Volume: 7 **Issue:** II **Month of publication:** February

DOI: http://doi.org/10.22214/ijraset.2019.2081

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 7 Issue II, Feb 2019- Available at www.ijraset.com

NI-Labview based Monitoring and Control of Charging Unit for Hybrid Electric Vehicle

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Abstract: Energy and environmental issues are among the most important problems of public concern. Solar energy may be one of the alternative solutions to overcome energy shortage and to reduce greenhouse gaseous emission. Nowadays electric vehicles are replacing conventional vehicles because of their environment-friendly operation and less maintenance. Using electric vehicle in cities can significantly improve the air quality there. The basic principle of a solar-based electric vehicle is to use energy that is stored in a battery to drive the motor and it moves the vehicle in forward or reverses direction. The DC voltage from the PV panel is then booted up using a boost DC-DC converter, and then an inverter, where DC power is converted to AC power and also DC power ultimately runs the Brushless DC motor which is used as the drive motor for the vehicle application. The idea proposed here is to optimize the charging of the battery in the solar-powered vehicle and monitoring the parameters using Ultra high-frequency communication by LabVIEW. Data communication is done using NI MyRio hardware. Here the vehicle is powered by solar energy which uses solar power effectively. It optimizes the charging of the battery in two ways. The first method is tracking the solar light in order to receive the maximum voltage through light sensors. The second method is using a conventional rooftop mounting technique for the solar panel has been used and mounted on the top of the vehicle. The parameters of the vehicle are monitored in a Graphical User Interface. The GUI used here is LabVIEW. Data communication is done using NI MyRio hardware. The aim of our project is to design and develop the co-simulation approach for embedded control of electrical solar system based on NI-LabVIEW and NI-MultiSIM for electric vehicle application.

Keywords: Hybrid electric vehicle, PV panel, Boost converter, MyRio hardware, NI-LABVIEW and NI-MultiSIM…

I. INTRODUCTION

Renewable energy is one of the alternative solutions to overcome energy shortage and to reduce greenhouse gaseous emission. In solar based electric vehicle the battery stored energy is used to drive the BLDC motor. The DC voltage from the PV panel is boosted up using a boost DC-DC converter then it is stored in a battery. Here is to optimize the charging of the battery in solar powered vehicle and monitoring the parameters using Ultra high frequency communication by Labview. The Data communication is done using NI MyRio hardware. The parameters of the vehicle are monitored in a Graphical User Interface. The GUI used here is LabVIEW.

