European Journal of Molecular & Clinical Medicine
ISSN 2515-8260 Volume 7, Issue 4, 2020

Dynamic modelling of a multi terminal fuzzy logic controller for electric vehicle charging plants based on hybrid energy system

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Abstract— Electric vehicles (EVL) are eventual increase along hybrid energy electric vehicles also lead require foe rapid charging. Rapid charging needs very huge power dynamics, these rapid charging's not sustained by normal electrical utility. In this manner, the utilization about to renewable energy sources close by the electrical network by EVL charging endures growing territory of intrigue. In this work, a photovoltaic (PV) renewable source is utilized to help huge dynamic power EVL charging's. Be that as it may, PV output is an irregular control about to subject to the climate situations. In this way, renewable PV energy source is combined to battery to store the energy and it tied with grid for rapid dynamics, giving the consistent source to on location EVL rapid charging about to sustainable power source positioned for quick charging stations, PV established quick recharging plants concern with cost adequate, if number of EVL s connected to grid this can very efficient, reliable and cost effective also for rapid rate of charging plants. Be that as it may, quick charging plants, particularly super-quick charging plants may give pressure power network within probable over-burden at cresting time, unexpected power stress along with voltage droop. In this paper examines the complete model for multi connection converters established to EVL recharging plants constructed along to PV power plants with storage system like battery. In this project, fuzzy logic control plan along with PV generation, EVL rapid recharging plants along with energy storage device implemented to enhanced adjustment in addition to power droop variations, and compensations of voltage sag. Therefore, in the impact of grid power in decreased because of the coordinating comparing every day recharging request and satisfactory daytime PV power production. Different charging methods are introduced to EVL charging using PV combination of storage system analyses in MATLAB simulations results.

Key words: Electric vehicles, photovoltaic renewable source, grid, fuzzy logic control

1. Introduction

The ebb and flow natural difficulties of decreasing ozone harming substances and the potential lack of petroleum products persuade far reaching research on electric vehicle (EVL). The investigations to EVL are huge register of customer tendency about to switch for EVLs and the substitutes about normal mechanical engines. This eagerness is the principle factor in anticipating future interest for EVLs. In future, here creators delineated than charge at the principle targets EV business is confronting. Common, EVL discharging stages were conferential confer into the power rapid charging. Among all the renewable energy sources, most promising energy is solar PV effective best option. With the developing enthusiasm for diminishing the non-renewable energy source usage and contamination, EVL have risen as a relevant option in contrast to traditional gas motor engines. The turn of events and expanding use about EVLs requirement generally conveyed charging plants because of the restricted EVL battery limit.

Nonetheless, huge size of straightforwardly grid associated charging plants, particularly quick and rapid charging plants, then tight utility solidness along dependability in top interest over-burden and power quality issues. A few analysts are incorporating PV cell producing in EVL discharging foundation; be that as it may, PV reconciliation is as yet considered the small bit of intensity power about EVL charging plants in looks into. Concerning the more popularity of quick charging all along the day, then fast improvement about PV production advances power utilization at top hour within sufficient day production. Regarding the irregularity of sun-oriented vitality, storage device its battery is utilized into control the DC line or burden voltage, and power quality issues. Thinking about the powerful thickness and high effectiveness benefits about multi terminal power converter system, multi terminal DC-DC converters is utilized in this undertaking about EVL discharging plant as opposed to utilizing three different DC-DC converter systems. All the previously mentioned explore, then charging plant models to be arranged in two categories, utilizing AC line either DC line. The PV along battery is together viewed to be DC charging, DC line charging plant into picked there into advance use proficiency about sun-oriented vitality along decline the expense along misfortunes of converter system. Contrasted and separated multi stage converter systems, non-secluded multi terminal converter system can be normally gotten from buck boost converter systems can highlighted an increasingly minimal structure, huge power area, the huge productivity contrasted and disengaged multi terminal converter system. As needs be, the DC line non disconnected construction along Silicon switch endures utilized in this task, can utilize productivity and limit the force misfortunes.

2. Design aspects

Nonetheless, EVL is just practical then power utilizes the discharge the originates ahead non-conventional source along cannot ahead petroleum product fundamental generators. Here the discussions are made to PV based charging plants about EVL are selecting the enthusiasm for late occasions that gives a spotless and maintainable strategy into charging EVLs. Then the objective of this proposition is to "Build up an exceptionally proficient, empowered keen charging plant framework about EVL at work environments that is fueled by sunlight-based vitality". Then the proposition is made out of there principle components – framework configuration, power electronic converter system along keen charging calculations.

3. Proposed system

In the figure shows the construction of PV with combined battery to charging EVLs and it has three sources PV panels, battery and utility grid, including PV is unidirectional source, battery and utility grid is two directional supply, three supplies having three individual converter system is shown in figure 1a. Then the approached charged or discharged plant is shown figure Fig. 1b, and three sources are connected at a common bus through an individual converter system. Battery is used to supply and keep the common bus voltages if high or less voltage is happening. In this structure will give different modes of operation discussed the next sections.

