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Modernization of Electric Vehicle Charging System Using Hybrid Algorithm

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Abstract—

As fossil fuel reserves are depleted, fuel prices rise, and their continued availability becomes uncertain as a result of ongoing worldwide crises and conflicts, there has been a noticeable change in focus toward electric vehicles. In addition, there is an ongoing requirement to integrate renewable energy sources into the EV Charging chain in order to lessen the indirect strain on thermal and nuclear power stations. As a solution to these issues, the planned work centers on the creation of a grid solar hybrid electric car.

The proposed system will feature an AI-controlled solar-powered boost converter, a PWM (Pulse Width Modulation) based low-cost DC rectifier, and a power transistor-based grid interface to maintain a common DC bus at the necessary potential. It will also feature an intelligent computer-controlled PWM switching system that prioritizes the use of solar energy harvested from the vehicle's roof in battery charging while in vehicle charging mode, thereby reducing the grid's workload. In order to further enhance the system, PWM-controlled regenerative braking will be included to power the DC bus when braking.

In this study, we will look at how to build a Solar PV boost converter that leverages AI principles, with the help of a simulation, Embedded C, and MATLAB. Based on the current PV voltage, a Levenberg Marquqardt ANN is utilized to make an approximation of the Solar Boost PWM.

Keywords— *Electric Vehicle, Grid-Solar Hybrid DC Motor PWM Control, Intelligent Electronic Switching, Artificial Intelligence, Fuzzy Logic.*

I. Introduction

Sales of plug-in electric vehicles (EVs) are expected to reach seven million by 2025, and demand for EVs is higher than ever. Despite this, there has been a rising tide of demand from consumers and commercial fleets alike for better battery performance and charging infrastructure.

Scientists have to find a way to satisfy the public's ever-increasing appetite for electricity without compromising the grid's ability to swiftly, reliably, and safely transport that power. The National Renewable Energy Laboratory is at the forefront of extreme fast charging (XFC) projects and grid integration alternatives to satisfy energy demands (NREL).

Climate change, brought on by global warming, is one of our planet's biggest problems right now. Rising public awareness of air pollution and the increasing instability and high cost of fossil fuel supply have pushed policymakers and researchers to investigate alternatives to the conventional internal combustion engine vehicles that rely on fossil fuels. One significant step toward realising this goal is the widespread use of electric vehicles in the transportation industry. Possible benefits of electric vehicles (EVs) include a reduction in harmful air and noise pollution emissions, increased energy efficiency in comparison to internal combustion engines, and the eventual replacement of oil as the primary energy source for road transport. It is expected that the number of individuals around the world who utilise electric vehicles will rise as their increasing popularity spreads. However, there are several particular challenges associated with and influenced by electric vehicles, which affect the electricity infrastructure. While many academic studies have looked at how transportation systems contribute to greenhouse gases, only recently have they begun to understand how EVs impact power grids. Currently, plugged-in electric vehicles (EVs) are the market's dominant segment (PEV). Researching the effects of PEVs on power grids requires their classification. Drivetrain architecture and powertrain architecture are two examples of the types of architectures used to define plug-in charging systems. The drivetrain architecture of PEVs consists of an electric motor, a battery, and a mechanism of charging the battery via the power grid. Depending on whether or not these additional components are present, the PEV can be further separated into Battery electric vehicles (BEVs), Plug-in Hybrid electric vehicles (PHEVs), and Extended range electric vehicles (EREVs).

II. Literature Review

Kotla Aswini et. All (2021) A vehicle-to-grid infrastructure has been developed in response to the increasing popularity of electric automobiles. With car-to-grid technology, electric vehicles may send electricity back into the grid from their batteries. This means that the peak load can be reduced, the load levelling voltage can be managed, and the power system's dependability can be improved. In this study, we designed a portable bidirectional charger that may be used to charge and discharge the on-board batteries of electric vehicles. To charge the batteries in G2V mode, the grid provides a continuous, sinusoidal current with a power factor of 1. [1]

Molla et. All (2021) Due to their superior performance and negligible impact on the environment, electric vehicles are gaining in popularity around the globe. Successful implementation of electric vehicles relies on efficient communication between energy storage systems and power electronics converters. In contrast, power from batteries is unreliable, unregulated, and prone to significant voltage drops. To transmit power from a battery-powered energy storage system to an electric motor in an electric car in a safe and reliable manner, converters, controllers, and modulation methods are employed. This survey of power electronic converters for electric vehicles discusses the converter, controller, modulation, and optimization of these components, among others. In this analysis, we examine and contrast a number of different state-of-the-art and practically relevant DC-DC converter topologies for usage in electric vehicle (EV) drive trains. [2]

Sheng-Yu Tseng et. All (2022) The findings of this study present a multi-source hybrid converter suitable for charging lithium-ion batteries. Due to the low output voltage, a bigger step-down voltage is required when connecting a lithium battery charger to utility lines or PV arrays. While a buck converter is preferred for PV arrays, a fly back converter is required for charging batteries from PV arrays and utility lines. Converters that use a hybrid design have been shown to be compatible with both traditional power grids and renewable energy sources like solar panels. The proposed hybrid converter makes it possible to achieve different charging currents and MPPT operations when using solar energy. As an added bonus, its maximum conversion efficiency is over 91% at full load and around 95% at 80% of full load. During the on-cycle of the suggested switch, ZVS can be used to activate switches M1 and M2. [3]

Oleksandr Korkh et. All (2020) In this article, we provide an overview of isolated matrix inverters. This research helps establish a criterion for classifying the existing choices. About 30 alternative topologies were studied to determine their key advantages and disadvantages. An isolated matrix inverter's flexibility is measured by its ability to handle changes in input power and output voltage. Uninterruptible power supplies, high and low voltage/power solar systems, low power fuel cells, various battery and/or electric car chargers, and audio amplifiers are only some of the possible uses for these inverters. Research in this area categorises galvanic ally isolated inverters into three separate groups: two-stage, quasi-single-stage, and single-stage. [4]

Sajib Chakraborty et. All (2019) Topologies for DC-DC converters used in BEVs and PHEVs are discussed (PHEVs). Each converter architecture is analysed in terms of its output power, component count, switching frequency, electromagnetic interference (EMI), losses, efficiency, effectiveness, reliability, cost, and cost (component count). Additionally, the study compares and contrasts the structure, pros, and cons of AC-DC and DC-DC converter topologies commonly used in Fast Charging Stations. For the first time, this study provides a comprehensive assessment of DC-DC converter topologies for BEV and PHEV power trains and a preview of future research directions. [5]

Divya Krishnan Nair et. All (2021) The transportation sector has undergone a radical transformation as a result of the widespread adoption of electric vehicles. If only this were the case, EVs would be fantastic for the environment and produce no pollution at all. However, depending on how they are charged, they can significantly strain the grid and increase carbon emissions. Putting in charge stations for solar-powered electric vehicles is the best solution to this problem. The purpose of this research was to document the process of building a zero-voltage switching snubber-equipped, off-grid charging station for electric automobiles. The proposed system consists of solar panels equipped with boost converters as well as a bidirectional converter and energy storage devices equipped with snubber circuits. [6]