II. PROPOSED BLOCK DIAGRAM

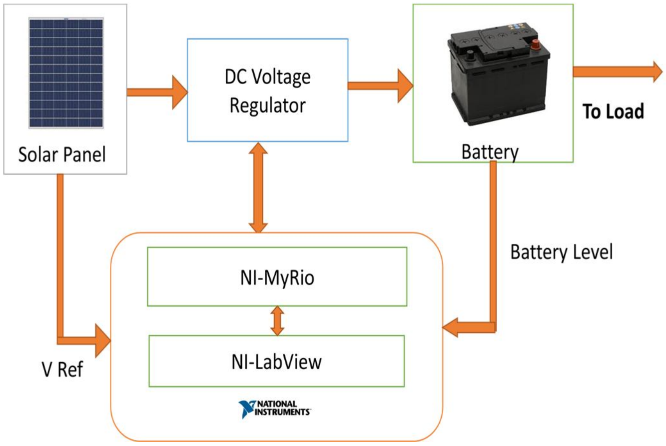


FIG -1: BLOCK DIAGRAM

A. PV Panel

Photovoltaic solar panel absorbs light or photons from the sun. It is the input source to generate electricity from the PV panel. The PV panel arrangement and dimensions as shown in the figure: 2. A solar panel or photovoltaic module as a set of solar photovoltaic (PV) modules electrically connected in hybrid electric vehicle and mounted on top of HEV's and supporting a structure. A PV module is a group of solar cells is connected and assembled in parallel. Solar panels are the part of a larger photovoltaic system to generate DC supply. Then it converted and used for commercial and residential applications. Each PV module is rated by its output power under standard test conditions for all type of PV modules. The efficiency of a module determines the area of a module receives the light and conversion of this energy. A single solar module can produce only a minimum amount of power; most of the installations contain multiple modules. A PV system includes an array of photovoltaic modules, battery storage, a converter, inverter, interconnection wiring, and optionally a solar MPPT tracking mechanism. PV modules use light energy from the Sun to generate electricity through the photovoltaic effect is photons with chemical and physical. The majority of modules use crystalline silicon cells. The structural member of a module or panel can either be the top layer or the back layer for a support group of cells. Cells must also be protected from environmental effects. Most modules are hard, but semi-flexible ones based on thin-film cells. The cells must be connected electrically in series or parallel from one to another.

The solar panel as shown in the Figure.1.1 used in the solar vehicle is of the rating of 150 WP. The point that should be carefully maintained while making a solar vehicle is the mounting of the solar panel. The PV panel should be mounted on top of the HEV'S in such a way that it receives maximum sun rays so that it gives maximum efficiency. For the vehicle designed, we have mounted the solar panel in SOUTH-EAST direction during the time 6 AM to 12noon. After that, the panel is changed to a SOUTH-WEST direction during the time 12noon to 6 PM. The PV panel used solar cells in the electric vehicle is multi-crystalline. we are using the multi - crystalline cell is that it is more efficient than the mono-crystalline cell and the rate of conversion of energy is very fast in the former. 48 solar cells are used in the PV module of this electric vehicle. The upper frame of this solar module is covered with thick glass to avoid breakage of the solar panel is connected to the solar module for charging. This helps to keep the battery charged always. This is also done as the efficiency of a solar module is only 17%. Thus under this condition, the battery gets fully recharged again within 180mins-210mins.

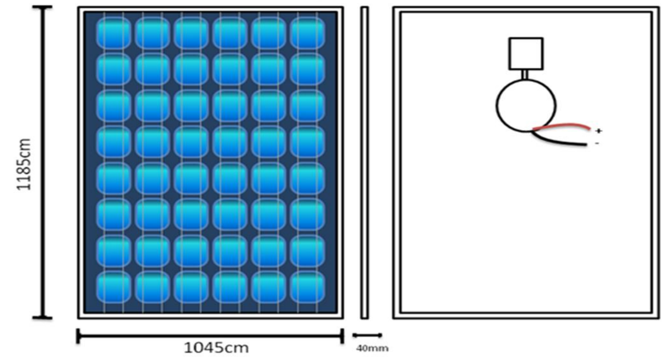


Fig -2: PV panel

B. DC-DC Boost Converter

Figure:3 shows basic circuit of a DC-DC boost converter circuit consists of a power switch (M), a diode (D), an inductor (L), a capacitor (C), switching controller and load (R). This can be used for interface connection between low PV array voltage to a high battery bank input voltage or any DC load. The DC-DC boost converter is used to boost up or step up the output voltage to be greater than the input voltage. Controller for boost converter will control the switch for turn-ON and turn-OFF to the input voltage to the needed value of output voltage. When the switch is turned-ON, the diode will be reverse biased and electrical energy will be stored in the inductor. Thus, the capacitor will supply the current to load. When the switch is turned OFF, the electrical energy stored will be transferred from the inductor to the capacitor and load. The DC-DC boost converters have two type of operation which is continuous-conduction mode and discontinuous-conduction mode. When the DC-DC boost converter operates in continuous conduction mode, the inductor current will be greater than zero at all time whereas, during discontinuous conduction mode, the inductor current will drop to zero after each switching cycle. Recent research trends for DC-DC boost converter with PV based power quality management are submitted for harmonic elimination, zero voltage regulation, power factor correction and load balancing Circuit of DC boost converter.

