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Improving Grid-Tied Electric Vehicle Charging Efficiency with a Neuro-Network-Inspired Intelligent Maximum Power Point Tracking (MPPT) Controller

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Abstract- A new solution is being sought for as the demand for power continues to climb throughout the world. As a possible solution, grid-synchronized electric vehicles are being explored. The extensive usage of electric cars and their subsequent integration into the grid causes a multitude of power system challenges, such as imbalances in supply and demand, voltage, and frequency. One solution to these issues is the incorporation of solar power into this interface. A smart grid advancement that enables energy exchange between the grid and the EV is vehicle-to-grid (V2G) technology. The purpose of this project is to use a smart maximum power point tracking (MPPT) controller driven by a neural network to enhance the efficiency of charging grid-connected electric vehicles.In order to get electricity from solar panels to an inverter, a Relift-Luo converter is used. In order to track the solar panels' output, the proposed system employs an innovative method called artificial neural network maximum power point tracking (ANN-MPPT). The proposed system might provide energy management with the aid of a battery system and a bidirectional battery converter. In order to bring STATCOM devices into grid synchronization, this study employs a Recurrent Neural Network (RNN) controller in conjunction with the D-Q theory of transformation. The goal of this research is to find ways to improve power quality using STATCOM and to apply these improvements in a variety of situations. The whole system is validated using a MATLAB simulation 2021a.

1. INTRODUCTION

Modern power grids prioritize environmentally friendly technology as a result of rising awareness of the need to reduce energy use and the rapid expansion of renewable energy sources. Wind turbines and photovoltaic (PV) systems are now the most popular green technology. Because of its many benefits, including cheap cost, high efficiency, minimal maintenance, and high consistency, PV is the most reliable and environmentally friendly option. Nevertheless, the linked system's stability is negatively impacted by the ever-changing ambient operating circumstances, including temperature, irradiance, partial shading effects, and humidity, which have a significant impact on the PV's stability and generation.

Microgrids use energy storage systems (ESSs) to improve the system's quality and stability, reduce power mismatch between produced and needed power, and deliver continuous power from intermittent sources like PV. The battery is the most common and fundamental kind of energy storage due to its simplicity and widespread usage. Nevertheless, due to their moderate power density and high energy density, batteries provide sluggish charging and discharging speeds. As opposed to batteries, which allow for rapid charging and discharging, supercapacitors have a low energy density but a high power density. In order to reap the advantages of both technologies, hybrid energy storage systems (HESSs) combine batteries with supercapacitors. With HESS, the transient current from the batteries is diverted to the supercapacitors, extending the life of the batteries.

Installing a unidirectional DC/DC converter allows for management of the PV arrays' power output, while a bidirectional converter controls the charging and discharging of the battery bank, which is connected to the DC bus. The point of common coupling (PCC) is on the AC side, and DC loads are fed directly from the DC bus. AC loads are situated on the other side. A transformer is used to increase the AC voltage to the grid voltage before it is connected to the utility grid. Depending on the system and grid conditions, the PV-battery system may switch between grid-connected and island modes by adjusting the breaker status at the PCC. For instance, in the case of a severe AC bus malfunction, it may be necessary to open the breaker to prevent grid back-feeding current. It is essential for PV-battery system power management algorithms to regulate power flow and react quickly to changes in order to keep power production and consumption in balance, since PV output power and load demand might fluctuate continuously throughout the day. In addition, for a dependable power supply, it is essential to stabilize the DC bus and AC bus voltages independently of system changes.

A PV-battery unit's power management method revolves on droop control, which allows the PV-battery unit and another power source to share the load. This updated version takes into account various power units. Both of these methods are effective at controlling power consumption and production, but they are primarily concerned with controlling the flow of electricity from the PV-battery unit to the other producing units. The approaches also don't take DC bus and load systems into account. In a PV-battery-hydropower system, a hierarchical control algorithm is used to manage the active and reactive power. In a hybrid PV-battery-diesel system, a similar technique is used to regulate the AC bus voltage by means of the hydropower generator. Neither of these methods, however, takes voltage regulation into account in the event that the hydropower or diesel generator stops working.

To provide steady bus voltage and smooth grid synchronization, a model predictive control system is used for the regulation of voltage source converters (VSCs) in both isolated and grid-connected modes. An island system that uses photovoltaic (PV) and battery power and uses multi-segment adaptive droop control to regulate power. This approach is capable of monitoring and supplying the system with the maximum PV power according to its needs, and it can also adjust its operating point. Taking into account the state of charge of storage systems, total generation, peak demand, and total demand all contribute to the development of the proposed management plan. To maximize the system's lifetime in the face of fluctuating power output, adaptive droop control often optimizes the charging and discharging of battery storages. Methods for controlling and managing power are covered in order to reduce the charging and discharging rates of the battery and to better monitor the operating point of the power converters for quicker dynamic response.

This work presents CAPMS, a centralized control system for PV-battery systems. It efficiently and flexibly regulates power flows among power sources, loads, and the utility grid. The suggested technique efficiently controls the voltage on the DC and AC buses, seamlessly switches between grid-connected and islanding modes of operation, and balances power in the hybrid PV-battery system in a short amount of time.

2. LITERATURE SURVEY

A.Moghassemi et al [2021] suggested a novel Dynamic Voltage Restorer (DVR) for on-grid photovoltaic (PV) systems that is based on the Trans-Z-source Inverter (TransZSI). In response to voltage disturbances, a direct voltage regulator (DVR) may inject a voltage to the point of common coupling (PCC) that the user specifies. Reason being, the MCBC controller minimizes transients to an absolute minimum. The UVT-MCBC is able to identify the beginning and ending locations of all voltage disturbances with great accuracy and precision since the flickers are eliminated after each injected voltage interval. A number of different layouts were suggested in order to improve the voltage-gain and reduce the voltage stress of ZSIs. An impedance network consisting of a capacitor and a transformer, known as TransZSI, has achieved exceptional results. Having said that, there are limits to both the SBC and MBC techniques. Increasing the output voltage is the most that the SBC technique can do. Voltage stress causes a drop in the modulation index as ST rises.

H. García-Pereira et al [2022] suggested that a FESS might help reduce frequency variations in a standalone system that uses the El Hierro power system to operate a diesel plant, wind farm, and pump-storage hydropower facility. A well-established technology, the flywheel energy storage system (FESS) has a number of desirable characteristics, such as a low maintenance need, a high round-trip efficiency, a high power density, resistance to depth of discharge effects, and the ability to endure continuous charge-discharge cycling without deterioration over time. With these FESS features, the frequency quality issue may be tackled efficiently. Nevertheless, while taking into account the cycles that flywheel manufacturers promise, NLP GCS would not significantly shorten the lifespan of the flywheel.

S. Gangatharan et al [2020] suggested a new way to manage energy in hybrid microgrids, which would improve home power distribution systems by cutting down on conversion times. The power availability of the renewable energy system is verified against the load requirement, and the demand is satisfied. Moreover, the deployment of the batteries is dependent on their charge condition. To control energy networks, one looks at the interconnecting DC voltage fluctuation. In order to activate the battery backup, the voltage level of the battery bank is used. The goal function for managing microgrid energy in the optimization-based control approach is to minimize costs. Battery management solutions aim to optimize costs by running at lowest tariff, with an emphasis on peak demand control for economical energy costs. Similarly, when renewable power sources are unavailable or electricity is intermittent, batteries in standalone microgrid systems are turned on. However, there are a number of technological hurdles that microgrids constructed with solar PV must overcome because of their intermittent nature.

A. K. Podder et al [2021] suggested that, in order to keep HEV operations running at peak efficiency, drive cycles might be improved. Conducting a comprehensive analysis of several HEV control techniques for four distinct configurations: battery-UC, FC-UC, FC-battery, and FC-battery-UC. Objectives, control aspects, operating circumstances, fuel consumptions, dynamic responses, battery lifespan, etc. are used to compare and contrast various control systems for various configurations in the research. According to the comparative study, the EMS based on fuzzy logic is the most efficient and versatile option for battery-UC setup. For battery-FC arrangement, rule-based EMS is the way to go since it can manage the battery SOC level within a particular range while minimizing fuel usage. The linear and sliding approach based on FC-UC HESS is an effective way to achieve optimum power-sharing and system stability. Application of fuzzy logic to FC-battery-UC Flexibility, management of the battery and UC state of charge, and reduced fuel usage are all benefits of HESS. Nevertheless, in typical operating circumstances, FC meets the power need.

J. Martinez-Rico et al [2021] advised investigating the significance of using a multi-objective optimization to plan the manufacturing schedule. Both the plant's net profitability and the battery's value loss, which are determined by the number of cycles and the change in market price, are optimized using the multi-objective cost function. The production schedule optimization approach, which optimizes the revenues generated from implementing the energy arbitrage, and minimizes the loss of value of the BESS at the same time. Both the influence of the price decline over time and the loss of life associated with changes to its state of health (SOH) are taken into account when calculating the loss of value. However, the objective function must also be linearized for the issue to be solved, much as in MILP optimization.