Joao L. Afonso et. All (2021) There have been recent developments in power quality adjustment challenges that necessitate novel power electronics solutions. Smart grids rely heavily on power electronics converters for several vital technologies like renewable electricity, electric transportation, and battery banks. This relates to the issue of subpar electrical power. Furthermore, this paper offers a comprehensive review of power electronics technologies that can be used to enhance grid performance, outlining the main power electronics topologies for each technological solution and highlighting and explaining the various causes and effects of power quality issues in smart grids. Integration of critical technologies into smart grids, such as renewable energy sources (RES), energy storage systems (ESS), electric mobility, and railway systems, is increasing the demand for power electronics converters. [7]

Maura Musio et. All (2014) This paper describes a straightforward and generic battery model for usage at charging stations, with a particular emphasis on lithium rechargeable batteries used in electric vehicles. The algorithm needs to be mathematically described in detail, its model parameters determined, and its ability to replicate the dynamics of fast charging processes over time verified. This study analyses and empirically assesses the use of a generalised and simplified lithium battery model with the goal of investigating its potential application in the coordination and energy management of EV charging operations at off-board charging stations. It is evident that the battery model for lithium iron phosphate batteries is quite accurate when experimental data is compared to the simulation findings under varied charging settings. [8]

Reinhold Koch et. All (2013) In recent years, there has been a rise in interest in both traction batteries for electric vehicle propulsion and stationary batteries for balancing the inconsistent output of renewable energy sources. Every one of these uses necessitates a battery with exceptional performance characteristics, especially regarding energy density and discharge rate. Batteries are usually connected in series to ensure that the motor or the grid receives a sufficient voltage. Each battery in a battery stack should be charged at the same rate to maximise the stack's capacity and lifespan. The flux additive MIMO DC/DC converter is proposed for use in balancing battery modules. It enables the direct and simultaneous transfer of energy in both directions. The concept for a two-way, bidirectional converter has been proven to operate, and a prototype has been constructed and tested. First experimental results evaluating the viability of a charge balancer are given. [9]

Hui Xiong et. All (2020) Due to its high energy density and low self-discharge rate, lithium batteries have become the primary power source for zero-emission vehicles. Internal resistance and self-discharge rate are two examples of characteristics that cause variation between individual cells in series battery packs that are used in the real world. These variations will lessen the battery pack's efficiency and longevity and may even compromise the battery system's safety. Using a fly-back converter, this paper presents a new equalisation technique to enhance the dependability of series battery packs. Inconsistency can be measured quantitatively by the quantity of energy still present in a single cell. Because of the fly back converter, we know that all batteries are being charged at the same pace. It's low-priced, simple, and reliable, so it passes our test. [10]

Parthasarathy Nayak et. All (2019) The capacity of an EV's battery to be charged is set by the power converter. The importance of making a wise choice of converter architecture is emphasised by a number of factors (PFC). We provide a fly-back-based clamp circuit for an isolated single-stage AC-DC converter in this study, which can be used to recharge the batteries of electric vehicles. While a full-bridge inverter is used on the DC side, a half-bridge cycloconverter (HB) is used on the AC side (FB). Grid-to-vehicle (G2V) and vehicle-to-grid (V2G) communication are two areas where soft switched unipolar pulse width modulation finds use. [11]

Abdul Hassan Jaafar et. All (2016) Governments have known for a long time that IC-engine cars are a major obstacle to reducing global warming. Governments have long acknowledged that reducing the number of internal combustion engines (IC engines) is a crucial aspect of this effort. Around 90% of the country's greenhouse gas emissions are caused by cars and trucks. A 25% increase in average fuel use is necessary for Malaysia to achieve its aim of reducing CO2 intensity by 40% by 2020 from 2005 levels. The increasing use of electric vehicles is one solution (EVs). Lack of charging infrastructure, especially in heavily travelled locations, is a major barrier to wider adoption of electric vehicles. [12]

Avinash V. Shrivastav et. All (2020) The research aims to find out how likely it is that both EVs and CSs would thrive in the Indian market. Energy allocation and energy mix market processes in India have improved thanks to the growing privatisation, liberalisation, and expansion of distributed and renewable power generation in the country's electrical market. In this piece, we analyse the commercial possibilities of EVs in the current energy market in a systematic way. Smart charging, vehicle-to-grid connections, solar power for recharging electric vehicles, contactless charging, and on-road charging are five of the most important technologies that will facilitate the eventual switch to electric transportation. [13]

Rahul Kumar et. All (2020) Electric vehicles (EVs) have gained popularity as a more ecologically friendly method of transportation over the past decade, but widespread acceptance has been impeded by concerns such as high purchase prices, a lack of public charging stations, and worries over restricted driving range. The ability to charge an electric vehicle at home or at the workplace eases the mind of the owner who worries about being stranded. In this study, we design, implement, and test a portable charging system for electric vehicles (BEVs). This charger supplies the grid with reactive electricity while also transmitting energy from the vehicle (V2G). The onboard charging system employs a three-phase alternating current to direct current (AC-DC) matrix converter topology. The charging current and reactive power flow are controlled via direct power control (DPC) and space vector modulation (SVM), respectively. [14]

Juntao Yao et. All (2021) In an active clamp fly back converter (ACFC) using a GaN IC, the initial step is to develop models for radiated electromagnetic interference (EMI) (IC). The converter's capacitive connections that cause radiated EMI are isolated and tested to ensure they are no longer a problem. The addition of capacitive couplings has enhanced the radiated EMI model. This revised model allows us to suggest and empirically assess strategies for reducing capacitive couplings and radiated EMI. Initially, an ACF converter constructed with GaN switching components was used to represent radiated EMI. Capacitive couplings between the pulsating voltage nodes and the input and output cables are critical for radiated EMI analysis, but the impedance produced by the diode bridge itself is irrelevant. [15]

Parthasarathy Nayak et. All (2019) The capacity of an EV's battery to be charged is set by the power converter. The importance of making a wise choice of converter architecture is emphasised by a number of factors (PFC). Specifically, we provide a fly-back-based clamp circuit for an isolated single-stage AC-DC converter used to refuel the batteries of electric vehicles. While a full-bridge inverter is used on the DC side, a half-bridge cycloconverter (HB) is used on the AC side (FB). Grid-to-vehicle (G2V) and vehicle-to-grid (V2G) communications can both benefit from the use of soft switched unipolar pulse width modulation (UPWM). The high-frequency transformer's filter inductor and leakage inductor must be connected to a clamp circuit for the converter to operate. [16]