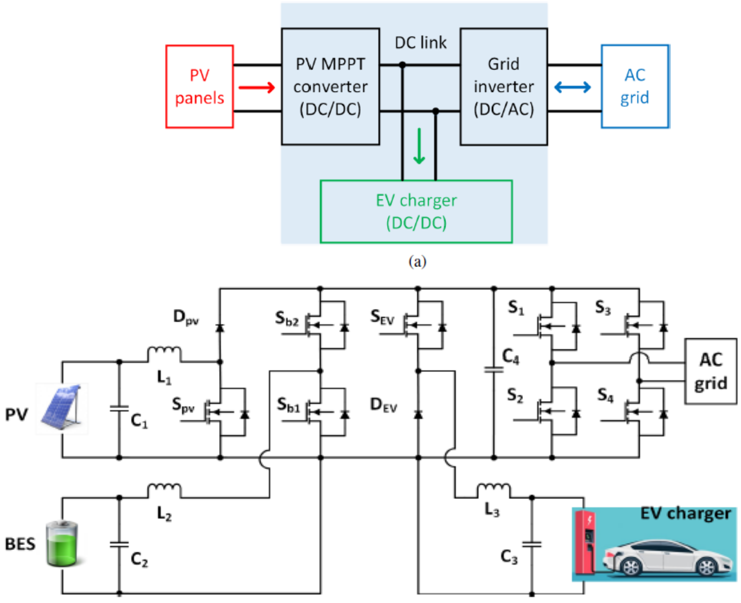


Figure1: Multi terminal converter system construction, (a) EVL is connected to PV array without battery (b) EVL is connected PV and combination of battery.

A. Mode 1: Photovoltaic cell to Electric vehicle (EVL)

In the first mode PV source is directly supply the load, it can observe in figure 2a. The switches spv, sb1 and sb2 switches off state in the EVL is on condition this can be shows the fallowing equations

$$i_{PV} = C_1 \frac{dv_{C1}}{dt} + i_{EV}$$

$$C_2 \frac{dv_{C2}}{dt} = \frac{v_{Bat} - v_{C2}}{r_b} - i_{L2}$$

$$i_{EV} = C_3 \frac{dv_{C3}}{dt} + \frac{v_{EV}}{R_{EV}}$$

$$v_{C1} - v_{C3} = L_3 \frac{i_{L3}}{dt}$$

$$L_2 \frac{i_{L2}}{dt} = -v_{C2}$$

Where C1, C2, and C3 are the terminal capacitance of the terminal and L1, L2, L3, is the port inductances rb port resistance, as shown in Fig 3. 1b; iPV ,iEV , iL2, and iL3 indicates that output currents for PV system,

$$\frac{V_{DC}}{V_{PV}} = \frac{1}{1 - D_{pv}}$$

Where VDC, VPV, along Dpv shows common DC bus voltages, PV voltage cell, along duty ratio about switches Spv, respective.

B. Mode 2: Battery energy storage in to EVL

Which Spv along SEV along turn on Sb1 and Sb2 were turn off, battery storage system endures discharging into effective EVL burden, is describes in.2b. these equations are made as fallows.

$$i_{PV} = C_1 \frac{dv_{C1}}{dt}$$

$$L_2 \frac{i_{L2}}{dt} = v_{DC} - v_{C2}$$

$$v_{DC} - v_{C3} = L_3 \frac{i_{L_3}}{dt}$$

$$C_2 \frac{dv_{C2}}{dt} = \frac{v_{Bat} - v_{C2}}{r_b} - i_{L2}$$

$$i_{EV} = C_3 \frac{dv_{C3}}{dt} + \frac{v_{EV}}{R_{EV}}$$

VDC is DC bus voltage and, it is equals to the against capacitor C4. Duty cycle for of Sb1 switch is fallows

$$\frac{V_{DC}}{V_{Bat}} = \frac{1}{1 - D_{b1}}$$

When VDC, VBat, and Db1 represent the DC link voltage, voltage of BES, and duty cycle of switch Sb1, respectively.

C. Mode 3: PV to Battery energy storage

Sb2 is turn on the Sb1, Spv along SEV were turn off, battery storage is to charging ahead of PV excess energy of the system, seen in the figureFigure. 2c. The equations fallows:

$$i_{PV} = C_1 \frac{dv_{C1}}{dt} - i_{L2}$$

$$L_2 \frac{i_{L2}}{dt} = v_{C1} + v_{DC} - v_{C2}$$

$$L_3 \frac{i_{L3}}{dt} = v_{DC} - v_{C3}$$

$$C_2 \frac{dv_{C2}}{dt} = \frac{v_{Bat} - v_{C2}}{r_b} - i_{L2}$$

$$i_{EV} = C_3 \frac{dv_{C3}}{dt} + \frac{v_{EV}}{R_{EV}}$$

Duty cycle is of the switch Sb2 fallows:

$$\frac{V_{Bat}}{V_{DC}} = D_{b2}$$

Where Db2 represents the duty cycle of the switch Sb2.

