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Comparison Of Sensor Controlled Hybrid Electric Vehicle Controlled By PID-P& O MPPT And PID-INC MPPT

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***Abstract*— The growth in the automobile industry has been rising due to the improvements in the design with the employment of renewable energy resources and energy storage devices. This manuscript provides a novel solar- fuel cell based hybrid electric vehicle with maximum power point tracking system. Also two tracking algorithms named as perturb and observe method and incremental conductance have been analysed with the combination of proportional + integral + derivative controller. The proposed vehicle has been controlled with the sensors generating hall signals and speed form the vehicle. It concludes with the comparison of performance of two proposed trackers for the proposed electric vehicle using MATLAB simulink software.**

***Index Terms*— Hybrid electric vehicle, solar-fuel hybrid system, perturb and observe MPPT, incremental conductance technique.**

I. INTRODUCTION

The conventional vehicles exploiting the life of entire world due to huge amount of gases that are being spitted out of the vehicles. If this goes on increasing the survival may become a complicated issue [1]. So there has to be an alternative that overcomes the problems of fuel based vehicle and replaces with renewable based vehicle. So, among the numerous types of sources, solar energy has been [2-3] opted due to its huge advantages and also fuel cell has been chosen as another source for driving the vehicle.

But the renewable sources suffer from problem of variable power values for varying irradiance and temperature conditions. So to extract the maximum power from the solar panel, tracking algorithm has been opted which [4-6] tracks the maximum power for variable weather conditions. Among the available tracking techniques, like hill climbing, fixed duty cycle, constant voltage method, perturb and observe, incremental conductance have been chosen for tracking the solar energy. Perturb and observe tracking algorithm finds the peak power point with certain perturbations and observations with a step size. Incremental [7] conductance algorithm finds the peak power point with the change in both power of the solar system and also with the change in voltage. Also this tracking algorithm suffers with the problems of transient variations in the output parameters. So to attain stability in the transient [8] and steady state performance the trackers have been analysed with the PID controller where the proportional gain reduces the steady state error, integral gain nullifies the steady state error and derivative gain reduces the overshoot problem.

The paper is organized as follows; Section I presents introduction to the proposed PID fed MPPT trackers based electric vehicle, Section II deals with the block diagram explanation of proposed MPPT trackers based hybrid

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electric vehicle, Section III deals with perturb observe and incremental conductance MPPT techniques, Section IV deals with the simulation of the proposed vehicle and results and Section V deals with the conclusions drawn from the projected work.

II. Block Diagram Explanation Of Proposed Vehicle

The block diagram model of the MPPT controlled vehicle is given in Fig.1 which consists of photovoltaic system and fuel cell system generating electricity with two types of MPPT techniques fed PID controller.

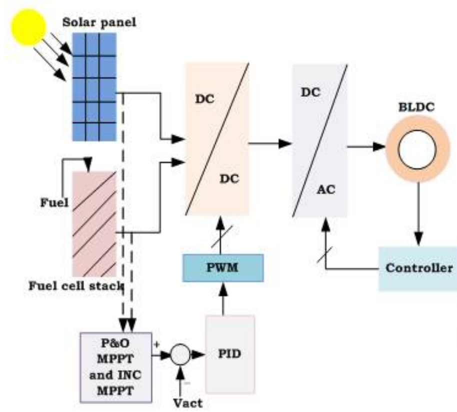

Fig 1: Block Diagram Of The Proposed Vehicle

When the solar rays falls up on the panel, it generates [3] DC energy and when the hydrogen is being pumped into the fuel cell, it also generates DC energy. The DC energy from both the sources is integrated and the hybrid energy will be directed to high gain interleaved boost converter which enlarges the magnitude of voltage at the output of the converter.

The boosted output from the converter will be passed to inverter which converts the DC output from the converter into AC input to drive the [11-14] BLDC motor. Also the integrated output will be passed to [15] maximum power point tracker for attaining the maximum power all the times from the hybrid system.

