PHOTOVOLTAIC BASED ELECTRIC VEHICLE USING MAXIMUM POWER POINT TRACKING

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Abstract- *This project proposes a stochastic model predictive controller (MPC).. The modified MPC minimizes the oscillation which provides a rapid search method to track global maximum power point (GMPP) in a lesser period. The MPC based maximum power point tracking (MPPT) technique provides tracking of MPC with zero oscillations and high PV power tracking under rapid weather fluctuations. The MPC technique acquires MPC and provides soft tuning of parameters to achieve high PV power tracking with zero oscillations around GMPP. Finally provides optimal PV power tracking with accurate efficiency, fast convergence velocity, and less computational period. This topology is modelled and its response is manifested through simulation studies using MATLAB/Simulink under different atmospheric conditions. Rule-based control approach and the MPC optimization algorithm are used to allocate power in a hybrid energy storage system (HESS) in a reasonable manner. Finally, the findings reveal greater efficiency in tracking the solar power and the suggested Energy Management system (EMS) has a lower energy consumption rate and battery deterioration rate.*

Keywords: **Model Predictive Control (MPC),Maximum Power Point Tracking (MPPT), Global Maximum Power Point (GMPP), Photovoltaic (PV), Electric Vehicle**

I. INTRODUCTION:

Photovoltaic (PV)/ Battery hybrid energy storage systems have been thoroughly tested in electric vehicles (EVs), as this method of optimization can fulfil the needs of an EV, including high power /energy capacity, long battery life. The Energy Management strategies provide an effective but non-flexible approach to the issue of energy management, which basically applies the specified control principles through that of the given rules according to the operating modes of the converter which are used. The PV system behaviour is based on the PV charging procedure, which works under maximum power point (MPP) and generates PV power that can be transferred to load. The maximum power transfer theorem thus operates with the principle of maximum power transfer only when the internal resistances should be equalized so as to load the resistance. Therefore, a maximum power point tracking (MPPT) is needed to solve the PV system's non-linear behaviour and the injection of maximum PV power into the load through a DC-DC converter, which is controlled by regulating duty ratio through maximum power point tracking (MPPT) algorithms.

1.1. Existing system:

Many research studies examined other MPPT methods. In this work, the PSO-MPPT method was used in more than one application. The procedure of this method is shown. After setting the PSO configuration, the algorithm will then start searching for the best duty cycle corresponding to the global best position of the i^th particle.

So, with the first particle, we will apply the corresponding duty cycle which is randomly chosen in this case. Then, the measured output PV voltage and current will be thus used for calculating the related PV power output. This value will be stored and nominated. With the same strategy, the algorithm will compare the obtained power value to the global best power value. If this new one is better, it will be then be affected by the new global best position value. This action will not finish unless all the particles are tested. Then, each particle will change its position and velocity, and these steps will be repeated until the convergence criterion is obtained.

1.2. Drawbacks of Existing system:

- Analytical expressions for power losses (converter losses and cell losses) were used to produce variations in component failure rates that depend on the operating state of the system.
- The overall cost of the system is high

1.3. Proposed system:

The MPC based MPPT technique provides tracking of GMPP with zero oscillations and high PV power tracking under rapid weather fluctuations. The MPC technique acquires GMPP and provides soft tuning of parameters to achieve high PV power tracking with zero oscillations around GMPP. Power electronically controlled (DC-DC converter), Ultra capacitor-battery energy storage system is proposed which supply power to the BLDC motor to drive a vehicle. Whole system is simulated in MATLAB Simulink with input as vehicle drive cycle. Speed, Torque and the power requirement of the vehicle are to be calculated using vehicle dynamics and drive cycle information. Based on the above calculation, the selection of energy device will take place. Ultra capacitor is controlled through buck-boost converter to absorb/supply power from/to vehicle system under deceleration/acceleration mode

2. Block diagram of the proposed system :

The proposed system is comprised of an input for the PV panel which is of irradiation and temperature. Based upon the Voltage and Current from the PV panel it is thus analyzed with that of the algorithm to get the PWM pulse. This is thus passed on to the Bidirectional D-DC converter. The voltage is thus improved and here can be stored with that of Hybrid Energy storage system, which uses the ultra-capacitor to store the charge. Which is then, the power is utilized by the BLDC motor to drive the Electric Vehicle.

