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Performance Analysis of EV Charging Station Using Solar System with Dc Grid

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ABSTRACT*- Due to the shortage of fossil fuels, everyone in the globe has been working to find fresh renewable power sources. It is crucial to study how EV charging stations affect the electrical grid and whether it is possible to make this system more cost-effective by using solar roof top systems in order to ensure the safe and consistent efficiency of the power distribution network. Each state is selling using electric powered cars (EVs) to fight the hassle of world warming because of transportation. As the number of electric vehicles on the road rises, using infrastructure that depends on fossil fuels to recharge EVs is neither environmentally friendly nor economical. As a result, an inexperienced strength-based electric vehicle charging station has a lot of capacity and control. A Battery Energy Storage System (BESS) and a powered by sunlight electric vehicle charging station are necessary in the current circumstances. More grid assistance is advised to ensure that the charging station has consistent power without adding to the system's burden. A green charging station setup is built and tested in MATLAB/Simulink for the best strength control using the Adaptive Neuro Fuzzy Inference System (ANFIS), voltage-managed MPPT, PID controller, and Grid.*

Keywords – *Electric Vehicles, BESS, Adaptive Neuro-Fuzzy Inference System, MPPT, PID controller, Neural Network, PV.*

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I. INTRODUCTION

The need for current transport systems is increasing, which contributes to manage global warming along with some hazardous changes in the environment. Air pollutants and greenhouse fuelling emissions are the result of the hazardous environmental pollutants that internal combustion engine (ICE) vehicles release. The main culprits behind these detrimental environmental effects are vehicles with Internal Combustion (IC) engines. The world's present reliance on gasoline-powered cars could be alleviated in part by the use of electric vehicles (EVs). When compared to internal combustion engines, electric vehicles utilize less power and emit less noise and pollution. They can also be used to minimize the use of oil in transportation, provided that the power is generated from non-oil reasserts in [1,2]. If the motors are charged the usage of power from the electric grid, while greater EVs are placed on the road, charging the motors gets harder. [3] The grid's ability to operate and be controlled will inevitably degrade if an increasing number more electric vehicles (EVs) are connected to it. Furthermore, there are no advantages to charging EVs on the electric grid using conventional energy sources. Therefore, an effective infrastructure for charging electric vehicles powered by energy generated from renewable sources is needed. Another more ideal method [4–7] involves using a battery energy storage system (BESS) that can serve as a buffer between the utility and the EV charging station (EVCS).

However, despite the fact that the use of BESS will assist ease a number of the stress at the software grid, the full-size range of EVCSs anticipated with inside the destiny nevertheless poses a problem. Therefore, an powerful infrastructure for charging electric powered cars powered via way of means of renewable electricity is wanted An powerful battery electricity garage system (Battery energy storage system) this is mixed together sun Photovoltaic cell is explored in [8]with inside context of a charging station. In [9], it's miles mentioned a way to put in force and modify electricity float in renewable electricity-primarily based totally (WECS) photovoltaic (PV) arrays and wind electricity conversion structures for charging electric powered cars (EVs). In [10], it's miles addressed a way to create an powerful, adaptive, and PV-primarily based totally EV charging station the use of environmental facts In [11] it's miles defined a way to rate electric cars with inside the place of business utilizing solar and batteries. Discusses the most electricity factor monitoring of a standalone 4-panel PV array the use of ANFIS approach.

The proposed study offers a comprehensive neural network-based method for managing the electricity used by solar- and battery-powered electric car charging stations that are connected to the AC grid. Under varying irradiance and temperature conditions, the maximum electricity possible from photovoltaic cells is produced using an ANFIS voltage-controlled approach.

The state of charge (SOC) of the BESS parameters and the sunlight output are used by a neural network to regulate the AC grid's power output. The foremost supply of electricity is photovoltaic sunlight. PV presents the electricity wished for charging the EV all through instances of most irradiance, and any greater is dispatched to the AC grid and used to strength the BESS. The electric vehicle (EV) can be charged using a battery while PV energy isn't working at night. In order to price electric powered vehicles, sun or BESS electricity is required. To provide an uninterrupted power supply, the AC grid may occasionally be used to generate electricity for charging EVs and BESS. Simulating the proposed system in MATLAB/Simulink

II. MODEL OF ELECTRIC VEHICLE CHARGING STATION

In Fig. 1, a proposed powered with the aid of using daylight charging station with strength garage with inside the shape of batteries and an AC grid is proven schematically. When examining the suggested work, a 400V DC bus with a single EV battery will be taken into account. Table I displays the technical information about the components.

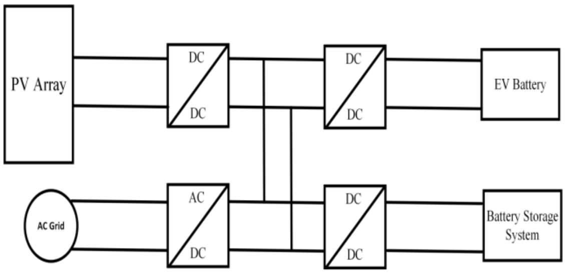


Figure 1. Block Diagram of EV Charging Station

A. Inverter With Grid:

Research is being done on the 230V, 50Hz alternating current grids to accommodate the accelerated energy requirements of the electric vehicle charging station. The grid is a source of 230V AC power in MATLAB/Simulink. To connect the 500V DC bus to the alternating current grid, an inverter is utilized. Neural network to provide pulses for inverter switches By the use of the photovoltaic array's output electricity and the BESS's %SOC as enter information to a neural community, the Simulink version is created.

