MULTI CHARGING OPTIONS OF ELECTRICAL VEHICLE SOLAR PV-BATTERY, GRID CONNECTED AND DIESEL GENERATOR BASED ELECRICAL VEHICLE CHAGING STATION

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***Abstract*— In this paper, a solar photovoltaic (PV) array, a battery energy storage (BES), a diesel generator (DG) set, and a grid-based electric vehicle (EV) charging station (CS) is utilized to offer non-stop charging in islanded, grid-connected, and DG set connected modes. The CS rather uses a solar PV array and a BES to charge the EV battery However, if the storage battery is depleted or the solar PV array generation is unavailable. However, the power from DG set is drawn in a manner that it always operates at 80%–85% loading. Further still, it should be noted that point of common coupling voltage has to be synchronized with grid/generator voltage so as to provide incessant flow. Here, we are using PI, FUZZY and ANN controllers. By using controllers reduce the THD (total harmonic distortion) values. When reduce the THD, then increase efficiency.**

***Keywords*—EV Charging Station, Solar PV Generation, Controllers, Power Quality, DG Set.**

1. INTRODUCTION:

At the present, electric vehicles (EVs) are recognized as one of the most efficient modes of transportation with no back emission. Considering this advantage, 3 million vehicles have already been deployed onto the road and it is projected to exceed 100 million by 2030.

In this paper, a PV array, grid, energy storage and DG set supported CS is presented, which operates in islanded, grid connected and DG set connected modes. This allows for usage of the energy generated by the PV array in all operating conditions. MATLAB/SIMULINK software has been used to design charging station. Conversely, the DG set is subjected to loads that are at least 80% of its rated value because the EV charger requires reactive currents as well as harmonics which are supplied by voltage source converter (VSC). The PI, FUZZY and ANN controller are used to reduce the THD. Then increase the efficiency. Therefore, this research presents a PV array, grid and energy storage system and DG set supported CS which operates in islanded, grid connected and DG set connected modes so that the PV array energy is utilized for all operating conditions.

2. SOLAR PHOTOVOLTAICS

The Energy conversion devices which are used to convert sunlight to electricity by the use of the photo-voltaic effect are called solar cells. These arrays, which are made up of thousands of individual cells, can serve as central power plants that distribute electrical energy produced by sunlight to consumers in the commercial, residential, and industrial sectors.

Silicon is used to create the vast majority of solar cells, and as silicon forms vary from amorphous (non-crystalline) to polycrystalline to crystalline (single crystal), the technology is becoming more and more efficient and less expensive. In contrast to batteries or fuel cells, solar cells don't need fuel or rely on chemical reactions to generate electricity. Moreover, they are completely mechanically inert, unlike electric generators.

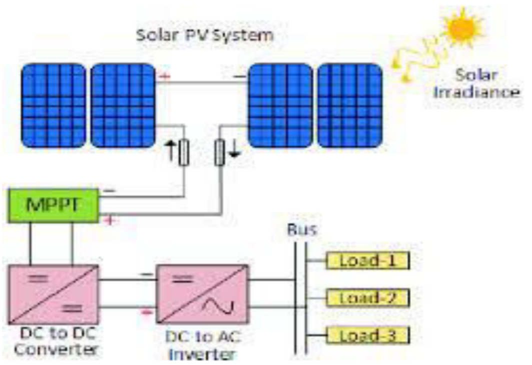


Fig: Solar Photovoltic

2.1 Solar Cell Characteristics

The current-to-voltage characteristic, the power-to-voltage characteristics of a solar cell are non-linear, which make it difficult to determine the maximum power point. It is straightforward to determine the maximum power point on a linear curve as maximum power is transferred at the midpoint of the current-voltage characteristic. A typical V-I characteristic of solar cell is shown in Fig

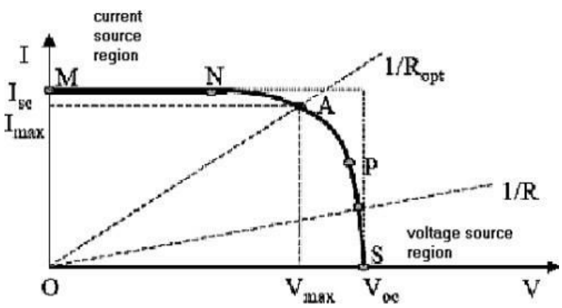


Fig: solar cell characteristics

3.BATTERY

The battery stores energyin electrochemical form and is the most widely used tool for storing energy in branching packs. The main types of electrochemical batteries are cannot reverse the electrochemical reaction in a primary battery, and the battery is discarded after a complete discharge.

