insufficient, and the grid supplies active power to household appliances. The fundamental load current is extracted using the Logarithmic hyperbolic cosine (LHC) based algorithm for IBEVC's harmonic compensation. The Dual active bridge (DAB) converter is used to isolate the battery from the supply for bidirectional power flow to the battery for charging and discharging. Extended phase shift (EPS) modulation is used to boost the DAB's efficiency and reduce inductor current and device current stress. In-depth discussion is given to the IBEVC's various charging and discharging modes and power quality enhancement capabilities.

Nikitha Paidimukkala et al. [2], this research activity is mainly on the integration of photovoltaic smart grid (PV) and electric vehicles (EVs) with bidirectional power flow capability by charging/discharging using power converters and

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power quality improvement. Due to the increasing energy demand due to the rapid population growth, there is a need to modernize the power grid by improving the power quality so that the energy converted by photovoltaic photovoltaics (SPVs) can be transmitted and stored in batteries as surplus power that can be used during peak demand. EV batteries are charged during low demand and discharged during peak demand. EVs act as both loads and energy suppliers for SG. Simulation results demonstrate the operation of the networked intelligent G2V system by observing and improving factors such as power factor, power control, and harmonic elimination by using MATLAB/Simulink software to build a power electronics network that can perform bidirectional power flow and balance the network. Then, the improvement of power quality of the integrated system is studied in detail by analyzing the power compensation, voltage regulation and harmonic mitigation of the integrated system.

M. Safayatullah et al. [3], wide-scale reception and extended development of electric vehicles (EVs) require innovative work of force electronic converters to accomplish high power, minimal expense, and solid charging answers for the EV battery. This paper presents an extensive survey of EV off-board chargers that comprise of ac-dc and dc power stages from the power organization to the EV battery. Although there are two types of EV chargers, on-board and off-board, it is essential to use off-board chargers for dc fast and ultra-fast charging in order to significantly reduce the volume and weight of the EV. The most recent topologies and control strategies for ac-dc and dc-dc power stages for off-board chargers are discussed here, with a focus on technical details, ongoing progress, and challenges. Also, the vast majority of the new multiport EV chargers coordinating PV, energy capacity, EV, and matrix are introduced. Also, similar examination has been completed for the geographies and the control plans of ac-dc rectifiers, dc converters, and multiport converters as far as design, power and voltage levels, proficiency, bidirectionality, control factors, benefits, and impediments which can be utilized as a rule for future exploration headings in EV charging arrangements.

C. Dhanamjayulu et al. [4], proton Exchange Membrane Fuel Cell (PEMFC) energy generation systems, an alternative to distributed energy generation systems, rely heavily on power converters. So there spurs an interest for great power molding utilized in PEMFC frameworks. This article proposes a converter geography as a power interface and furthermore presented a staggered inverter geography for different degrees of activity. The converter moves forward the information voltage to the evaluated voltage and changes to the DC transport, the staggered inverter switches the voltage over completely to AC and feeds to AC loads. An entire unit stack that can output positive and zero sequences is developed in this article. The expansion of H-scaffold to the key unit known to be a development flowed H-span staggered inverter bringing about the arrangement of all groupings like positive, zero and negative levels. The regular staggered inverters are contrasted and the proposed inverters as far as switch count, DC sources, diodes, through which the lesser prerequisite of parts in a staggered inverter is feasible to notice, which brings about the decrease in cost, dv/dt stress, part space of the driver circuit. With this execution, the better chance of control, increment the nature of result, dependability of the inverter with a decreased THD, and stress. The converter yield is tried and confirmed in MATLAB, and the separate consequences of the various levels like five, seven and fifteen of a solitary stage flowed inverter are tried tentatively and in MATLAB Simulink.

F.E.U. Reis et al. [5], electric vehicles (EVs) fueled by batteries and other energy stockpiling gadgets (ESDs), e.g., ultracapacitors, are supposed to assume a significant part in the improvement of a more practical future. Given their strong reliance on power electronic converters, charging stations (CSs) are expected to become the primary sources of energy for charging the batteries in this context. For CS applications, this paper examines a bidirectional single-phase, three-level stacked neutral-point-clamped (3L-SNPC) converter that can act as an inverter or a rectifier depending on the direction of power flow. Moreover, the inferred investigation can be effortlessly stretched out to the improvement of a three-stage rendition. Taking into account that the CS is equipped for coordinating the utility lattice and environmentally friendly power sources, it is feasible to ingest or infuse energy into the air conditioner matrix with high power factor and decreased symphonious substance of the current. Compared to typical two-level structures used in EV CSs, the bidirectional topology has the main advantages of having a three-level voltage waveform across each leg and the neutral point; additionally, filtering requirements are reduced. the voltage weights on all semiconductors are equivalent to half of the complete dc-interface voltage; power consider is almost solidarity any activity mode; furthermore, the voltages across the dc-connect capacitors are adjusted. The power and control stages' comprehensive designs are presented, and the laboratory prototype's experimental findings are discussed in depth.

