DESIGN AND ANALYSIS OF SOLAR AND BATTERY FED GRID CONNECTED EV CHARGING STATION

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ABSTRACT: In this paper we suggested an EV charging station that is connected to a battery energy storage system (BES) and has improved grid power quality. In order to estimate the unit templates (UTs) and the reference grid currents, the positive sequence components (PSCs) of the three phase grid voltages are assessed. Bidirectional buck-boost converters are used to connect the EV and BES at a dc link. When it is sunny, the EV draws power from the solar array; when it isn't, it draws power from the grid. Furthermore, the point of common coupling voltages synchronizes with the grid voltages when the system is connected to the grid. MATLAB/SIMULINK, which was created to validate the satisfactory response under various dynamical situations, is used for testing.

KEYWORDS: PV ARRAY, EV, BES, UT, POWER QUALITY, PSC.

I.INTRODUCTION: AT THE gift time, the call for of electrical car (EV) is propagating in the world, and therefore, the EV charging station set up is also required. A hierarchical architecture is supplied in [1] for making decisions on EV merging, law of EV trajectories, and operation controller. The fallow area usage for the constructing of EV charging station and use of the parking roof for solar photovoltaic (PV) array set up were provided in [2]. Lyu et al. [3] have reviewed the EV charging station ingesting strength from the grid only. Another converter with zero voltage switching and discontinuous PWM for the charging of EV the use of the grid power has been confirmed in [4]. However, it does no longer demonstrate the bidirectional float of active electricity. Son and Lim [5] have supplied bidirectional f low of lively strength. Charging of the EV using grid consumes a huge quantity of strength. An alternate supply of power should be to be had in abundance with low jogging cost. Varghese et al. [6] have validated the EV charging station powered with renewables. However, this charging station suffers from several reservations from load aspect in addition to grid facet. When PV generation isn't enough, then EV is discharged to supply the strength required through the grid. This kind of feature is called as vehicle to grid (V2G) as supplied experimentally in [7]. Scheduling and allocation of V2G the usage of a smart device framework have been supplied in [8]. The strength control in case of V2G and automobile to domestic (V2H) mode has been demonstrated in [9]. An on-line energy management for gasoline cell-based totally hybrid multitask vehicle the usage of the game idea has been offered in [10]. Delprat and Riad Boukhari [11] have established electricity control for hybrid automobile through reduction of the computation attempt. Another approach of the strength management for EV charging via putting reference power stages for EV has been established in [12].

A deep reinforcement gaining knowledge of approach for hybrid electric powered automobiles strength control on gasoline cellular/battery/ultracapacitor with action trimming has been mentioned in [13]. The integration of the battery energy garage (BES) for EV charging is huge spreading these days for peak shaving. However, using extra battery increases the general value of the partial energy processing converter, that's applied in [14]. In this idea, the converter controls the energy switch of the BES to the EV battery, for this reason reducing the losses. Rafi and Bauman [15] have presented a fast charging of EV in brief time and to feed to grid in the course of peak hours. The battery degradation is taken into consideration as an objective feature. Another charging station with a battery has been established in [16] to increase the flexibility of the grid and EV.

The owner may additionally offer the charged battery for renting or on boarding motive. Similarly, the aggregators encompass the batteries in virtual power plants and might deploy them or provide the service inside the clever grid. Numerical simulation is finished to explain the idea, and battery management is executed by using the specialists. Balakhontsev et al. [17] have said massive evaluate on the EV chargers, supply system, and the BES. The on-/off board chargers, specific topologies with one-of-a-kind rework ers, and energy ranges had been discussed. Park et al. [18] have offered an on-board charger with PFC performed the usage of dual-lively-bridge converter. An onboard charger the usage of grid for battery charging has been presented in [19]. Zinchenko et al. [20] have provided a fairly efficient on-board charger. This charger is single level, for that reason lowering the variety of additives used and growing the overall performance of the device by way of the elimination of whole one stage. The on-board charger is used handiest for low-electricity packages. Singh et al. [21] and Jain et al. [22] have presented an EV charging station. In [21], EV is charged the use of PV and grid best. However, if PV array generation and grid are unavailable, then EV battery isn't always charged. This drawback is triumph over in [22]; right here, a BES is likewise integrated. However, the EV battery and BES are included the usage of a not unusual dc–dc converter. The voltage level of EV battery is continually lower than BES. Therefore, separate dc–dc converter should be used for the EV battery and BES integration on the dc hyperlink.

II.LITARATURE SURVEY:

1 “Energy management strategy for electric vehicle charging station as flexible power reserve,

This paper proposes an energy management strategy (EMS) for a grid-connected PV-based electric vehicle charging station (EVCS). The EVCS is controlled using a proportional-resonant (PR) controller and to leverage on the EVCS as a flexible power reserve, an EMS is proposed by relying on delayed load transient. The proposed EMS sets the reference power of the EVCS’s PR controller based on the state-of-charge (SOC) of the EV battery, provides good load-shaving capability and is easy to implement due to its simple structure. Through simulation studies, performance of the proposed EMS has been validated under different dynamic conditions for a 5kW-rated EVCS.