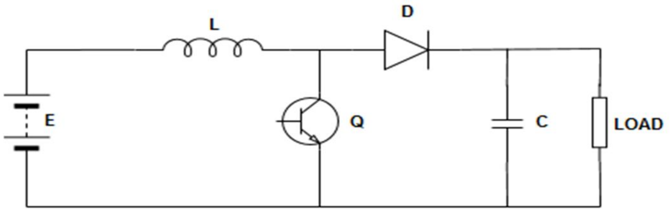


Fig -3: DC-DC Boost Converter

C. Battery Unit

A Battery is a device that can create electricity from the chemical reaction. It converts the MOLECULES inside the battery into electricity. They produce DC supply from the battery. Electricity (electricity that flows of electrons in one direction, and does not switch back). Using the electricity from the battery can provide electricity in areas that do not have electric power distribution. It can be one cell or a group of cells is connected in parallel to reach the required voltage for user application. Each cell has an anode is a positive terminal, a cathode is negative terminal and electrolyte is a substance produce an electrically conducting solution. The electrolyte can be liquid or solid. It is a type of lead-acid and can be dangerous to touch. The chemical reaction of anode reacts with the electrolyte to produce electrons. The cathode reacts with the electrolyte creates the holes and wants electrons. An electric current transferred from happens when a wire connects the anode to the cathode, and the electrons move from one end to the other end. Depending on the type of electrolyte a battery is called a wet cell or dry cell battery. The battery cells can be connected to make a large battery. Connecting the positive terminal of one cell to the negative terminal of the next cell is called connecting them in series. Each battery is connected together are the voltages added together. Four 12 volt batteries connected in series will make 48 volts. Connecting the positive of one cell to the positive terminal of the other, and the negative terminal to the negative is called connecting them in parallel. The voltages are the same cannot be changed, but the current is added together. Voltage is the potential difference to the electrons through the wires, it is measured in volts. Current is a number of electrons are flowing through the wire, it is measured in amps. The multiple of current and voltage is the power (P=VI) of the battery. It is measured in watts.

D. Graphical System

LabVIEW-Laboratory Virtual Instrument Engineering Workbench is a system design platform approach, a software development tool originally developed and support the requirements of virtual instrumentation. Researchers can use LabVIEW to design (modeling and simulation), prototype (proof of concept), and deploy (field implementation) new technologies that result from R&D activities. Researchers can implement the activities with a highly interactive process known as graphical system design, used for data process of an approach that leverages virtual instrumentation (modular, customizable, software-defined instrumentation). The graphical system design approach can improve the productivity of experimental research on various requirements. To understand, consider that researchers often have hundreds of measurements that they use to “feed” their mathematical models in a graphical system design approach. Often, researchers implement data analysis, data visualization, and data mining tasks offline using different software tools. To monitoring and control of solar based battery charging unit in a hybrid electric vehicle can be achieved using Ultra high-frequency communication by LabVIEW. Data communication is done using NI MyRio hardware. The performance and power parameters of the PV panel used electric vehicle are monitored in a Graphical User Interface.

III. MODELING

A. Design of Solar Panel

Figure: 4 shows the PV panel designing circuit for calculation of parameters.

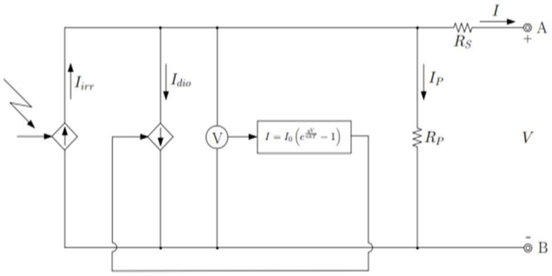


Fig -4: PV panel designing circuit.