M. Abarzadeh et al. [6], another design of the particular staggered converter (MLC) in light of the equal association of three-level dynamic unbiased point-clasped (3L-ANPC) cells as well as its better regulation strategy is proposed for 1

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MHz, 1 MW electric vehicle (EV) megacharger. In the proposed resembled secluded ANPC-MLC, just six high-recurrence silicon carbide (SiC) power switches working at 333 kHz are expected to produce 1 MHz exchanging recurrence range. Also, the working voltage of all power gadgets is split, the size of the primary exchanging recurrence consonant group is diminished by the component of five, and the heap current is similarly circulated between the 3L-ANPC legs by utilizing the proposed better balance technique. Thus, the measured quality, effectiveness, and power thickness of the proposed converter are quite expanded, while the worth of detached parts and the general exchanging misfortune are amazingly diminished. Moreover, an improved plan of the one 3L-ANPC cell of the proposed resembled measured ANPC-MLC for 1 MHz, 1 MW EV megacharger utilizing Ansys SIwave, Icepak, and Q3D limited component technique stages is introduced and examined exhaustively. The gave trial aftereffects of the down-scaled arrangement check the possibility and suitability of the proposed design as well as its better exchanging design.

M. N. Hamidi et al. [7], a better MLI geography utilizing another essential unit structure with a diminished number of parts is proposed in this review. Its single conservative module is comprised of two fundamental units associated with the left and right sides of a pressed H-span. The geography produces 9-Level result when worked evenly and 17-Level result when worked unevenly. Indistinguishable greatness of DC sources is utilized for the even activity, while non-indistinguishable extents in a three parted succession are utilized for the topsy-turvy activity. The low-recurrence balance conspire is applied for the exchanging control where the exchanging points are pre-determined. The numerical plans for the exchanging are likewise considered to lessen the absolute consonant bending (THD) at the result. The proposed geography is additionally observed to be predominant as far as the expected number of switches per yield level and all out impeding voltage contrasted with regular and as of late detailed MLIs. With these benefits, continuous establishment of the proposed geography will possibly require lesser space and become less expensive. The achievability of the proposed geography is approved for its 9-Level and 17-Level tasks through exploratory check on yield qualities, THD, impeding voltage, power-sharing and productivity.

C. Dhanamjayulu et al. [8], fostered another geography for the single-stage hilter kilter flowed staggered inverter and acknowledged with ideal equipment parts. This arrangement helps to considerably diminishing the quantity of semiconductor switches and DC sources, consequently decreases the door drivers necessity. A waveform with a large number of staircase voltage levels is produced by the proposed multilevel inverter, resulting in low total harmonic distortion at the outputs. The arrangement is deviated and creates 31 level different result voltages. MATLAB/Simulink mathematical programming used to confirm the demonstrating and approved tentatively in research center scale model. The testing of the inverter executed under both consistent state and dynamic burden evolving conditions. A bunch of mathematical and exploratory outcomes are given and shown obvious proof of fulfilling the assumption with hypothetical turn of events. Applications involving renewable energy would benefit greatly from the proposed converter.

Y. Yang et al. [9], to further develop greatest power point following (MPPT) execution, a variable and versatile irritate and notice (P&O) technique with current prescient control is proposed. This is applied in three-stage three-level nonpartisan point clipped (NPC) photovoltaic (PV) age frameworks. In PV generation systems, three-phase NPC inverters use a combination of decoupled power control and a space vector modulation block to independently control the active power and the reactive power. To adjust the unbiased point voltage of the three-stage NPC matrix associated inverter, a corresponding and basic control by changing the stay season of little voltage vectors is utilized. A three-stage NPC inverter evaluated at 12 kVA was laid out. The exhibition of the proposed technique was tried and contrasted and the decent irritation MPPT calculation under various circumstances. Exploratory outcomes affirm the attainability and benefits of the proposed technique.