2 A review of topologies of quick charging stations for electric vehicles

Having a network of fast charging stations seems necessary in order to make EVs more attractive and to achieve larger uptake of them. Currently, 50 kW quick chargers that can charge a typical EV in about an hour are commercially available. However, a 240 kW fast charging level which can charge a typical EV in 10 minutes has been introduced in standards. It is expected that this high power fast chargers will be available in near future. A charging station must supply charging power in multi-megawatt levels when multiple EVs are being fast charged simultaneously. Here, charging station topology plays a crucial role in enabling future growth and providing fast charging with best quality of service, lowest cost and minimum grid impact. This paper presents a topological survey of charging stations available in the literature. Various charging station topologies are presented, compared and evaluated based on grid support, power density, modularity and other factors.

3 "High-efficiency single-stage on-board charger for electrical vehicles,

This paper presents an isolated single-stage on-board electric vehicle charger without an intermediate DC-link. Based on an isolated current-source topology, the converter features soft-switching in semiconductors regardless of load variation for the full AC line voltage range. Moreover, it requires no external snubber or clamp circuits. The power factor correction and voltage regulation are provided by a relatively simple phase shift modulation, while the amount of circulating energy is kept at minimum. The charger is distinguished by its efficiency characteristic – the maximum is achieved in the constant power charging mode. The control method, component stresses, and design constraints of the topology are analyzed. The concept is verified using a 3 kW experimental SiC-based prototype, which reaches a peak efficiency of 96.4%. Moreover, the charger has demonstrated efficiencies above 95% with the THD of 4.1% when operating in constant power mode at the maximal power.

III.PROPOSED SYSTEM:

3.1 SYSTEMCONFIGURATION

Fig. 1 shows the developed EV charging station with BES. The VSC facilitates the bidirectional power exchange between the grid, EV, BES, and PV array. For exchange with the grid, it converts dc electricity to ac and vice versa. At the common dc link, independent bidirectional dc–dc converters connect the EV and the BES. This converter regulates the BES and EV's charging and discharging. To reduce harmonic current, the VSC is connected to the PCC via interacting inductors. The system is connected to the grid and synchronized by a static transfer switch (STS).

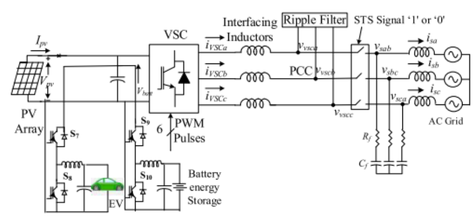


Fig. 1. System topology.

3.2. CONTROL APPROACH

EV charging is the system's primary function. The BES is charged using the residual power in the event that the grid is unavailable. Either BES, EV, or both are released to the grid when necessary. The control is divided into five categories: 1)

MPPT control, 2) synchronization and standalone mode (SM) control, 3) grid connected (GC) mode control, 4) BES control, and 5) EV control.

A. GC Mode Control

The VSC switching pulses are generated in the GC mode using the control, as shown in Fig. 2. 1) Computation of Unit Templates (UTs): The positive sequence components (PSCs) of the grid voltages [23] are computed, as demonstrated in Fig. 3.

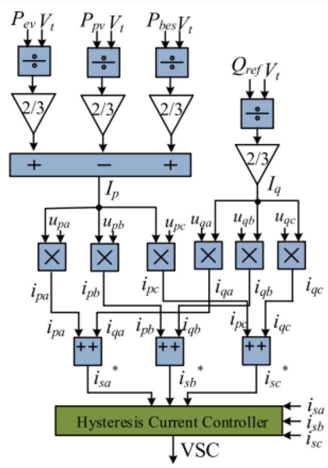


Fig. 2. GC control.

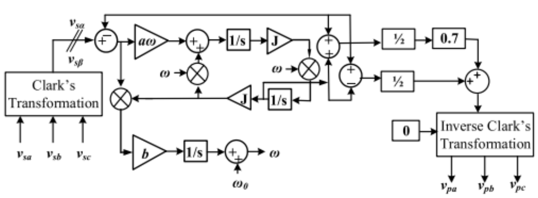


Fig. 3. PSCs estimation.

2) Fundamental Grid Current Active and Reactive Component Computation: The grid currents active component (Ip) includes dc power component. These are PV feedforward component, EV feed-forward, and BES feed-forward components. The PV feed-forward component is estimated as

$$I_{pv} = \frac{2}{3} * \frac{P_{pv}}{V_t}.$$

The EV feed-forward component is estimated as

$$I_{ev} = \frac{2}{3} * \frac{P_{ev}}{V_t}.$$

The feed-forward component of BES power is estimated as

$$I_b = \frac{2}{3} * \frac{P_b}{V_t}.$$

Therefore, the net active component becomes

$$I_p = \frac{2}{3} * \left(\frac{P_{ev}}{V_t} + \frac{P_b}{V_t} - \frac{P_{pv}}{V_t}\right).$$