V. Viswanatha et. All (2022) The article's whole focus was a review of the most cutting-edge bidirectional DC-DC converter topologies and intelligent control algorithms, a discussion of the research gaps that exist in the field, and a call for more investigation. Topology and control strategies for bidirectional buck-boost DC-DC converters are discussed. Many different topologies for bidirectional DC-DC converters are discussed, including those that utilise transformers and those that do not. Non-isolated converters, unlike fly back converters, which use transformers, do not produce a DC channel between their input and output. A transformer-less converter is preferable when the load doesn't require much safety from high voltage. The topology and control of DC-DC converters are the focus of this study. [17]

Sheng-Yu Tseng et. All (2022) This study creates a zeta/fly back hybrid converter that could power LED roadway lighting and electronic billboards. The addition of a battery charger and discharger is essential if the PV array is to supply energy for an LED lighting system. Zeta converters can now be used to charge batteries for a wider variety of photovoltaic (PV) systems. Since it is simpler to use, a fly back converter is also employed for battery discharge. An active clamp circuit is used to recover usable power from the fly back converter's leaking inductor. Through the use of switch integration methods, the zeta and fly back conversions can be combined to form the zeta/fly back hybrid converter. [18]

Ming-Hung Lu et. All (2012) Key concerns in the push for EVs include the widespread availability of charging infrastructures and the guarantee of charging safety (EVs). In addition to federal regulations, several international pilot programmes, including those in the United States, China, and Taiwan, ensure that electric vehicles and related infrastructure meet all applicable safety standards. IEC, SAE/UL/GB, JEVS, and JEVS are just few of the standards you'll need to know in order to participate in this game. However, a compilation of the various regions' standards may take a long time and provide only limited guidance until the standards have been tried and evaluated. For that reason, this research set out to compile a comprehensive analysis of charging equipment's design, operation, efficiency, and security in relation to those aforementioned factors. [19]

III. Methodology

3.1 Proposed Work Circuit Diagram

Power is generated using a 10W solar panel, which is connected straight to a diode 1N5822 for unidirectional current supply and backward current protection before being fed into a boost converter circuit and ultimately the bus.

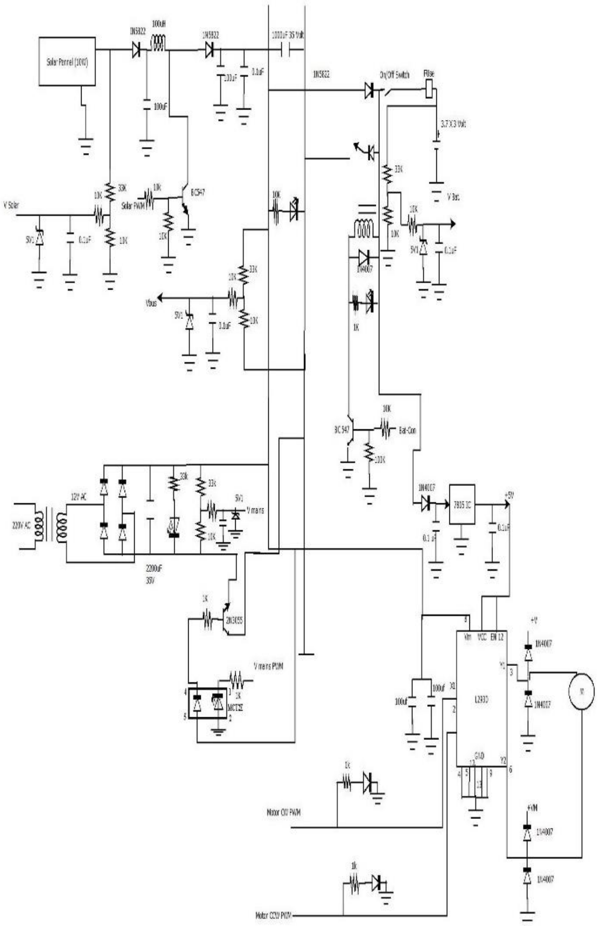


Figure: 3.1 Proposed Work Circuit Diagram

This solar pwm input was decided by MATLAB and is coupled to a boost converter circuit via a 10K resistance that is in turn connected to a transistor that is receiving a solar pwm signal. Solar power is fed into a voltage regulator comprised of a zener diode(5V1) and a capacitor filter. When the battery voltage is greater than the bus voltage, a relay-based switching circuit will allow the battery to be charged. As soon as the voltage drops, the battery kicks in to power the bus. L293D motor driver IC is connected to the motor through the bus and its supply voltage, Vcc, is supplied by a 7805 voltage regulator IC. The power supply circuit, which is coupled to the bus via transistor, may be seen in the lower left corner of this diagram.

Figure: 3.2 Proposed Work Hardware Image

In the above figure we can see our full proposed work hardware, including all of the components and circuits.

Protocol:

Arduino Send: Solar_Voltage, Mains_Voltage, Bus_Voltage, Battery_Voltage, Accelerator_Position, Break_Position.

Matlab Send: Motor Clock Wise PWM, Motor Anti Clock Wise PWM, Solar PWM, Mains PWM, Battery Connect, Y

3.3 Block Diagram

This block diagram demonstrates how a 10W solar panel is wired in series with a boost converter, and how the output of the converter is then sent into the bus. The relay-based switching circuit for charging and discharging the battery is depicted in the right-hand portion of the circuit.

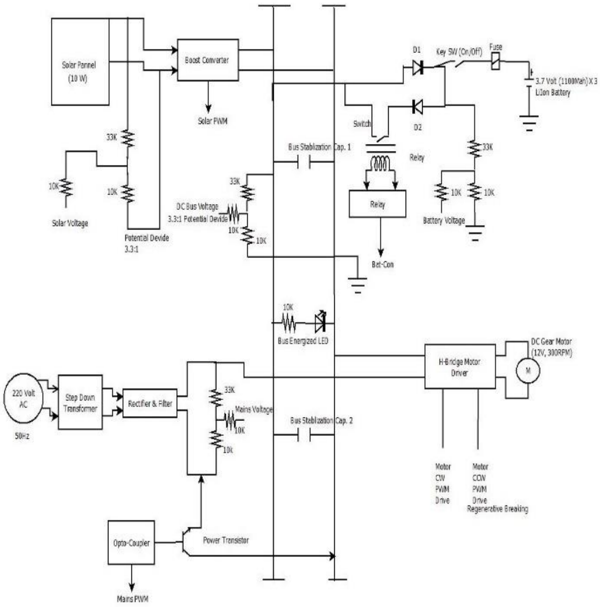


Figure: 3.3 Proposed Work Block Diagram

Further, a voltage divider circuit, used to generate an Arduino-compatible supply voltage, is shown in the block diagram's leftmost section. Alternate potential divider circuit with bus stabilising capacitor is employed. In the power supply portion, a step-down transformer converts 220V to 12V for use with the rectifier circuit, and from there, DC power is distributed to the H-Bridge motor driver IC so that the latter can adjust the DC motor's rotational direction. The bus voltage is regulated using Mains PWM and a power transistor, with the help of an opto-coupler IC.