IV. MULTI LEVEL INVERTER

Figure 2 shows the multilevel converter modulation methods. The modulation control schemes for the multilevel inverter can be divided into two categories, fundamental switching frequency and high switching frequency PWM such as multilevel carrier-based PWM, selective harmonic elimination and multilevel space vector PWM Multilevel SPWM needs multiple carriers.

Each DC source needs its own carrier. Several multi-carrier techniques have been developed to reduce the distortion in multilevel converters, based on the conventional SPWM with triangular carriers. Some methods use carrier disposition

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and others use phase shifting of multiple carrier signals. By generalizing, for an 'n' level multilevel inverter, (n-1) carriers are needed. The implementation of the various carrier PWM techniques that is possible for multi-level inverters are:

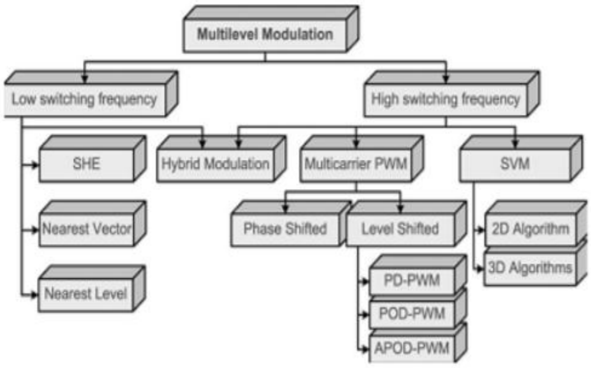

Figure 1: Multilevel converter modulation methods

1. **Operating Principle**
Multi-level inverters work by synthesizing a stepped AC voltage from several levels of DC input. The output waveform is smoother compared to conventional inverters, reducing the need for complex filtering. The voltage levels are created by combining power sources or using a single DC source with various switching techniques.

2. **Types of Multi-Level Inverters**
There are three primary types of MLIs commonly used in applications:

1. Diode-Clamped Multi-Level Inverter (DCMLI):
   a. Uses clamping diodes to limit the voltage across switches.
   b. It generates multiple voltage levels by using capacitors and diodes to divide the input voltage.
   c. Advantages: High efficiency at low switching frequencies.
   d. Disadvantages: Complexity increases as the number of levels increases due to the need for a large number of diodes.
2. Flying Capacitor Multi-Level Inverter (FCMLI):
   a. Employs capacitors in the inverter circuit to generate multiple voltage levels.
   b. Voltage levels are produced through the charge and discharge cycles of these capacitors.
   c. Advantages: Higher flexibility in modulation.
   d. Disadvantages: Increased complexity due to the need for many capacitors, making the control more challenging.
3. Cascaded H-Bridge Multi-Level Inverter (CHBMLI):
   a. Consists of multiple H-bridge inverters connected in series to generate higher voltage levels.
   b. Each H-bridge unit operates independently and can have its own DC source, making it modular and scalable.
   c. Advantages: Simple structure, modularity, and ease of control.
   d. Disadvantages: Requires isolated power sources for each H-bridge, increasing system complexity.

V. PV ARRAY

The photovoltaic cell converts the light energy into electrical energy depending on the irradiation of the sun and temperature in the atmosphere. Basically PVC is a PN junction diode [11, 12]. But in PN junction diode DCI AC source is needed to work, but here light energy is used as a source to produce DC output. PVC is a current control source not a voltage control source. The equivalent electrical circuit diagram of PVC is shown in the Figure 2.

$$I_D = I_0[\exp(V + IR_S)/KT - 1] \qquad (1)$$

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Therefore PVC output current is given in equation 2.