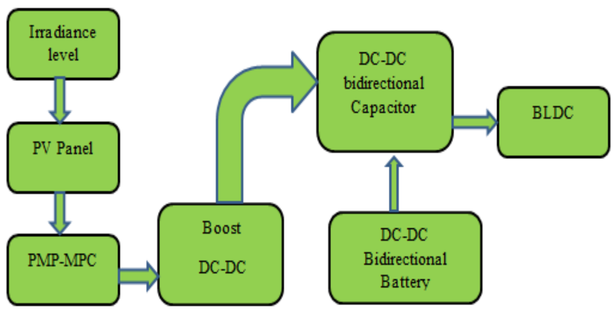

Fig 1. Block diagram of the proposed system

3. DESIGN AND METHODOLOGY

3.1. PV Array

In PV panels, PV cells convert sunlight into electrical energy, which is one of the best approaches for achieving electrical power for long duration. The conversion from sun light to electrical power greatly depends on various factors such as the insolation level and cell efficiency. Solar PV systems are used today in many applications such as lighting, battery charging, water pumping, and satellite power systems etc. This article proposes a PV system to charge EVs using a boost converter that uses the MPPT algorithm. PV modules are designed in system with 1500 V and different ranges of Li-ion battery. The PV array gives the power to boost converter. This converter reduces the voltage of PV string to system volt for each system as required. This buck converter used the MPPT concept to get the best power and energy from the PV array and then give it to load which is the electric vehicle battery proposed.

3.2. MPC based MPPT:

The aim of MPC is to optimize power management over a moving horizon. Therefore, speed forecasting using Markov chain model can be leveraged to supply the preview power requirements. Reference SOC planning defines the upper and lower boundaries of the SOC values in each horizon for which the optimization algorithm, either DP or MPC, must be implemented, thus guiding when the battery discharges to achieve better fuel economy. This method was chosen, as it can be used to obtain the local solution of each horizon, yielding MPC, and can improve computational efficiency of MPC. Numerically, this type of MPC results in a two-point boundary value problem that can be solved using the shooting method.

The MPC based MPPT technique provides tracking of GMPP with zero oscillations and high PV power tracking under rapid weather fluctuations. The MPC technique acquires GMPP and provides soft tuning of parameters to achieve high PV power tracking with zero oscillations around GMPP.

Power electronically controlled (DC-DC converter), Ultra capacitor-battery energy storage system is proposed which supply power to the BLDC motor to drive a vehicle. Whole system is simulated in MATLAB Simulink with input as vehicle drive cycle. Speed, Torque and power requirement of vehicle are calculated using vehicle dynamics and drive cycle information. Based on above calculation, selection of energy device will take place. Ultra capacitor is controlled through buck-boost converter to absorb/supply power from/to vehicle system under deceleration/acceleration mode.

3.3. Model predictive control

The principle of the model predictive control is to determine the optimal behaviour of a system over a time horizon that we will call the whole horizon T. To find the input (or control) trajectory and the state trajectory of the system, an iterative algorithm is applied in the following way. At each time step, the control trajectory is computed by solving an optimization problem over a finite prediction horizon P that can be different from the whole horizon T.. Once this problem is solved at the time step t, only the first step of the control

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trajectory is applied to get the state of the system at the time step t + 1. Then, another optimal control problem is solved based on the new state of the system and with a shifted prediction horizon. This iterative procedure is repeated until the last time step of the whole horizon T

More formally, the optimal control problem (OCP) solved at each time step t of the MPC algorithm is the following:

$$\min_{x,u} \quad l(x_P) + \sum_{k=0}^{P-1} g(x_k, u_k)$$

$$\text{subject to} \quad x_0 = x\hat{}_0$$

$$x_{k+1} = f(x_k, u_k) \quad \text{for } k = 0, \dots, P-1$$

$$h(x_k, u_k) \leq 0 \quad \text{for } k = 0, \dots, P-1$$

x is the vector that gathers all the state variables of the system from time k = 0 to k = P and **u** the one with all the control variables from time k = 0 to k = P − 1. In model predictive control, the control variables are also called manipulated variables. $g(x_k, u_k)$ is the cost at each time k and l is the terminal reduction. The meaning of each constraint of the OCP is the following:

• The constraint enforces the current state of the system $x\hat{}_0$, to be the initial state x0 of the system for the optimal control problem.