B. Photovoltaic Cell With Boost Converter:

MATLAB/Simulink has been used to test a charging station architecture using a 2000W photovoltaic cell with a 298.4V voltage across the open circuit.. A improve converter is used to increase the photovoltaic (PV) array voltage in order that it is able to attain the desired bus voltage for DC of 400V, order to increase the amount of electricity produced by the photovoltaic array, The use of a proportional-integral (PI) controller in conjunction with an ANFIS voltage controller is made.

Table1. Charging Station Data

Array Data	
Series Connected Modules Per String	8
Parallel Cells	1
Module Data	
MPPT voltage	31.1
MPPT current	9.10
Short-Circuit Current	8.86
Open Circuit Voltage	38.03
Number Of Cells	60
EV Battery Data	
Rated Capacity	7Ah
The Initial soc	9.5%
Nominal Voltage	240v
Batteries Types	Lithium-Ion
Boost Converter Data	
Capacitance	4.0805μf
Inductance	0.0156H
Switching Frequency	10 KHz
Battery Energy Storage System Data	
Nominal Voltage	240.5 V
Rated Capacity	40Ah
Battery Type	Lithium-Ion

C. Battery Energy Storage System (Bess) With DC DC Bidirectional Converter:

Extra solar power is gathered, stored, and utilized to power a system for storing energy from batteries this is used to power electric vehicle charging at night. The BESS system's charging and discharging are managed by a bidirectional boost DC-DC converter. Regarding the battery charging station, a 240V 40Ah BESS is employed. At least 20% SOC of BESS is expected to be discharged each day.

D. Battery of Electric Vehicle:

A 240V, 7Ah battery at the charging station is being investigated. The EV battery is charged using a DC-DC boost converter and PI controller from a 500V DV bus. For modeling purposes, the battery of the approaching EV is predicted to have an initial SOC of 10, using the battery's nominal power supply voltage (Vn), residual state of charge (SOC), and amp-hour rating (Ah).Calculating the energy needed (Eev) to recharge an electric vehicle (EV) battery is possible.

$$.E_{ev} = \frac{V_n * SOC_r * Ah}{100} \dots\dots\dots\dots (1)$$

III. ONTROL METHODLOGY OF EV CHARGING STATION

A. ANFIS Working:

ANFIS Networks are a particular kind of network that mimic the behavior of neural and fuzzy inference systems. There are no synaptic weights in the flexible neural network, which comprises both adaptive and non-adaptive nodes. The moniker "adaptive network" refers to how quickly the network may be transformed into a standard feed-forward neural network structure (13).

The ANFIS adaptive network and an adaptive Takagi-Sugeno fuzzy controller have a similar structure. This adaptable network functions similarly to adaptive neuro fuzzy inference system(ANFIS). The values of the parameters for the input and output of the ANFIS network are changed for the input/output set of data using back-propagation gradient descent and least-squares techniques.. Both the input and output parameters of the ANFIS network are commonly referred to as linear and nonlinear components. The five-layer ANFIS structure is shown in Figure 2

- Layer1:

The first nodes in that layer is referred to as an adaptive node, and the parameters in this layer are nonlinear parameters from the ANFIS network. Eq. (2) gives the function of every node as follows,

$$L_{1,i} = \mu A_i(e) \quad for\ i = 1,2 \dots\dots..j$$

$$L_{1,i} = \mu B_i(\Delta e) \quad for\ i = 1,2 \dots j \dots (2)$$

Hence, for the Ai and Bi membership characteristics of each node, e and Δe, respectively, stand in for the inputs of the layer 1 node i's. The distribution of the input parameters determines the membership function for each node, and its Gaussian membership function is frequently used for this purpose. The function of Gaussian membership is expressed as follows: as a result of Equation (3).

$$f(x,\sigma,c) = e^{\frac{(x-c)^2}{2\sigma^2}} \dots\dots\dots\dots\dots\dots(3)$$

The width and middle of the Gaussian club characteristic are denoted with the aid of using σ and c. Middle and width are the nonlinear parameters. Throughout training, these non-linear characteristics change.

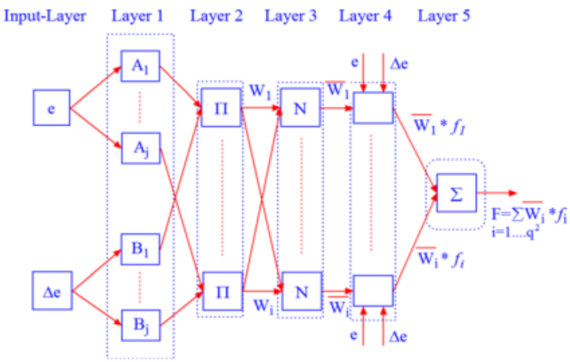


Figure 2.Five-Layer ANFIS Network

- Layer 2:

a stationary junction this is represented by the symbol "Π" and whose output is composed of signals from Layer 1 nodes. The node function is stated in Equation (4) as

$$L_{2,k} = W_i = \mu A_i(e)\, \mu B_i(\Delta e)\ for\ i = 1,2..j^2 \dots (4)$$

The firing strength of the rule base is determined by the output of every layer 2 node.

