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Modern Approach to Multi-Tier Power Transfer between PV to GRID, EV to GRID, GRID to EV

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Abstract: ***In this project, electric vehicles (EVs) that are connected to the power grid and photovoltaic cells (PV) at the same time are used. Electric vehicle (EV) batteries are utilized in micro-grids as a source of power to supply the power grid during periods of peak electricity demand. By storing excess solar energy and reintroducing it to the grid during times of high demand, EVs can aid in the regulation of the electrical grid. Inverters that are connected to the grid, rooftop solar systems, battery electric vehicles (BEVs), boost converters, bidirectional half-bridge converters, output filters with L, LC, or LCL, and transformers are all part of the new micro-grid design proposed in this study. The essential components of this micro-grid are depicted and modelled, and a simulation of how they function is also provided. The simulation findings also examine the BEV's charging and discharging scenarios.***

Keywords: Solar PV System, Energy Storage Systems, MATLAB, SIMULINK, Electric Vehicle Battery System

1. Introduction

It goes without saying that as long as the world's population continues to increase annually, there will be more cars on the road. The issue is that oil and gas won't be able to meet demand, leaving electricity and various forms of electric cars as the sole options. Furthermore, by reducing air pollution, electric vehicles (EVs) can help the environment. The three types of electric automobiles available on the market are battery electric vehicles (BEVs), plug-in hybrid electric vehicles (PHEVs), and hybrid electric vehicles (HEVs). The amount of batteries in BEVs and PHEVs has increased, and both are powered by the power grid. The typical BEV battery capacity ranges from 40 to 80 kWh, while some models currently come with 200 kWh batteries. A great method to reduce car emissions and provide a clean source of electricity is to charge electric vehicles with renewable energy. If the idle EV battery is used to feed the power grid, the EV will become a crucial component of the smart grid as a dispersed energy storage system. Lithium-ion battery storage systems are frequently used as storage batteries for EVs. There are three charging stages for EVs. For Level 1 charging, a plug is connected to the (120 V) outlet. Although it is slow, this strategy is appropriate for short distance trips. A dedicated outlet supplies electricity at 240 V and up to 30 A during Level 2 of the charging process. Finally, DC fast charging (Level 3) charges EV batteries in less than an hour by providing up to 90 kW of charging power at 400 V. The use of electric vehicles has positive effects for the environment and the economies of all nations, but it also has significant drawbacks for the electricity system. Fast level 3 charging stations' high charging demands contribute to a number of challenges, such as an electricity shortage, spikes in peak demand, voltage instability, and dependability problems for the power system. Therefore, to lessen the strain of using electric vehicles on the power grid, all nations should explore employing renewable energy sources like solar and wind energy.

1.1 Proposed System

In our proposed micro grid system utilize photovoltaic cells to charge the Battery Electric Vehicles (BEVs), the bidirectional half bridge DC/DC converter, bidirectional inverters, Battery, DC/DC converters, and PV arrays make up the EV charging station. Through the bidirectional inverter, the charging station is linked to the microgrid. Power transfer between the grid and the charging station is managed by the bidirectional inverter. The bidirectional inverter and the microgrid are connected in parallel with the local load. The PV array produces energy that can be used to power local loads or the grid. By tracking the maximum power point of a PV array, a DC/DC converter is employed to maximize power output (MPPT). EV charging and discharging are managed by the bidirectional half bridge DC/DC converter. A V2G between EVs and the microgrid is made possible by the bidirectional inverter and the bidirectional EV charger.

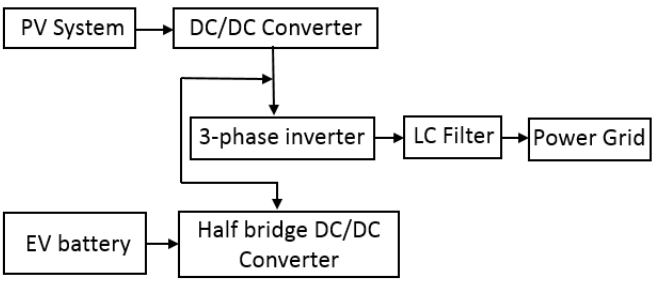

Figure 1: Proposed Multi-Tier System

1.2 Miniature Model

System compromises of PV Solar cells, DC-DC controller, 3-Phase inverter, LC filter, Power Grid System, EV Battery, Half bridge converter. System Voltage in AC consists of 240V AC and DC system works in 12V DC. Opto-coupler system to separate the AC and DC systems.