• The constraint makes sure that the state variables satisfy the dynamics of the system.

• The constraint represents the set of constraints imposed on the state variables and the manipulated variables at each time k.

3.4. MPC Algorithm

For t = 0,.., T − 1 :

(1) Set $x\hat{}_0 = x_t$, where $x_t$is the current state of the system.

(2) Solve the optimal control problem for$x\hat{}_0 = x_t$ to obtain the optimal control sequence **u**∗.

(3) Define the MPC control law value μP (x_t):= **u**∗(0).

(4) Apply the control value μ_P (x_t) to the system, t = t + 1 and go to (1).

The MPC is used to optimally determine the deployment of minimizing the oscillations with that of predicting the maximum power point tracking at various horizons so as to get the maximum PV power which could be fed to that of the battery for energy storage systems which can run the required load.

3.5. DC-DC Boost Converter

A boost converter is a DC-to-DC power converter which steps up voltage (while stepping down the current) from its input to its output. It is a class of switched-mode power supply (SMPS) that containing at least two semiconductors that is a diode and a transistor, and at least one energy storage element: a capacitor, inductor, or the two in combination. To reduce voltage ripple, filters made of capacitors are normally added to such a converter's output and input.

The key principle that drives the boost converter is that the tendency of an inductor to resist changes in current by creating and destroying a magnetic field. In a boost converter, the output voltage is always higher than that of the input voltage. When the switch is closed, current flows through the inductor in clockwise direction and the inductor stores some energy by generating a magnetic field. The polarity of the left side of the inductor is positive. When the switch is opened, current will then be reduced as the impedance is higher. The magnetic field created will be destroyed to maintain the current to that of the load. Thus the polarity will get reversed (means left side of inductor will be negative now). As a result of this, two sources will be in series which will cause a higher voltage to charge the capacitor through that of the diode D. If the switch is cycled fast enough, then the inductor will not discharge fully in between charging stages, and thus the load will always see a voltage greater than that of the input source alone when the switch is in open state. Also when the switch is opened, the capacitor in parallel with the load is thus charged to this combined voltage. When the switch is then closed and the right side is shorted out from the left side, the capacitor is then able to provide the voltage and energy to the load. At this time, the blocking diode prevents the capacitor from discharging through the switch. The switch must be opened again fast enough to prevent the capacitor from discharging too much.

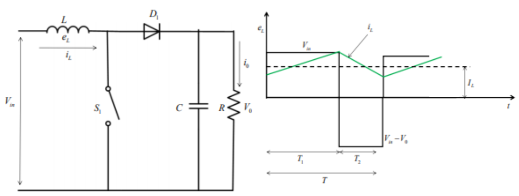


Fig 2. DC DC Boost Converter

Battery or solar in power systems stack cells in series to achieve higher voltage. However, sufficient stacking of the cells is not possible in many of high voltage applications due to lack of space. Boost converters can also increase the voltage and reduce the number of cells.

3.6. DC DC Bidirectional Battery

The battery is hybridized with ultra-capacitor with a DC-DC converter. This will thus increase the life of the battery which will reduce the maintenance cost of the vehicle like of Battery replacement. It will also improve the vehicles performance during higher acceleration and deceleration and provide better voltage regulation in the system. In dynamic conditions, that is during higher acceleration or deceleration periods, the Ultra Capacitor will thus act as the charging and discharging device due to its ability to act faster and while in normal working mode the battery will then supply the load making the system optimized.

