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Implementation of Solar PV-Battery & Diesel Generator Based Electric Vehicle Charging Station

Mr.K.Trinadh Babu , Mr.Pisini Raghuvarma , Mr.Gorle Bhaskararao , Ms.Nekkala Bhagya Laxmi Bhavana , Ms.Gonapa Laharika , Mr.Medi Nithish

[1]Mr.K.Trinadh Babu , M.E(Ph.D) , Assisstant Professor , Department Of Electrical and Electronics Engineering , Anil Neerukonda Institute Of Technologies And Sciences[ANITS]

[2]Mr.Pisini Raghuvarma , Student , Department Of Electrical and Electronics Engineering , Anil Neerukonda Institute Of Technologies And Sciences [ANITS]

[3]Mr.Gorle Bhaskararao, Student , Department Of Electrical and Electronics Engineering , Anil Neerukonda Institute Of Technologies And Sciences [ANITS]

[4]Ms.Nekkala Bhagya Laxmi Bhavana, Student , Department Of Electrical and Electronics Engineering , Anil Neerukonda

Institute Of Technologies And Sciences [ANITS]

[5]Ms.Gonapa Laharika , Student , Department Of Electrical and Electronics Engineering , Anil Neerukonda Institute Of Technologies And Sciences [ANITS]

[6]Mr.Medi Nithish , Student , Department Of Electrical and Electronics Engineering , Anil Neerukonda Institute Of Technologies And Sciences [ANITS]

Abstract:- In this project, to provide incessant charging during islanded, grid-connected and DG-connected modes, a solar PV (Photovoltaic) array, a Battery Energy Storage (BES), a Diesel Generator (DG) set and a grid-based EV Charging Station (CS) are used .The charging station is mainly designed to charge the Electric Vehicle (EV) battery using a solar Photo Voltaic (PV) array and a BES. However, the charging station intelligently takes power from the grid or DG (Diesel Generator) set in the event of an empty storage battery and inaccessible solar PV array generation. However, in order to achieve optimum fuel efficiency under all loading conditions, the power from the DG collection is drawn in a way that often operates at 80-85% loading. In addition, the charging station controls generator voltage and frequency without a mechanical speed controller in conjunction with the storage battery. In addition, to obtain ceaseless charging, the PCC (Point of Common Coupling) voltage is synchronized to the grid/generator voltage. In order to improve the operating efficiency of the charging station, the charging station also conducts the vehicle to grid active/ reactive power transfer, vehicle to home and vehicle to vehicle power transfer. Using the Matlab/Simulink software, the operation of the charging station is validated.

Key Words:- Solar PV system,battery storage,diesel generation,electric vehicle charging points,power conversion and control

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1.INTRODUCTION:-

1.1.Objective:-

The primary objective of this project is to design and implementation of solar pv-battery and diesel generator based electric vehicle charging station. The project aims to provide incessant charging during islanded,grid connected and DG connected modes. Key objectives include developing the necessary infrastructure, such as solar power generation and pv power system,electric energy storage system,grid support,Dg set.

EVs nowadays are also used as a distributed energy resource for providing various ancillary services due to the huge amount of energy stored in EV batteries. Singh et al. have presented a PV array based CS for providing charging facility along-with the vehicle-to-grid reactive/active power, active power filtering and vehicle-to-home. Saxena et al. have implemented a grid tied PV array system for EV and residential application. Razmi et al. have proposed the power management strategy with multi-mode control of an integrated residential PV-storage battery system for both grid-connected and islanded operation. Erdinc et al.

1.2.Description:-

Designing an electric vehicle (EV) charging station powered by a combination of solar photovoltaic (PV) panels, battery storage, and a diesel generator involves a carefully planned system that ensures reliable, sustainable, and efficient energy supply. Here's a description of how such a system could be implemented.

This hybrid solar PV-battery-diesel generator EV charging station represents a sustainable and resilient approach to meeting the energy demands of electric vehicles, particularly in areas with unreliable grid access or where reducing carbon emissions is a priority.