Table -1: Parameters of PV panel

Maximum Power (Pmax)	215 Wp
Voltage at Maximum Power (Vmpp)	29 V
Current at Maximum Power (Impp)	7.4 A
Open Circuit Voltage (Voc)	36 V
Short Circuit Current (Isc)	7.8 A
Panel Efficiency	13.1 %

Table 1 & 2 shows the parameters obtained from the data sheet of PV panel and performance parameters form simulation results

Table -2: Data sheet parameters

Parameters	Values
Iirr(ref)	8.122
Io(ref	6.012 × 10−9
n(ref)	0.005649
RP(ref)	2.093
RS(ref)	1.128

B. Design Of Boost Converter

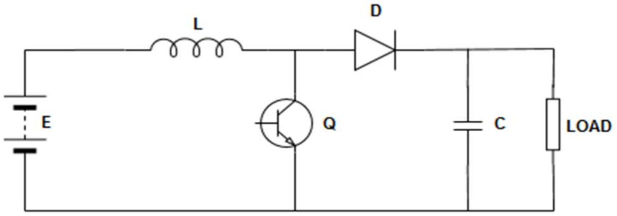


Fig -5: Basic converter circuit

Assuming a non ideal inductor R load = 40 Ω.

$P_m = P_{out} + P_{loss}$
$V_s I_L = V_0 I_0 + I_L^2 R_L$
$V_s I_L = I_L (1-D) V_0 + I_L^2 R_L$
$V_s = (1-D) V_0 + I_L^2 R_L$
$= (1-D) V_0 + ((V/R)/ (1-D)) R_L$
$V_0 = ((V/(1-D))(1/(1+ R_L(R+ (1-D))$

For V_s= 48Vdc and $V_0 > 220$Vdc , D=0.78 For maximum ripple voltage at 5%, C=4.4μF at switch Frequency=40KHZ, minimum inductor value = 36mH.

Table -3: DC-DC boost converter parameters

Parameters	Values
V_s	48V
Capacitance	4.4µF
inductance	36mH
D	0.8

C. Design of battery

1) Battery capacity

$$Q= I*t$$

Where Q is the charge in coulombs, I is the current in amps and t is the time in seconds.

$$E=C*Vavg$$

Where E is the energy stored in watt-hours, C is the capacity in amp-hours and Vavg is the average voltage during discharge.

2) Back of the envelope

$$C=xT$$

Assume the current drawn is x amps, the time is known as T hours then the capacity C in amp-hours.

3) Cycle life considerations

$$C' = C\backslash 0.8$$

It isn’t good to run for a battery all the down to zero during each charge cycle.

Table -4: battery parameters

Capacity	Nominal Capacity : 2600mAh
Discharge Performance	≥114min
Capacity Retention	Capacity≥2080mAh
Cycle Life	300 cycles the residual capacity ≥2050mAh
Charge Current	0.52A
Storage	Discharge time≥4hours

IV. SIMULATIONS

A. Labview Simulation

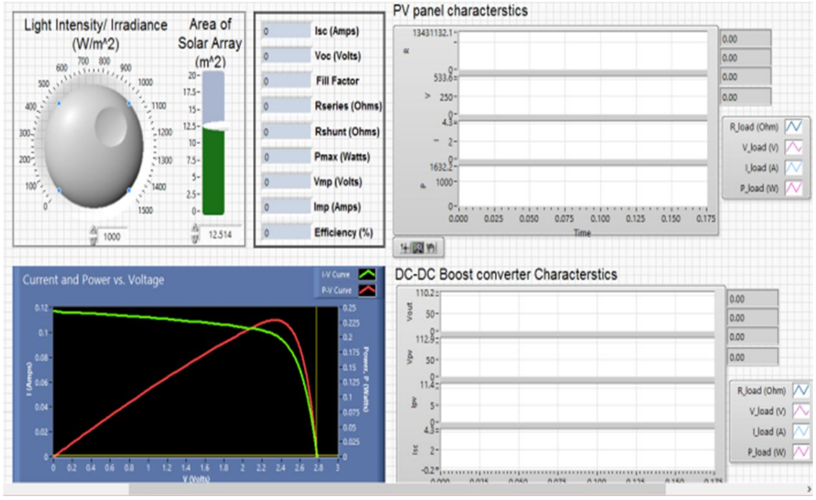


Fig -6: PV system simulation circuit in LABVIEW

B. Power parameters

1) *Maximum Power:* The power produced by the cell in Watts can be easily calculated along the V-I curve and use the formula P=IV. At the I_{SC} and V_{OC} points, the power will be zero and the maximum value for power will occur between the two. The voltage and current at this maximum power point are denoted as V_{MP} and I_{MP} respectively.
2) *Efficiency:* Efficiency is the ratio of the electrical power output P_{out}, and to the solar power input, P_{in}, into the PV cell. P_{out} can be taken to be P_{MAX} since the solar cell can be operated up to its maximum power output in the V-I curve to get the maximum efficiency.