- Layer3:

The letter 'N' stands for fixed layers nodes. The output is calculated by split the value of each node by the total number of nodes. Equation (5) gives the nodes function as

$$L_{3,i} = \overline{W_i} = \frac{W_i}{\sum_{i=1} j^2 W_i} \dots\dots\dots\dots (5)$$

- Layer4:

That node is modifiable. Equation (6) describes the behavior of this node as follows:

$L_{4,i} = W_i f_i = W_i (P_i e + Q_i \, \Delta e + r_i) \dots\dots\dots\dots\dots (6)$

The community series parameters generally referred to as the linear parameters of AFIS networks, are the normalized layer three firepower and (Pi, Qi, ri). During the mastering phase, those parameters are tuned the usage of the least-squares method.

- Layer5:

The layer represented by the symbol "" contains a fixed node known as the output layer. Equation (1) gives the output of this layer, which was determined using the weighted average method. (7) as

$\boldsymbol{L_{5,i}} = \sum_{i=1} j^2 \ \overline{W_i} f_i = \frac{\sum_{i=1} j^2 W_i f_i}{\sum_{i=1} j^2 W_i} \quad \dots\dots\dots(7)$

Layers 2 and 4's linear and nonlinear parameters are changed via a hybrid technique.. The steepest descent and least-squares approaches are combined in the hybrid ANFIS parameters algorithm.

Hybrid techniques use both forward and backward propagation as two modes of propagation. Forward propagation of the hybrid algorithm sends the output of each node to layer 4. Layer 4 uses the least squares method to change the linear parameters..

The hybrid approach's backward propagation involved incorrect signals travelling backward while gradient descent was used to change the nonlinear parameters. Due to the fact that the search space's dimensionality is greatly decreased during training, this hybrid technique converges much more quickly than conventional backward propagation techniques (14, 15).

B. MPPT using ANFIS NETWORK -PI Controller:

Model of ANFIS voltage control MPPT

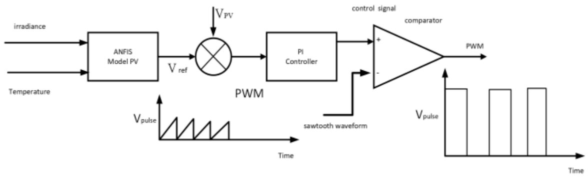


Figure 3. Modal Voltage Controlled MPPT

This MPPT framework builds a precise duplicate of the original PV plant using ANFIS. Irradiance and temperatures are employed as the two inputs to the process together with a single result (voltage), to train the ANFIS under varying irradiance and temperature situations. To create an error voltage, a voltage reference is measured at the ANFIS system's output and contrasted with the real PV voltage. The duty cycle for the pulse width modulator (PWM) is generated by the proportional-integral controller after analyzing the error voltage. The DC-to-DC boost converter needs the pulse width modulation generator's pulse output to extract the maximum amount of current from the photovoltaic array.

C. AC Grid Based on Neural Networks:

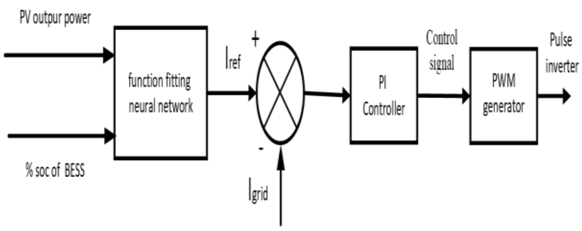


Figure 4: Block Modal of Neural Network

To build the neural network model that runs in MATLAB/Simulink, data on the photovoltaic array's output with variable BESS irradiance and SOC are utilized.

Simulink model of the neural network is where the current reference was found, and the error current is produced by comparing it to the input current of the AC grid. The duty cycle for the inverter is generated by the proportional-integral controller after it has processed the error current.

IV. WORKING OF CHARGING STATION

A. Working Modes:

- 1^{st} Modes: EV battery charging by PV array alone. In this mode, we vary the irradiance of the solar cells while keeping the temperature constant and extracting the maximum possible current from the solar array using a voltage-controlled AFIS strategy.
- 2^{nd} Modes It is only possible to utilize BESS to charge both the BESS and the EV battery when it is attached to a DC bus. ANFIS is applying a PV panel at MPPT.
- 3^{rd} Modes: EV batteries are charged using both the sun's energy and Battery energy storage system with a range of irradiance. ANFIS makes sure that the photovoltaic system can produce the most power possible.
- 4^{th} Modes: The electric vehicle's battery is charged via the alternating current grid and BESS at night when the photovoltaic system has no irradiance The movement of current in an alternating current (AC) network is managed by a functioning neural network.
- 5^{th} Modes: The PV array's irradiance and temperature are variable. The alternating modern grid receives any EV battery charging while a solar photovoltaic array, BESS, and AC grid are all associated greater electricity.