Secondary battery is another name for rechargeable battery. This battery type converts chemical energy to electrical energy. The electrochemical reaction inside the secondary battery is reversible. Once discharged, can recharge it from an external supply with immediate modern-day injection. The internal output of a typical electrochemical mobile is shown in the picture. It has nice and awesome electrode plates with insulating separators and a chemical electrolyte in the middle

TABLE: Average Cell Voltage during Discharge in

Electrochemistry	Cell Volts	Remark
Lead-acid	2.0	Least-cost technology
Nickel-cadmium	1.2	Exhibits memory effect
Nickel-metal hydride	1.2	Temperature sensitive
Lithium-ion	3.6	Safe, contains no metallic lithium
Lithium-polymer	3.0	Contains metallic lithium
Zinc-air	1.2	Requires good air management to limit self-discharge rate

Different Rechargeable Batteries

3.1 Types of Battery

There are at six major rechargeable electro-chemistries available today. They are as follows:

- Lead-acid (Pb-acid)
- Lithium-ion (Li-ion)
- Nickel-cadmium (NiCd)
- Nickel-metal hydride (NiMH)
- Lithium-polymer (Li-poly)
- Zinc-air

4.CONVERTERS:

Basically, An AC-DC bidirectional converter is a power electronic device capable of converting electrical power bidirectionally between alternating current (AC) and direct current (DC) forms. It allows energy to flow in both directions, enabling power transfer from AC to DC and vice versa. These converters are commonly used in applications such as renewable energy systems, energy storage systems, electric vehicle charging, and grid-tied systems where energy needs to be efficiently managed and transferred between AC and DC sources. These are the forms of signals needed for variable frequency drives (VFDs), uninterruptible power supplies (UPSs), static var compensators (SVCs), active filters, FACTS, and voltage regulators. For a sine wave ac output; we need to be able to control amplitude, frequency as well as phase. Based on the type of ac output waveform, these topologies can be classified as voltage source inverters (VSIs), where the independent controlled ac output is a voltage waveform.

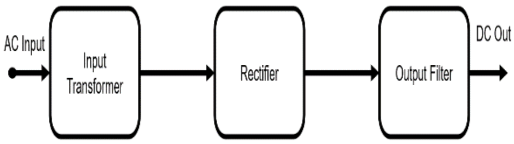


Fig: Simulation diagram of Speed controlof DC Motor without controller

4.1 TYPES OF INVERTERS:

Here Generally inverters are of Two Types:

1. VOLTAGE SOURCE INVERTER

2. CURRENT SOURCE INVERTER

1. VOLTAGE SOURCE INVERTER

A Voltage Source Inverter (VSI) is a power electronic device used to convert DC power to AC power. It's a crucial component in various applications including renewable energy systems, motor drives, and uninterruptible power supplies.

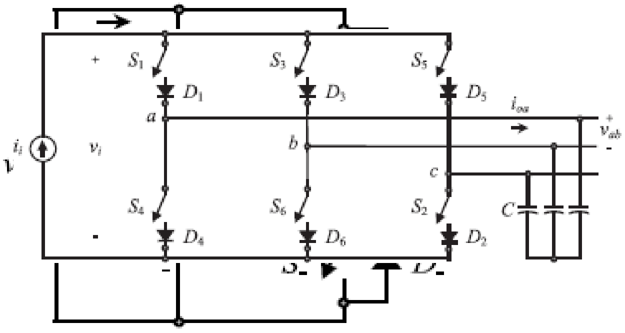


Fig Single-phase half-bridge VSI.

2. CURRENT SOURCE INVERTER

A dc power flow, these static power converters generate ac output current waveforms. For sinusoidal ac outputs, its magnitude, frequency, and phase should be controllable. Due to the fact that the ac line currents ioa, iob, andioc feature high di=dt, a capacitive filter should be connected at the ac terminals in inductive load applications (such as ASDs).

Fig: Current source inverter

Should be closed at any time; however it cannot be opened because the dc bus is of the current-source type hence there must be one top switch and another bottom switch. Although both constraints can be expressed concisely as 'at each instant only one top switch and one bottom switch shall close. Three-phase CSIs have nine admissible states which yield zero ac line currents. In this case either through S1-S4 or S3 –S6 or through S5-S2, freewheels dc link current.