3.4 ANN Flow Chart

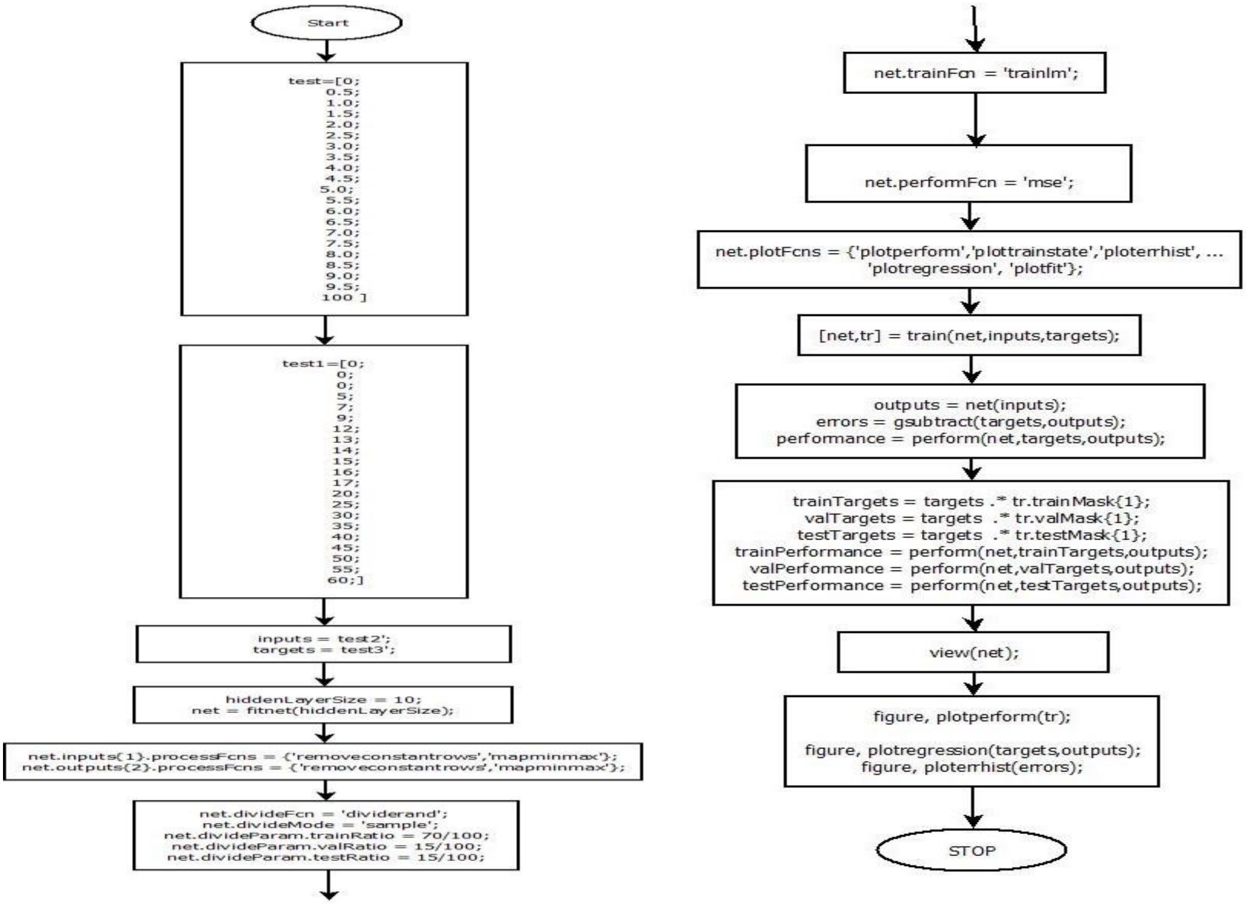


Figure: 3.4 ANN Flow Chart

in this above flow chart we can see 1st ANN code is start then call to test and test1 values then inputs and targets values, then hidden layer size then remove consstanrows, then divided train, val, and test ratio. then train fcn then plot function and train (net,input,targets) then calculate performance then after some calculation figure plot like plotregression and ploterrhist (error histogram) then code will be stop.