1.3.Focus Of The Project:- The focus of your project is on implementing an electric vehicle (EV) charging station powered by a hybrid system consisting of solar photovoltaic (PV) panels, a battery storage system, and a diesel generator. This setup aims to provide a reliable and sustainable energy source for EV charging, leveraging renewable energy while ensuring consistent availability through battery storage and backup power from the diesel generator.

2.COMPONENTS:-

2.1.Operation with Batteries:-

At night, an off-grid PV system may use batteries to supply loads. Although the fully charged battery pack voltage may be close to the PV panel's maximum power point voltage, this is unlikely to be true at sunrise when the battery has been partially discharged. Charging may begin at a voltage considerably below the PV panel maximum power point voltage, and an MPPT can resolve this mismatch.

When the batteries in an off-grid system are fully charged and PV production exceeds local loads, an MPPT can no longer operate the panel at its maximum power point as the excess power has no load to absorb it. The MPPT must then shift the PV panel operating point away from the peak power point until production exactly matches demand. (An alternative approach commonly used in spacecraft is to divert surplus PV power into a resistive load, allowing the panel to operate continuously at its peak power point.)

In a grid connected photovoltaic system, all delivered power from solar modules will be sent to the grid. Therefore, the MPPT in a grid connected PV system will always attempt to operate the PV modules at its maximum power point.

The presented charging station,uses a solar PV array, a storage battery, a DG set and grid energy to charge the EV and to feed the load connected to charging station. The solar PV array is connected at DC link of voltage source converter (VSC) through a boost converter and a storage battery is connected directly to DC link. The grid, a single phase SEIG (Self Excited Induction Generator), an EV and a nonlinear load, are connected on the AC side of VSC through a coupling inductor. A ripple filter at PCC, is used to eliminate the switching harmonics from the grid and the generator current and to make these currents sinusoidal. An excitation capacitor is connected to the auxiliary winding of the SEIG. A small capacitor is also connected across the main winding of the SEIG. A synchronizing switch is used between grid/DG set and PCC for controlled connection/ disconnection of charging station to grid/DG set.

2.2. DG - Set :-

A diesel generator is the combination of a diesel engine with an electric generator (often an alternator) to generate electrical energy. This is a specific case of engine-generator. A diesel compression-ignition engine often is designed to run on fuel oil, but some types are adapted for other liquid fuels or natural gas.

Diesel generating sets are used in places without connection to a power grid, or as emergency power-supply if the grid fails, as well as for more complex applications such as peak-lopping, grid support and export to the power grid.

Proper sizing of diesel generators is critical to avoid low-load or a shortage of power. Sizing is complicated by the characteristics of modern electronics, specifically non-linear loads. In size ranges around 50 MW and above, an open cycle gas turbine is more efficient at full load than an array of diesel engines, and far more compact, with comparable capital costs; but for regular part-loading, even at these power levels, diesel arrays are sometimes preferred to open cycle gas turbines, due to their superior efficiencies.

The packaged combination of a diesel engine, a generator and various ancillary devices (such as base, canopy, sound attenuation, control systems, circuit breakers, jacket water heaters and starting system) is referred to as a "generating set" or a "genset" for short.

Set sizes range from 8 to 30 kW (also 8 to 30 kVA single phase) for homes, small shops and offices with the larger industrial generators from 8 kW (11 kVA) up to 2,000 kW (2,500 kVA three phase) used for large office complexes, factories. A 2,000 kW set can be housed in a 40 ft (12 m) ISO container with fuel tank, controls, power distribution equipment and all other equipment needed to operate as a standalone power station or as a standby backup to grid power. These units, referred to as power modules are gensets on large triple axel trailers weighing 85,000 pounds (38,555 kg) or more. A combination of these modules are used for small power stations and these may use from one to 20 units per power section and these sections can be combined to involve hundreds of power modules. In these larger sizes the power module (engine and generator) are brought to site on trailers separately and are connected together with large cables and a control cable to form a complete synchronized power plant. A number of options also exist to tailor specific needs, including control panels for autostart and mains paralleling, acoustic canopies for fixed or mobile applications, ventilation equipment, fuel supply systems, exhaust systems, etc. Diesel generators, sometimes as small as 200 kW (250 kVA) are widely used not only for emergency power, but also many have a secondary function of feeding power to utility grids either during peak periods, or periods when there is a shortage of large power generators.