V. SIMULATION MODEL TEST RESULT AND DISCUSSION

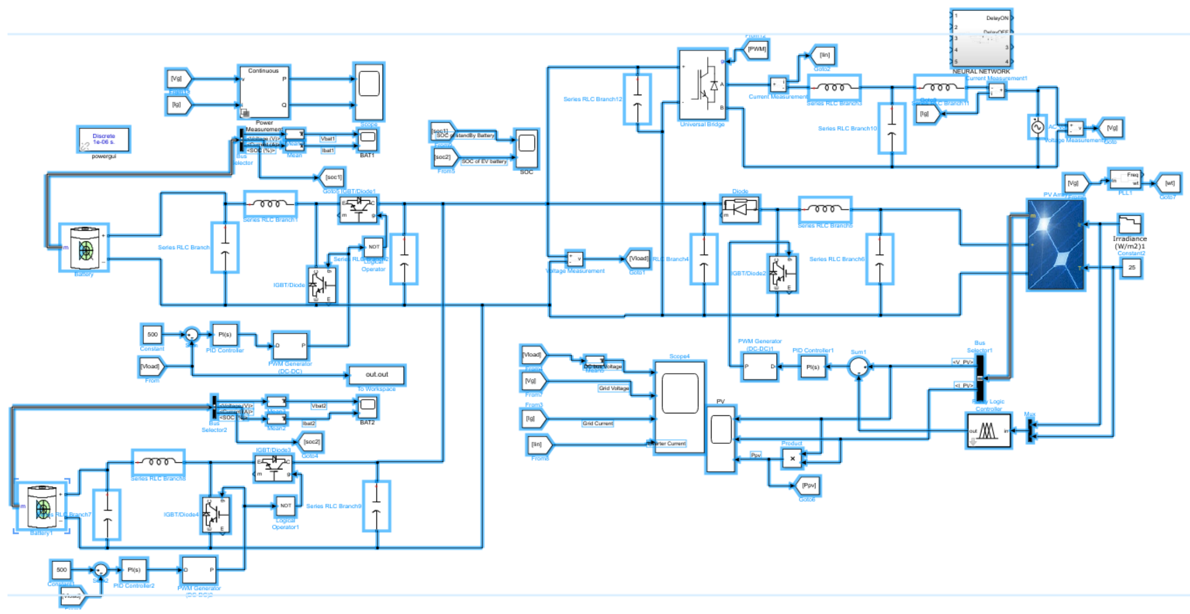


Figure :5 Simulation Model of Electric vehicle Charging Station

TEST RESULT AND DISCUSSION

Simulation model of electric vehicle charging station is shown in fig 5.The developed Simulink model is evaluated in a range of temperature and solar exposure situations. The neural network-based Simulink model of a charging station for electric vehicles powered by solar panels is shown in Fig 6.

A. PV Array Modal With ANFIS Controller Training:

With the help of the data from the PV array, the ANFIS voltage controller is trained. The relationship between temperature and irradiance and the voltage that exists at the point of greatest power is measured. After this data is imported, The subtractive clustering grid partition method is used to find the value for the membership for the inputs. 100 cycles of testing were used to train and evaluate the AFIS controller utilizing a hybrid learning method. Next, utilizing the test data, the ANFIS controller is assessed. A reference PV model is created from the ANFIS controller following thorough testing method..

B. 1^{st} Mode:

While maintaining a constant temperature of 250 C, the PV array's maximum irradiation of 1000 W/m2 generates 2000 W of power. The photovoltaic voltage remains constant but solar power varies with irradiance, allowing for the maximum amount of power to be harvested from the Photovoltaic array as shown in Fig. 6. Initial consideration is made for the EV's 9% SOC for simulation purposes. The battery is charging, as seen by the negative EV battery current in Fig.7.

C. 2nd Mode:

According to Fig.8, the BESS and EV batteries are both charged. With the greatest power possible from the PV array being extracted at various temperatures and irradiances, as shown in Fig 9.

D. 3rd Mode:

The photovoltaic array, Battery energy storage system, and electric vehicle (EV) battery are connected by a DC bus in Fig 10, which keeps a voltage of 500 volts while transferring power to a direct current (DC) bus that corresponds to the irradiance. To vehicle solar array temperatures fluctuate. Fig 11 shows how an electric vehicle battery is charged using a DC bus power supply and BESS. Shows the energy flow from BESS to EV battery expressed as a decrease in BESS %SOC (expressed in EV battery). % of SOC growing.