The reactive component (Iq) is computed by reference
reactive power (Qref)

$$I_q = \frac{2}{3} * \frac{Q_{ref}}{V_t}.$$

3) Grid Currents Reference (GCR) Evaluation: The GCR (i∗sa, i∗ sb, and i∗sc) is evaluated as

$$i_{sa}^* = i_{pa} + i_{qa},\ \ i_{sb}^* = i_{pb} + i_{qb}, i_{sc}^* = i_{pc} + i_{qc}$$
$$i_{pa} = I_p \times u_{pa},\ \ i_{qa} = I_q \times u_{qa}$$
$$i_{pb} = I_p \times u_{pb},\ \ i_{qb} = I_q \times u_{qb}$$
$$i_{pc} = I_p \times u_{pc},\ \ _{qc} = I_q \times u_{qc}$$

where ipa, ipb, and ipc are the per phase active currents and iqa, iqb, and iqc are the per phase reactive currents.

The reference grid currents obtained are subtracted from actual grid currents. The error obtained is given to hysteresis current controller and VSC gate pulses are obtained.

B. BES Control BES control extracts peak power from PV source and reference value for dc link is obtained. In event of absence of PV array power, controller uses a constant reference value. The block diagram of overall control is shown in Fig. 4(a).

C. EV Control Algorithm The EV is controlled by giving desired switching pulses to dc–dc converter. For charging of the EV battery, the current reference is estimated by comparing reference EV voltage with actual EV voltage and providing this error to the PI controller. However, if grid requires active power from EV, then EV battery current reference is estimated by dividing reference EV power with EV voltage, as shown in Fig. 4(b).

D. Synchronization and Standalone Control When grid is unavailable, signal S = 0 for the STS, the VSC operates in the SM, as shown in Fig. 5(a). The grid (θg) and PCC voltage angle (θs) are compared, and the error is estimated as It is then given to the PI controller and reference PCC voltages are computed. These reference PCC voltages are then compared with actual PCC voltage to obtain the voltage error. This error is passed to the PI controller, and hence, PCC reference currents are obtained. The reference grid currents obtained are subtracted from actual grid currents. The error obtained is given to hysteresis current controller and VSC gate pulses are obtained. When PV array power and BES power are unavailable or not that much enough for the charging of EV battery, the islanded control shifts to the GC control after meeting the specified boundary conditions via synchronizing. The boundary conditions necessary for the GC operation of the system are the amplitude, frequency, and angle, as shown in Fig. 5(b).

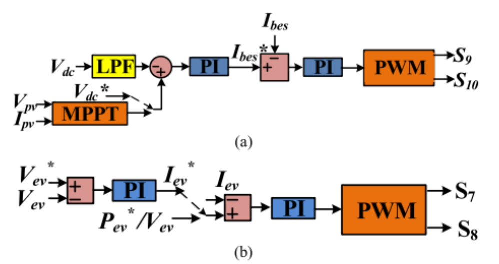


Fig. 4. Control approach. (a) BES control. (b) EV battery charging/discharging control algorithm.

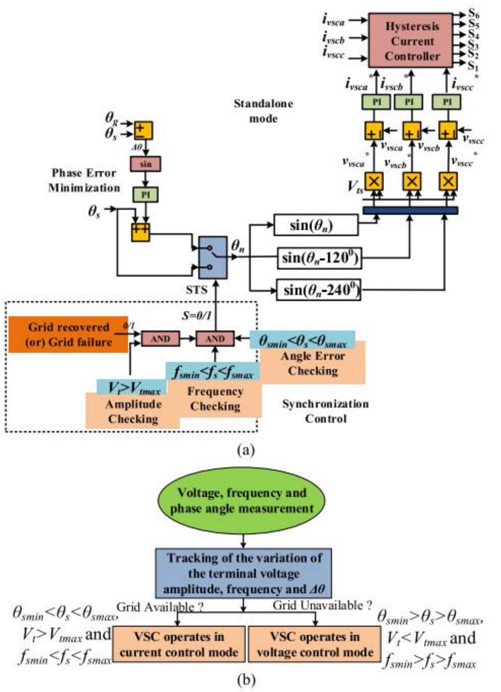


Fig. 5. (a) Synchronization and standalone control. (b) System-level coordination control for transition between the GC mode and SM.

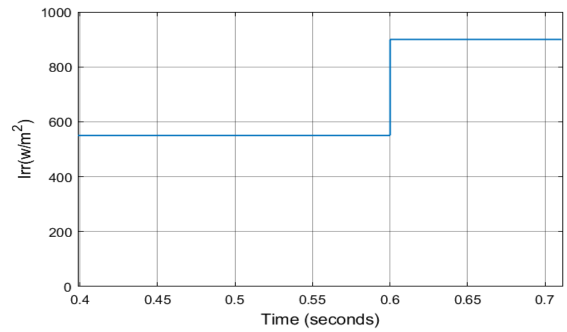
IV.SIMULATION RESULTS:

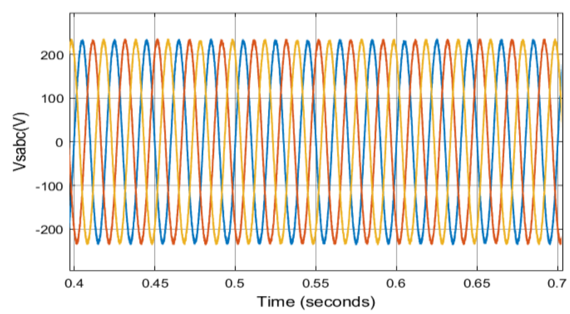
The performance system is shown in this section.