5.CONTROLLERS

5.1 ARTIFICIAL NEURAL NETWORKS

Artificial neural networks, also called “artificial neuron nets”, “neuron nets” or simply ANN are computational tools that emulate the connections within a neuron in the nervous system of humans and other animals. Among the several types of non-linear processing systems, artificial neural nets remain as one type suitable for a variety of tasks, particularly when there is no already existing algorithm for solving a task. ANNs can be trained to solve particular problems.

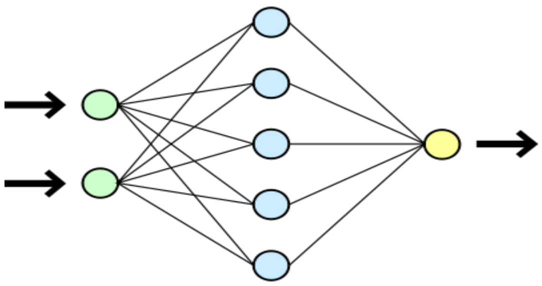


Fig: A Neural network

Most Neural Networks began with just one model neuron. Such kind of neuron possesses several inputs together with only one output for all these inputs. Every value of input is multiplied by weight attached before using it.

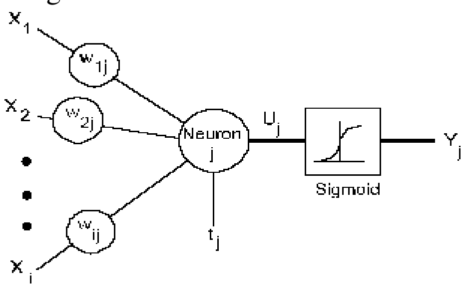


Figure 5.2. A Model Neuron

Learning in a neural network is called *training*. Just like athletics training, training for neural networks needs a coach who tells it what should have been its response. Simulation results are obtained using electromagnetic transient program EMTDC for 230 kV power system and various types of faults on different system conditions and parameters.

5.2 PI CONTROLLER

PI (Proportional and Intergal) Controller, which is a widely used technique in the control system to correct in-error between commanded set point with actual value based on a feedback of some sort.

5.3 FUZZY LOGIC CONTROLLER

Fuzzy controllers are very simple conceptually. Comprising input stage, processing stage and output stage. Input Stage maps sensor or other inputs such as switches thumbwheel etc into relevant membership functions and truth values.

Here, we are using some fuzzy rules, there are;

Fuzzy Rules

[System]

Name='fifthwithfuzzy'

Type='mamdani'

Version=2.0

NumInputs=2

NumOutputs=1

NumRules=25

AndMethod='min'

OrMethod='max'

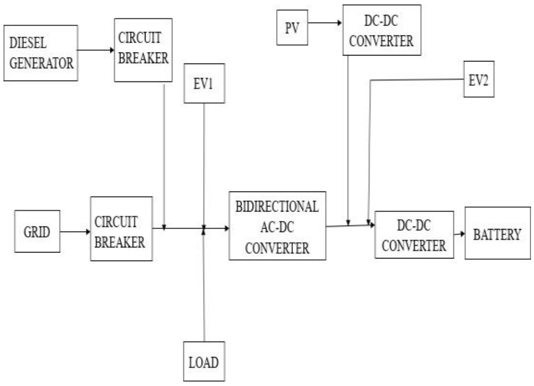
ImpMethod='min'

AggMethod='max'

DefuzzMethod='centroid'

6. SYSTEM DESCRIPTION

6.1 BLOCK DIAGRAM



6.2 CIRCUIT DESCRIPTION

The presented of CS as diesel generator and 2 circuit breaker and a Pv array and two dc-dc converters and two electric vehicle loads where they are named as EV1 And EV2 and a load. Where the bidirectional converter is used to convert from ac-dc(rectifier) and as well as dc-ac(inverter). Here the battery used is a energy storage battery.

a solar PV array, a storage battery, a DG set, and grid energy to charge the EV and to feed the load connected to the CS. The solar PV array is connected at dc link of the VSC through a boost converter and a storage battery is connected directly to dc link. The grid, a single phase self-excited induction generator (SEIG), an EV, and a nonlinear load are connected on the ac side of the VSC through a coupling inductor.

6.3 CONTROL STRATEGIES

This discusses as many control strategies in the CS.