Ships often also employ diesel generators, sometimes not only to provide auxiliary power for lights, fans, winches etc., but also indirectly for main propulsion. With electric propulsion the generators can be placed in a convenient position, to allow more cargo to be carried. Electric drives for ships were developed prior to World War I. Electric drives were specified in many warships built during World War II because manufacturing capacity for large reduction gears was in short supply, compared to capacity for manufacture of electrical equipment. Such a diesel-electric arrangement is also used in some very large land vehicles such as railroad locomotives.

2.3.Solar Panel:-

Photovoltaic solar panels are composed of solar cells organized in patterns of 32, 36, 48, 60, 72, or 96 cells. The voltage produced by the cells depends on their configuration. For instance, a 32-cell panel may output 14.72 volts (0.46 volts per cell). The power generated by a solar panel is determined by the equation P (power) = V (voltage) x I (current). Solar panels come in various sizes for commercial and residential installations.

Solar panels absorb energy from the sun's rays, and the energy is transferred to the semiconductor, creating an electric field that generates voltage and current. The voltage remains relatively constant, but the current can vary based on the amount of light. To increase solar power capacity, multiple solar panels can be connected in series, raising the system's voltage. Series connections are used when a grid-connected inverter or charge controller requires 24 volts or more. To wire panels in series, connect the positive terminal of one panel to the negative terminal of the next panel. In conclusion, using solar energy for homes is a sustainable and efficient way to harness the sun's power and increase our reliance on renewable energy sources.

2.4. Battery:-

A battery is an electrochemical device that stores chemical energy and converts it into electrical energy when needed. It typically consists of one or more cells, each containing two electrodes (an anode and a cathode) separated by an electrolyte. When connected to an external circuit, a chemical reaction occurs within the battery, causing electrons to flow from the anode to the cathode, generating electricity.

Batteries are available in various types, including alkaline, lithium-ion, lead-acid, nickel-metal hydride, and lithium polymer, each with unique characteristics suited for specific applications. Alkaline batteries, for example, are commonly used in household devices, while lithiumion batteries power portable electronics like smartphones and laptops. Rechargeable batteries, such as lithium-ion and nickel-metal hydride, can be recharged multiple times, offering cost-effective and environmentally friendly energy solutions.

Batteries are essential for powering a wide range of devices, from small consumer electronics to electric vehicles and renewable energy storage systems, driving innovation in many industries as research continues to improve battery performance, safety, and sustainability.

2.5.Grid support:- Emergency standby diesel generators, for example such as those used in hospitals, water plant, are, as a secondary function, widely used in the US and, in the recent past, in Great Britain to support the respective national grids at times for a variety of reasons. In the UK the tenders known as the Short Term Operating Reserve have exhibited quite variable prices, and from 2012 the volume of demand-side participation, which mainly entails the use of on-site diesels, has dropped as the tendered prices fell. Some 0.5 GWe of diesels have at times been used to support the National Grid, whose peak load is about 60 GW. These are sets in the size range 200 kW to 2 MW. This usually occurs during, for example, the sudden loss of a large conventional 660 MW plant, or a sudden unexpected rise in power demand eroding the normal spinning reserve available.

This is beneficial for both parties - the diesels have already been purchased for other reasons; but to be reliable need to be fully load tested. Grid paralleling is a convenient way of doing this. This method of operation is normally undertaken by a third party aggregator who manages the operation of the generators and the interaction with the system operator.

These diesels can in some cases be up and running in parallel as quickly as two minutes, with no impact on the site (the office or factory need not shut down). This is far quicker than a base load power station which can take 12 hours from cold, and faster than a gas turbine, which can take several minutes. Whilst diesels are very expensive in fuel terms, they are only used a few hundred hours per year in this duty, and their availability can prevent the need for base load station running inefficiently at part load continuously. The diesel fuel used is fuel that would have been used in testing anyway.