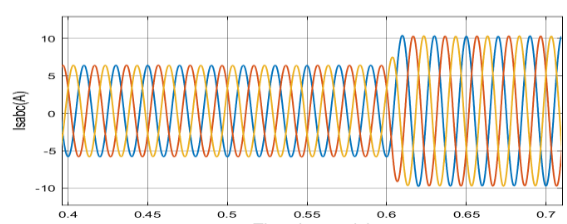
A. Performance Under Variation of Solar Insolation During rise in PV array irradiation from 600 to 1000 W/m2 , PV array generation increases, since EV and battery are in floating mode, as shown in Fig. 6.

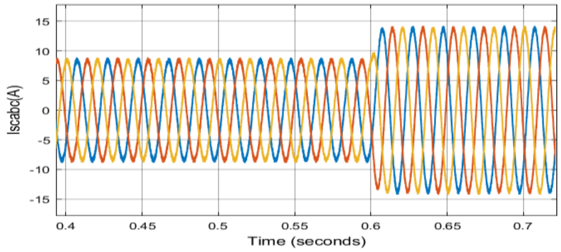
B. Performance of System at Outage of Grid Simulated performance at grid outage is shown in Fig. 7(a). When grid outage is observed, charging station operates in SM. Therefore, grid currents and voltages immediately become zero. The BES compensates for surplus power and starts charging. EV charging remains unchanged.

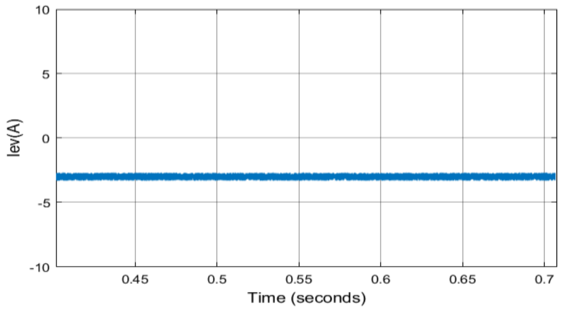
C. Performance of System at Grid Reconnection The simulated response of system at grid recovery is presented in Fig. 7(b). During grid restoration, the VSC synchronizes to the grid, and the grid voltages and the currents are appeared. The BES starts discharging without affecting the EV charging.

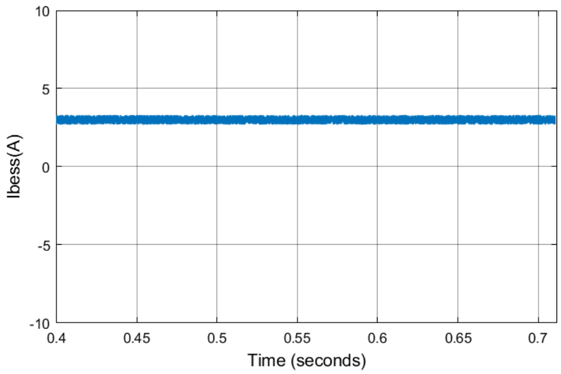







Iscabc(A)
Time (seconds)


Iev(A)
Time (seconds)