3.5 Arduino Block Diagram

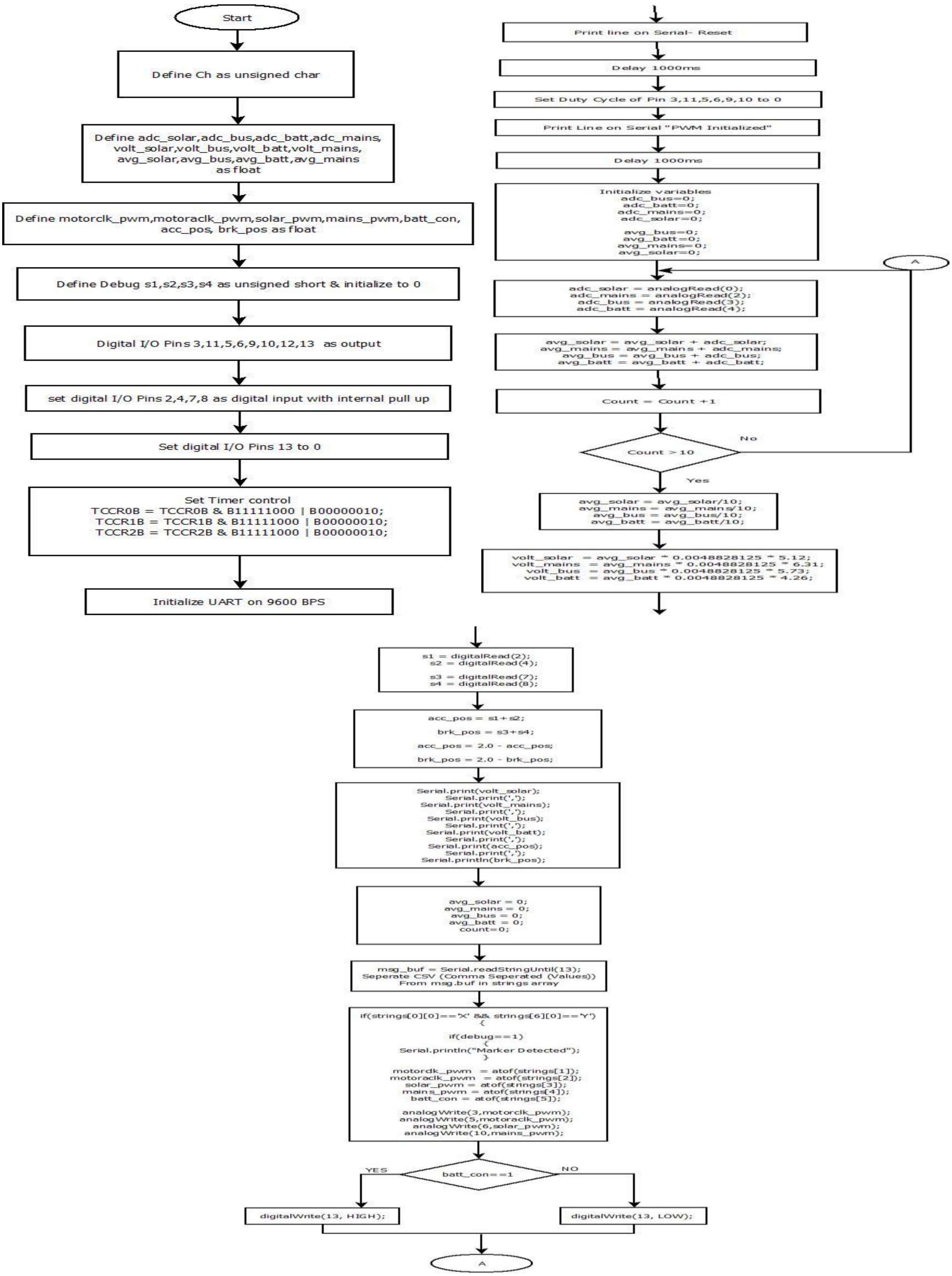
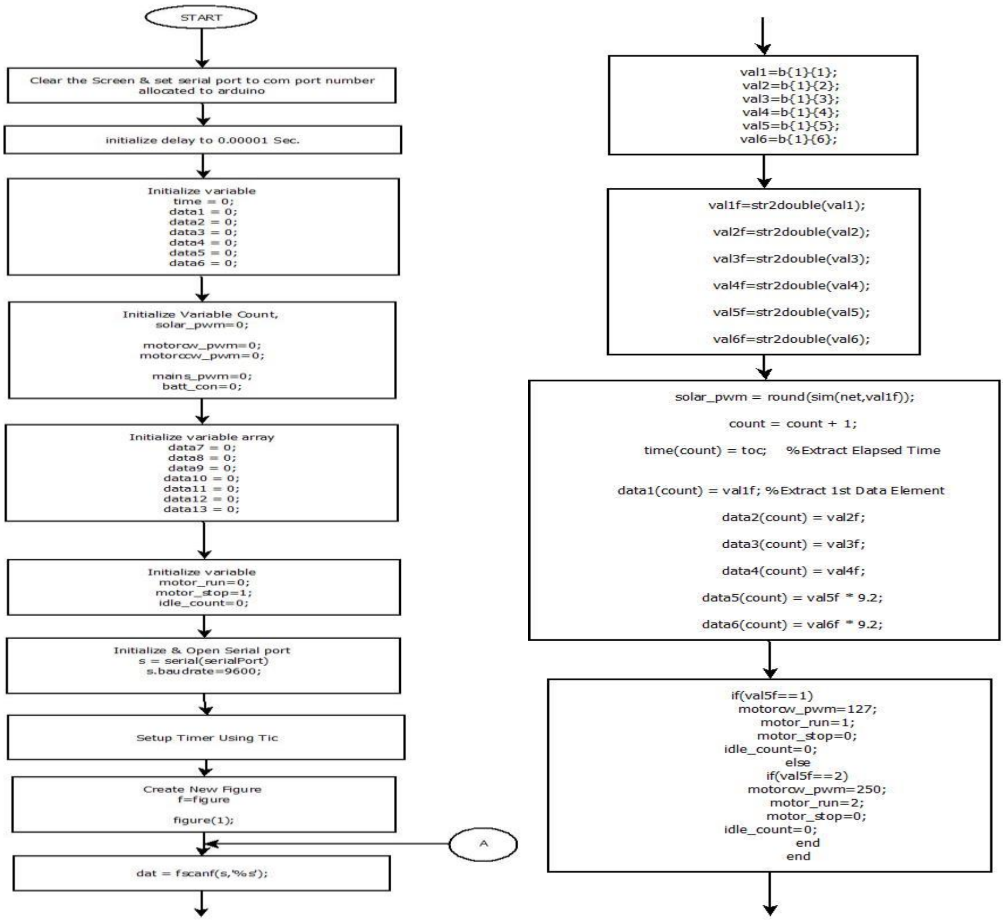


Figure: 3.5 Arduino Block Diagram

in the above block diagram we can see 1st main code is start then unsigned char is start then define adc solar, adc bus, adc battery, adc mains and solar, bus, battery, mains voltage and all of these average value then define motor clock etc. then initialize S1,S2, S3, S4 to zero then define pins as output, then set input pins with internal pull up then set timer control and initialize UART on 9600 BPS, then print line on serial then delay 1000ms, then set duty cycle of pin then print line "pwm Initialized" then delay 1000ms then initialize some important variables, then set solar, mains, bus and battery voltage to analog read then count = count+1 then a "if" condition will be apply that is if count > 10 is yes then avg calculation followed other wise if its not true then again goes to analog read then digital pins read adn serial print all voltages all avg voltage equal to zero, then seperate CSV then print some values on serial then again check a if condition that is batt_con == 1 if its true then digital pin 13 is high other wise if not true then pin 12 is low then algorithm goes to statement A.