3.7. Ultra Capacitors:

An ultra-capacitor, which is also called as super capacitor, is an electrical component which capable of holding hundreds of times more electrical charge quantity than a standard capacitor. This characteristic would make ultra-capacitors more useful in devices that would require relatively less current and low voltage. In some situations, an ultra-capacitor can take the place of rechargeable low-voltage electrochemical battery. The principal disadvantage of the ultra-capacitor, compared with the older capacitor designs, is that the ultra-capacitor cannot withstand high voltage. Whereas, an electrolytic capacitor might be rated at several hundred DC volts, ultra capacitors which will have maximum ratings of about 5 DC volts. In order to use ultra-capacitors at higher voltages, multiple components must be connected in series. Then their voltage ratings will add up, just as battery voltages add in a series connection.

3.8. BLDC motor

A **brushless DC motor** which is also known as a **BLDC motor** is an electronically commuted DC motor which does not have any brushes. The controller thus provides pulses of current to that of the motor windings which will control the speed and torque of the synchronous machine .These types of motors are highly efficient in producing a larger amount of torque over a large speed range. In brushless motors, the permanent magnets rotate around a fixed armature and can overcome the problem of connecting current to that of the armature. Commutation with electronics have a large scope of capabilities and flexibilities. They are known for smooth operation and holding the torque when stationary

4. SIMULATION ANALYSIS AND OUTPUT:

The Mat lab simulation is thus designed of an input for the PV panel which is of irradiation and temperature. Based upon the Voltage and Current from the PV panel it is thus analysed with that of the MPC to get the PWM pulse. This is then passed on to the Bidirectional DC-DC converter which is connected. The voltage is thus improved and here can be stored with that of Hybrid Energy storage system, which uses the ultra-capacitor to store the charge. Which is then, the power is utilized by the BLDC motor to drive the Electric Vehicle.

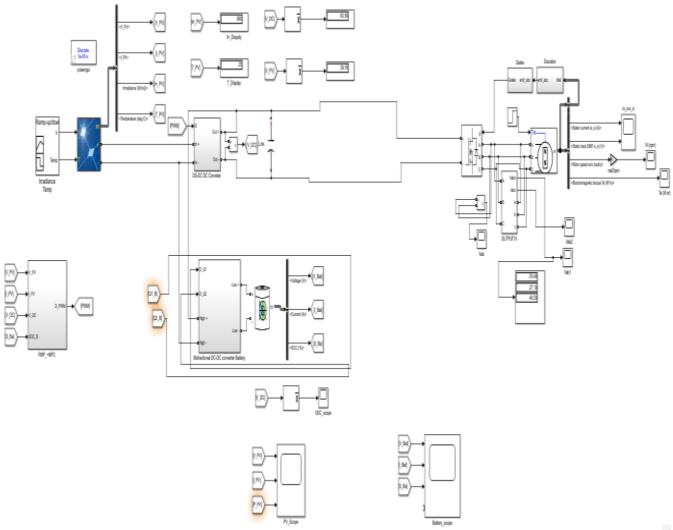


Fig3 .Simulation model for PV based maximum power point tracking using MPC

The solar power is thus tracked with the solar panel and its been estimated the irradiance and the temperature in which its power is been utilized. The estimated irradiance is calculated to be of 980w/m2 and 25 degree Celsius of Solar power which is been given as input.

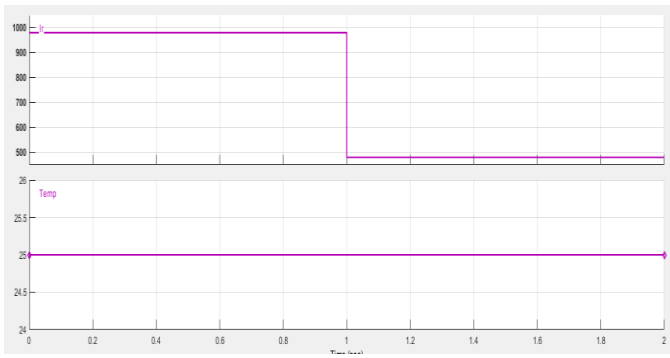
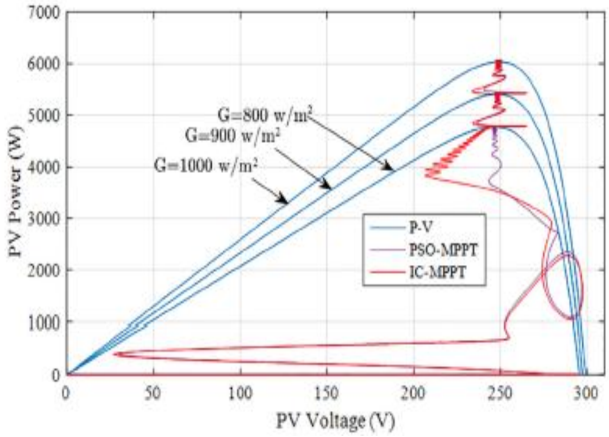