In Great Britain, National Grid can generally rely upon about 2 GW of customer demand reduction via back-up diesels being self-dispatched for about 10 to 40 hours a year at times of expected peak national demand. National Grid does not control these diesels - they are run by the customer to avoid "triad" transmission network use of system (TNUoS) charges which are levied only on consumption of each site, at the three half-hours of peak national demand. It is not known in advance when the three half-hours of peak national demand (the "triad" periods) will be, so the customer must run his diesels for a good deal more half-hours a year than just three. The total capacity of reliably operable standby generation in Britain is estimated to be around 20 GW, nearly all of which is driven by diesel engines. This is equivalent to nearly 29% of the British system peak, although only a very small fraction will ever be generating at the same time. Most plant is for large offices blocks, hospitals, supermarkets, and various installations where continuous power is important such as airports. Therefore, most is in urban areas, particularly city and commercial centers. It is estimated that around 10% of plant exceeds 1 MW, about 50% is in the 200 kW-1 MW range, and the remaining 40% is sub-200 kW. Although it is growing, only a very small proportion is believed to be used regularly for peak lopping, the vast majority just being only for standby generation. The information in this paragraph is sourced from section 6.9 of the government report: "Overcoming Barriers to Scheduling Embedded Generation to Support Distribution Networks"

A similar system to Great Britain's Short Term Operating Reserve operates in France. It is known as EJP; at times of grid stress, special tariffs can mobilize at least 5 GW of diesel generating sets to become available. In this case, the diesels prime function is to feed power into the grid.

During normal operation in synchronization with the electricity net, power plants are governed with a five percent droop speed control. This means the full load speed is 100% and the no load speed is 105%. This is required for the stable operation of the net without hunting and dropouts of power plants. Normally the changes in speed are minor. Adjustments in power output are made by slowly raising the droop curve by increasing the spring pressure on a centrifugal governor. Generally this is a basic system requirement for all power plants because the older and newer plants have to be compatible in response to the instantaneous changes in frequency without depending on outside communication.

2.6.Controller:- This is not desirable to overcharge and under discharge a lead acid battery. Both overcharging and under discharging can badly damage the battery system. To avoid these both situations a controller is required to attach with the system to maintain flow of current to and fro the batteries. Inverter It is obvious that the electricity produced in a solar panel is DC. Electricity we get from the grid supply is AC. So for running common equipment from grid as well as solar system, it is required to install an inverter to convert DC of solar system to AC of same level as grid supply. In off grid system the inverter is directly connected across the battery terminals so that DC coming from the batteries is first converted to AC then fed to the equipment. In grid tie system the solar panel is directly connected to inverter and this inverter then feeds the grid with same voltage and frequency power.In modern grid tie system, each solar module is connected to grid through individual micro – inverter to achieve high voltage alternating current from each individual solar panel.

The inverter here converts the DC of the solar panel to grid level AC and then feeds to the grid as well as the consumer’s distribution panel depending upon the instantaneous demand of the systems. Here grid-tie inverter also monitors the power being supplied from the grid. If it finds any power cut in the grid, it actuates switching system of the solar system to disconnect it from the grid to ensure no solar electricity can be fed back to the grid during power cut. There is on energy meter connected in the main grid supply line to record the energy export to the grid and energy import from the grid.

As we already told there is another type of grid-tie system where multiple micro-inverters are used. Here one micro

3inverter is connected for each individual solar module. The basic block diagram of this system is very similar to previous one except the micro inverters are connected together to produce desired high AC voltage.

In previous case the low direct voltage of solar panels is first converted to alternating voltage then it is transformed to high alternating voltage by transformation action in the inverter itself but in this case the individual alternating output voltage of micro inverters are added together to produce high alternating voltage.

Solar Cell

The name solar cell means that it is a cell or a plate which converts solar energy into the useful electrical energy. The energy which we get from sun is enormous and it is a great source of energy. Its energy will never finish so this is also known as the main source of renewable energy. With the scarcity of non-renewable energy it is of utmost importance to find a way out to solve the energy problem by some means within a very short period of time. So there is a way out which is now developing. That is we are now able to convert the sun energy to electrical by some means and that is why the importance of solar cell comes into play.