3.6 MATLAB Flow Chart



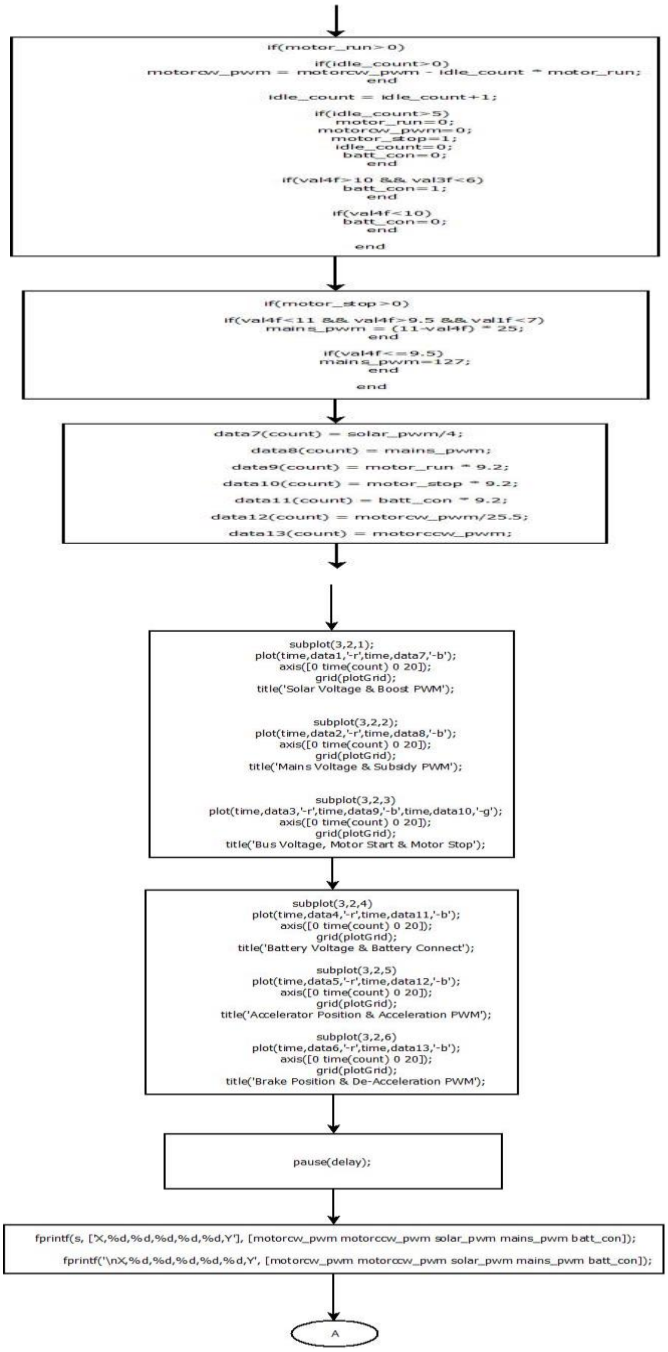


Figure: 3.6 Matlab Flow Chart

In the flow chart we can see 1st main matlab code is start then clear all the screen then initialize delay to 0.00001 second. then initialize these variable to zero time, data1, data2, data3, data4, data5, data6. then initalize variable count. then initialize variable array. then initialize variable motor run to zero, motor stop to one and idle count to zero. then initialize serial port and setup time using tic then create new figure. then calculate some values then a contion will be apply that is if val5f==1 then motorrow_pwm=127, motor_run=1; motor_stop = 0; other wise if val5f ==2 then motorcw_PWM= 250; motor_run=2; motor_stop=0, idle_count = 0; and if motor stop>0 and if(val4f<11 && val4f>9.5 && val1f<7) mains_pwm = (11-val4f) * 25; if(val4f<=9.5) mains_pwm=127; then data7(count) = solar_pwm/4; data8(count) = mains_pwm; data9(count) = motor_run * 9.2; data10(count) = motor_stop * 9.2; data11(count) = batt_con * 9.2; data12(count) = motorcw_pwm/25.5; data13(count) = motorccw_pwm; then subplot(3,2,1); plot(time,data1,'-r',time,data7,'-b'); axis([0 time(count) 0 20]); grid(plotGrid); title('Solar Voltage & Boost PWM'); subplot(3,2,2); plot(time,data2,'-r',time,data8,'-b'); axis([0 time(count) 0 20]); grid(plotGrid);

title('Mains Voltage & Subsidy PWM'); subplot(3,2,3) plot(time,data3,'-r',time,data9,'-b',time,data10,'-g'); axis([0 time(count) 0 20]); grid(plotGrid); title('Bus Voltage, Motor Start & Motor Stop'); subplot(3,2,4) plot(time,data4,'-r',time,data11,'-b'); axis([0 time(count) 0 20]); grid(plotGrid); title('Battery Voltage & Battery Connect'); then subplot(3,2,6) plot(time,data6,'-r',time,data13,'-b'); axis([0 time(count) 0 20]); grid(plotGrid); title('Brake Position & De-Acceleration PWM'); then apply pause delay then print all readings then algorithm again goes to condition 'A' as shown in the flow chart.

IV. Results

4.1 ANN Results

In the proposed system artificial neural network technique is used to improve the overall performance of the solar boost converter via pwm. The results and discussion of all the figures related to artifical neural network is given below.

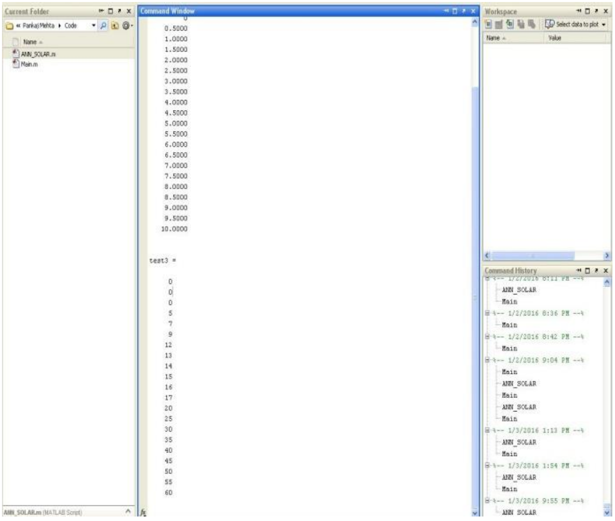


Figure: 4.1 Command Window with Test Data

In this figure we can see training data used for trained our artificial neural network. Here we used two data solar voltage and boost PWM of training artificial neural network.

In the below table we tabulated this data.

Table: 4.1 ANN Training Table of Solar Voltage and Boost PWM

S. No.	Solar Voltage	Boost PWM
1	0	0
2	0.5	0
3	1.0	0
4	1.5	5
5	2.0	7
6	2.5	9
7	3.0	12
8	3.5	13
9	4.0	14

10	4.5	15
11	5.0	16
12	5.5	17
13	6.0	20
14	6.5	25
15	7.0	30
16	7.5	35
17	8.0	40
18	8.5	45
19	9.0	50
20	9.5	55
21	10.0	60

Error histogram is the histogram of the errors between target values and predicted values after training a feedforward neural network. As these error values indicates how predicted values are differing from the target values, hence these can be negative.

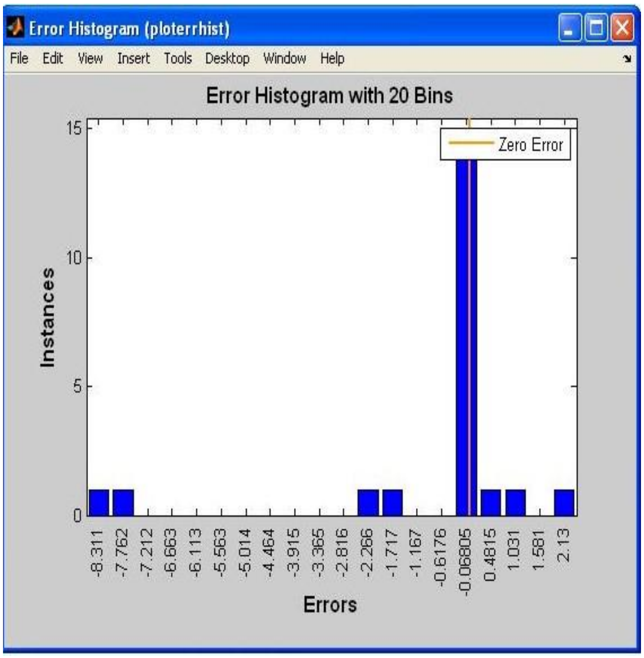


Figure: 4.2 Error Histogram

In the above graph it shows that the highest error (total 15) lies in the range of 0.068 and we can say that 90% error are lies in the negligible range which indicates that our system is perfect

4.2 Main Results

The proposed Modernization of Electric Vehicle Charging System Using Hybrid Algorithm, system is designed and performance results and graphs taken in environment of the MATLAB software, and the dynamic results of different modes of operation are given. The results that are shown in this thesis show how well the proposed charger works. Modernization of Electric Vehicle Charging System Using Artificial Intelligence Controller Solar PV Boost Converter, system is designed and performance results and graphs taken in environment of the MATLAB software, and the dynamic results of solar voltage and boost pwm plots with different time interval is shown below, in this thesis authors focused on solar voltage controlled using boost pwm by using the trained artificial neural network, in the below graphs we can see solar voltage with respect to boost pwm, for scaling in graph we divided boost pwm data by 4, so actual pwm is shown in table that is given below, here red colour shows solar voltage and blue colour shows boost pwm values. Below graph are taking with different time interval here we can see solar voltage & boost pwm graph with different time interval.