Figure 2: Miniature System Model

1.3 Model Selection

The factors we have considered for our experiment are given as input DC Battery external supplied with 12V DC 37.Ah capacity and 120V AC system for Grid and Control power supply, PIC Microcontroller, Bi-directional converters with IGBT circuit.

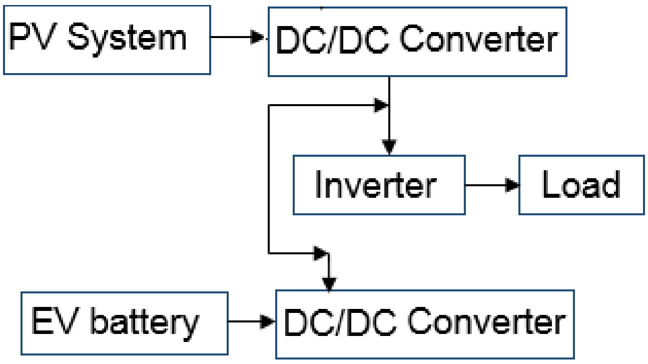

Figure 3: Hardware System Model

2. Experimental Results

The experimental modes are with three operation modes PV to Grid and the following modes achieved through help of PIC microcontroller and Control switches to swap the sources between the PV, EV and Grid. Simulation model shows the system configuration and simulation results.