C. Performance Parameters

1) *Shunt Resistance (R_{SH}) and Series Resistance (R_S):* During operation, the efficiency of solar cells is reduced by the dissipation of power across internal resistances. These can be modeled as a parallel shunt resistance (R_{SH}) and series resistance (R_S). R_S and R_{SH}, from the slopes of the I-V curve at V_{OC} and I_{SC}, respectively. The resistance at Voc, however, is at proportional to the series resistance but it is larger than the series resistance. R_{SH} is represented by the slope at I_S.
2) *Short Circuit Current (I_{SC}):* The short circuit current I_{SC} corresponds to the short circuit condition when the impedance is low and the voltage equals 0. $I \text{ (at } V=0) = I_{SC}$
3) *Open Circuit Voltage (V_{OC}):* The open circuit voltage (V_{OC}) occurs when there is no current passing through the cell or there no load is connected to the system.

   $$V \text{ (at } I=0) = V_{OC}$$
4) *Fill Factor (FF):* The Fill Factor (FF) is necessary for a measure of the quality of the solar cell. It is calculated by comparing the maximum power with the theoretical power (P_T) that would output at both the open circuit voltage and short circuit current together.
5) V-I Characteristics: PV cells can be a current source in parallel with a diode. When there is no light present to generate any electricity, the PV cell behaves like a diode. As the intensity of incident light increases, electricity is generated by the PV cell.

   $$I = (I_l - I_D)$$

D. CO-Simulation

In co-simulation, the different subsystems from various platforms are coupled problem are modeled and simulated in a distributed manner. co-simulation is a joint simulation of the already well-established tools and semantics; when they are simulated with their suitable solvers. The main advantage of Co-simulation is a validation of multi-domain and cyber-physical system by offering a flexible solution which allows consideration of multiple domains with different time steps at the same time. Simulation will be executed in main domain.