D. Remaining Mode of operations: PV system into battery storage, utility Grid into EVL, along PV array into utility grid then operating principles about remaining modes combining PV array into battery storage system, utility grid into EVL, along PV cell into utility grid system. Even the mathematical methodologies are equal to compare methods into different modes 1 in to 3.

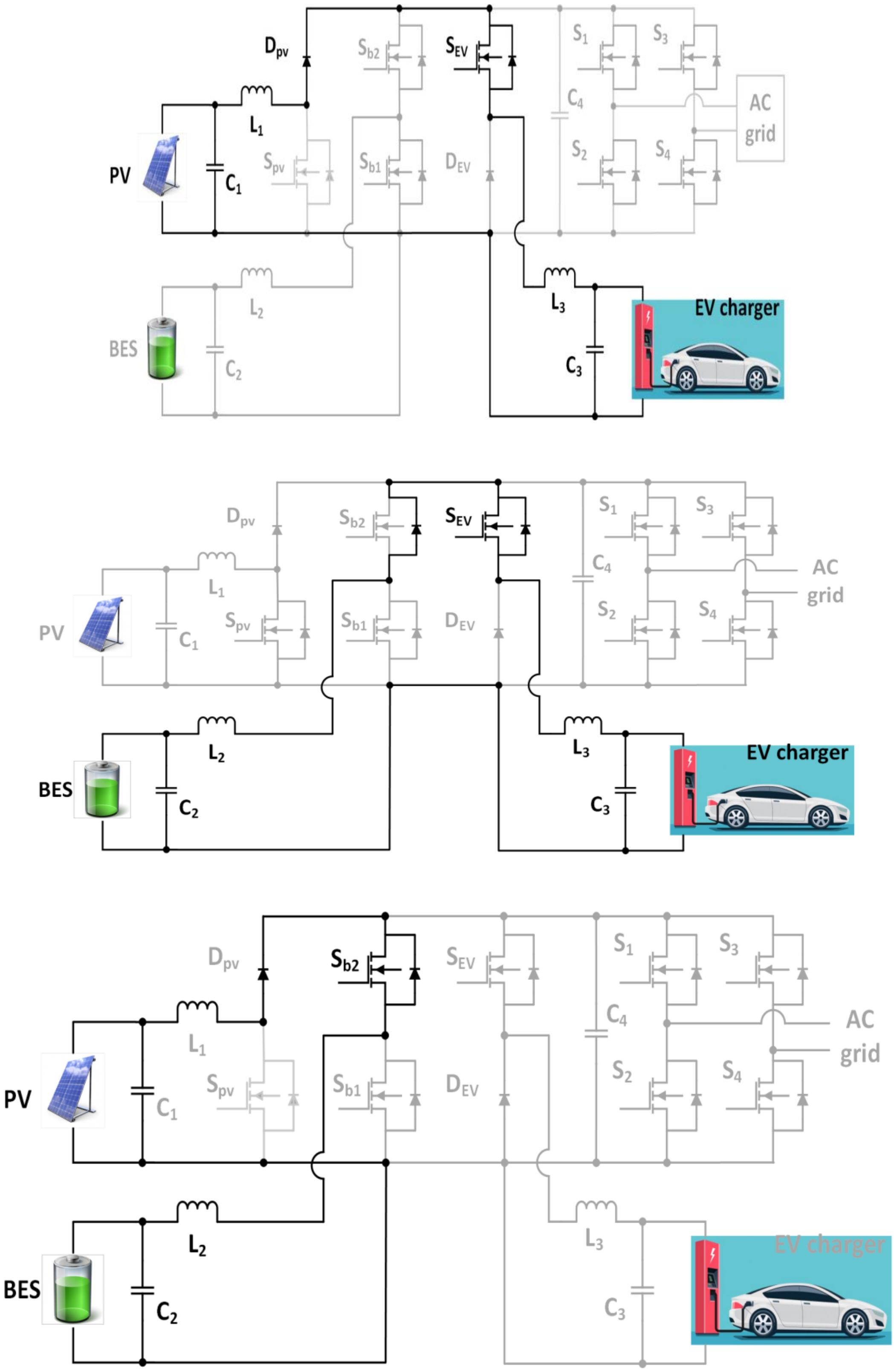


Fig.2: Multi terminal converter system operation modes, (a) PV supply is equal to EVL (b) Battery energy storage supply EVL charging during lack of PV power (c) PV power excess the EVL and charging mode of battery

4. Simulation results

CASE-1: EV CHARGING

The discrimination of approach charging/discharging plant operates and controlling proposals, the Simulink models followed in constructed Figure.1b modelled in MATLAB/SIMULINK. First PV panels are modelled containing 14 strands series along 5 strands parallel connecting. The PV array open circuit output voltage is to 16kW 500V into feed into EVL discharger /charger along with MPPT algorithm shows in Fig. 3atoharvestthe maximum power in any situations of PV array to keep the continues the same voltage at DC common bus.