A. <u>Control of the VSC in Islanded Mode (Absence of DG Set and Grid)</u>

The CS is landed control mechanism guarantees the system's steady functioning in the event of a grid outage, maintaining uninterrupted solar power generation and both ac and dc EV charging. Without requiring significant management modifications, the storage battery can handle both the DC charging and the solar PV generating

$$i_c^*(s) = i_c^*(s-1) + z_{\text{pv}}\{v_{\text{ce}}(s) - v_{\text{ce}}(s-1)\} + z_{\text{iv}} v_{\text{ce}}(s).$$

B. Control of the VSC in Diesel Generator Set or Grid-Connected Mode

In the grid-connected mode, the controller task is to decide the amount of power to be exchanged with the grid. In DG set connected mode, DG set operates in constant power mode for achieving maximum fuel efficiency.

$$I_{\text{sp}} = I_p - I_{\text{ef2}} - I_{\text{pf}}$$
$$I_{\text{sq}} = 0.$$

and

$$I_{\text{sp}} = I_p - I_{\text{ef2}} - I_{\text{fp}} - I_{\text{pf}}$$
$$I_{\text{sq}} = I_{\text{vq}} - I_q$$

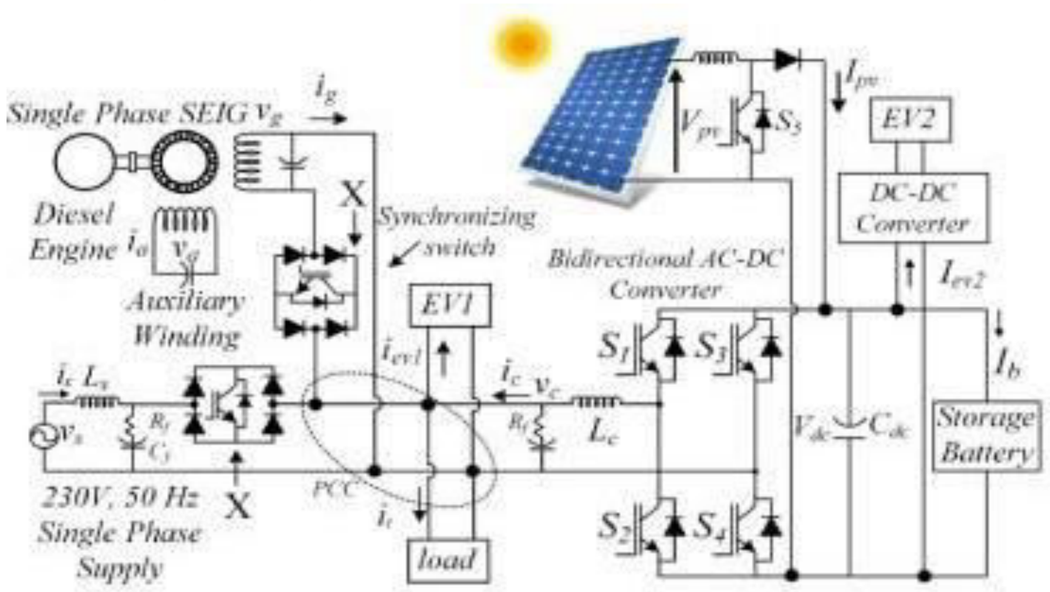


Fig: Topology of a CS.

C. Voltage and Frequency Control for DG Set

For operating the DG set at single point, the frequency and voltage of the DG set are regulated using decoupled control of the VSC. In decoupled control, the frequency is regulated by the active power and the voltage is regulated by reactive power. Therefore, two PI controllers are used for voltage and frequency regulations. Given that voltage regulation is carried out by PI control.

$$I_{vq}(s) = I_{vq}(s-1) + z_{vp}\{V_{me}(s) - V_{me}(s-1)\} + z_{vi}V_{me}(s)$$

$$I_{fp}(s) = I_{fp}(s-1) + z_{fp}\{f_e(s) - f_e(s-1)\} + z_{fi}f_e(s)$$

$$I^{*}_{ev2}(s) = I^{*}_{ev2}(s-1) + z_{evp}\{V_{er}(s) - V_{er}(s-1)\} + z_{evi}V_{er}(s)$$

where Ver is the EV battery voltage error and zevp and zevi are the controller gains. Using the reference and sensed battery currents, the switching signals of the converter are derived using the PI controller and pulsewidth modulation generator. The PI controller for duty cycle calculation is expressed as

$$d_{ev}(s) = d_{ev}(s-1) + z_{ep}\{I_{er}(s) - I_{er}(s-1)\} + z_{ei}I_{er}(s)$$