Though it is developing but if it is developed completely, then every household may produce the energy of its own. The solar cell is a device which is made of p-n junction diode which effect photovoltaic effect to convert light energy into electrical energy.

Construction of Solar Cell

The junction diode is made of SI OR GaAs . A thin layer of p-type is grown on the n-type semiconductor. Top of the p-layer is provided with a few finer electrodes which leaves open space for the light to reach the thin p-layer and it under lays p-n junction. Bottom of the n-layer is provided with a current collecting electrode.

3.A MPPT OR MAXIMUM POWER POINT TRACKER:- MPPT or Maximum Power Point Tracking is algorithm that included in charge controllers used for extracting maximum available power from PV module under certain conditions. The voltage at which PV module can produce maximum power is called 'maximum power point' (or peak power voltage). Maximum power varies with solar radiation, ambient temperature and solar cell temperature. Typical PV module produces power with maximum power voltage of around 17 V when measured at a cell temperature of 25°C, it can drop to around 15 V on a very hot day and it can also rise to 18 V on a very cold day

is an A MPPT or maximum power point tracker electronic DC to DC converter that optimizes the the match between solar array (PV panels), and the battery bank or utility grid. To put it simply, they convert a higher voltage DC output from solar panels (and a few wind generators) down to the lower voltage needed to charge batteries.(These are sometimes called "power point trackers" for short - not to be confused with PANEL trackers, which are a solar panel mount that follows, or tracks, the sun).

4.CHARACTERSTICS AND PARAMETERS OF A SOLAR CELL :- Solar cell is the basic unit of solar energy generation system where electrical energy is extracted directly from light energy without any intermediate process. The working of a solar cell solely depends upon its photovoltaic effect hence a solar cell also known as photovoltaic cell. A solar cell is basically a semiconductor device. The solar cell produce electricity while light strikes on it and the voltage or potential difference established across the terminals of the cell is fixed to 0.5 volt and it is nearly independent of intensity of incident light whereas the current capacity of cell is nearly proportional to the intensity of incident light as well as the area that exposed to the light. Each of the solar cells has one positive and one negative terminal like all other type of battery cells. Typically a solar or photovoltaic cell has negative front contact and positive back contact. A semiconductor p-n junction is in the middle of these two contacts. While sunlight falling on the cell the some photons of the light are absorbed by solar cell. Some of the absorbed photons will have energy greater than the energy gap between valence band and conduction band in the semiconductor crystal. Hence one valence electron gets energy from one photon and becomes excited and jumps out from the bond and creates one electron – hole pair. These electrons and holes of e-h pairs are called light-generated electrons and holes. The light – generated electrons near the p-n junction are migrated to n-type side of the junction due to electrostatic force of the field across the junction. Similarly the light – generated holes created near the to junction are migrated to p – type side of the junction due same electrostatic force. In this way a potential difference is established between two sides of the cell and if these two sides are connected by an external circuit current will start flowing from positive to negative terminal of the solar cell. This was basic working principle of a solar cell now we will discuss about different parameters of a solar or photovoltaic cell upon which the rating of a solar panel depends. During choosing a particular solar cell for specific project it is essential to know the ratings of a solar panel. These parameters tell us how efficiently a solar cell can convert the light to electricity.

5. ENERGY STORAGE SYSTEMS:-

One of the distinctive characteristics of the electric power sector is that the amount of electricity that can be generated is relatively fixed over short periods of time, although demand for electricity fluctuates throughout the day. Developing technology to store electrical energy so it can be available to meet demand whenever needed would represent a major breakthrough in electricity distribution. Helping to try and meet this goal, electricity storage devices can manage the amount of power required to supply customers at times when need is greatest, which is during peak load. These devices can also help make renewable energy, whose power output cannot be controlled by grid operators, smooth and dispatchable.

They can also balance microgrids to achieve a good match between generation and load. Storage devices can provide frequency regulation to maintain the balance between the network's load and power generated, and they can achieve a more reliable power supply for high tech industrial facilities. Thus, energy storage and power electronics hold substantial promise for transforming the electric power industry.