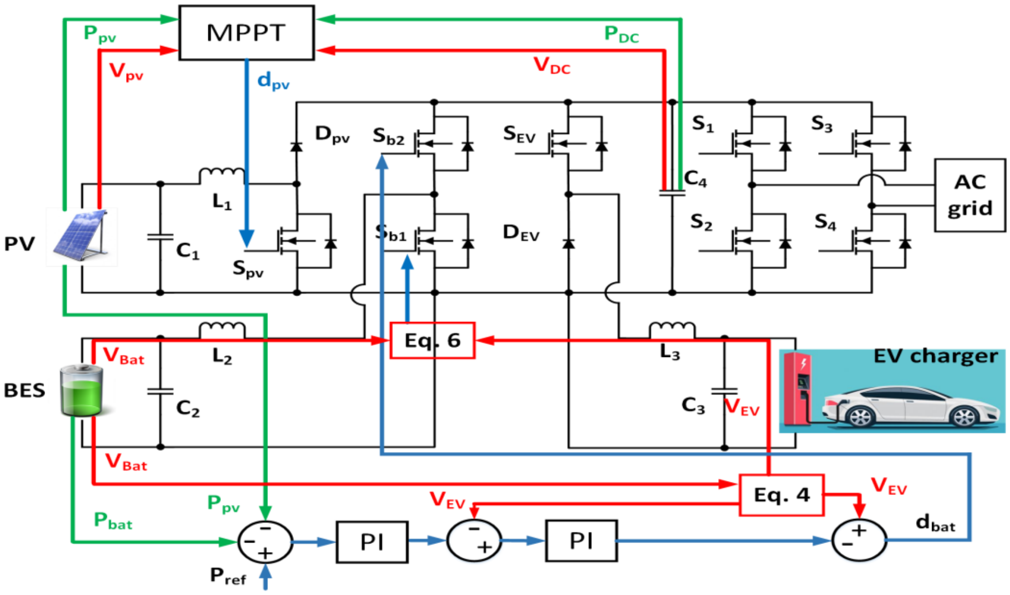
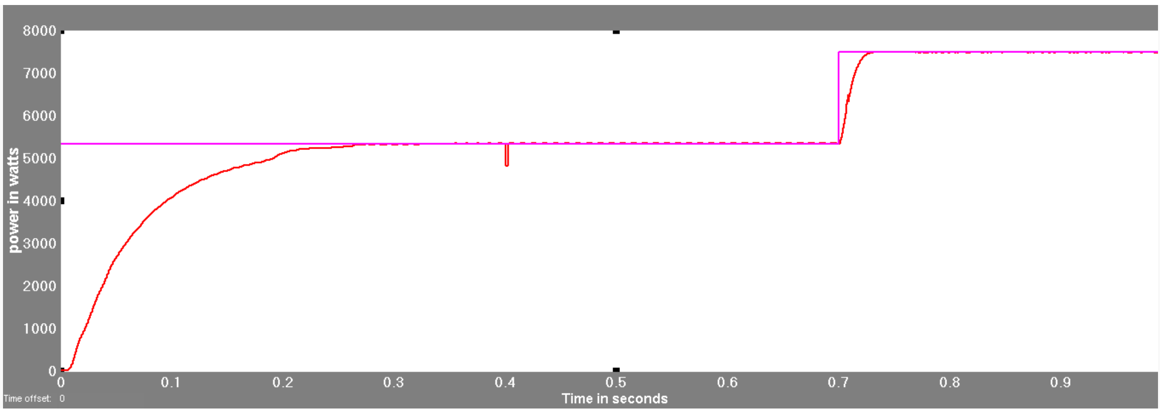
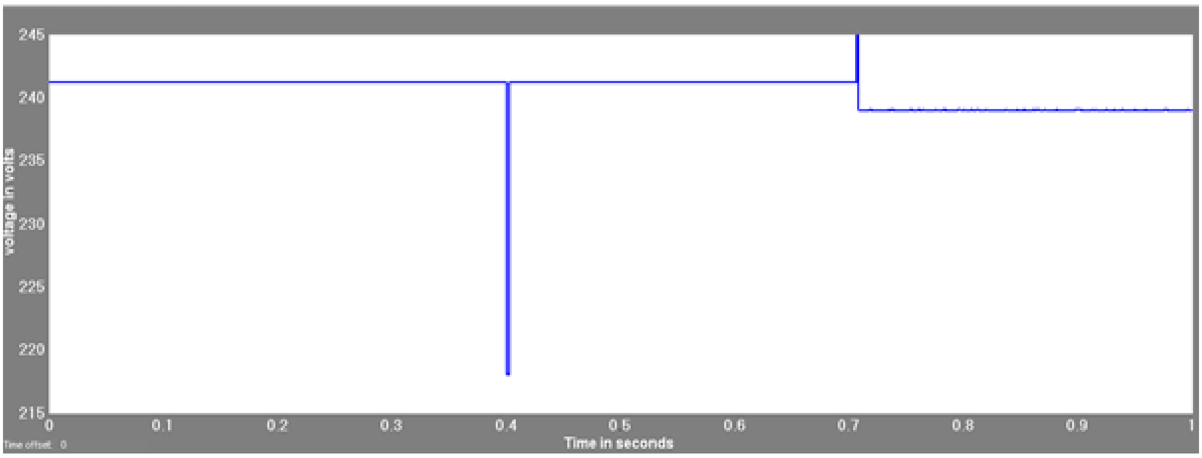