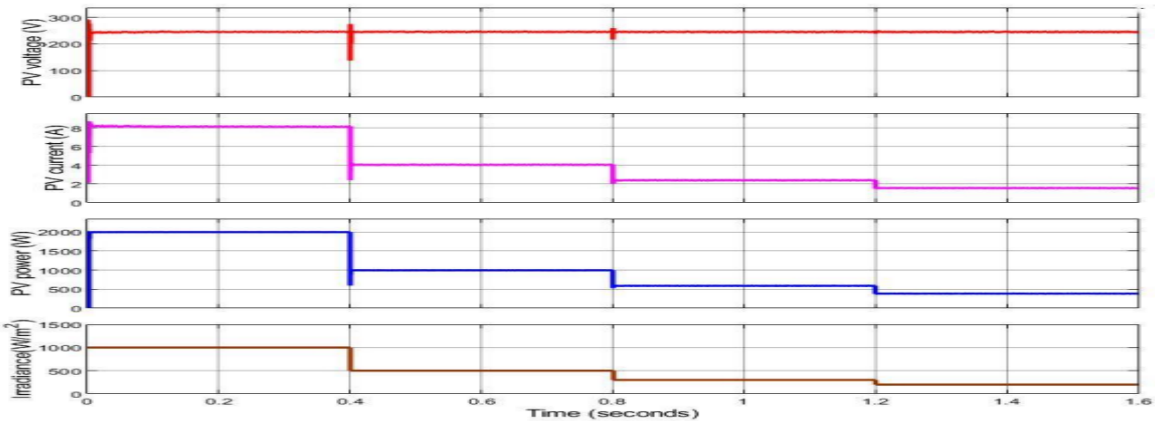


Figure: 6 PV Voltage, Current, Power, Irrdiance

E. 4th Mode:

As shown in Fig 12, approximately 0.1 s after the start of the simulation time, when the power output of the PV system reaches zero at night, the functioning neural network begins to control the current flow in the grid. The AC grid and DC bus are interconnected by an inverter. When the grid feeds the direct current (DC) bus, Fig 13 depicts the grid voltage and current passing through the inverter. The DC bus is utilized to recharge the batteries of electric vehicles, as seen in Fig 14..