U. R. Nair et al [2020] An autonomous island microgrid equipped with photovoltaic (PV), dispatchable (GW) generator, and hybrid energy storage systems (ESS) was designed with an MPC-based energy scheduling system in mind. Because it can take future production and load demand into consideration while making choices, MPC-based energy scheduling outperformed a fuzzy-based heuristic approach. Relocating battery charging to the peak generating phase significantly reduces dwell time at high state-of-charge (>0.8) battery levels. Using MPC, regenerative FC achieves smoother set-point adjustment. Among the many applications of MPC in electrical systems are the reduction of running costs, the enhancement of renewable energy use, and the prevention of deterioration in energy storage systems. Adding prediction data, however, is a painstaking process with heuristic approaches. For heuristic techniques to make decisions using forecast data, the rules for doing so must be well articulated.

P. Roy et al [2020] put up a plan for the operation of a wind-solar hybrid power system (WSHPS) that would use a hybrid energy storage subsystem that combines batteries and supercapacitors to run the system for eight hours straight. By making great use of the high power density of supercapacitors and the high energy density of batteries, the HESS framework employs a frequency control strategy to prolong the life of the batteries. Separating the power supply from the supercapacitor (SC) and the battery is accomplished using a low-pass filter (LPF). To get a good estimate of the grid reference power for every hour of dispatching, we build a number of control algorithms that depend on the battery charge. Making sure the HESS has enough capacity for operation the next day and minimizing the cost of energy storage are both helped by this estimate. While SESSs with supercapacitors have a poor energy density, they have a fast power ramp rate.

D. Tang et al [2021] put forth a power cruiser energy management system that takes into account the changing properties of each power source—fuel cells, batteries, and ultracapacitors—by using wavelet transforms and fuzzy logic. Using wavelet transform, the cruiser's energy demand is separated into frequencies, and then various energy sources are allocated according on their dynamic properties. The use of fuzzy logic to maintain a safe state of charge in the energy storage system is suggested as a means to guarantee the hybrid power system's long-term dependable functioning. A small cruise ship is suggested to use a hybrid power system that incorporates FCS, batteries, and UC. Achieving zero emissions is possible with the suggested hybrid power system. By dampening their jolting reaction time, we can increase fuel cell and battery efficiency and prolong their useful life. Nevertheless, current approaches to energy management fail to account for the ever-changing performance of energy sources, rendering them incapable of allocating energy demand in accordance with their dynamic properties.

K. A. Khan et al [2021] put forth a method of controlling batteries and supercapacitors independently using k-Type compensators and a nonlinear PI controller (NPIC), respectively. Also included is a comparison with a benchmark controller that is based on a low-pass filter (LPF). Type II compensators provide the basis of the BESS controller and the non-linear PI controller (NPIC) is the basis of the SCSS controller. The BESS is able to mimic the slow dynamics of the microgrid and start operating towards the average energy demand by using the error signal measured at the DC bus and appropriate pole and zero location to create a reference current. To regulate the DC bus voltage transiently, the NPIC controller uses a look-up table (LUT) to run the PI controller and provide the necessary SCSS reference current. As an example, the filters do a poor job of isolating power components.

A. U. Rehman et al [2021] designed a smart home energy management controller that optimizes load scheduling and reduces carbon emissions, power consumption, and power bills while simultaneously improving thermal, visual, air quality, and delay UC. This study takes into account a smart building that achieves its goals by shifting demand to peak hours and using electricity from EG, BSS, and RES, which stands for solar, thermal, and wind power. Together with other various shiftable and smart equipment, the massive HVAC load is intended to be reduced. To address the issue of energy management, it has been proposed to integrate power storage systems and generating systems in an effective manner. These systems include BSS, solar, thermal, WE, EVSS, and EEG. Nevertheless, cost decrease did not account for deterioration or capacity of batteries.

X. Gao *et al* [2020] suggested a new approach to energy management for HESS in IPS that relies on optimal state-of-charge (SOC) feedback in order to control the DC bus voltage fluctuations. An EMS based on state-of-the-art optimization is suggested in this research to mitigate pulse load and enhance the IPS's HESS size and lifespan optimization efforts. In this approach, we merge the SOC recovery control of supercapacitors with the LPF's variable filter time constant and SOC feedback. Allocating the reference power inside the HESS and properly compensating the pulse load is one advantage of the suggested technique. However, it may also maximize the HESS's compactness and extend the battery's cycle life. Nevertheless, optimizing the energy consumption of the whole system becomes challenging when ESDs operating under a decentralized control method do not communicate information with one another.

A. A. E. Tawfiq et al [2021] have postulated a multi-objective computational challenge for optimal grid-connected photovoltaic system siting and design to attain optimal generating reliability, taking into account certain states with varying generation probability. One of the most important RESs to emerge and play a significant part in electrical power networks lately is PV-based renewable energy production, which offers several benefits. A thorough investigation was conducted to enhance the dependability of a PV system that is connected to the grid, taking into account several elements. The number of PV plants in a given system, as well as the failure and maintenance rates of individual power system components, are among these considerations.Although it is still the most often mentioned drawback of solar energy, the price is going down as the market grows.

P. K. Sorte et al [2022] have suggested a grid-connected system that uses PV batteries and an efficient MPPT control method that incorporates adaptive PMA. With the CRC MPPT method, global power monitoring remains stable and converges quickly, even in partially shadowed conditions, and it's easy to apply. This method of control just considers the grid-tied mode of operation when calculating the basic component of the load current using complicated weight components. Nevertheless, thorough examination is required to address key issues such unexpected utility disconnection, smooth transition from grid-tied to island mode, source-to-source power management, and dependable operation in both island and grid-tied modes. Because it affects the power quality evaluation directly, the dc-link variation's behavior is also included for a fair comparison.

M. A. Khan et al [2022] have suggested a fault ride-through (FRT) control method for single-phase grid-connected solar (PV) systems (GCPVS) to achieve low voltage ride-through (LVRT). Using a cost function-based approach, this control technique achieves rapid and efficient control by taking use of the power converters' nonlinear nature. In addition, the grid receives voltage support from the proposed controller during voltage sags, thanks to the injection of lowest reactive current within the threshold. It has also been determined that, rather than providing voltage support, improving active power injections and decreasing active power oscillations are of utmost importance. Nonetheless, the dc-link voltage management forms the basis of the control method here, which is based on the power balance of the AC and DC sides of the inverter.

F. A. Alturki et al [2020] are committed to enhancing the performance of grid-connected PV systems and have suggested a novel use case for an MRFO-based PI controller. Using the ISE, we were able to minimize the fitness function and accomplish the target function. In order to provide smooth power quality and successful PV grid integration, PI-based controllers based on MRFO were used to improve the functioning of nonlinear power electronic equipment. Training a neural network, on the other hand, takes a long time as a lot of data is needed for proper calculation.

P. R. Bana et al [2020] have suggested an innovative closed-loop control method and a single-stage grid-tied PV system with reduced component count MLI interfaces. This study introduces a unique VLB MLI structure and three methods for choosing the magnitude of the dc-link, allowing for greater voltage steps with fewer parts. A 15-level output voltage is produced by the suggested MLI by use of two RUs that use two distinct types of sources. There is a considerable improvement over state-of-the-art MLIs in terms of both the number of switches and the CLR/TBV ratios. With a low CLR value and a lower TBV, the suggested VLB MLI is suitable for high-voltage/power applications and can readily expand to any number of levels with a reduced number of components. When it comes to solar photovoltaic systems, MLIs can do wonders for efficiency. Either a single-stage or two-stage integration with the grid was possible with this kind of system.

Y. Pan et al [2021] to operate island-style series PVBH systems with an innovative distributed control scheme. One potential approach to improving the integration of dispersed energy sources is the PVBH system, which stands for series photovoltaic battery hybrid. Nevertheless, current controls need heavily on communication to disseminate real-time control variables to all converters, or they are designed specifically for PVBH systems with a unity power factor. As the load demand changes, the battery takes over regulating the islanding grid's voltage and frequency, allowing the PV panels to gather as much electricity as feasible within the suggested management. In addition, all converter loads may be balanced by sharing reactive power.

C. -Y. Tang et al [2021] are now considering hybrid charging methods and bidirectional regulation of power flow for three-phase PV power and energy storage systems. In order to regulate the flow of electricity in both directions, the PV power system uses a three-phase grid-connected inverter. These methods allow for the dynamic regulation of power flow among the PV, battery, and inverter in response to various charging circumstances. You may change the time of positive and zero current charging according to various conditions, however the charging current is discontinuous. In contrast, the MPPT function will not be used if the current needed to charge the batteries is less than the maximum PV current; in this case, reducing the output PV power and current is necessary to keep the power flow balanced.

S. M. Said et al [2020] suggested a way for exchanging reactive power efficiently between renewable energy hybrid generators and energy storage devices. The suggested approach takes use of the new smart features of PV and SMES power inverters to back up the local load supply. When using the suggested technique, the DSTATCOM function is carried out by both the PV and SMES inverters. This means that there is no need to oversize the system components or incur transmission line losses in order to accomplish the local reactive power supply. The SMES is a useful accessory for reducing PV production variations and storing PV energy for later usage at night. For a clean environment, less reliance on fossil fuels, and complete stability and sustainability of power grids. Nevertheless, optimization of SMES capacity calculations to limit tie-line power flow and reduction of line power loss have not been addressed in this work.