Figure 3. Control diagram of PV and battery is connected to EVL.

About the battery energy storage controllers, effective main aim is control of power deficiencies along to support for load side voltages is shown in figure. 3. If solar power is ample, EVL discharging/charging by given from PV power only. PV production if excess, battery energy storage is to get charging along consumes locality. PV power if it is deficit due to atmospheric conditions, then battery comes to discharging state along power padding in between PV array along with EVL charging state.



(a) demand and consumed power of EV charging.

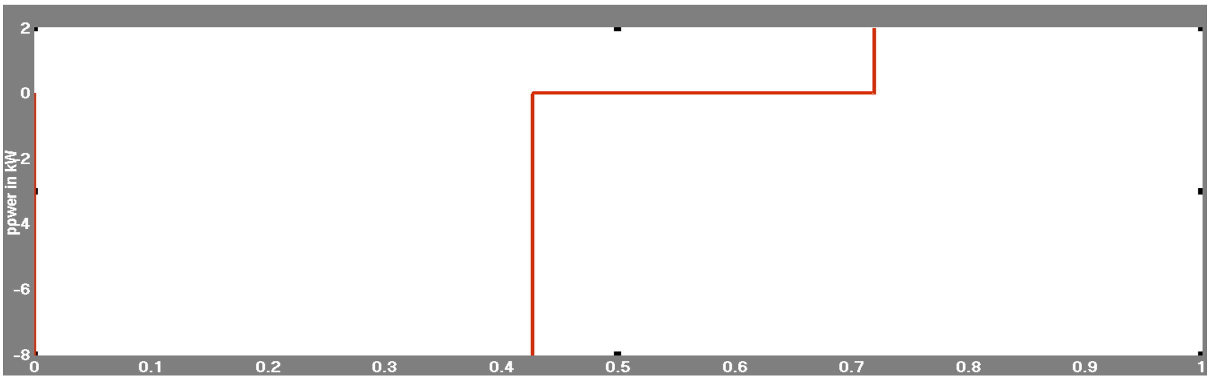


(b) Terminal voltage of the EV charger.

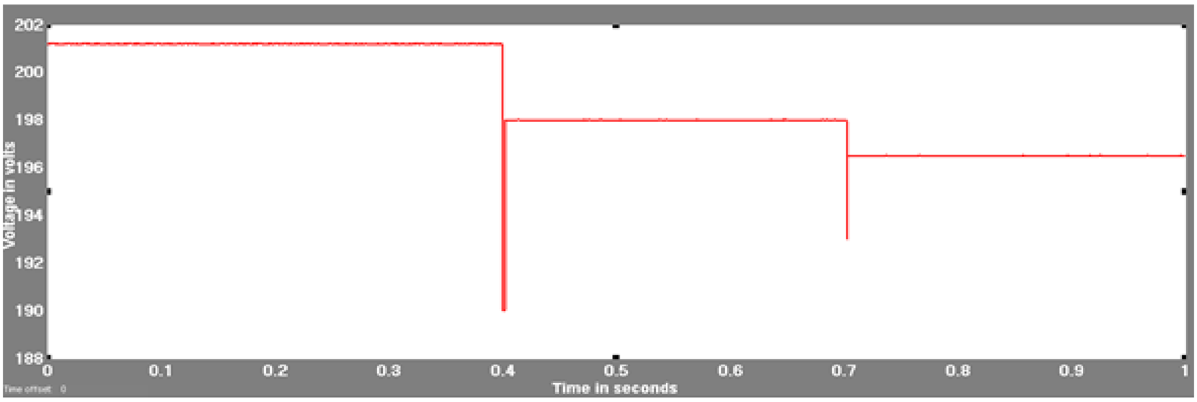
Fig.4: The simulation results of EV charging.

Here solar irradiance a step change in-between 700k/W2to 600k/W2at the time 0.4s then the power of solar power reduces in this time the battery getting discharge position and next at 0.7s time the load side EVL demand suddenly increased 5.7kW to 7.7kW it can see in the figure 4 in this conditions battery and PV array combined to gather can supplies to EVL charging.