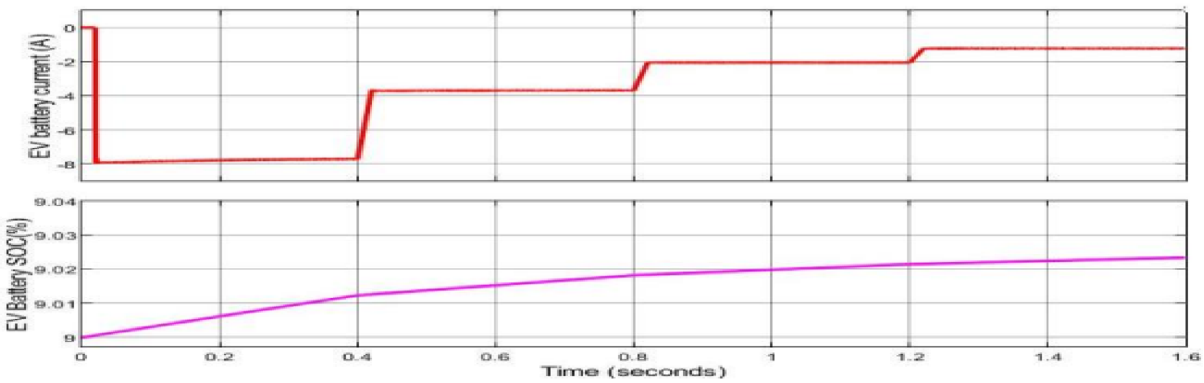


Figure: 7 %SOC and Electric Vehicle Battery Charging Current

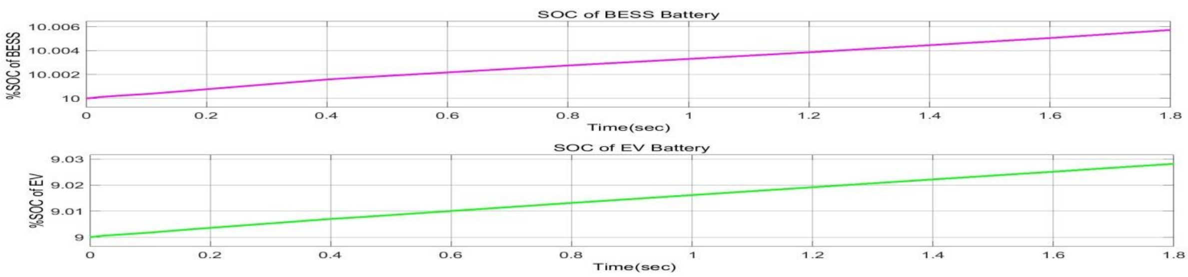


Figure: 8 %SOC of EV and % SOC of BESS

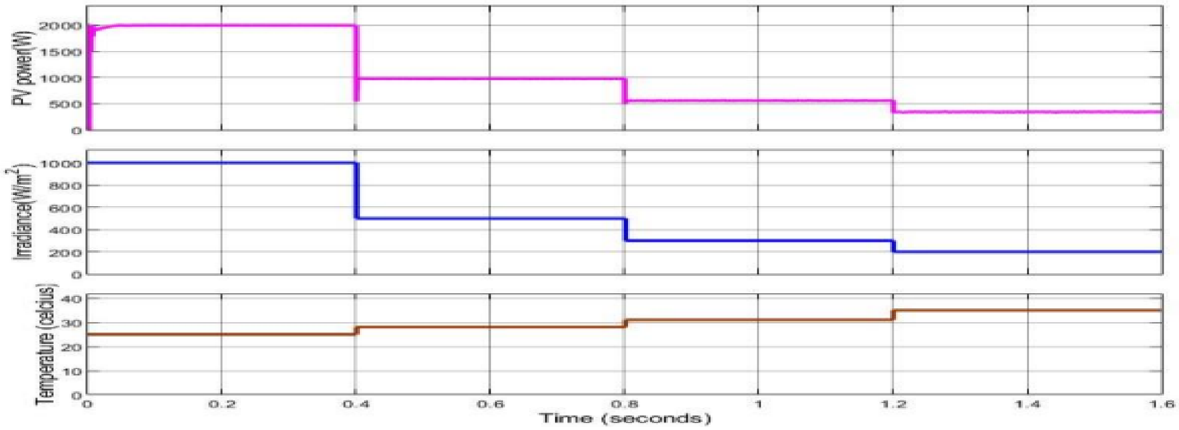


Figure : 9 Temperature and Irradiance and PV Power

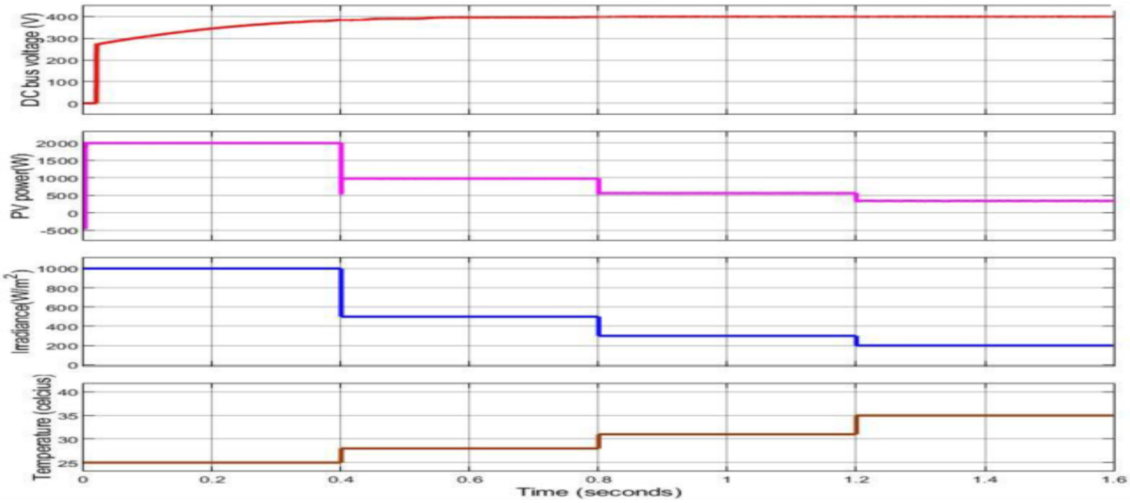


Figure: 10. Irradiance and Temperature of PV and DC Bus Voltage, PV output Power,