7.MATLAB & SIMULATION RESULTS

7.1 CIRCUIT DESCRIPTION

7.2 SIMULATION RESULT

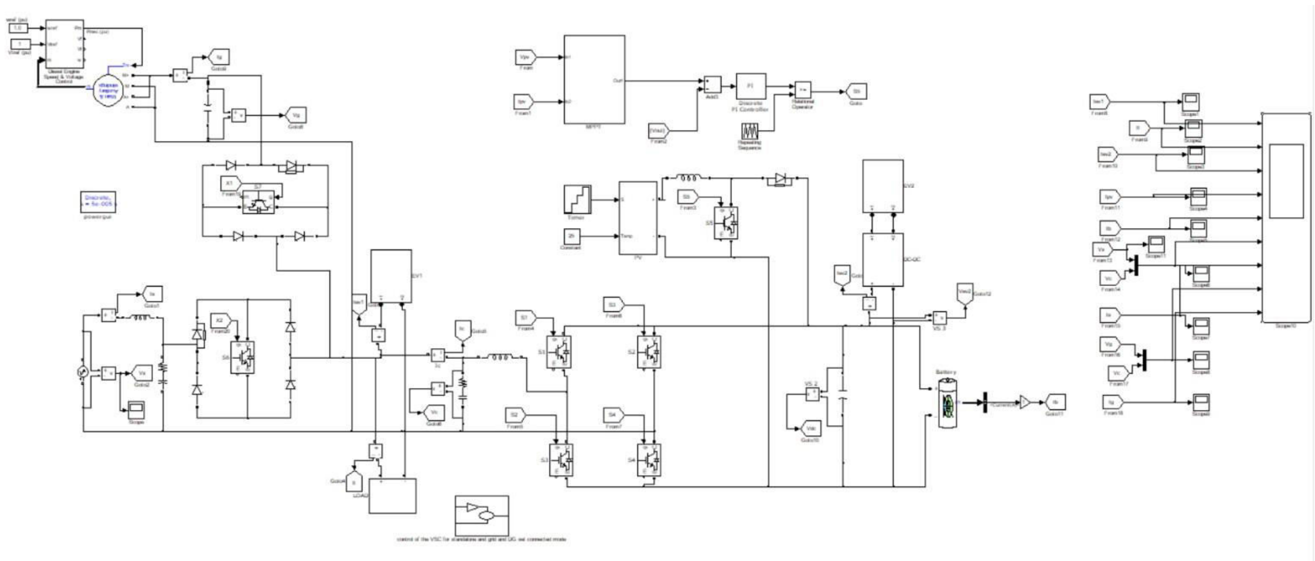
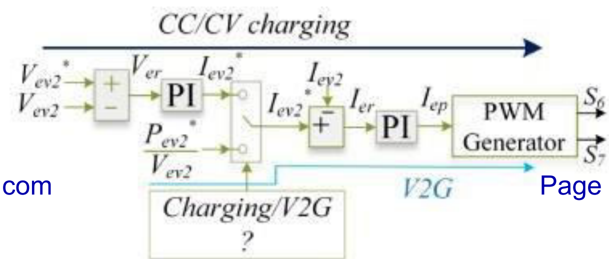


Fig: MATLAB Circuit Design



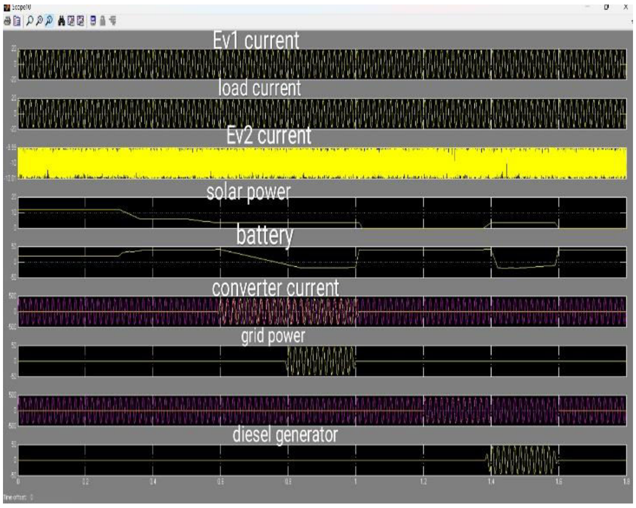
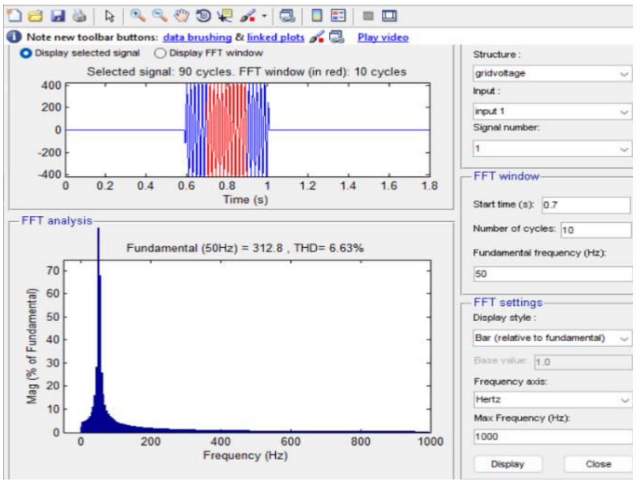