CASE:2- BATTERY ENERGY STORAGE:



(a) Output power from BES.



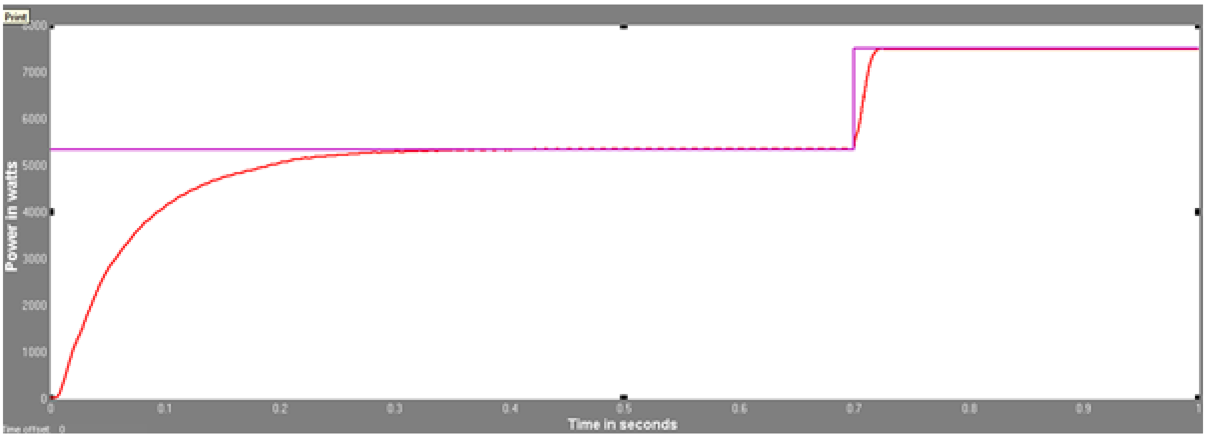
(b) Terminal voltage of the BES.

Fig.5: The simulation results of the BES.

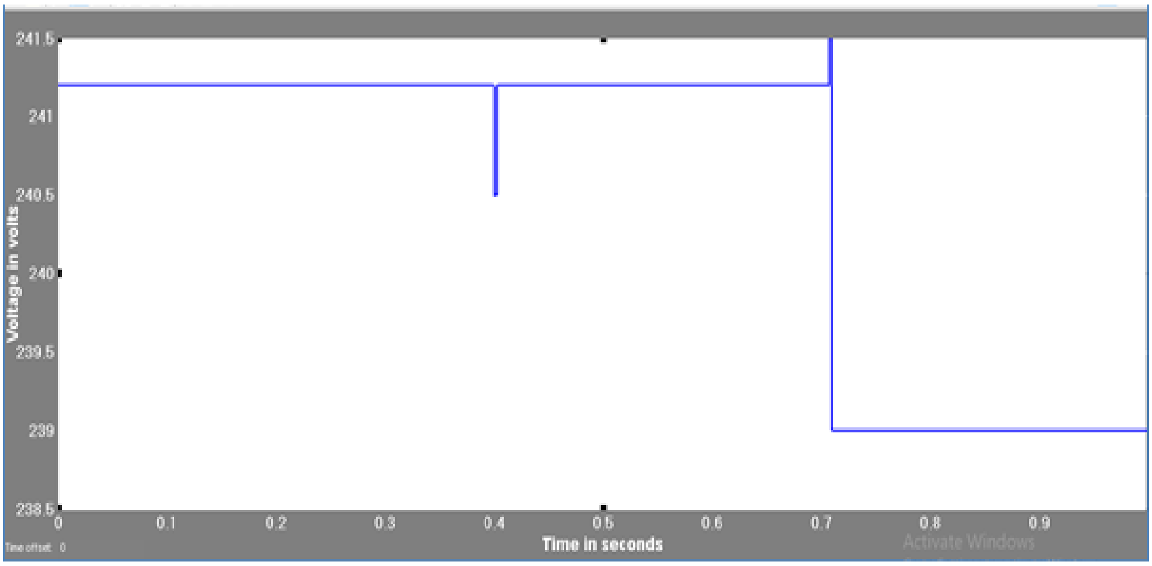
Next condition, the simulation time from 0 to 0.4 s, PV array power is greater than the EVL charging. Then PVto EVL and PV to battery modes are on, PV array power excess the EVL remaining power is moves to the battery and then it gets charging. After that from 0.4ms to 0.7ms, then PV array can provide 5.7kW can meet point EVL charging power. In these simulations, the system it is operated in to PV-to-EVL case along with no need of Battery charging/discharging condition. At 0.7ms the demand of EVL is increase, the demand of EVL is 7.7kW but the PV panel generating only 5.7kW remaining deficit power can be reached only the battery system as shown in figure 5.