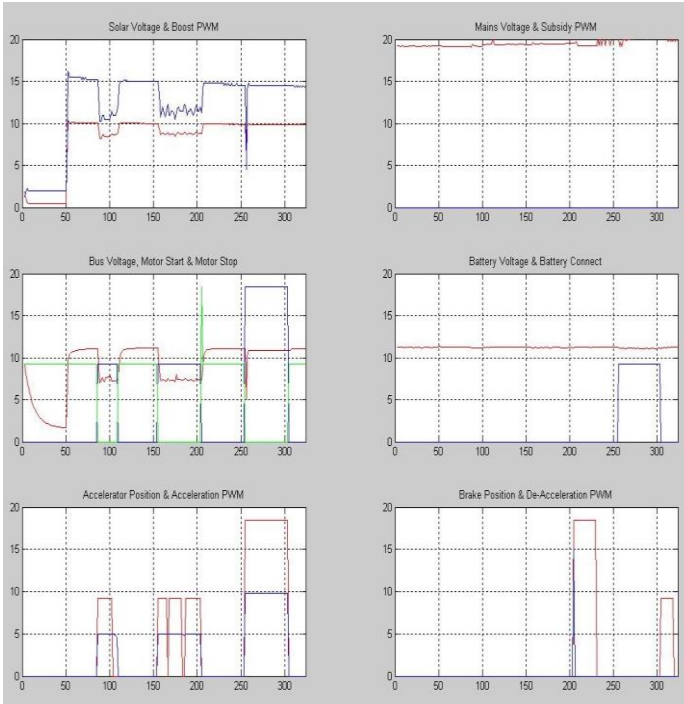


Figure: 4.3 Output Graph Plot 7

In the above graph we can see solar voltage & boost pwm, mains voltage & subsidy pwm, motor start and stop, battery voltage & battery connect, accelerator position & acceleration pwm, brake position & de acceleration pwm graphs with time interval 0-300 sec.

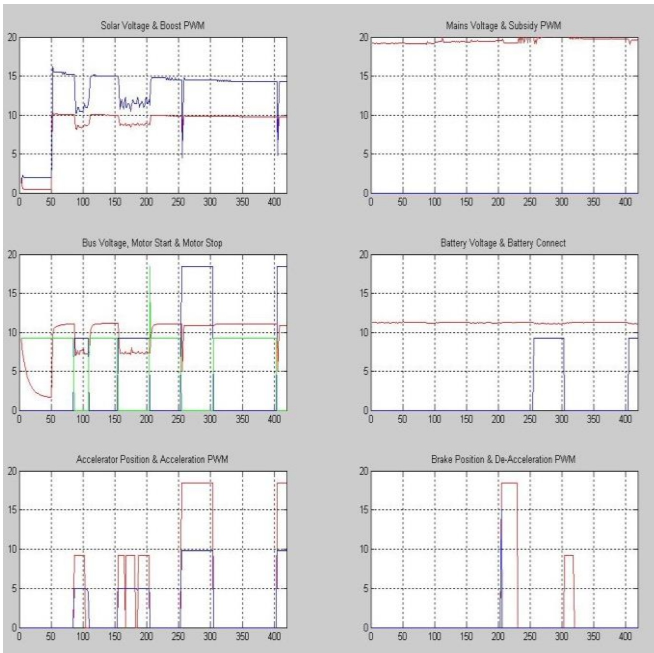


Figure: 4.4 Output Graph Plot 9

In the above graph we can see solar voltage & boost pwm, mains voltage & subsidy pwm, motor start and stop, battery voltage & battery connect, accelerator position & acceleration pwm, brake position & de acceleration pwm graphs with time interval 0-400 sec.

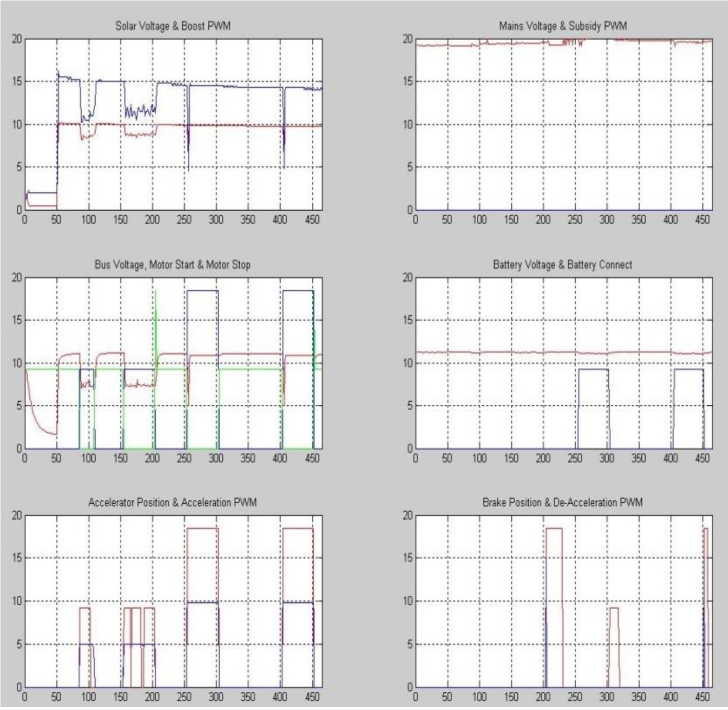


Figure: 4.5 Output Graph Plot 10

In the above graph we can see solar voltage & boost pwm, mains voltage & subsidy pwm, motor start and stop, battery voltage & battery connect, accelerator position & acceleration pwm, brake position & de acceleration pwm graphs with time interval 0-450 sec.