High voltage power electronics, such as switches, inverters, and controllers, allow electric power to be precisely and rapidly controlled to support long distance transmission. This capability will allow the system to respond effectively to disturbances and to operate more efficiently, thereby reducing the need for additional infrastructure. A major challenge being addressed by DOE is to reduce the cost of energy storage technology and power electronics and to accelerate market acceptance.

6.SYSTEM ANALYSIS AND DESIGN:

Designing a solar PV battery and diesel generator-based electric vehicle (EV) charging station involves several stages. Here's a structured approach to system analysis and design:

1. Requirements Analysis:-Load Requirements: Determine the power needs for the EV charging station, including the number of chargers, their power ratings, and peak usage times.Site Assessment: Evaluate the site for solar exposure, space for solar panels, and integration with existing infrastructure.Regulatory Compliance: Check local regulations and standards for EV charging stations, solar installations, and diesel generators.

2. System Components:-

Solar PV System:

Solar Panels: Calculate the number needed based on the expected solar irradiance and power requirements.

Inverter: Convert DC from solar panels to AC for the charging station.

Charge Controller: Regulate power from the solar panels to the battery storage.

Battery Storage:

Battery Type: Choose between lithium-ion, lead-acid, etc., based on capacity, efficiency, and cost.

Battery Capacity: Determine the required capacity based on daily load and desired autonomy (backup time).

Diesel Generator:

Generator Capacity: Size the generator to handle peak loads and provide backup when solar and battery resources are insufficient.

Fuel Storage: Plan for diesel storage and ensure safe and compliant handling.

Charging Stations:

Type of Chargers: Decide on Level 1, Level 2, or DC fast chargers depending on the application and user needs.

3. System Design:-

Energy Management:

Design an energy management system (EMS) to optimize the use of solar power, battery storage, and diesel generator.Implement load forecasting and scheduling to ensure efficient operation and minimize diesel generator use.

Integration:Design interfaces and control systems to integrate solar PV, batteries, and diesel generators seamlessly.Ensure proper switching mechanisms between solar, battery, and diesel power sources.

Monitoring and Control:Develop a monitoring system to track performance, energy production, and consumption.Implement control algorithms to manage energy flow and ensure reliability.

4. Implementation Plan:-Site Preparation: Prepare the site for installation of solar panels, battery storage, and diesel generator.

Installation:

Solar Panels: Install panels, inverters, and charge controllers.

Battery Storage: Install and connect batteries.

Diesel Generator: Install the generator and fuel storage system.

Charging Stations: Install and connect EV chargers.

Testing and Commissioning: Test all systems to ensure they function correctly and meet design specifications. Commission the system for full operation.

5. Maintenance and Support:-Regular Maintenance: Develop a schedule for routine maintenance of solar panels, batteries, and the diesel generator.

Troubleshooting: Establish protocols for addressing issues and ensuring system reliability.

6. Documentation:-System Documentation: Create detailed documentation for the installation, operation, and maintenance of the system.

User Training: Provide training for operators and maintenance personnel.

By following this structured approach, you can design and implement a robust solar PV battery and diesel generator-based EV charging station that is efficient, reliable, and sustainable.

7.ARCHITECTURE OF PROJECT:-

Designing an architecture for a project that involves implementing a solar photovoltaic (PV) battery and diesel generator-based electric vehicle (EV) charging station requires careful integration of various components. Here’s a high-level overview of the architecture:

1. Power Generation Sources

Solar PV Panels: These convert sunlight into electrical energy. The number and capacity of panels depend on the expected load and sunlight availability.

Diesel Generator: Acts as a backup power source when solar power is insufficient or during nighttime. It ensures continuous operation of the charging station.

2. Power Management System

Charge Controller: Manages the power from the solar panels to prevent battery overcharging and ensure efficient energy storage.

Inverter: Converts the DC power from the solar panels and batteries into AC power for the EV chargers and other station equipment.

Battery Storage: Stores excess energy generated by the solar panels for use during low sunlight conditions or high demand periods. Typically includes a Battery Management System (BMS) for monitoring and maintaining battery health.

Diesel Generator Controller: Automatically starts the generator when battery charge drops below a certain threshold or when solar power is insufficient.