$$I = I_L - I_D - I_{Sh} \tag{2}$$

$$I = I_L - I_0[\exp(q(V + IR_S))/KT - 1] - (V + IR_S)/R_{Sh} \tag{3}$$

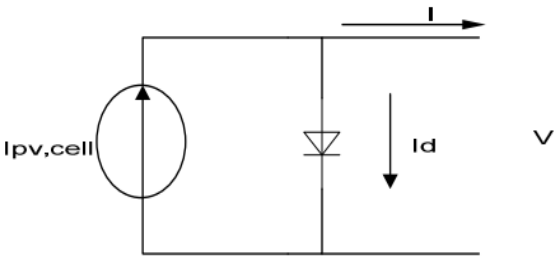

Figure 2: Show ideal photovoltaic cell equivalent circuit

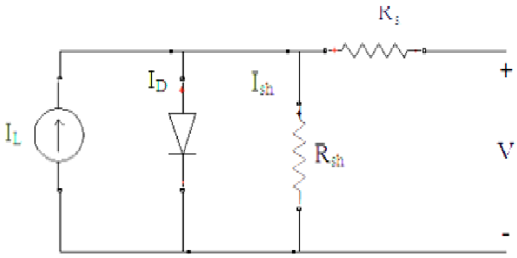

Figure 3: Equivalent Electrical Circuit of PVC

Where I_D the diode is current, R_{sh} is the shunt resistance, I_L is the light generated current of solar array. Solar cell is basically a p-n junction fabricated in a thin wafer or layer of semiconductor. The electromagnetic radiation of solar energy can be directly converted electricity through photovoltaic effect. Being exposed to the sunlight, photons with energy greater than the band-gap energy of the semiconductor are absorbed and create some electron-hole pairs proportional to the incident irradiation. Under the influence of the internal electric fields of the p-n junction, these carriers are swept apart and create a photocurrent which is directly proportional to solar insolation. PV system naturally exhibits a nonlinear I-V and P-V characteristics which vary with the radiant intensity and cell temperature.

VI. BIDIRECTIONAL SMART GRID TO ELECTRIC VEHICLE INTEGRATION SYSTEM

The rapid growth of electric vehicles (EVs) has introduced transformative changes in the global energy landscape, paving the way for innovative energy management systems. Among these, bidirectional smart grid integration systems, which enable Grid-to-Vehicle (G2V) and Vehicle-to-Grid (V2G) operations, are gaining significant attention. These systems facilitate a two-way flow of energy between the grid and EVs, offering solutions to enhance grid stability, optimize energy utilization, and promote the integration of renewable energy sources.

In the G2V mode, EV batteries are charged using power from the grid, often during off-peak hours when electricity demand is low. Conversely, in the V2G mode, stored energy from EVs can be fed back into the grid during periods of high demand, acting as a distributed energy resource. This bidirectional energy flow transforms EVs from passive energy consumers into active participants in the grid, contributing to load balancing, frequency regulation, and peak demand reduction.

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Despite its potential benefits, implementing bidirectional integration systems poses several challenges, including power quality issues, battery degradation, and the need for sophisticated control mechanisms. Addressing these challenges requires the development of advanced technologies such as smart bidirectional chargers, intelligent energy management systems, and robust communication infrastructures.

Electric Vehicle (EV):
- Equipped with high-capacity batteries capable of bidirectional power flow.
- Acts as a dynamic load (during charging) or a distributed energy resource (during discharging).

Smart Charger with Bidirectional Capability:
- AC/DC Converter: Converts AC power from the grid to DC for charging the EV battery.
- DC/AC Inverter: Converts DC power from the EV battery to AC for feeding back into the grid.
- Controller: Regulates charging and discharging operations, ensuring efficiency and safety.

Smart Grid:
- Supports real-time monitoring, control, and communication between grid operators and EVs.
- Enables load balancing, demand response, and integration with renewable energy sources.

Communication Infrastructure:
- Protocols: Open Charge Point Protocol (OCPP) or IEEE 2030.5 for EV-grid interaction.
- IoT Integration: Allows data exchange for real-time decision-making.

Control Systems:
- Energy Management System (EMS): Optimizes power flow and coordinates with grid operators.
- Fuzzy Logic Controllers (FLC): Address nonlinearities in grid and EV interactions, enhancing power quality.

Renewable Energy Integration (Optional):
- Solar PV or wind turbines integrated into the system to enhance sustainability.

VII. CONCLUSION

Multi-level inverters provide a highly efficient and reliable means of converting DC power to AC with reduced harmonic content and improved power quality. Their advantages in terms of efficiency, scalability, and lower voltage stress make them ideal for applications in renewable energy systems and EV chargers. However, the complexity and cost of MLIs, particularly with higher voltage levels, remain challenges that researchers are continuously addressing through improved design and control strategies. Throughout the years, the researchers have developed numerous types of battery models with different level of accuracy and complexity to predict the behavior of the Li-ion battery. Electrochemical battery models were based on electrochemical methodologies involving current densities at the electrodes, electrolyte concentration parameters and many other electro-chemistry parameters implementation for battery modeling.