Ibess(A)
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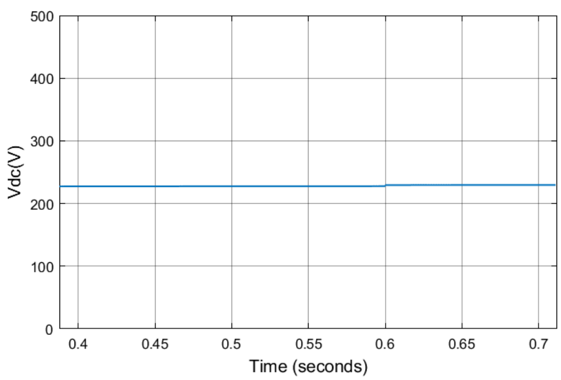
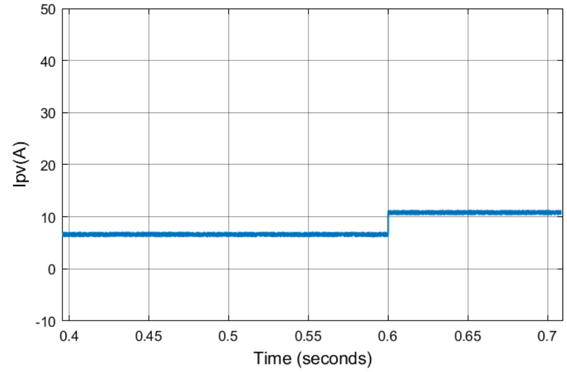
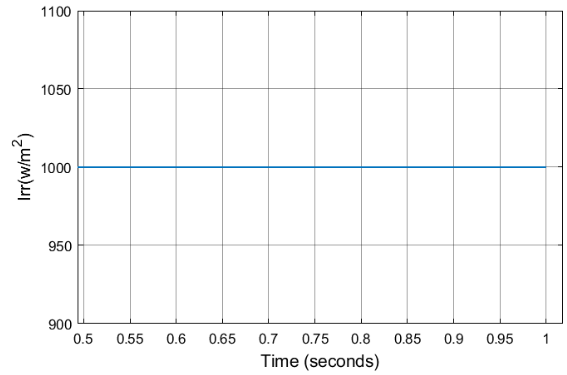
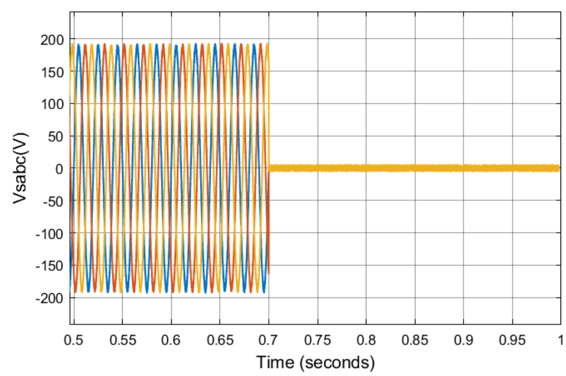
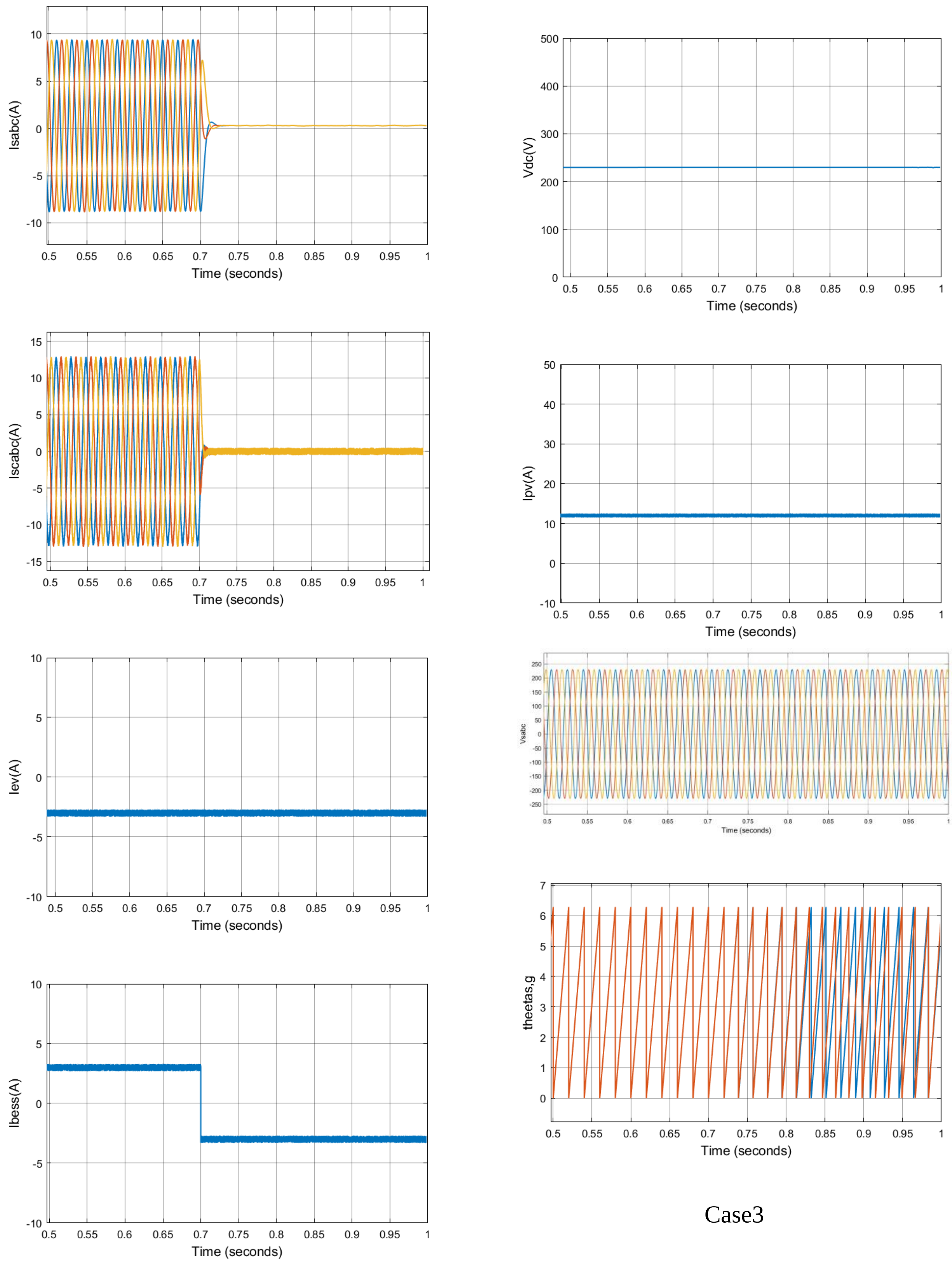