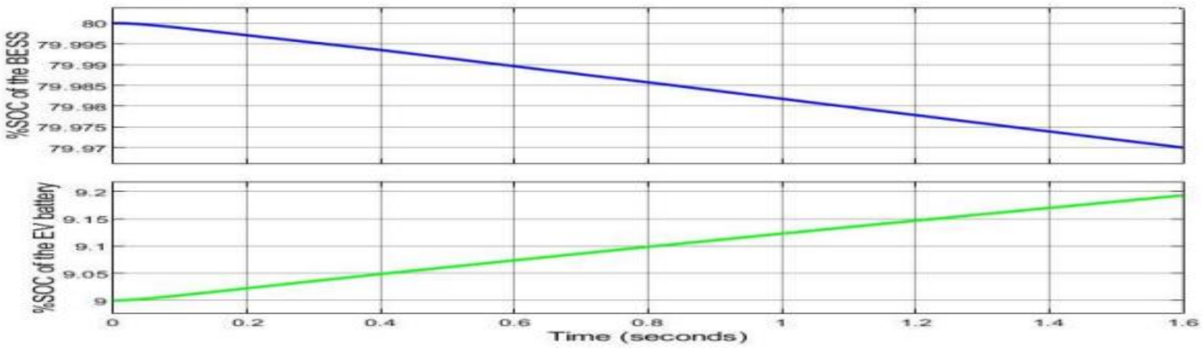


Figure : 11 % SOC Electric vehicle Battery and% SOC of BESS

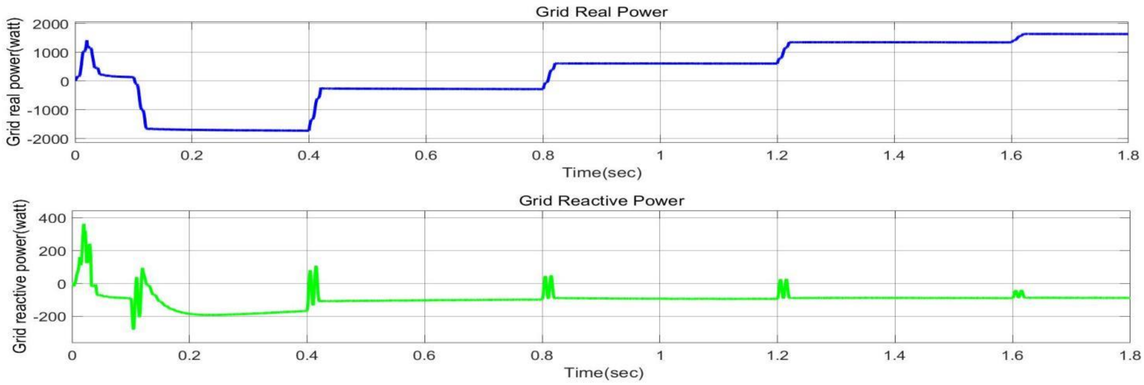


Figure: 12. Real and Reactive Power of AC Grid

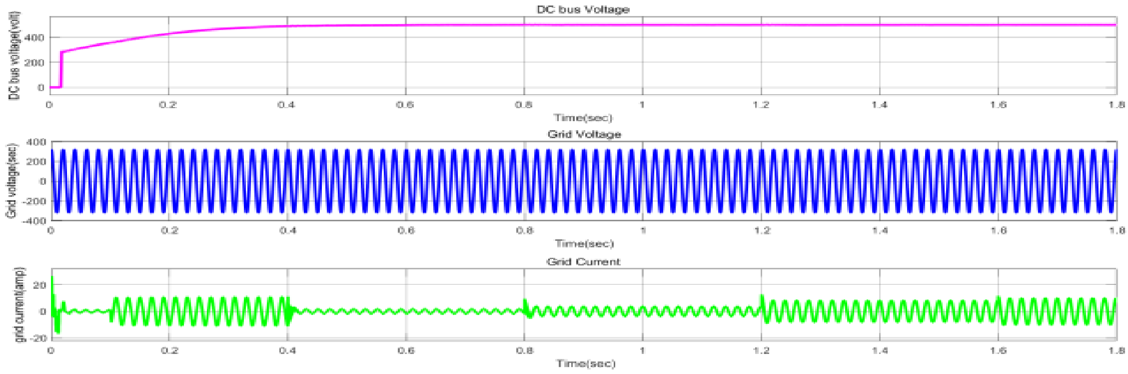


Figure: 13. DC Bus Voltage and ac Grid Voltage and Grid Current

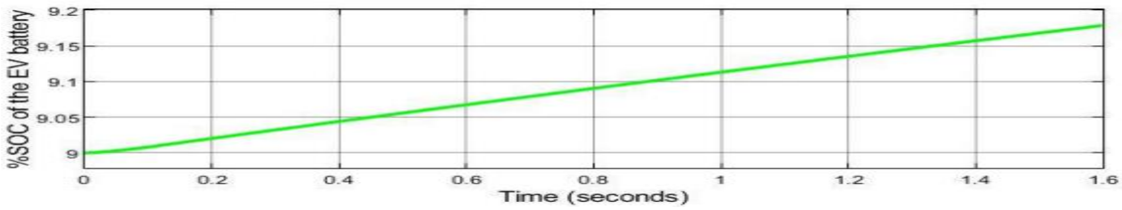
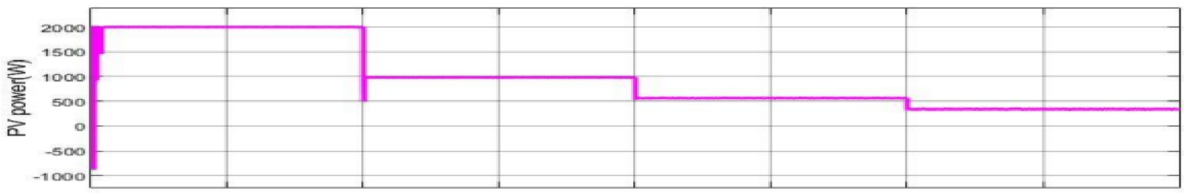
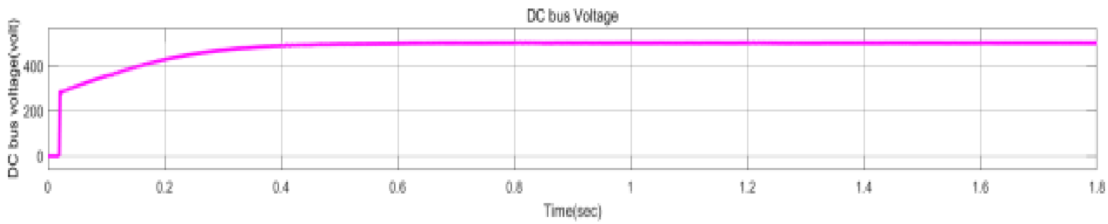


Figure :14. Charging of EV Battery

F. 5th Mode:

The alternating current grid power is first managed by the functionality fitting neural network at simulation time 0.1 seconds. Since the grid's real power is negative between simulation periods 0.1 and 0.4 seconds, as shown in Fig. 15, it is clear that electricity is being transferred into the alternating current (AC) system through a DC bus. Fig. 16 shows how BESS powers the direct current (DC) bus, which in turn charges the electric vehicle battery.