S. Chen et al [2021] suggested a model predictive control (MPC) approach for managing three-level bidirectional DC/DC converters interconnected to a HESS in a DC microgrid. After a two-stage boosting construction, the battery is able to suppress larger voltage level variations at the same grid voltage level. At each sampling moment, the MPC controller takes into account several state variables, and unlike the PI controller, it doesn't need the tiresome procedure of altering settings. Quick and precise control of current and voltage with reduced ripples is also achieved by the MPC algorithm that relies on a constant switching frequency. High- and low-frequency power allocation may be achieved with this HESS control approach without the requirement for filters. A slope limiter and the suggested outside voltage control may prevent the battery from being charged or discharged too quickly. The controller architecture will get more intricate with a high sampling frequency, however.

Aastha Chaurasia et al [2020] When a vehicle is using a regenerating brake, it slows down or stops more quickly than when using a conventional brake, which causes the excess kinetic energy to be converted into heat instead of stored in the battery for later use, like when the vehicle is accelerating.In regenerative braking, the engine's excess kinetic energy is not lost as heat; instead, a portion of this surplus energy is recovered by turning the motor in reverse and using it as an alternator, significantly improving the engine's fuel efficiency. Regenerative braking allows us to charge the battery significantly when braking, which ultimately improves the efficiency of electric cars. These vehicles mostly run on electrical energy, which is stored in a battery.

Anand Kumar et al [2020] Every car has a standard brake that, when applied, turns kinetic energy into heat, which slows down or stops the vehicle. However, a lot of energy is lost during braking since heat travels through the air and doesn't stay still. The goal of this project is to design a regenerative braking system for electric vehicles. This system would increase the efficiency of the vehicle by recovering energy from the wheels' kinetic energy and storing it in a rechargeable power supply. By doing so, it would help to reduce fuel consumption and improve the vehicle's performance when braking. A microcontroller, transducer, process sensor, and battery are used to accomplish this task, which is powered by a motor that converts KE to electricity. As before, the vehicle's acceleration is boosted by reusing energy when the throttle is turned down. It also helps it endure longer and lessens wear and tear.

Janak Deshmukh et al [2020] With the globe teetering on the edge of an energy catastrophe, it is more important than ever to preserve our planet's natural resources, particularly in light of the advances in modern technology. As a result of the friction between the brake pad and the disc, a significant amount of energy is wasted as heat when a car brakes. A technique called regenerative braking involves storing some of the vehicle's kinetic energy in a device that may be used for brief periods of time. There are a variety of methods for storing and reusing the lost energy in a regenerative braking system. The primary focus of this study is to provide an overview of the various recovery methods used by conventional, electric, and hybrid automobiles. Furthermore, the study provides the best approach to maximize energy recovery by combining regenerative braking with a traditional frictional braking system. The fundamentals, operation, and potential applications of regenerative braking systems are detailed in this article.

G. Jerome Nithin Gladson et al [2021] We need specialized equipment that can recover energy that is often squandered since we are living through an era of energy problems and rapidly diminishing resources. Thus, the regenerative braking system is one of these helpful technologies specifically for vehicles. A clutch mechanism that the rider controls selectively holds the specific braking mechanism in place, allowing it to store energy across several braking episodes. With regenerative braking, electric vehicles turn the motor into a generator and feed its output to an electrical load. Braking applies a decelerating force to the wheel via a brake-pad assembly that is placed concentrically with the hub of a ground-engaging wheel. This assembly provides frictional contact between the hub and clutch mechanism.

Harshil Mehta et al [2020] There is a net loss of energy every time we apply the brakes on our bicycle. Since energy cannot be generated or destroyed, this conclusion follows. Changing its shape is all that's needed. All that forward-moving kinetic energy needs to go somewhere when our vehicle slows down. Upon release, the majority of it is rendered ineffective due to its thermal properties. All that potential energy that might have been put to better use is going to waste. The Regenerative Braking System is the answer to this kind of issue. A new kind of braking system, this one can harness a lot of the bike's kinetic energy and turn it into mechanical or electrical power. One promising new technology in the automobile sector is regenerative braking, which has the potential to have a significant positive impact. Riding a bike with a regenerative braking system not only helps you get more power out of each pedal stroke, but it also makes your electric bike more efficient and lets you preserve some juice for when you need it. It is well-known that regenerative braking improves efficiency by increasing the vehicle's energy output relative to the energy input.

Yogendra Singh Rajpoot et al [2020] Limited fuel reserves and ongoing deterioration in air quality are two of the main reasons why the automotive industry is now confronting a huge challenge in reducing fuel consumption and greenhouse gas emissions. As part of this investigation, an experimental setup is constructed with the aim of reducing energy loss via reuse. In this particular investigation, a chain and sprocket are used to link an alternator to the driving shaft. The alternator is started by an electromagnetic clutch when the brakes are pressed, so that the energy lost during braking may be used to create electrical energy.

Rohan S Kulkarni et al [2020] It is well-known that "Energy can neither be created nor be destroyed, it can only be converted from one form to another.". Important new regenerative braking technology is detailed in this study. One of the most noticeable ways that electric vehicles may boost their potential is via the use of regenerative braking systems. Electric cars are quickly approaching the point where they will significantly impact both the automotive industry and environmental sustainability. Electric car utilization is down due to two main issues: the time it takes to charge the batteries and the availability of charging points. To keep the vehicle powerful and to transform the wasted energy into something useable, the regenerative braking system might be an important component. There must be a backup power supply to operate the vehicles as well. To put an end to their travels, electric cars use a mechanical brake that makes the wheels more noisy. But looking at it from an energy perspective, the mechanical brake releases a lot of energy, and the kinetic energy of the EV is converted into useful energy again. For the most part, modern cars rely on hydraulic braking systems. Because it generates heat that isn't necessary, the conventional way of braking results in significant energy loss. Regenerative braking has so emerged as a solution to eradicate all such drawbacks. In addition to improving the vehicle's efficiency, it aids in energy conservation. Therefore, it seems that automobiles equipped with regenerative braking systems will be standard in the near future. Additionally, using this technique, the car may produce energy whenever the brakes are deployed. In order to get reliable tachometer readings, the paper's authors have investigated several components and attempted to construct a model for the same. An additional component of this braking system is the tachometer, which, when coupled with the accompanying mobile app built around the Arduino-based tachometer, will allow us to monitor the energy created and its speed. Developing, analyzing, and testing a regenerative braking system has been the primary objective.

Komal Wanzare et al [2022] Electric cars may have their battery life extended with the help of a regenerative braking system. A broad variety of battery power options is included into the system. One approach that recovers and reuses energy while reducing break exhaust emissions is the Regenerating Breaking System. The system is transforming mechanical energy into electric energy, which is kinetic energy. Improved braking effectiveness, less brake wear, and prevention of physical damage are all economical advantages of these systems.

Pranav R et al [2021] Although various kinds of energy conversion might be used, since all the energy here is being dispersed as heat, the most frequent way that brakes work is by converting the kinetic energy of the moving item into heat via friction between two pushed surfaces. You can save a lot of the energy for later use since regenerative braking turns a lot of it into electricity. Also, to show how energy may be transformed, we will build a functional model of regenerative braking. With more research and development in the near future, regenerative braking has the potential to significantly reduce the use of non-renewable energy sources, even if it only transforms a small proportion of total kinetic energy into mechanical or electrical energy.

Aastha Chaurasia et al [2020] When a vehicle is using a regenerating brake, it slows down or stops more quickly than when using a conventional brake, which causes the excess kinetic energy to be converted into heat instead of stored in the battery for later use, like when the vehicle is accelerating.With regenerative braking, the engine's fuel economy is significantly improved since the excess kinetic energy is not lost as heat. Instead, a portion of this surplus energy is recovered by turning the motor in reverse and utilizing it as an alternator. Regenerative braking allows us to charge the battery significantly when braking, which ultimately improves the efficiency of electric cars. These vehicles mostly run on electrical energy, which is stored in a battery.

K. Meetam ***et al*** **[2023]** recommended for use in racing vehicles to enhance the ETC system's responsiveness. In order to get a mathematical model of the electronic throttle body, parameter identification is performed. The throttle valve cannot be controlled by the ETC system to precisely follow angular fixed points. To make the parameter estimates from the graphs easier, signal noise is reduced using a low pass filter. After that, a derivative gain is introduced to lessen the overshoot and reaction time. Due to the lengthy duration of the endurance circuit, the drivers of the racing cars need extensive training. Tuning the ECU's PID gains will enhance the ETC system. The steady-state error is improved by adding a little amount of integral gain. The purpose of this study is to enhance the electronic throttle valve control system's responsiveness via an examination of ECU behavior and the provision of tuning suggestions for the ECU. An approximation of the transfer function for the throttle valve and information about its behavior were both provided by the frequency response analysis, a potent technique.