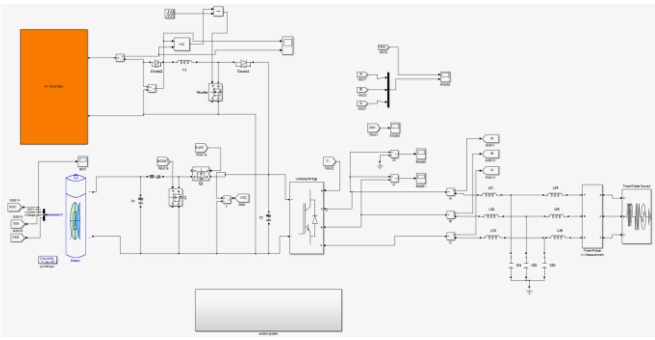

Figure 4: MATLAB System Model

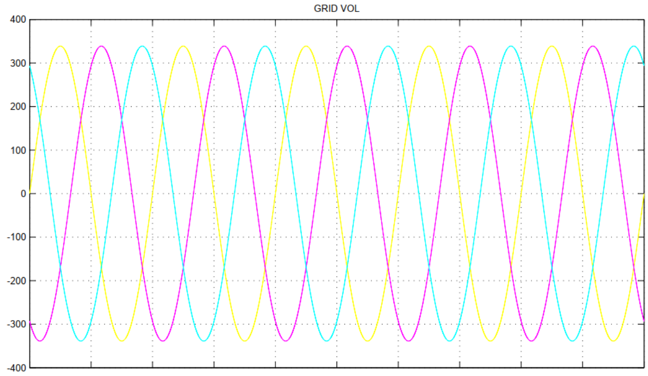

Figure 5: Grid Voltage

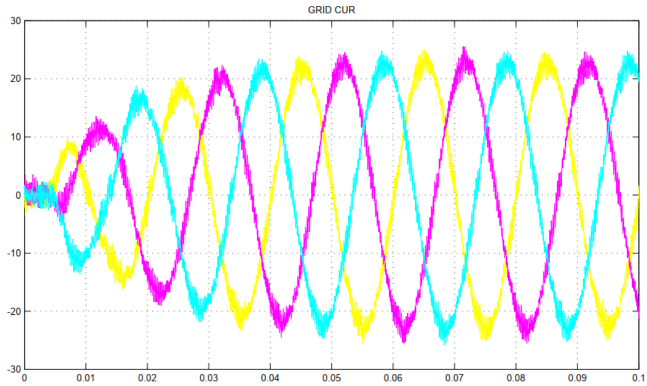

Figure 6: Grid Current

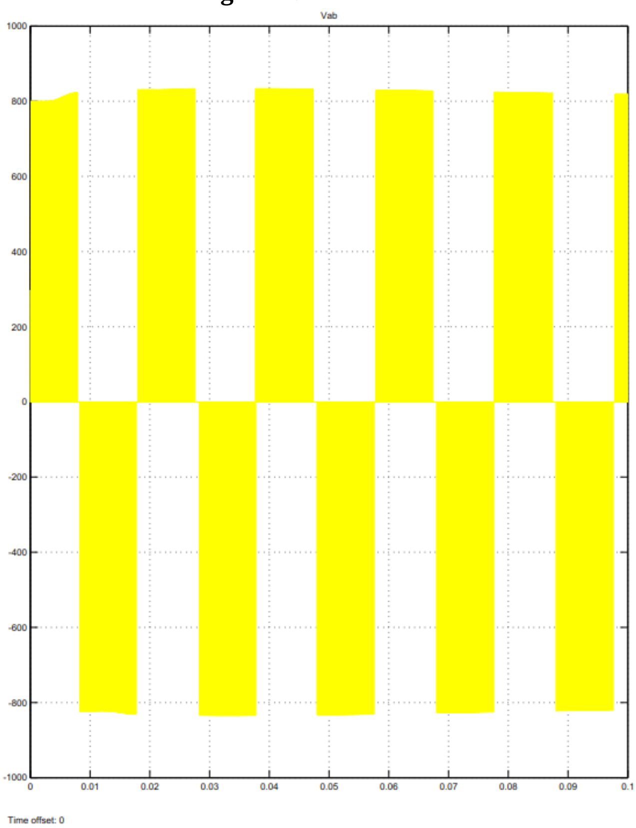

Figure 7: Grid Switching Voltage Vac

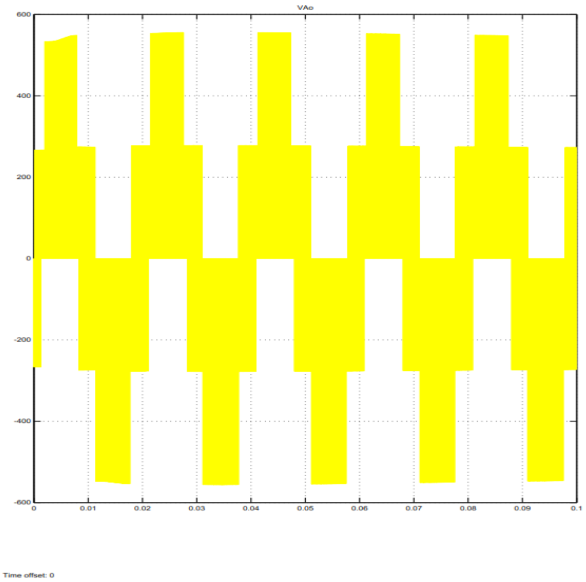

Figure 8: Grid Switching Voltage Vab

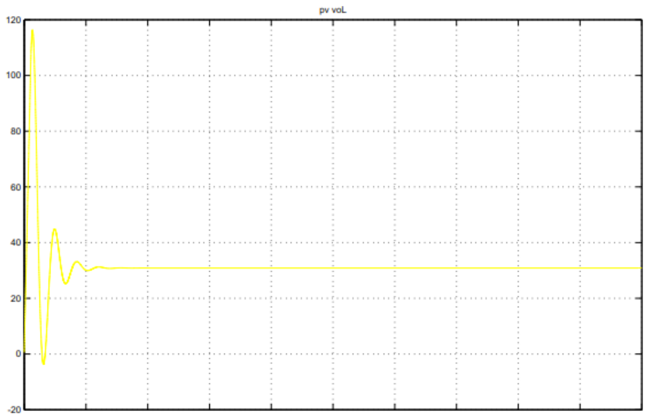

Figure 9: PV Voltage

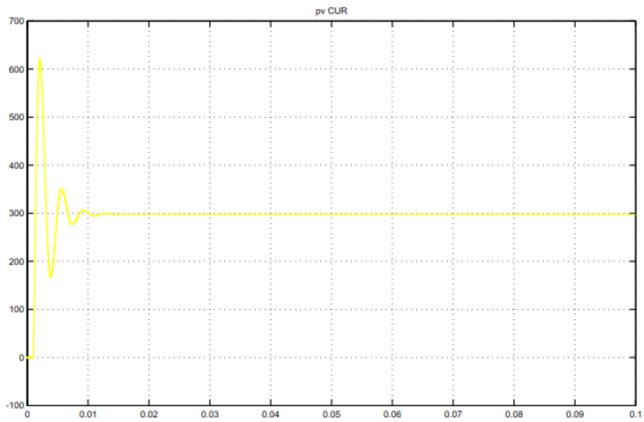

Figure 10: PV Current

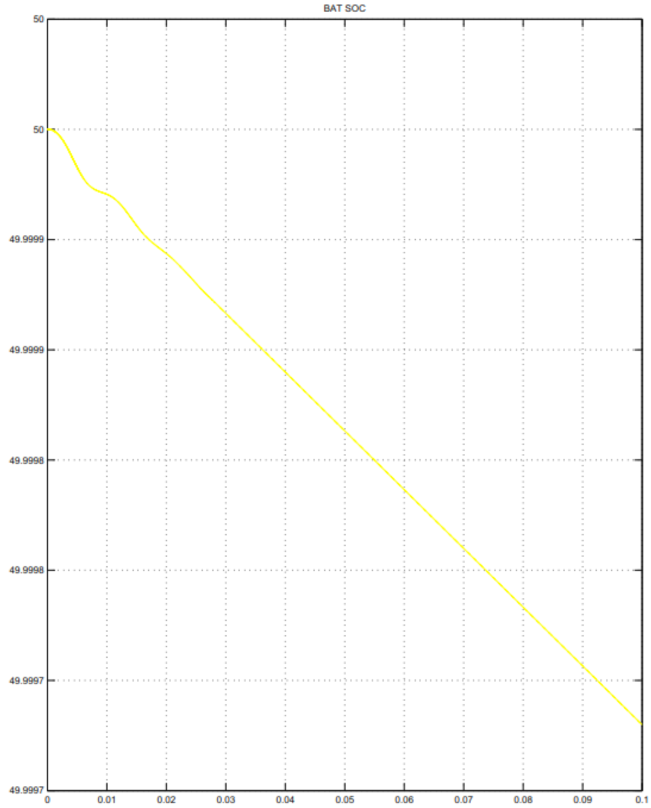

Figure 11: Battery State of Charge

3. Literature Review

[1] K Vinoth Kumar et.al(2021), Implementation of Smart Electric Vehicle Charging Station Driven Using Experimental Investigation, IEEE Electric vehicles are a moderately on-going innovation that is looking for its spot on the lookout. It has a few favorable circumstances, for example, the decreased nursery outflows, fuel reserve funds and its convenience. Lately, establishment of sustainable power offices is expanding quickly in light of the development to stifle the arrival of nursery gasses answerable for the warming of the earth and to save petroleum products, which are becoming progressively valuable. Besides, the expense of photovoltaic frameworks is diminishing step by step. Along these lines, it is accepted that cost of photovoltaic force will be falling later on. Nonetheless, in Japan, the enormous measure of surplus power from photovoltaic frameworks applies an awful impact on the force network. In this project, an EV charging station using sustainable power is proposed. The proposed EV charging station draws energy from photovoltaic frameworks and wind turbine at a low cost and uses that ability to charge a fixed battery. At that point the force is being utilized to charge electric vehicles; it also presents