Case3 fuzzy logic controller

In third case the controller added to controller to fuzzy logic controllers because of due to reduces of spikes or transients occurred in 0.4 ms and 0.7 ms observed in figures in 4 and 5. Using these fuzzy logic controllers it can eliminate transients up to 70% is shown in figures 6 and 7.



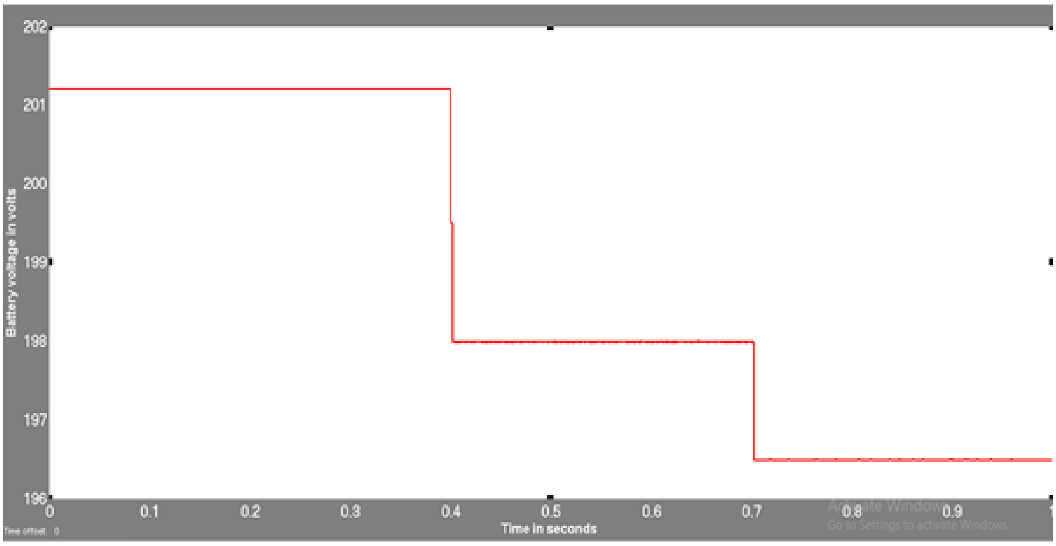
(a) Demand and consumed power of EV charging



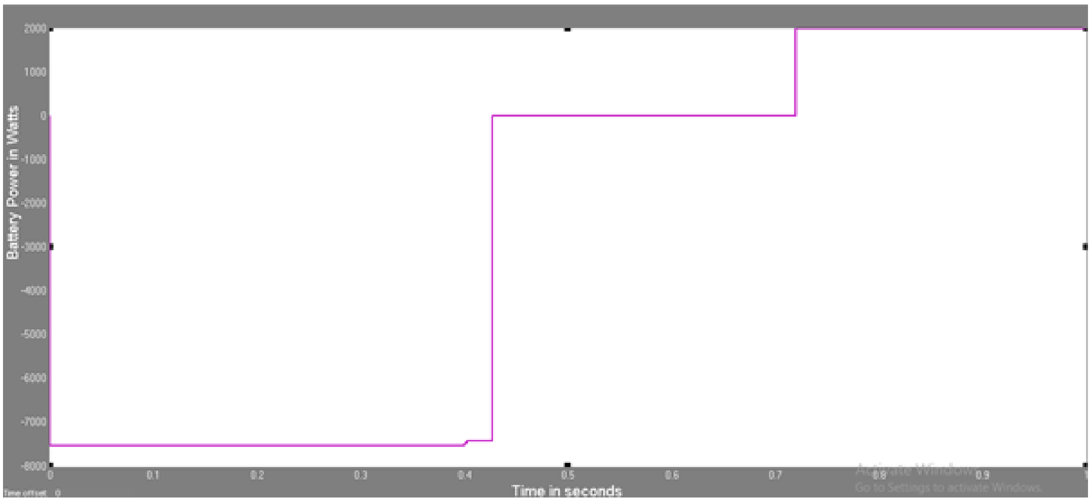
(b) Terminal voltage of the EV charger.

Fig.6: The simulation results of EV charging with fuzzy controller.

Figure 6 explains the simulations results of EVL charging with fuzzy logic controller examined that figure 6a power is given to EVL and its get charging, it can see 0.4ms and 0.7 ms there is variations is done input and load sides, in this particular timings transients produced for without fuzzy controller is shown in figures 4 and 5 comparing them figure 6 and 7 there is less transients occurred.



(a) Output power from BES



(b) Terminal voltage of the BES

Fig.7: The simulation results of the BES with fuzzy logic controller

5. Conclusion

PV and battery energy storage are connected to electrical vehicle charging without fuzzy logic controller. Battery energy storage device with controller endures to constructed control to voltage deficient, along with manages the power balances and transients at dynamic states. The approaches design, battery energy storage is beginning into discharges when its PV surf less about to EVL charging conditions, along start into charging if PV production endures excess either utility is variation demands, since the condition when the solar is not available. The examinations, the combination of EVL and PV production along battery energy storage a large steadiness along with efficiency of utility grid. Then various principle modes along with advance were considered, mat lab/Simulink models about to the multi terminal converter system influenced by EVL charging plants. PV is connected EVL case, PV is connected battery energy storage system, along with battery energy storage system is connected to EVL in normal condition, comparing conventional and fuzzy logic control is compensating the transients of the different varying conditions.