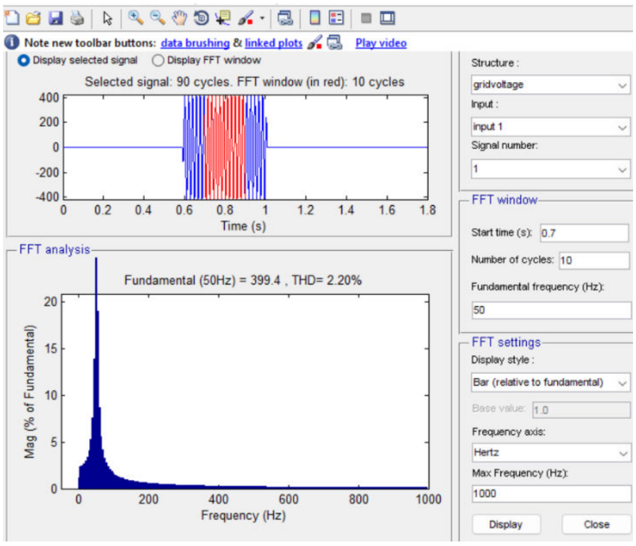
Fig: MATLAB Simulation Result

7.3 MATLAB SIMULATION CONTROLLERS RESULT

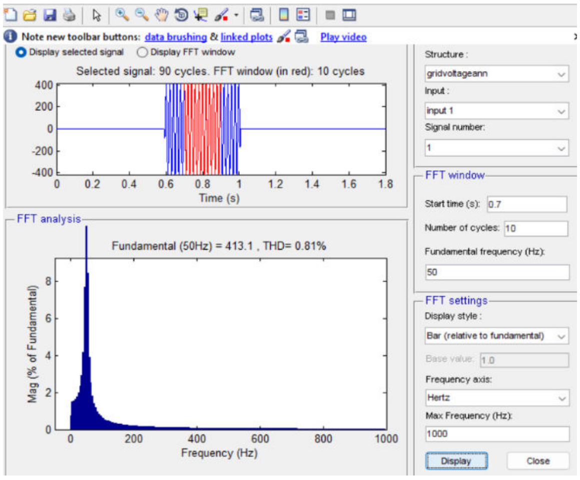
7.3.1 PI CONTROLLER



7.3.2 FUZZY CONTROLLER



7.3.3 ANN CONTROLLER



Comparation Between the Controllers

Controllers	Proportional and Integration (PI)	Fuzzy Logic	ANN Weight's
THD Total Harmonic Distortion	6.63%	2.20%	0.81%

8. CONCLUSIONS:

The EV charging, a PV array, a storage battery, a grid, and a DG set-based CS have all been put into practice. The results that have been given have confirmed that the CS can operate in three different modes: islanded operation, grid-connected, and DG set connected—all with a single VSC. The test findings have also confirmed that the CS functions satisfactorily under a variety of steady-state and dynamic situations brought on by variations in solar irradiation, EV charging current, and loading. The findings shown confirm that CS can operate as a stand-alone generator with good voltage quality, while test results in the DG set or grid connected mode have confirmed the capability of ANC-based. Moreover, the islanded, grid-connected, and DG set connected operations along with the automatic mode switching have increased the probability of maximum power point (MPP) operation of the PV array and It improves charging reliability while optimizing DG set loading.

The IEEE compliance operation of the CS with voltage and current THD always less than 5% verifies the effectiveness of the control. Form the above mentioned point, it can be concluded that this CS with the presented control have the capability to utilize the various energy sources very efficiently and They give constant and cheap charging of EVs.

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