Yiming Liu ***et al*** **[2023**showcased a filter method similar to Kalman's that allows for self-tuning backstepping control. By collecting and analyzing the noise signal, we can confirm that it is not a Gaussian distribution influencing the position sensor data. An estimation of the actual valve position is made using a Kalman-like filter in order to remove its impact on control accuracy. The settings of the backstepping controller are fine-tuned online using a fuzzy control-based self-tuning method to maximize the controller's performance. While the control amount does influence control accuracy, it has no effect on the overall estimating system's state variation. The measured value is unrelated to the gain of a Kalman or Kalman-like filter; rather, it is connected to the system's state value. Precise regulation of AET enhances engine efficiency and lessens pollutant output. Minimize tracking errors that are both maximum and root mean squared. Improve the position sensor's measurement accuracy by removing the impact of non-Gaussian white noise.

Yun Chen ***et al*** **[2023]** outlined the theory and signal conditioning circuit of the sensor that is relevant to the context. A gigantic magneto-resistive sensor with enhanced sensitivity is the basis of the technique; it detects the PD currents' magnetic fields. In high-voltage laboratory or field testing, detecting partial discharges is an excellent diagnostic approach for evaluating the insulation status of electrical power equipment. The xMR sensor reduces temperature drift, hysteresis, and improves linearity. This xMR sensor was used to correct for the magnetic field operating perpendicular to its sensitivity axis by reducing it. The PD signals will go over a low-impedance, high-frequency cable. When the magnetization vectors are oriented differently in different layers of a structure, the resistance changes noticeably. The xMR bridge's output is reduced to almost nothing by means of a closed-loop compensation circuit, which attenuates the very low-frequency signals.

Mohammed Aljebreen ***et al*** **[2023]** presented a novel approach to detecting distributed denial of service attacks on the Internet of Things (IoT) platform by using an ensemble learning algorithm and a snake optimizer. The goal of the DDAD-SOEL method is to detect DDoS assaults effectively and automatically. In order to do this, the DDAD-SOEL method selects feature subsets using the SO algorithm. Distributed denial of service assaults, which are becoming more common as Internet of Things devices proliferate, pose a serious threat to the availability and dependability of IoT services. Not much is known about how important feature selection with hyper parameter adjustment is for differentiating attack traffic from regular traffic. The DDoS detection pipeline has not consistently included many detection algorithms to use their combined predictive potential. In terms of hyperparameters, none of them are optimal for modifying the result. Even when dealing with complicated loss landscapes, hyperparameter adjustment gives effective convergence qualities.

Ziru Zhang ***et al*** **[2023]** considered a novel geographical unit to improve the ease and economy of e-bike sharing. To address the supply and demand mismatch in recurring clusters, operational solutions are developed using temporal clustering. In order to meet the high expectations of their customers, businesses in the shared mobility industry must operate efficiently and provide excellent service. Since demand can't be linked to certain station units as it is in station-based systems, the complexity of modeling rises due to flexibility. An increase in NRRs and typical user spending, with large swings still. The service is greatly enhanced by the developed operating strategies. Among all the techniques, the third set of repositions based on hourly clustering on the circle level demonstrated the greatest improvement in service. Tell us how popular and efficient various spatial units are in operation. The entire flow, arrivals, and departures of each geographical unit may be better understood with the help of general demand patterns and temporal clusters.

Erik Burani ***et al*** **[2022]** explain that a mathematical model is used in an application to more accurately calculate battery usage and, by extension, the assumed remaining range. Particularly for "not-in-shape" or older cyclists, a hardware-software solution that gives precise range information is vital. An integral part of many e-bike systems is a compact control device that shows important data including actual and projected range, current power usage, and speed. You can't make an informed prediction with this amount of computing power use. It is not unreasonable to expect the user to be able to input a numerical number. Using the manufacturers' methodology is no picnic and calls for specialized gear. By establishing a wireless link between the bike and the app, the bike's components may communicate their status to enhance computation.

Luis Ovalle *et al* [2022] used for the purpose of quarter car system spring mass stabilization. The use in actual systems is made easier by the proposal's simple nature. This technique selects five distinct continuous sliding-mode controllers from two comparable architectures to reduce chattering. The sprung mass of a quarter vehicle system is guaranteed to be exponentially stable in the face of a class of non-vanishing disturbances by these strong controllers. Oscillations are not prominent in the continuous sliding-mode controllers' responses. To accomplish the control goal, controllers need a lower total value for the control input. While the CSTA offers more precise and active control, the STA offers a more comfortable ride and seems to provide a middle ground response. We have simplified the work to ensure the system is stabilized robustly.

Hiroshi Imamura *et al* [2022] Developed statistical metrics and probability density function analytical formulas. According to the usual distribution of junction characteristics, and WER which is much less than one. Reducing the pulse width decreased the WER coefficient of variation. It takes several tens of years to attain thermal equilibrium since the thermal stability constant is considered to be rather big. A log-normal distribution is the one that WER's probability distribution function follows. To decipher the data, the magneto resistance effect is used. The magnetic tunnel junction, a fundamental component of STT MRAM, is composed of Fe-based magnetic electrodes sandwiched between a MgO insulating barrier. Mathematical models derived from the Fokker-Planck equation validate analytical statements.

Muhammad Ridwan Arif Cahyono *et al* [2022] showcases a system for monitoring and controlling electric bicycles that is based on the internet of things. You can find electric bicycles at most stores in Indonesia these days. Smartphone integration is still in its early stages in electric bicycles. In order to propel the electric bike with a BLDC motor, the controller was adjusted so that it could be combined with the ESP32. An Internet of Things (IoT) device based on the ESP32 microcontroller was used to measure the distance traveled using a GPS sensor using the Haversine technique, as well as to measure the speed of a bicycle, create a system to ensure the safety of the bicycle, and calculate the number of calories burned while pedaling. This time delay will hopefully be lessened in future system improvements made possible by research. The demand for oxygen and MET by the body is directly proportional to the degree of physical exercise. The lowest possible speed % is same for the medium and high gear settings. When the distance goes over the maximum limit, the system is considered to be inaccurate. A Wi-Fi module and a serial port led to the selection of the ESP32-based microcontroller. People are acquainted with the gear settings on vehicles and motorcycles for controlling speed, hence the word gear is used in situations where that function is required.

3. METHODOLOGY

3.1 BLOCK DIAGRAM OF EXISTING SYSTEM

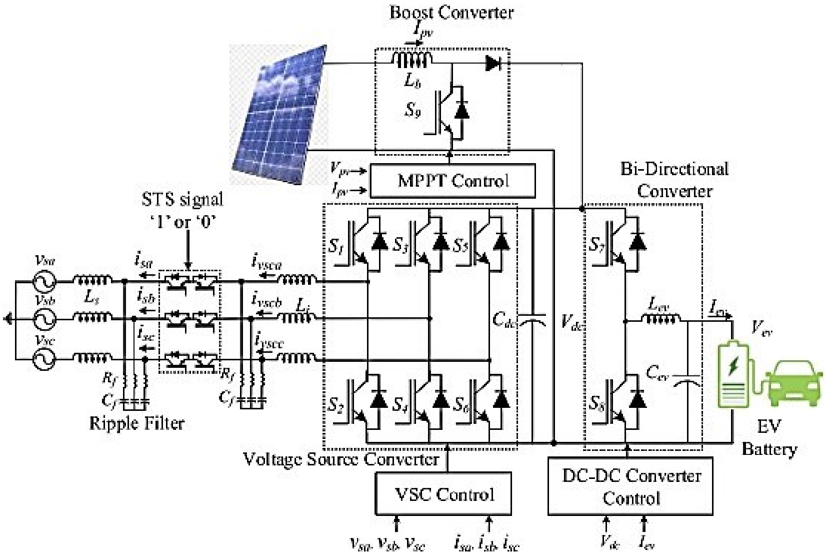

Figure 1 Existing System Block Diagram

An electric vehicle (EV) specific three-phase grid-interfaced charging station (CS) is created inside this system. The grid-interacting design of the CS allows it to counteract reactive power. The device may operate in several modes, such as charging and discharging electric vehicle batteries, compensating reactive power, and charging and correcting harmonics current at the same time. The CS continues to function faultlessly in grid-connected mode even when the grid voltage is imbalanced or distorted. At the Point of Common Coupling (PCC), the reference grid currents and phase voltages are precisely aligned by means of its elaborately built control system. The CS effortlessly switches to island mode, where a photovoltaic (PV) source charges the electric vehicle's battery, in the event that grid synchronism is lost. Tests conducted under a wide range of dynamic scenarios confirm the CS's functionality; the results show that the grid current distortion levels are always within the parameters specified by the IEEE-519 standard.

3.2 CONTROL SCHEME

A photovoltaic (PV) array is the principal component of the electric vehicle charging station. But the EV may provide electricity back onto the grid if needed. Since this is the case, the control is designed to facilitate EV-grid integration. In Figure 2, we can see the control structure. In this case, the charging or discharging of the EV battery is determined by the active reference power. The owner determines the electricity required to charge the electric vehicle's battery, whereas the grid determines the power required to discharge the battery. Return on investment (ROI) is defined by the reactive power command. The controller is designed to handle reactive power compensation and active power flow simultaneously. Electric vehicles are charging when the grid power indication is positive, meaning electricity is flowing from the grid to the car. The electricity is flowing out of the PV array or vehicle and into the grid if the grid power indication is negative, however. Just as leading reactive power is negative and sign convention is positive, trailing reactive power is negative. Also, the opposite is also true: a negative EV current indicates charging and a positive EV current indicates discharging.