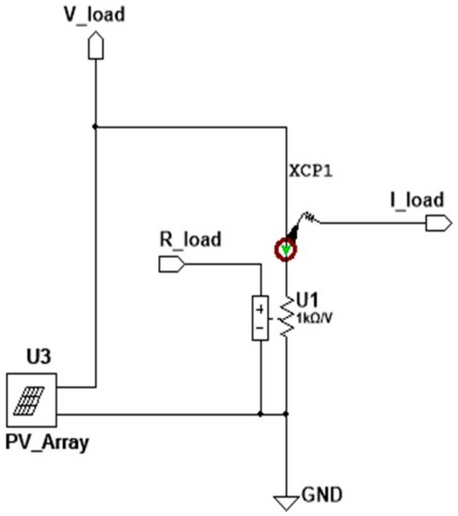


Fig -7: PV array simulation in MultiSIM

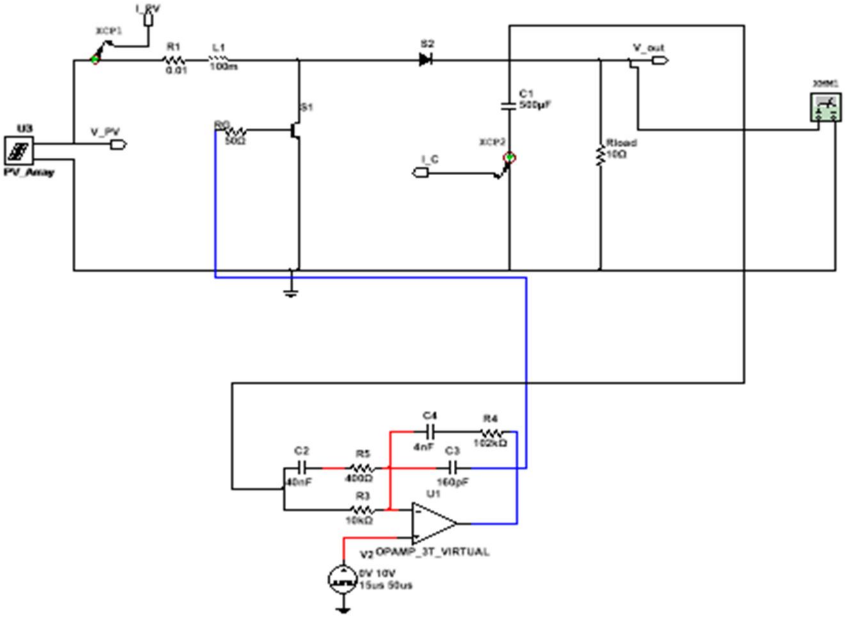
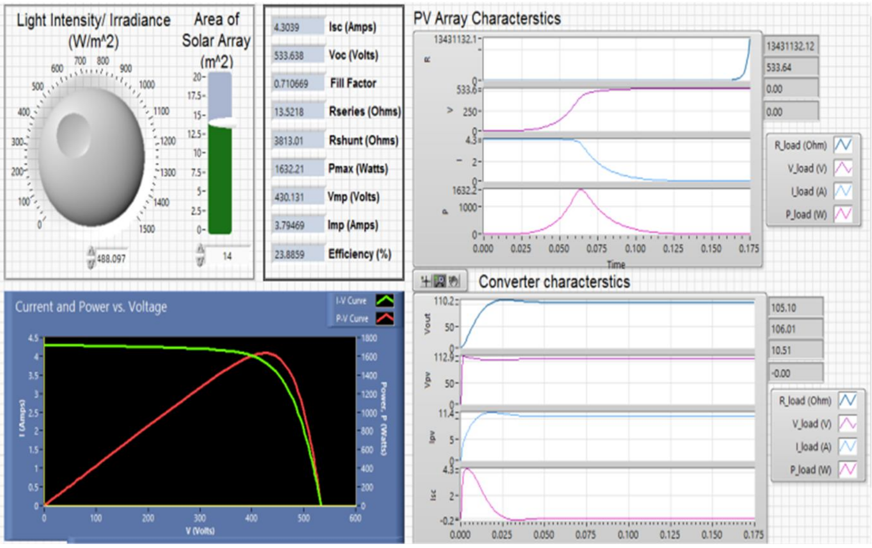


Fig -8: DC-DC Boost converter simulation in MultiSIM

E. Discription

The MultiSIM design helps to save prototype iteration and optimize printed circuit board (PCB) designs earlier in process. It is used for expertise in practical application such as designing, prototype and testing electrical circuits. In this circuit, the PV array is connected with the resistive load. The DC-DC boost converter also used to vary the out voltage simulated in MultiSIM. The simulations of the PV array and DC-DC boost converter is co-simulated with LABVIEW program as shown in the figure: 7 & 8.

V. SIMULATION RESULTS



Light Intensity/ Irradiance (W/m^2): 488.097
Area of Solar Array (m^2): 14

4.3039	Isc (Amps)
533.638	Voc (Volts)
0.710669	Fill Factor
13.5218	Rseries (Ohms)
3813.01	Rshunt (Ohms)
1632.21	Pmax (Watts)
430.131	Vmp (Volts)
3.79469	Imp (Amps)
23.8859	Efficiency (%)

PV Array Characterstics: 13431132.12; 533.64; 0.00; 0.00

Converter characterstics: 105.10; 106.01; 10.51; -0.00

Fig -9: Simulation results of LabVIEW

VI. CONCLUSIONS

This work presents a LABVIEW platform of monitoring, modeling, and simulation of hybrid electric vehicle connected PV systems. We propose the modeling of the PV system measurements of V-I curves and parameters of the PV panel. The simulation results provide the necessary data for monitoring the PV system and also the characteristics of the PV connected hybrid electric vehicle.

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