Vdc(V)
Time (seconds)


Ipv(A)
Time (seconds)

Case2


Irr(w/m2)
Time (seconds)


Vsabc(V)
Time (seconds)


Isabc(A)
Time (seconds)
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Iscabc(A)
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Ipv(A)
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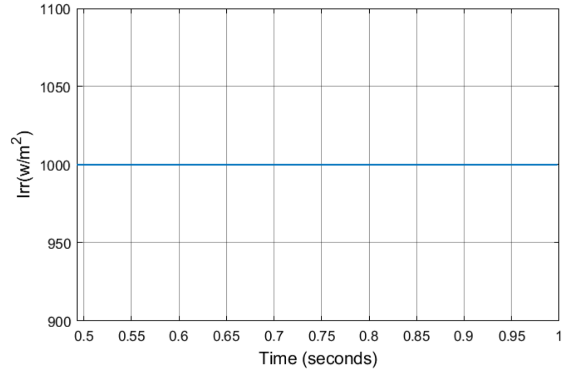
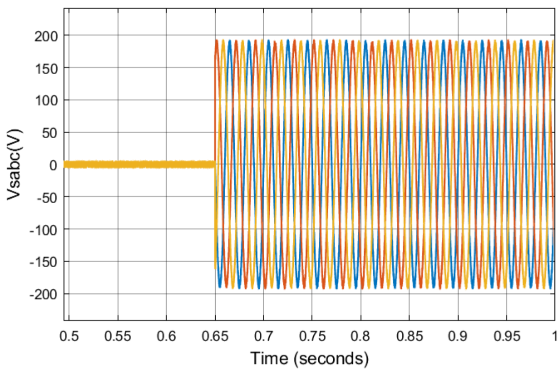
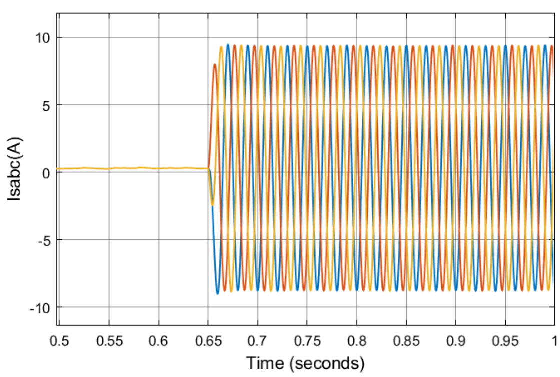
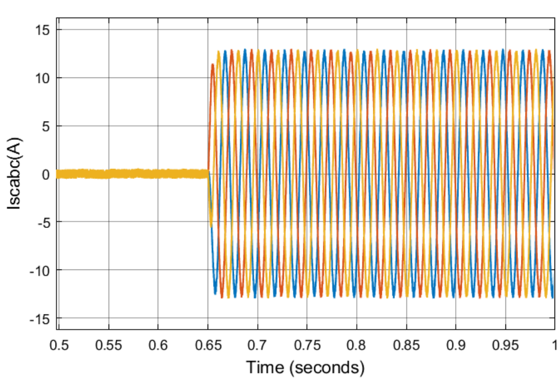
Case3


Irr(w/m2)
Time (seconds)


Vsabc(V)
Time (seconds)