3.3 DRAWBACKS OF EXISTING SYSTEM

- This intricately designed control system, while effective in aligning reference grid currents with phase voltages at the Point of Common Coupling (PCC), is complex to implement and maintain.
- This complexity lead to increased costs in terms of installation, monitoring, and troubleshooting.
- The seamless transition of the CS to islanded mode in instances of grid synchronism loss is a valuable feature.
- Voltage stability problems arise from this designed control system.

3.4 BLOCK DIAGRAM OF PROPOSED SYSTEM

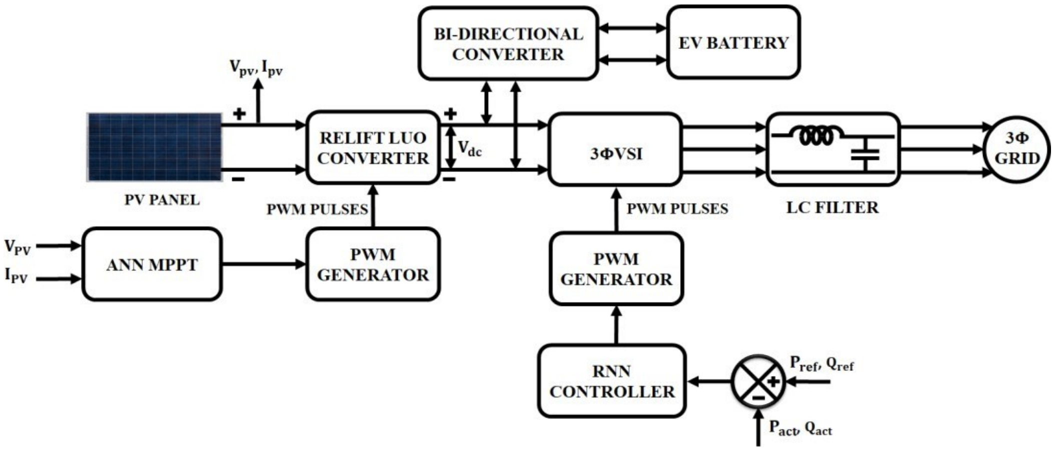

Figure 2 Proposed System Block Diagram

This system proposes an intelligent MPPT controller driven by a neural network to optimize grid-tied electric vehicle charging while improving power quality. Incorporating vehicle-to-grid (V2G) and grid-to-vehicle (G2V) capabilities, this project seeks to incorporate renewable energy from photovoltaic (PV) sources into the utility system. In order to make everything work together, it suggests a number of converters, such as bidirectional converters for charging batteries and other power sources. To maximize the efficiency of the solar panels, the system uses an innovative technique called Artificial Neural Network-based Maximum Power Point Tracking (ANN-MPPT). This proposed MPPT/Re-Lift Luo converter is designed to provide a DC voltage output with a high gain. The converter's surplus power is stored in a DC link, converted to AC via a 3-phase VSI, and then sent back into the grid once everything is in sync with the RNN controller. An LC filter is used to rectify the harmonic in VSI, allowing the current to be safely fed into the grid. Electric vehicles are able to effectively recycle the power they store back into the grid when they are not in use. One example of bidirectional power transfer is the use of grid-to-vehicle (G2V) and vehicle-to-grid (V2G) connections to feed excess power back into the grid. By doing simulations in MATLAB 2021a/Simulink, the suggested approach is confirmed.

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3.5 RELIFT-LUO CONVERTER

One kind of DC-DC converter is the re-lift Luo converter, which increases the voltage from the source to the load by a factor of 1:12.The Re-lift Luo converter takes after the original Self-Lift Luo converter by using the voltage lifting method. The Re-lift Luo converter differs from the self-lift circuit in that it makes use of extra voltage lift components, such as capacitors and inductors.

Self-lift Luo converter consists of 2 diodes $-$ D_1, D_2, 2 inductors$-$ L_1, L_2, 3 capacitors$-$ C_1, C_2, C_3, 1 power switch $-$ S_1.Re-lift Luo converter consists of 3 diodes $-$ D_1 , D_2, D_3, 3 inductors$-$ L_1, L_2, L_3 , 4 capacitors$-$ C_1, C_2, C_3, C_0, 2 power switches$-$ S_1, S_2.

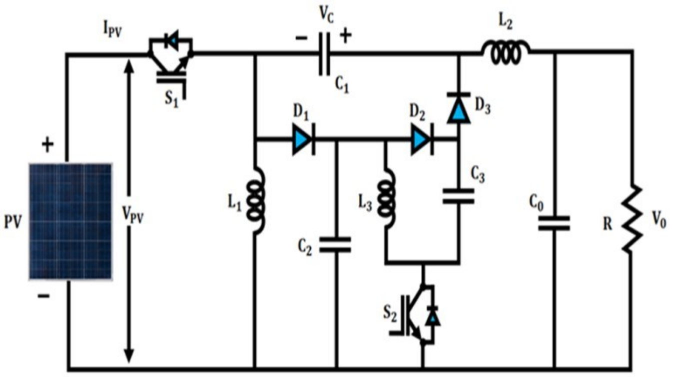

Figure: 3RE-LIFT LUO converter

To raise the voltage across the capacitors, Vc, the inductor L_3 serves as a ladder joint, linking C_2 and C_3. Voltage boosting applications employ capacitors C_2 and C_3 to provide a voltage V_c that is twice as high as the source voltage V_pv.

T ON condition

When the power switches, S_1 and S_2 are turned ON, the source instantaneous current flow is $I_{pv} = i_{L1} + i_{L2} + i_{L3} + i_{c2} + I_{c3}$. The inductors, L_1 and L_3 stores energy from the source. The inductor, L_2 gets charged by an energy got from the source and capacitor C_1. The current flowing towards the inductors L_1 , L_2 and L_3 get increased.The circuit diagram during the turn on condition of MOSFET is depicted below.

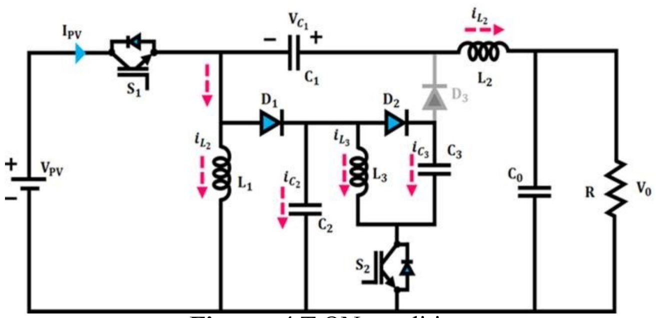

Figure: 4 T ON condition

T OFF condition

In the off state of the power switches S_1 and S_2, the source current I_pv is zero. The current flowing through the inductor, denoted as i_L1, charges the capacitor, C_1, via the circuit C_2-L_3 〖-C〗_3-D_3-C_1. At the same time, when it releases energy, the inductor L_2 sends current to the output capacitor C_0 and the load R.

The circuit diagram during the turn off condition of MOSFET is depicted below.

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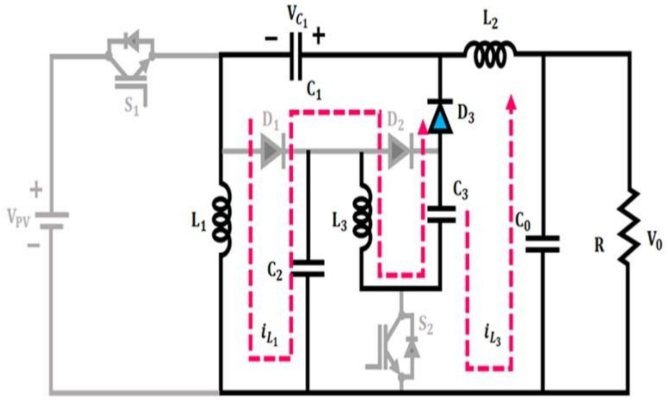

Figure: 5 T OFF condition

4. RESULT AND DISCUSSION

The proposed work is implemented in MATLAB simulation and the following results are obtained.