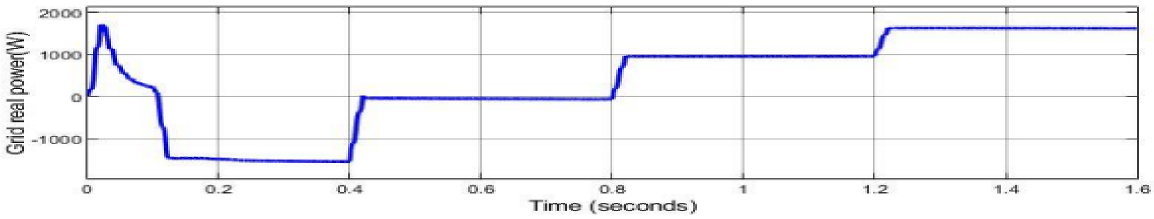


Figure: 15 PV Power, DC Bus Voltage and AC Grid Real Power

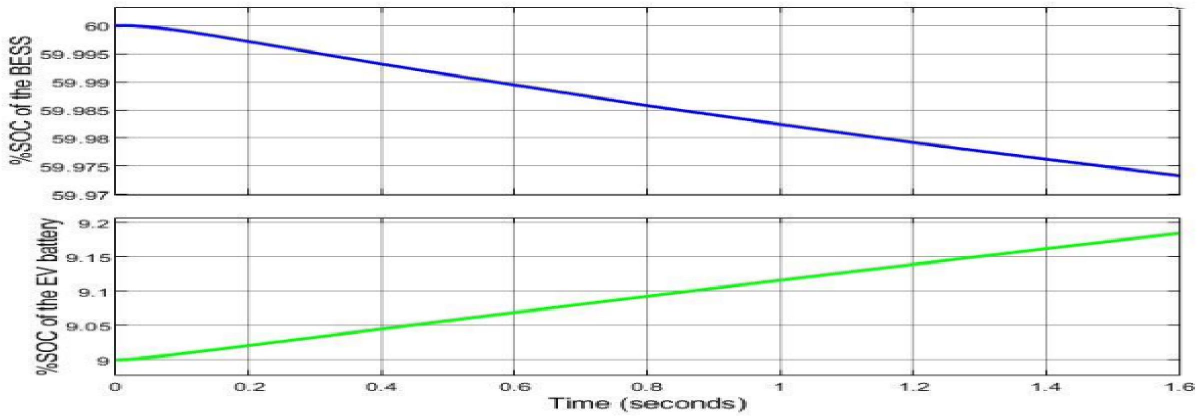


Figure :16. BESS powers supply to DC buses and charges EV batteries.

V. CONCLUSION.

- Neural networks, Proportional integral controllers, and ANFIS voltage regulation are combined to meet the evolving needs of all connected electric vehicles. The necessary performance can be attained by keeping a constant DC bus voltage. The station promises to maintain the bus voltage.
- When SOC of BESS is 10% and SOC of EV battery is 9% then both are charging mode and PV power is decreasing due to decrease the irradiance of PV array so power take from AC grid to manage the power .
- When SOC of BESS is 80% and SOC of EV 9% then BESS is also charge 80% but EV battery is charging mode and charging current also negative . when PV power extra generated due to higher irradiance so the power is feed to grid .
- In this two cases to observe when PV power is lower due to decrease irradiance so automatic power take from the AC grid to manage the constant power and it is feed to the DC grid for EV and BESS charging mode
- Finally conclusion power management strategy according to requirement power is give to grid when surplus power and when decrease the irradiance so PV power are also reduce in this time power take from grid and feed DC bus

REFERENCES

[1]. R. Irle, Global EV Sales for the 1st Half of 2019. EV Volumes. 2019
[2]. X. Sun, Z. Li and X. Wang, C. Li and "Technology Development of Electric Vehicles" A Review. Energies 2020, 13, 90.
[3]. NITI Ayoga report "Handbook for EV Charging Infrastructure Implementation,"
[4]. M.A.H. Rafi and J.A. Bauman, "Comprehensive Review of DC Fast Charging Stations with Energy Storage: Architectures, Power Converters, and Analysis," IEEE Trans. Transp. Electric. 2021
[5]. M. Yilmaz and P.T Krein, "Review of battery charger topologies, charging power levels, and infrastructure for plug-in electric and hybrid vehicles," IEEE Trans. Power Electron. 2013, 28, 2151–2169.
[6]. J. Francfort and S. Salisbury and J. Smart, T.Garetson and D. Karner, "Considerations for Corridor and Community DC Fast Charging Complex System Design," Idaho National Lab. (INL): Idaho Falls, ID, USA, 2017.
[7]. M. Nicholas and D. Hall, "Lessons Learned on Early Fast Electric Vehicle Charging Systems," The National Academies of Sciences, Engineering, and Medicine: Washington, DC, USA, 2018.
[8]. M. Fatnani and D. Naware, and A. Mitra, "Design of Solar PV Based EV Charging Station with Optimized Battery Energy Storage System," 2020 IEEE First International Conference on Smart Technologies for Power, Energy and Control (STPEC), 2020 pp. 1-5,
[9]. A. Verma and B. Singh, "An Implementation of Renewable Energy Based Grid-Interactive Charging Station," in 2019 IEEE Transportation Electrification Conference and Expo (ITEC), 2019, pp. 1–6
[10]. I. Colak and R. Bayindir and A. Aksoy, E. Hossain, and S. Sayilgan, "Designing a competitive electric vehicle charging station with solar PV and storage," 2015 IEEE International Telecommunications Energy Conference (INTELEC), 2015, pp. 1-6,
[11]. K. S. Vikas and B. Raviteja Reddy and S. G. Abijith and M. R. Sindhu, "Controller for Charging Electric Vehicles at Workplaces using Solar Energy," 2019 International Conference on Communication and Signal Processing (ICCSP), 2019, pp. 0862-0866,