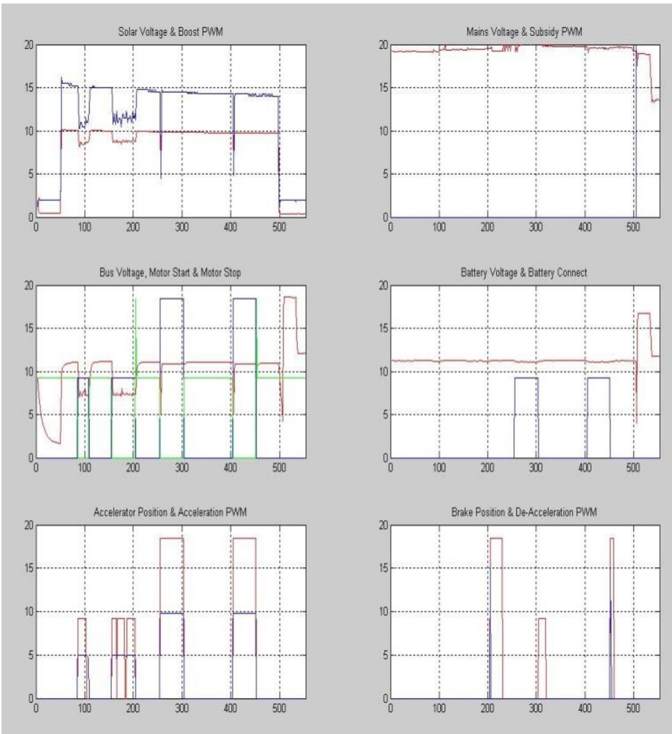


Figure: 4.6 Output Graph Plot 12

In the above graph we can see solar voltage & boost pwm, mains voltage & subsidy pwm, motor start and stop, battery voltage & battery connect, accelerator position & acceleration pwm, brake position & de acceleration pwm graphs with time interval 0-500 sec.

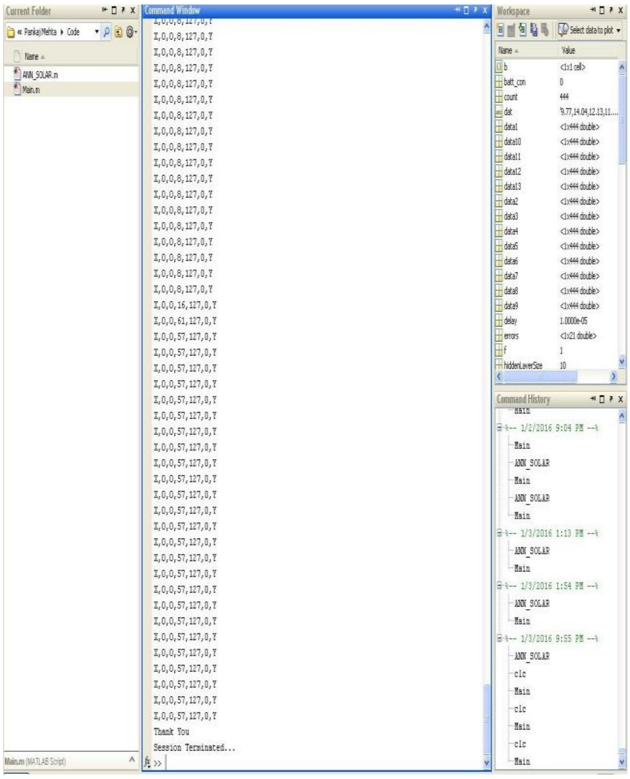


Figure: 4.7 Output Readings

In the below table we can analyze above graph data, here we tabulated solar voltage reading and scaled solar boost PWM and actual PWM with different time interval.

Table: 4.2 Analysis of above Graph Reading Data

S. No.	Time (Sec.)	Solar Voltage	Scaled Solar Boosts PWM	Actual PWM
1	50	10	17	68
2	100	8	11	44
3	150	8	11	44
4	200	9	12	48
5	250	7	9	36
6	300	10	14	56
7	350	10	14	56
8	400	5	9	36
9	450	10	14	56
10	500	1	2	8
11	550	1	2	8
12	600	10	14	56

Actual PWM is x4 to solar boost PWM because for simulate and simplicity graph we divided solar boost PWM to 4 for proper graph plotting so we can see graph readings easily.

4.3 Machine Learning Table

This machine learning table shows the compiled condition of the above graph results. On the basis of the below mentioned condition the graph show the solar voltage and boost pwm, mains voltage and subsidy pwm, bus voltage, motor start and motor stop, Battery voltage and battery connect, Accelerator position and Acceleration pwm, Break position and De- Acceleration pwm.

Table: 4.3 Machine Learning Data Table

Time Interval	Parameter 1	Parameter 2	Parameter 3	Parameter 4
0 Second	Mains ON	Solar OFF	Accelerator OFF	Break OFF
50 Second	Mains ON	Solar ON	Accelerator OFF	Break OFF
80 Second	Mains ON	Solar ON	Accelerator HALF	Break OFF
100 Second	Mains ON	Solar ON	Accelerator OFF	Break OFF
150 Second	Mains ON	Solar ON	Accelerator HALF	Break OFF
200 Second	Mains ON	Solar ON	Accelerator OFF	Break FULL
250 Second	Mains ON	Solar ON	Accelerator FULL	Break OFF
300 Second	Mains ON	Solar ON	Accelerator OFF	Break HALF
350 Second	Mains ON	Solar ON	Accelerator OFF	Break OFF
400 Second	Mains ON	Solar ON	Accelerator FULL	Break OFF
450 Second	Mains ON	Solar ON	Accelerator OFF	Break FULL
500 Second	Mains ON	Solar OFF	Accelerator OFF	Break OFF
525 Second	Mains ON	Solar ON	Accelerator OFF	Break OFF

V. CONCLUSION

Electrical vehicle is the only alternative efficient & environmental friendly transportation system. The author has proposed & demonstrated a novel system of grid-solar hybrid EV battery charging using artificial intelligence & customized fuzzy logic, that enables maxima in power extraction from vehicle roof mounted solar panels using neural network controlled boost converter, priority to solar energy is given while charging EV battery & only engaging the grid when battery SOC (State of charge) is less than 50%, or solar power is not available or fast charge is required also solar energy is utilize while vehicle running but tapping neural network controlled solar boost converter to maintain required DC bus potential for required motor power, & only to the deficit from the battery. As demonstrated by the results above the author has designed & developed a hardware model for proposed system comprising of arduino uno embedded controller board solar panel, PWM based H-bridge, DC motor with load which in turn acts as slave unit to the matlab program running on a PC/Laptop interfaced to the hardware model. The code acts as master unit & read & plot voltage solar, mains battery & states (accelerator brake) & than generate & boost PWM in accordance with brake/ battery SOC etc. as demonstrated by the above results, the proposed system has been successfully implemented.

VI. Future scope

There is a great deal of room for growth and improvement in the suggested system in light of the quick progress in EV technology and the changing system, as well as the depletion of fossil fuels and the rise in the price of gasoline and diesel as a result of international conflict. High efficiency power converters and ultra-efficient photovoltaic solar panels can be the primary areas of research and development. It will allow for advancements to be made in MOSFET/IGBT technology, which will decrease switching losses and other power losses, speed up switching, and lessen latency and transients. Smart grid needs necessitate the use of an efficient and intelligent electronic switching and control system, which can be implemented on DSPs (Digital Signal Processing) in order to achieve inexpensive electronic control cards/boards.

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