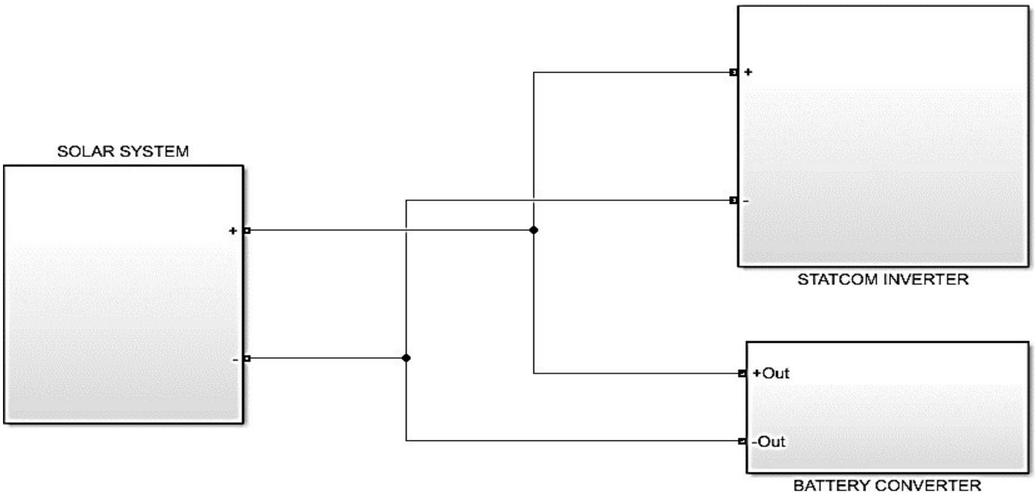

Figure 6over All Simulation Diagram

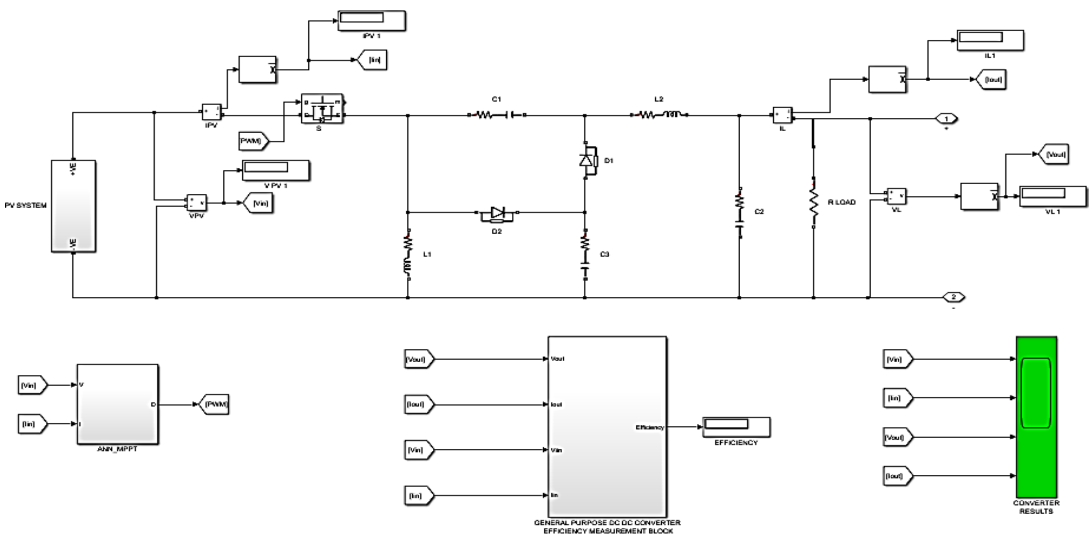

Figure 7 Simulation Diagram for solar with converter

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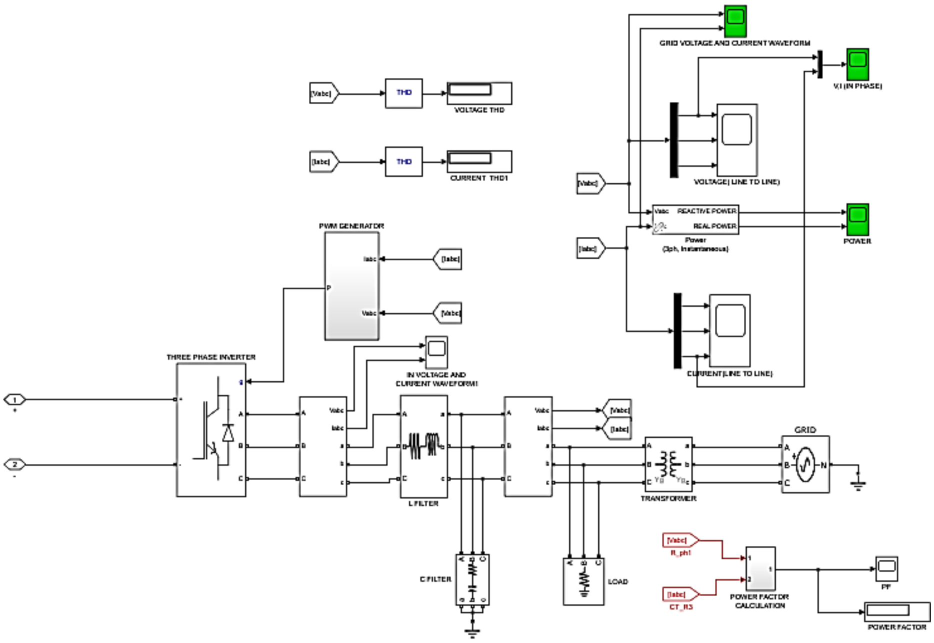