a few opportunities for electric force supply from sustainable wellsprings of electric vehicle charging stations. This paper conjointly introduces associate in Nursing energy management and management methodology for power offer of electrical vehicles charging station. Solar photovoltaic arrays and wind turbine are integrated to interchange energy from fuel and reduce pollution from carbon emissions. An additional main supply is also added in order to maintain

regular power supply to the system, here we are using proteus software to simulate the circuit

[2] Petreus Dorin et.all(2021)," Renewable energy EV charging station" , 2021 International Aegean Conference on Electrical Machines and Power Electronics (ACEMP) & 2021 International Conference on Optimization of Electrical and Electronic Equipment (OPTIM), IEEE Due to the increased interest in electric vehicle (EV) technologies and the cost reduction of photovoltaic systems, industrial development of battery charging stations for electric vehicles based on solar energy has started. Although it is convenient to charge EVs at night, when there is less electricity consumption, there will always be consumers who prefer or need to charge their EV during daytime and even during peak hours. In this paper, an EV charging station integrating renewable energy in the form of solar energy is proposed and analyzed. Using a local battery pack, the charging station allows semi-fast and fast charging and can be installed in individual homes and apartment buildings, where the maximum power delivered by the grid is limited to 3.6kW. The charging station uses converters widely available on the market. A simulation model for this charging station is developed and various distinct operation modes are presented, validating the correct operation of the entire system.