References

[1] V. Rallabandi, D. Lawhorn, J. He, and D. M. Ionel, "Current weakening control of coreless afpm motor drives for solar race cars with a three port bi-directional dc/dc converter," in 2017 IEEE 6th International Conference on Renewable Energy Research and Applications (ICRERA), Nov 2017, pp. 739–744.
[2] Y. Liu, Y. Tang, J. Shi, X. Shi, J. Deng, and K. Gong, "Application of small-sized smes in an ev charging station with dc bus and pv system," IEEE Trans. on Applied Superconductivity, vol. 25, no. 3, pp. 1–6, June 2015.
[3] M. Ahmadi, N. Mithulananthan, and R. Sharma, "A review on topologies for fast charging stations for electric vehicles," in 2016 IEEE International Conference on Power System Technology (POWERCON), Sep. 2016, pp. 1–6.
[4] J. C. Mukherjee and A. Gupta, "A review of charge scheduling of electric vehicles in smart grid," IEEE Systems Journal, vol. 9, no. 4, pp. 1541–1553, Dec 2015.
[5] H. Zhu, D. Zhang, B. Zhang, and Z. Zhou, "A nonisolated three-port dc/dc converter and three-domain control method for pv-battery power systems," IEEE Trans. on Industrial Electronics, vol. 62, no. 8, pp. 4937–4947, Aug 2015.
[6] A. Hassoune, M. Khafallah, A. Mesbahi, and T. Bouragba, "Smart topology of evs in a pv-grid system based charging station," in 2017 International Conference on Electrical and Information Technologies (ICEIT), Nov 2017, pp. 1–6.
[7] B. Honarjoo, S. M. Madani, M. Niroomand, and E. Adib, "Non-isolated high step-up three-port converter with single magnetic element for photovoltaic systems," IET Power Electronics, vol. 11, no. 13, pp. 2151–2160, 2018.
[8] S. Bai, D. Yu, and S. Lukic, "Optimum design of an ev/phev charging station with dc bus and storage system," in 2010 IEEE Energy Conversion Congress and Exposition, Sep. 2010, pp. 1178–1184.
[9] H. Zhu, D. Zhang, B. Zhang, and Z. Zhou, "A nonisolated three-port dc/dc converter and three-domain control method for pv-battery power systems," IEEE Trans. on Industrial Electronics, vol. 62, no. 8, pp. 4937–4947, Aug 2015.
[10] H. Zhu, D. Zhang, Q. Liu, and Z. Zhou, "Three-port dc/dc converter with all ports current ripple cancellation using integrated magnetic technique," IEEE Trans. on Power Electronics, vol. 31, no. 3, pp. 2174–2186, March 2016.
[11] G. Carli and S. S. Williamson, "Technical Considerations on Power Conversion for Electric and Plug-in Hybrid Electric Vehicle Battery Charging in Photovoltaic Installations," IEEE Trans. Power Electron., vol. 28, no. 12, pp. 5784–5792, Dec. 2013.
[12] P. Goli and W. Shireen, "PV powered smart charging station for PHEVs," Renew. Energy, vol. 66, pp. 280–287, Jun. 2014.
[13] G. R. C. Mouli, M. Leendertse, V. Prasanth, P. Bauer, S. Silvester, S. van de Geer, and M. Zeman, "Economic and CO2 Emission Benefits of a Solar Powered Electric Vehicle Charging Station for Workplaces in the Netherlands," in 2016 IEEE TransportationElectrification Conference and Expo (ITEC), 2016, pp. 1–7.
[14] P. J. Tulpule, V. Marano, S. Yurkovich, and G. Rizzoni, "Economic and environmental impacts of a PV powered workplace parking garage charging station," Appl. Energy, vol. 108, pp. 323–332, Aug. 2013.

[15] M. Brenna, A. Dolara, F. Foiadelli, S. Leva, and M. Longo, "Urban Scale Photovoltaic Charging Stations for Electric Vehicles," IEEE Trans. Sustain. Energy, vol. 5, no. 4, pp. 1234–1241, Oct. 2014.
[16] M. van der Kam and W. van Sark, "Smart charging of electric vehicles with photovoltaic power and vehicle-to-grid technology in a microgrid; a case study," Appl. Energy, vol. 152, pp. 20–30, Aug. 2015.
[17] P. Kadar and A. Varga, "PhotoVoltaic EV charge station," in 2013 IEEE 11th International Symposium on Applied Machine Intelligence and Informatics (SAMI), 2013, pp. 57–60.