Isabc(A)
Time (seconds)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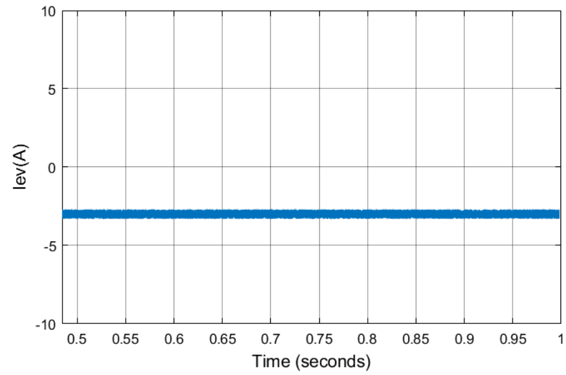
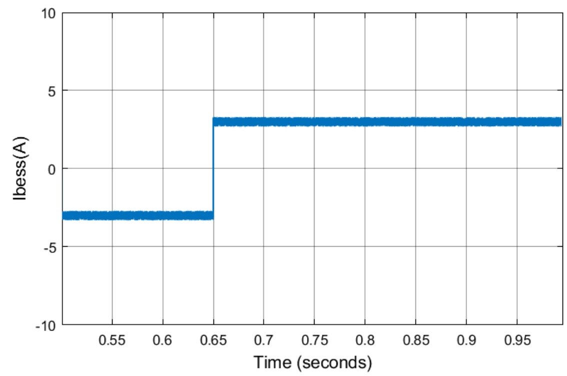
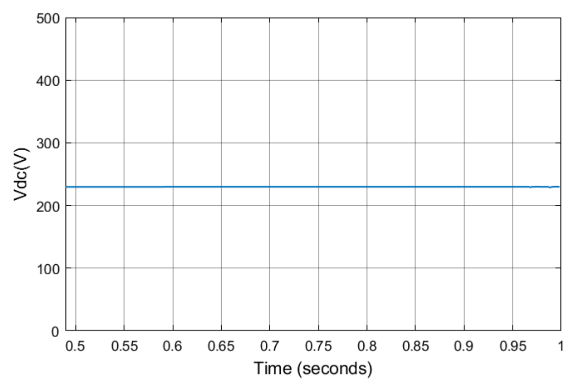
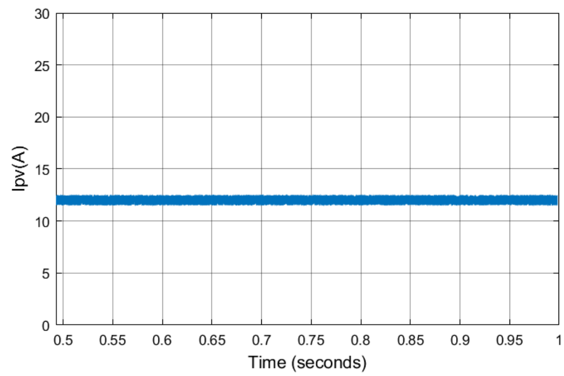
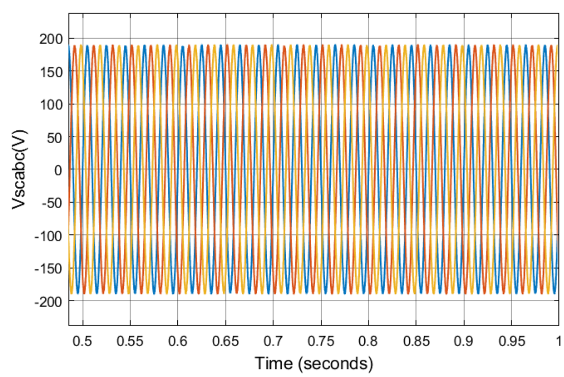
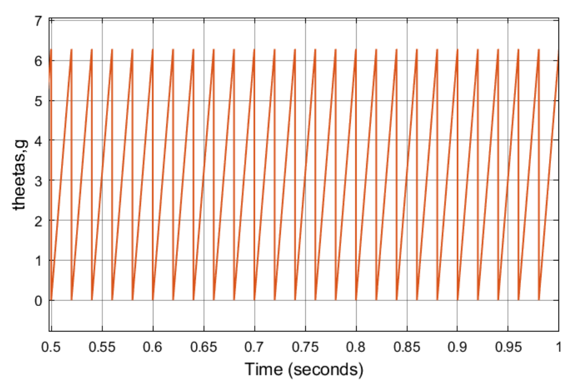

Iev(A)
Time (seconds)


Ibess(A)
Time (seconds)


Vdc(V)
Time (seconds)







V. CONCLUSION

This is where the charging station with BES that is mostly reliant on PV arrays is located. In a variety of dynamic scenarios, such as intermittent PV insolation with a BES in floating mode, compensating mode, and constant energy grid mode, test results have confirmed the enhanced electrical outstanding performance of EV charging stations. The machine's reaction when the BES system is converted or discharged has also been examined in element.

VI. REFERNCES

[1] N. Chen, B. van Arem, T. Alkim, and M. Wang, "A hierarchical model-based optimization control approach for cooperative merging by connected automated vehicles," IEEE Trans. Intell. Transp. Syst., vol. 22, no. 12, pp. 7712–7725, Dec. 2021.

[2] S. Prajapati and E. Fernandez, "Rooftop solar PV system for commercial office buildings for EV charging load," in Proc. IEEE Int. Conf. Smart Instrum., Meas. Appl. (ICSIMA), Kuala Lumpur, Malaysia, Aug. 2019, pp. 1–5.

[3] D. Lyu, T. B. Soeiro, and P. Bauer, "Design and implementation of a re-configurable phase-shift full-bridge converter for wide voltage range EV charging application," IEEE Trans. Transp. Electrific., early access, May 20, 2022, doi: 10.1109/TTE.2022.3176826.

[4] L. Gong et al., "A dynamic ZVS-guaranteed and seamless-modetransition modulation scheme for the DAB converter that maximizes the ZVS range and lowers the inductor RMS current," IEEE Trans.

Power Electron., vol. 37, no. 11, pp. 13119–13134, Nov. 2022.

[5] J.-C. Son and D.-K. Lim, "Novel method of deriving torque and speed curve of the permanent magnet synchronous motor using initial state finite element analysis," IEEE Trans. Magn., vol. 58, no. 8, pp. 1–6, Aug. 2022.

[6] S. S. Varghese, G. Joos, and S. Q. Ali, "Load management strategy for DC fast charging stations," in Proc. IEEE Energy Convers. Congr. Expo. (ECCE), Oct. 2021, pp. 1620–1626.