REFERENCES

1. Allu Bhargav and Indrajit Sarkar, "Solar Isolated Bi-directional Electric Vehicle Charger with Power Quality Enhancement Features", IAS Global Conference on Renewable Energy and Hydrogen Technologies (GlobConHT), IEEE 2023.
2. Nikitha Paidimukkala and Narottam Das, "Power Quality Improvement of a Solar Powered Bidirectional Smart Grid and Electric Vehicle Integration System", IEEE Sustainable Power and Energy Conference (iSPEC), IEEE 2022.
3. M. Safayatullah, M.T. Elrais, S. Ghosh, R. Rezaii, I. Batarseh, A Comprehensive Review of Power Converter Topologies and Control Methods for Electric Vehicle Fast Charging Applications, IEEE Access 10 (2022) 40753–40793.
4. C. Dhanamjayulu, S. R. Khasim, S. Padmanaban, G. Arunkumar, J. B. Holm-Nielsen, and F. Blaabjerg, ''Design and implementation of multilevel inverters for fuel cell energy conversion system,'' IEEE Access, vol. 8, pp. 183690–183707, 2020.
5. F.E.U. Reis, R.P. Torrico-Bascope, F.L. Tofoli, L.D.S. Bezerra, Bidirectional threelevel stacked neutral-point-clamped converter for electric vehicle charging stations, IEEE Access 8 (2020) 37565–37577.

6. M. Abarzadeh, W.A. Khan, N. Weise, K. Al-Haddad, A.M. EL-Refaie, A new configuration of paralleled modular and multilevel converter controlled by an improved modulation method for 1MHZ, 1MW EV charger, IEEE Trans. Ind. Appl. 57 (2020) 3164–3178.
7. M. N. Hamidi, D. Ishak, M. A. A. M. Zainuri, and C. A. Ooi, ''Multilevel inverter with improved basic unit structure for symmetric and asymmetric source configuration,'' IET Power Electron., vol. 13, no. 7, pp. 1445–1455, May 2020
8. C. Dhanamjayulu, G. Arunkumar, B. J. Pandian, and S. Padmanaban, ''Design and implementation of a novel asymmetrical multilevel inverter optimal hardware components,'' Int. Trans. Electr. Energy Syst., vol. 30, no. 2, p. e12201, Feb. 2020.
9. Y. Yang and H. Wen, ''Adaptive perturb and observe maximum power point tracking with current predictive and decoupled power control for grid-connected photovoltaic inverters,'' J. Mod. Power Syst. Clean Energy, vol. 7, no. 2, pp. 422–432, Mar. 2019.
10. A. K. Podder, N. K. Roy, and H. R. Pota, ''MPPT methods for solar PV systems: A critical review based on tracking nature,'' IET Renew. Power Gener., vol. 13, no. 10, pp. 1615–1632, Jul. 2019.
11. P. Bhatnagar, R. Agrawal, and K. K. Gupta, ''Reduced device count version of single-stage switched-capacitor module for cascaded multilevel inverters,'' IET Power Electron., vol. 12, no. 5, pp. 1079–1086, May 2019.
12. C. Dhanamjayulu and S. Meikandasivam, ''Implementation and comparison of symmetric and asymmetric multilevel inverters for dynamic loads,'' IEEE Access, vol. 6, pp. 738–746, 2018.
13. X. Liu, C. Zheng, J. Wu, J. Meng, D. I. Stroe, and J. Chen, 'An improved state of charge and state of power estimation method based on genetic particle filter for lithium-ion batteries', Energies, vol. 13, no. 2, 2020.
14. J. Tian, R. Xiong, W. Shen, and J. Wang, 'A Comparative Study of Fractional Order Models on State of Charge Estimation for Lithium Ion Batteries', Chinese J. Mech. Eng., 2020.
15. J. Tian, R. Xiong, W. Shen, and J. Wang, 'A Comparative Study of Fractional Order Models on State of Charge Estimation for Lithium Ion Batteries', Chinese J. Mech. Eng., 2020.
16. G.R.C. Mouli, J. Schijffelen, M. van den Heuvel, M. Kardolus, P. Bauer, A 10kW solar-powered bidirectional EV charger is compatible with Chademo and COMBO, IEEE Trans. Power Electron. 34 (2018) 1082–1098.
17. A.R. Bhatti, Z. Salam, M.J.B.A. Aziz, K.P. Yee, A critical review of electric vehicle charging using solar photovoltaic, Int. J. Energy Res. 40 (2016) 439–461.
18. A.R. Bhatti, Z. Salam, M.J.B.A. Aziz, K.P. Yee, R.H. Ashique, Electric vehicles charging using photovoltaic: status and technological review, Renew. Sustain. Energy Rev. 54 (2016) 34–47.

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