3. EV Charging Infrastructure

Charging Stations: Hardware units where electric vehicles are connected to charge. These stations should be equipped to handle the power supply from both the solar and diesel sources.

Power Distribution Panel: Manages the distribution of electrical power from the solar PV system, battery storage, and diesel generator to the EV chargers.

4. Control and Monitoring System

Central Control Unit: Coordinates the operation of the solar PV system, battery storage, diesel generator, and charging stations. It ensures optimal power distribution and system efficiency.

Monitoring System: Provides real-time data on the performance of the solar panels, battery state, generator status, and energy consumption. This can be implemented through a graphical user interface or remote monitoring system.

5. Support Infrastructure

Safety Systems: Includes fuses, circuit breakers, and emergency shutdown mechanisms to ensure safe operation of the charging station.

Cooling Systems: Required for both the diesel generator and electronic components to prevent overheating and ensure reliable operation.

6. Integration and Communication

Data Communication: Ensures seamless communication between the control unit, monitoring systems, and charging stations. It may involve network connections and data protocols for efficient data exchange.

User Interface: Provides interaction points for users to initiate charging, check status, and potentially pay for charging services.

7. Site Infrastructure

Physical Layout: Includes space for solar panels, battery storage, diesel generator, and EV chargers. Adequate space and protection from environmental factors are essential.

Electrical Cabling and Safety: Ensures proper wiring and safety standards to handle the power loads and integrate all system components.

This architecture ensures that the EV charging station can reliably provide power through a combination of renewable and backup energy sources while maintaining operational efficiency and safety.

8.FUTURE SCOPE:-

Increased Integration of Renewable Energy: As solar technology advances and becomes more cost-effective, integrating higher proportions of solar power will likely become more feasible. This shift will reduce reliance on diesel generators, making the station more sustainable.

Advancements in Energy Storage: Improved battery technology can enhance energy storage efficiency, making it possible to store more solar energy for use during periods of low sunlight. This will make the system more reliable and reduce dependency on diesel generators.Enhanced Grid Connectivity: Future charging stations might integrate more seamlessly with smart grids, allowing for better load management and utilization of excess energy. This could involve bi-directional energy flow, where stored energy in EV batteries can be fed back into the grid.Technological Innovation: As electric vehicle technology evolves, charging stations will need to adapt to new standards and faster charging technologies. This may include ultra-fast chargers and advanced power electronics.Policy and Regulation: Future regulations and incentives could promote cleaner energy sources and penalize fossil fuel usage, accelerating the transition to renewable energy sources and reducing reliance on diesel generators.

Cost Reductions: The decreasing cost of solar panels and batteries will make the setup and operation of such stations more economical, encouraging broader adoption and further development of hybrid energy systems.Urban and Rural Expansion: The model could be adapted for both urban and remote rural areas, improving the availability of EV charging infrastructure and supporting the growth of electric vehicle adoption in diverse regions.Overall, the future scope involves a transition towards greater sustainability, technological advancement, and integration with broader energy systems.

9.CONCLUCION:-

An implementation of PV array, storage battery, grid and DG set based charging station has been realized for EV charging. The presented results have verified the multimode operating capability (islanded operation, grid connected and DG set connected) of the CS using only one VSC. Test results have also verified the satisfactory operation of charging station under different steady state conditions and various dynamics conditions caused by the change in the solar irradiance level, change in the EV charging current and change in the loading. The operation of charging station as a standalone generator with good quality of the voltage, has been verified by the presented results. Whereas, test results in DG set or grid connected mode, have verified the capability of ANC based control algorithm to maintain the power exchange with the grid at UPF or the optimum loading of the DG set.Moreover, the islanded operation, grid connected and DG set connected operations along with the automatic mode switching have increased the probability of MPP operation of the PV array and optimum loading of DG set along with increasing the charging reliability. The IEEE compliance operation of the charging station with voltage and current THD always less than 5% verifies the effectiveness of the control. Form the above mentioned point, it can be the capability to utilize the various concluded that this charging station with the presented control have energy sources very efficiently and provides the constant and cost effective charging to the EVs.

Future scope: In order to improve the performance of the controller the PI controller is replaced with fuzzy, ANFIS.

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