Fig 4. PV Irradiation and Temperature estimation

The below is the comparison of existing PSO algorithm in tracking the solar power in which the MPC algorithm attains 1 k w/m 2, which when compared to that of PSO algorithm which reaches of 800 w/m2. Hence the MPC MPPT could track higher efficient power from PV.



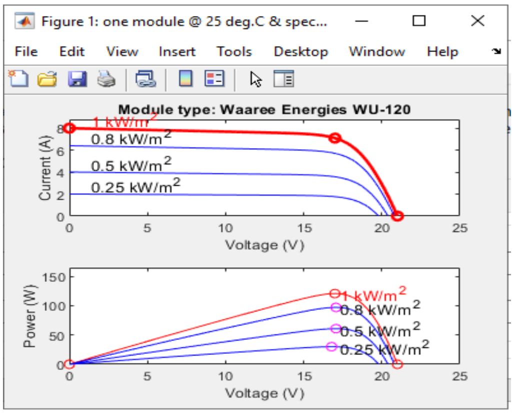


Fig 5. Comparison of PV power from PSO MPPT & MPC MPPT

5. HARDWARE BLOCK DIAGRAM:

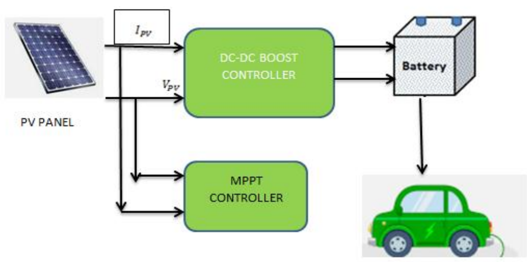


Fig 6. Hardware model

5.1 Hardware Output:

The hardware output rule-based control approach and the MPC optimization algorithm are used to allocate power in a hybrid energy storage system (HESS) in a reasonable manner. Finally, the findings reveal that the suggested EMS has a lower energy consumption rate and battery deterioration rate than the rule-based method.

6. RESULTS OF MPC MPPT

The state of charging profiles yielded from the MPC method based on four preview horizons (5s, 10s, 15s, and 20s).. The quantitative results are thus summarized in the final SOC levels almost which reached the boundary value in each case, suggesting that the four horizons consume a similar amount of electricity. As the prediction horizon increases, the total cost is thus slightly reduced. It can be observed that as the preview horizon increases, computational time per second of the driving cycle significantly increases. This may be because of the time required for MPC calculations over the longer horizons, which involves speed prediction, iterative calculation of the State of charge (SOC) and co-state variables and interpolations for obtaining battery internal resistance and that of the open circuit voltage from look-up tables, which are more time-consuming over longer horizons. Hence, the case (horizon = 5s) looks to be a preferable solution with a very good balance between optimality and computational efficiency.

7.ADVANTAGES

The reliability of the system is balanced is balanced such that the tracking of solar has increase in efficiency with this MPC methodology and therefore gives a high performance of the battery and the other energy management system.

8. CONCLUSION

The performance of the proposed **MPC ALGORITHM** method has been compared experimentally using the dSPACE platform with conventional **MPC ALGORITHM** based MPPT. Thus, the proposed PV power system has been used.

The presented control strategy shows a higher quality in the injected current into the electrical system, by making it possible the connection of solar arrays at various points, without causing problems to the control algorithm and to the quality of the power supply. This is therefore can be observed that the proposed algorithm is able to track better PV energy so as to provide better power to the system and to the connected load i.e.,to the electric vehicle providing better efficiency to the battery.

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