[7] A. S. M. J. Hasan, L. F. Enriquez-Contreras, J. Yusuf, M. J. Barth, and S. Ula, "Demonstration of microgrid resiliency with V2G operation," in Proc. IEEE Transp. Electrific. Conf. Expo (ITEC), Jun. 2021, pp. 243–248.

[8] S. Zhang and K.-C. Leung, "A smart cross-system framework for joint allocation and scheduling with vehicle-to-grid regulation service," IEEE Trans. Veh. Technol., vol. 71, no. 6, pp. 6019–6031, Jun. 2022.

[9] Y. Yi, G. Verbic, and A. C. Chapman, "Optimal energy management strategy for smart home with electric vehicle," in Proc. IEEE Madrid PowerTech, Jun. 2021, pp. 1–6.

[10] R. Ghaderi, M. Kandidayeni, M. Soleymani, L. Boulon, and J. Pedro F. Trovão, "Online health-conscious energy management strategy for a hybrid multi-stack fuel cell vehicle based on game theory," IEEE Trans. Veh. Technol., vol. 71, no. 6, pp. 5704–5714, Jun. 2022.

[11] S. Delprat and M. Riad Boukhari, "Reducing the computation effort of a hybrid vehicle predictive energy management strategy," IEEE Trans. Veh. Technol., vol. 70, no. 7, pp. 6500–6513, Jul. 2021.

[12] A. Husnain, A. Bamigbade, H. AlBeshr, and T. Ghaoud, "Energy management strategy for electric vehicle charging station as flexible power reserve," in Proc. 47th Annu. Conf. IEEE Ind. Electron. Soc. (IECON), Oct. 2021, pp. 1–5.

[13] Z. Fu, H. Wang, F. Tao, B. Ji, Y. Dong, and S. Song, "Energy management strategy for fuel cell/battery/ultracapacitor hybrid electric vehicles using deep reinforcement learning with action trimming," IEEE Trans. Veh. Technol., vol. 71, no. 7, pp. 7171–7185, Jul. 2022.

[14] K. Zheng, W. Zhang, X. Wu, and L. Jing, "Optimal control method and design for modular battery energy storage system based on partial power conversion," IEEE Access, vol. 9, pp. 133376–133386, 2021.

[15] M. A. H. Rafi and J. Bauman, “Optimal control of semi-dual active bridge DC/DC converter with wide voltage gain in a fast-charging station with battery energy storage,” IEEE Trans. Transp. Electrific., vol. 8, no. 3, pp. 3164–3176, Sep. 2022.

[16] L.-G. Manescu et al., “Smart storage and grid services based on ˘ removable modular batteries for EV,” in Proc. Int. Conf. Appl. Theor. Electr. (ICATE), May 2021, pp. 1–6.

[17] A. Balakhontsev, O. Beshta, V. Boroday, S. Khudolii, and S. Pirienko, “A review of topologies of quick charging stations for electric vehicles,” in Proc. IEEE Int. Conf. Mod. Electr. Energy Syst. (MEES), Sep. 2021, pp. 1–4.

[18] Y. Park, S. Chakraborty, and A. Khaligh, “DAB converter for EV onboard chargers using bare-die SiC MOSFETs and leakage-integrated planar transformer,” IEEE Trans. Transp. Electrific., vol. 8, no. 1, pp. 209–224, Mar. 2022.

[19] G. T. Chiang, T. Shuji, S. Takahide, Y. Hand, Y. Kitamura, and M. Fukada, “Coupled magnetic-based integrated isolated onboard battery charger and boost motor drive unit for electric vehicles,” IEEE Trans. Transp. Electrific., vol. 8, no. 1, pp. 135–148, Mar. 2022.

[20] D. Zinchenko, A. Blinov, A. Chub, D. Vinnikov, I. Verbytskyi, and S. Bayhan, “High-efficiency single-stage on-board charger for electrical vehicles,” IEEE Trans. Veh. Technol., vol. 70, no. 12, pp. 12581–12592, Dec. 2021.

[21] B. Singh, V. Jain, A. Chandra, and K. Al-Haddad, “Power quality improvement in a PV based EV charging station interfaced with three phase grid,” in Proc. 47th Annu. Conf. IEEE Ind. Electron. Soc. (IECON), Oct. 2021, pp. 1–6.

[22] V. Jain and B. Singh, “A three phase grid connected EV charging station with PV generation and battery energy storage with improved power quality,” in Proc. IEEE Ind. Appl. Soc. Annu. Meeting (IAS), Oct. 2021, pp. 1–8.

[23] A. T. Nguyen and D.-C. Lee, “Advanced grid synchronization scheme based on dual eSOGI-FLL for grid-feeding converters,” IEEE Trans. Power Electron., vol. 37, no. 6, pp. 7218–7229, Jun. 2022.

[24] D. Alex, V. C. Gogineni, S. Mula, and S. Werner, “Novel VLSI architecture for fractional-ordercorrentropy adaptive filtering algorithm,” IEEE Trans. Very Large Scale Integr. (VLSI) Syst., vol. 30, no. 7, pp. 893–904, Jul. 2022.