[3] Viswanathan Ganesh et.all(2021)," Safety Feature in Electric Vehicle at Public Charging Station", 2021 7th International Conference on Electrical Energy Systems (ICEES),IEEE The growth of Electric Vehicle has become an inevitable requirement in the coming days, as it helps in the reduction of carbon emission and footprint which can reduce the current pace of climate change. Since the growth of Electric Vehicles Had Increased, but the customers are afraid of charging infrastructures in the region of Asian/African continent as there is a huge gap between the charging infrastructure and Charging companies. They are afraid of Vehicle to Grid Concept during Fault conditions as it can damage the health of the battery in the long run. This paper deals with an isolation mechanism in combination with a grid-connected Photo voltaic system which goes hand in hand with the main grid and shares the amount of required power with the supply grid. A case study with five Electric vehicles charging at various instances depicting a real-life study.

[4] MOHD RIZWAN KHALID et.all(2021)," A Comprehensive Review on Structural Topologies, Power Levels, Energy Storage Systems, and Standards for Electric Vehicle Charging Stations and Their Impacts on Grid",IEEE The penetration of electric vehicles (EVs) in the transportation sector is increasing but conventional internal combustion engine (ICE) based vehicles dominates. To accelerate the adoption of EVs and to achieve sustainable transportation, the bottlenecks need to be elevated that mainly include the high cost EVs, range anxiety, lack of EV charging infrastructure, and the pollution of the grid due to EV chargers. The high cost of EVs is due to costly energy storage systems (ESS) with high energy density. This paper provides a comprehensive review of EV technology that mainly includes electric vehicle supply equipment (EVSE), ESS, and EV chargers. A detailed discussion is presented on the state-of-the-art of EV chargers that include on-/off-board chargers. Different topologies are discussed with low-/high-frequency transformers. The different available power levels for charging are discussed. To reduce the range anxiety the EV chargers based on inductive power transfer (IPT) are discussed. The last part of the paper focuses on the negative impact of EV chargers along with the remedies that can be adopted. The international standards decided by different institutions and adopted universally are discussed in the latter part of this paper and finally, this paper concludes with the near to future advancement in EV technology.

[5] Qifu Cheng et.al(2021)," A Smart Charging Algorithm Based on a Fast Charging Station Without Energy Storage System", CSEE JOURNAL OF POWER AND ENERGY SYSTEMS, VOL. 7, NO. 4, JULY 2021 With the growing popularity of electric vehicles (EV), there is an urgent demand to solve the stress placed on grids caused by the irregular and frequent access of EVs. The traditional direct current (DC) fast charging station (FCS) based on a photovoltaic (PV) system can effectively alleviate the stress of the grid and carbon emission, but the high cost of the energy storage system (ESS) and the under utilization of the grid-connected interlinking converters (GIC) are not very well addressed. In this paper, the DC FCS architecture based on a PV system and ESS-free is first proposed and employed to reduce the cost. Moreover, the proposed smart charging algorithm (SCA) can fully coordinate the source/load properties of the grid and EVs to achieve the maximum power output of the PV system and high utilization rate of GICs in the absence of ESS support for FCS. SCA contains a self-regulated algorithm (SRA) for EVs and a grid-regulated algorithm (GRA) for GICs. While the DC bus voltage change caused by power fluctuations does not exceed the set threshold, SRA readjusts the charging power of each EV through the status of the charging (SOC) feedback of the EV, which can ensure the power rebalancing of the FCS. The GRA would participate in the adjustment process once the DC bus voltage is beyond the set threshold range. Under the condition of ensuring the charging power of all EVs, a GRA based on adaptive droop control can improve the utilization rate of GICs. At last, the simulation and experimental results are provided to verify the effectiveness of the proposed SCA.

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