Figure 8 Simulation Diagram for Three Phase Grid System

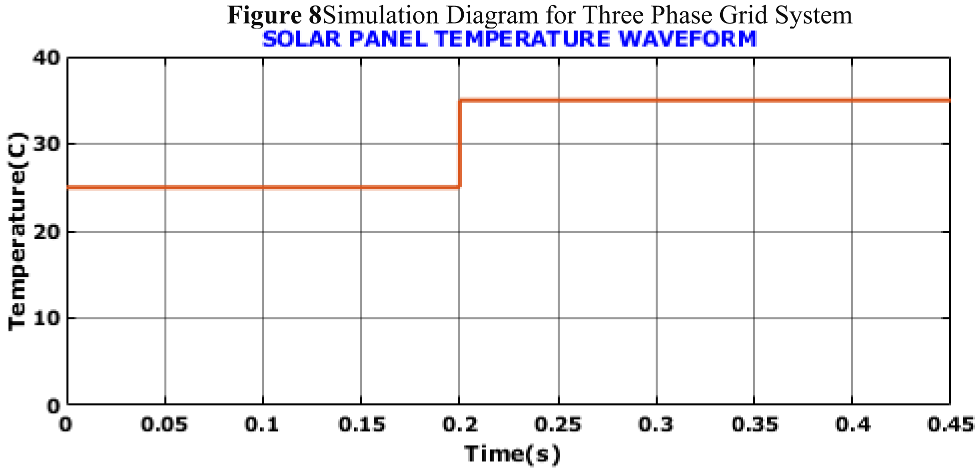

Figure 9 Solar Panel Temperature waveform

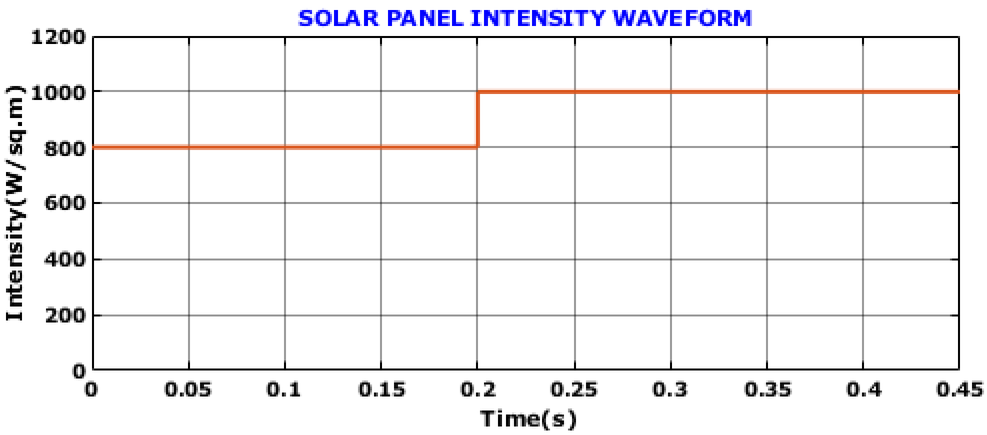

Figure10 Solar Panel Irradiation waveform

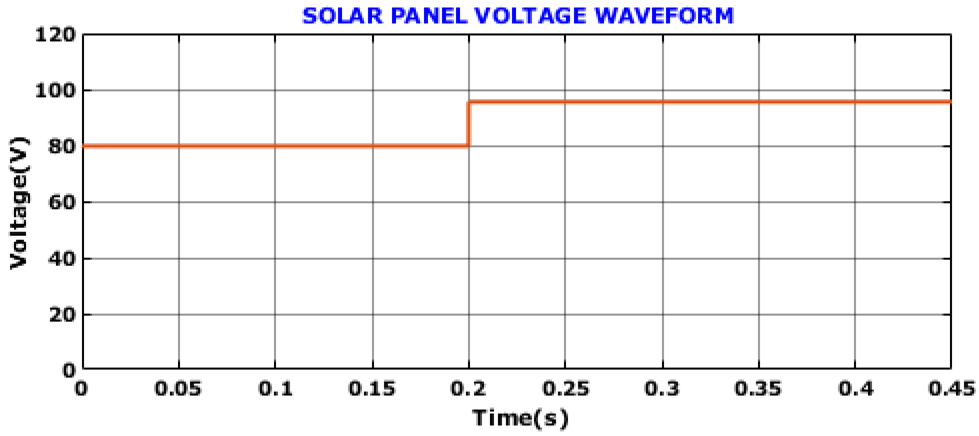

Figure 11 Solar Panel Voltage waveform

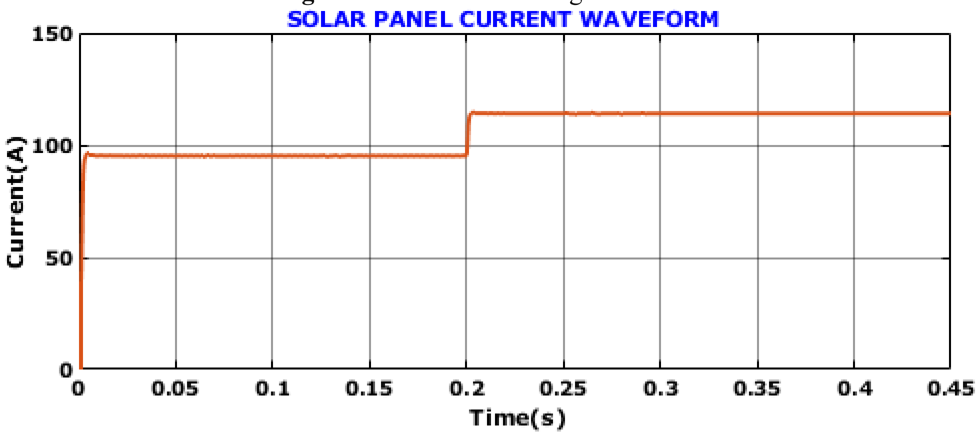

Figure 12 Solar Panel Current waveform

The frequency, voltage, temperature, and irradiation of the Relift Luo converter are shown in Figures 5.5, 5.6, 5.7, and 5.8. At 600 volts, the converter's output value is finally attained.An inductor stores energy and then releases it to the load at a greater voltage, allowing it to attain this unique function.

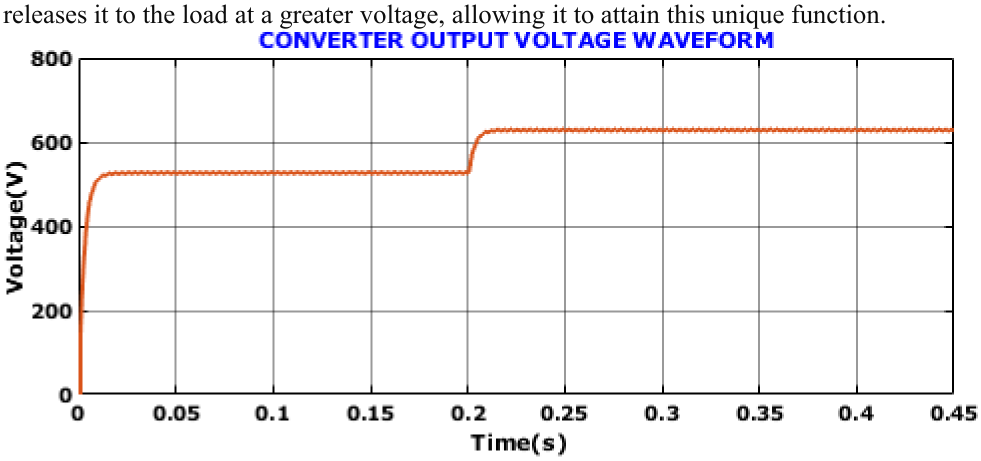

Figure 13 Converter Output Voltage Waveform

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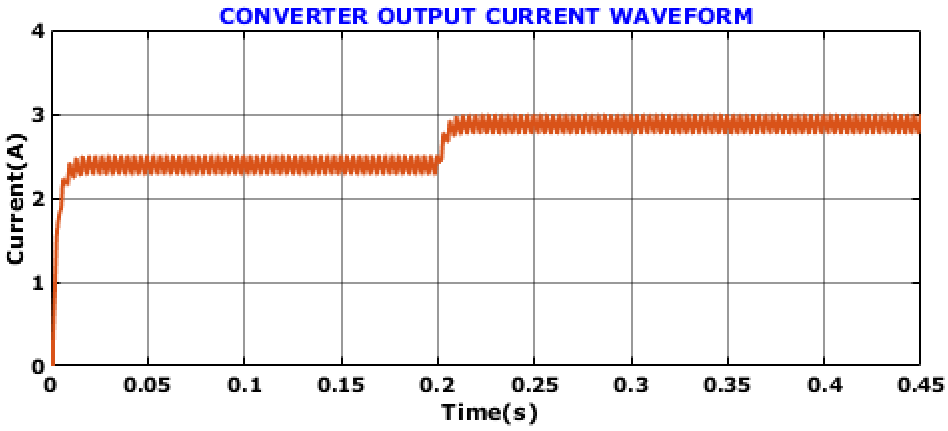

Figure 14 Converter Output Current Waveform

Figures 5.9 and 5.10 show the waveforms of the converter's voltage and current, respectively. It is clear that the current is at its highest point when the voltage is at its highest.

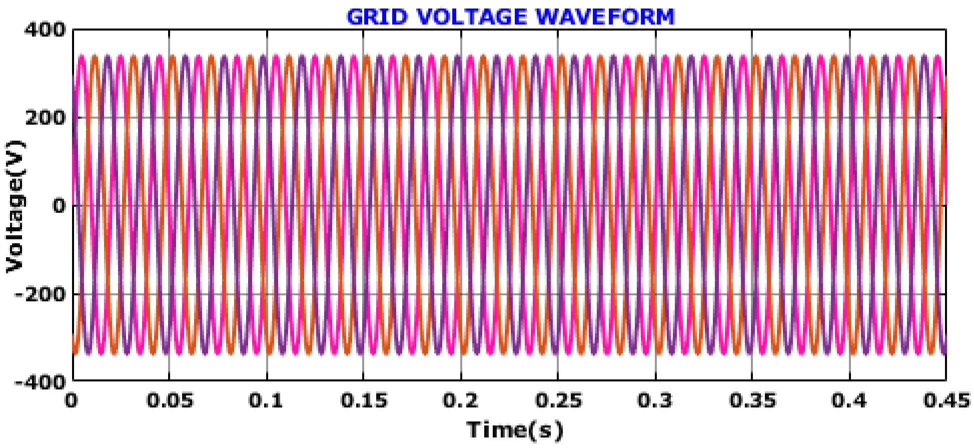

Figure 15 Grid Voltage waveform

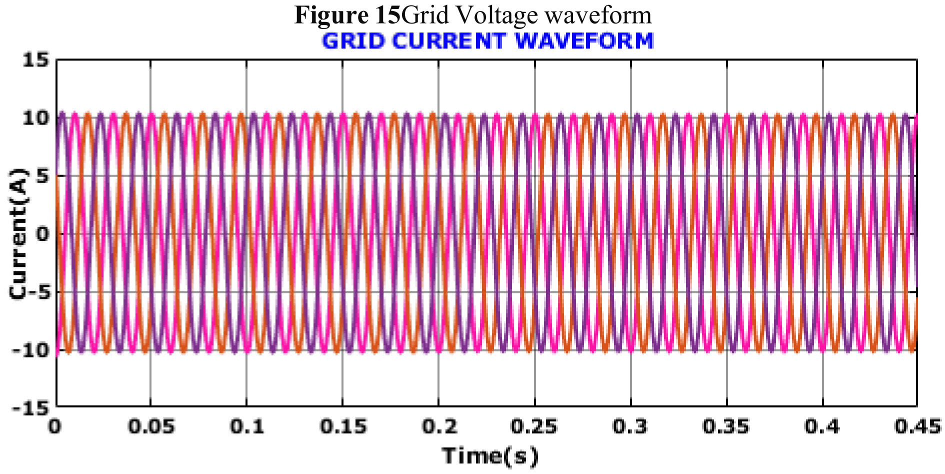

Figure 16 Grid Current waveform

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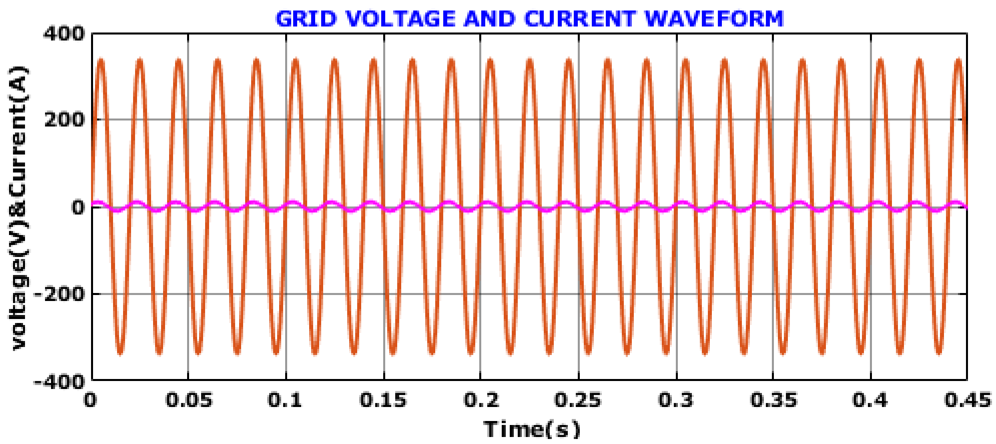

Figure 17 Grid Voltage and Current waveform

A sinusoidal waveform with a constant voltage and frequency is shown in Figures 5.11, 5.12, and 5.13 for the grid's output voltage and current.

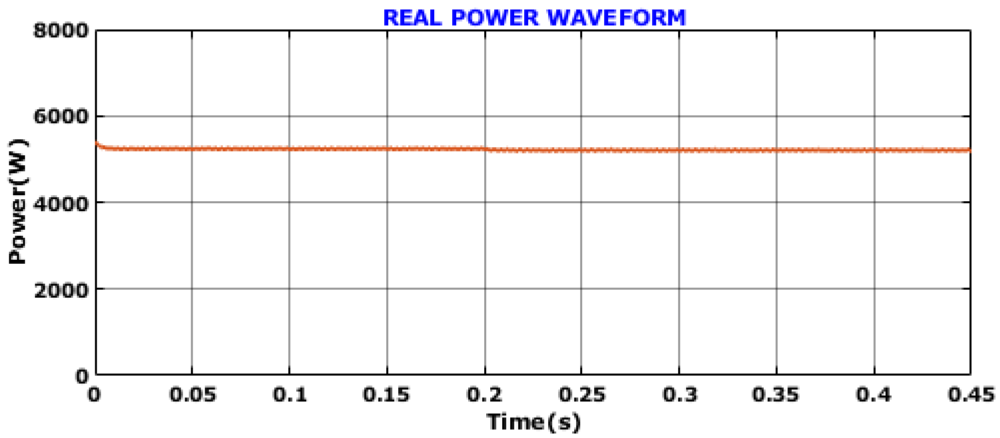

Figure18 Real Power waveform

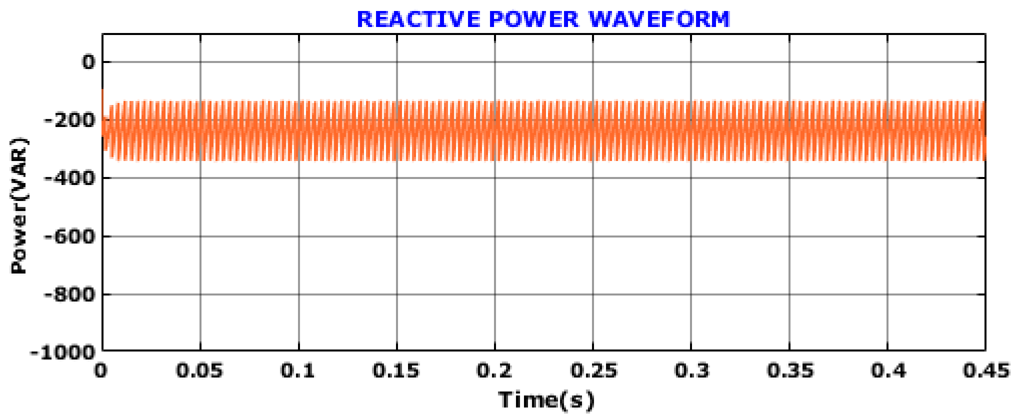

Figure 19 Reactive Power Waveform

The true power obtained was 5250 watts, as shown in Figures 5.18 and 5.19, which display the reactive power waveform of this study.

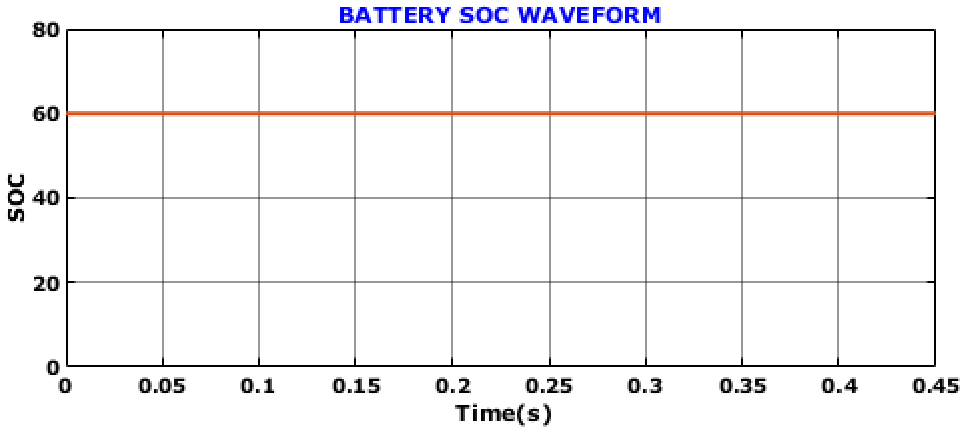

Figure 20 Battery SOC Waveform

The battery system-on-chip waveform, shown in figure 5.20, gives a system-of-chip estimate of around 60%.

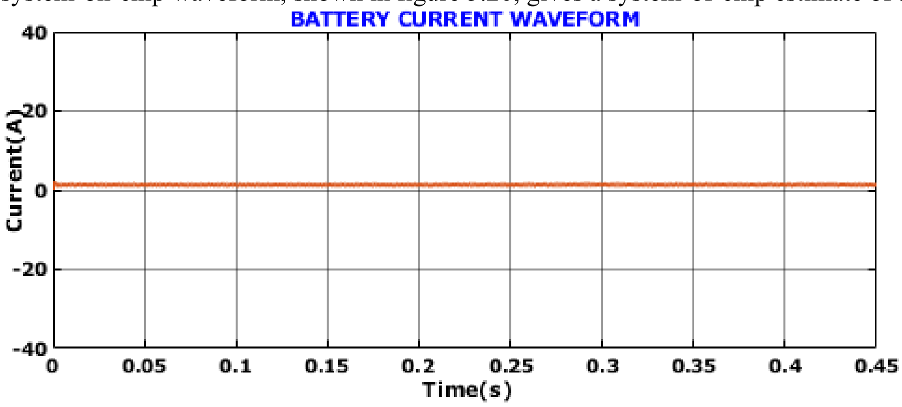

Figure 21 Battery Current Waveform

The battery current waveform, shown in figure 5.21, gives a state-of-the-cell estimate of around 80%. With the ability to send power in both directions, electric vehicle batteries can be charged more efficiently and any excess power may be sent to other areas of the grid when demand is low.

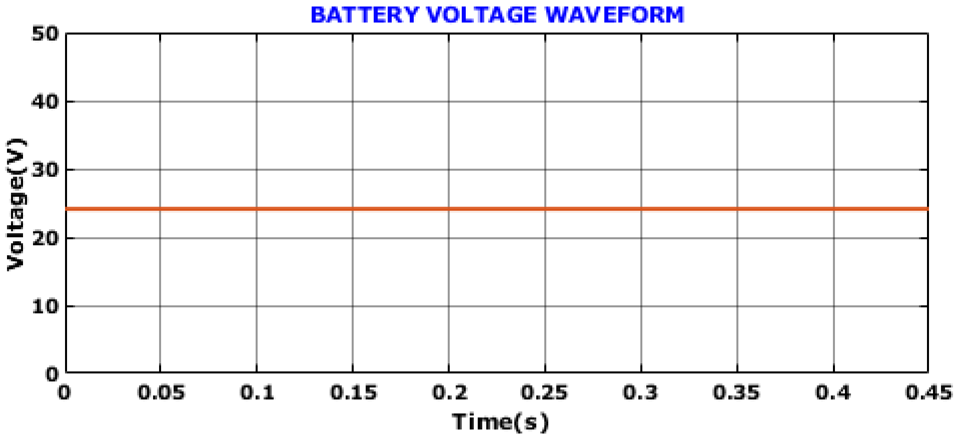

Figure 22 Battery Voltage Waveform

The waveforms in figures 5.21 and 5.22 show the current and voltage levels in the battery.The voltage of the battery is 24 volts and the current is 1.8 amps. Electric vehicles are able to effectively recycle the power they store back into the grid when they are not in use.

CONCLUSION AND FUTURE SCOPE

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CONCLUSION

Improving Power Quality for Grid-Tied Electric Vehicle Charging using a Neural Network-Driven Intelligent MPPT Controller is the focus of this study. Optimal battery management and intelligent Maximum Power Point Tracking (MPPT) control for PV systems are major steps towards improving system performance and energy efficiency. While an RNN controller maintains grid voltage stability and synchronization, a novel approach based on Artificial Neural Networks (ANN-MPPT) optimizes solar panel output. The meticulous attention to detail in attaining optimum power flow and system balance is shown by the bidirectional converters for battery charging and other power sources, as well as the addition of an LC filter to boost inverter output. A comprehensive strategy for controlling energy production, storage, and distribution is shown by the control outputs for PV/battery input power sources and injecting AC power into the grid. Improved system performance, efficiency benefits, and low harmonic distortions were shown by results of simulations performed using MATLAB 2021a and hardware implementation utilizing a DSPIC30F4011 Controller.

FUTURE SCOPE

- Model predictive control (MPC) and adaptive control are examples of sophisticated control techniques that may be used to improve the efficiency of interleaved converters.
- Active synchronous rectifiers have the potential to enhance the overall efficiency and power density of power electronic systems by integrating with other systems like inverters and DC-DC converters.
- To enhance the efficiency, stability, and dynamic responsiveness of active synchronous rectifiers, research might focus on creating cutting-edge control methods for these devices.
- Improving methods for identifying and preventing system failures may enhance system safety and dependability while decreasing unplanned downtime.

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