The maximum voltage tracked by the tracker is fed to PID controller where it compares the actual voltage with the peak voltages and generates processed error. The processed error will be compared with the carrier signal there by generating gate pulse for the high gain interleaved boost converter.

The expression for the voltage at the output of the solar cell can be given as

$$V_{pv} = I_{pv} R \qquad (1)$$

The expression for the current through the solar cell can be given as

$$I_{pv} = I_{sc} e^{\frac{V}{\eta V_t} - 1} \qquad (2)$$

The expression for the filter inductances of the converter can be given as

$$L = \frac{K V_{in}}{\Delta I f_s} \qquad (3)$$

The expression for the filter capacitances of the converter can be given as

$$C = \frac{K V_0}{R \Delta V f_s} \qquad (4)$$

III. PID Controller Fed MPPT Trackers

3.1 Perturb and observe MPPT

The flow chart for perturb and observe MPPT technique is given in Fig.2 where the inputs for the tracker are voltage, current of the hybrid system. Then it calculates change in power, change in voltage. The changes are being compared with their past change values and the difference between past value and present value will be calculated. If there occurs greater than zero, then perturbation [9-10] will be in the similar path. If there exists lesser than zero then perturbation gets reversed and moves in reverse direction.

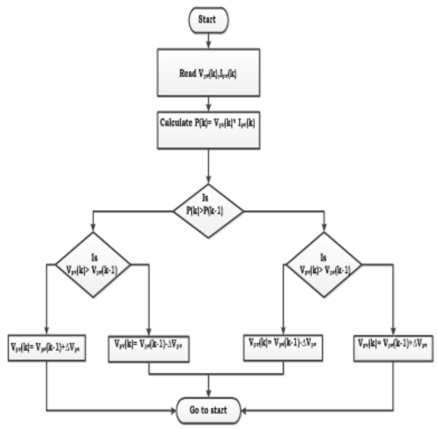

Fig 2: P&O MPPT Flowchart

3.2 *Incremental conductance MPPT*

Perturb and observe will suffers from the problem of swinging around the maximum power point which can be overcome with incremental conductance MPPT technique anywhere it achieves the peak power and prevents the perturbations if maximum point is reached. If maximum power is not achieved, then lane of perturbation will be achieved [9-10] using dI/dV and –I/V. It is attained through the verity that dP/dV is negative, if the tracking is to the right side of maximum power and that dP/dV is positive, if the tracking is to the left side of maximum power. It calculates at what point peak power will be attained instead of fluctuating around maximum power point like as perturb and observe method does.

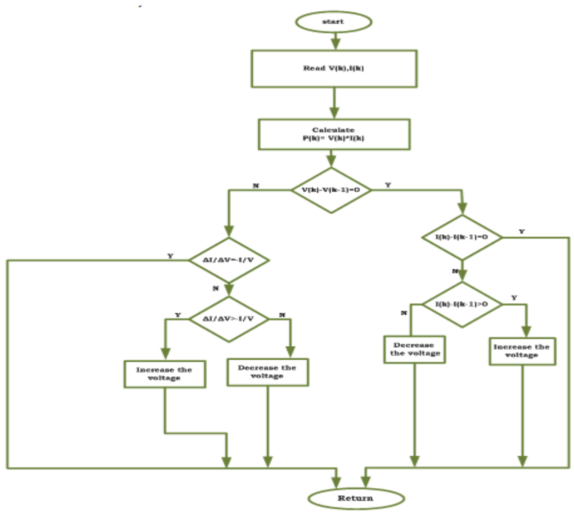

Fig 3: Incremental Conductance MPPT Flowchart

IV. SIMULATION OF PROPOSED ELECTRIC VEHICLE

The proposed PID controller based electric vehicle has been simulated using MATLAB simulink and the following are the results obtained.

➢ **PID-P&O controller and PID-INC controller**

The solar and fuel cell systems are integrated and the integrated voltage of hybrid system is given below.

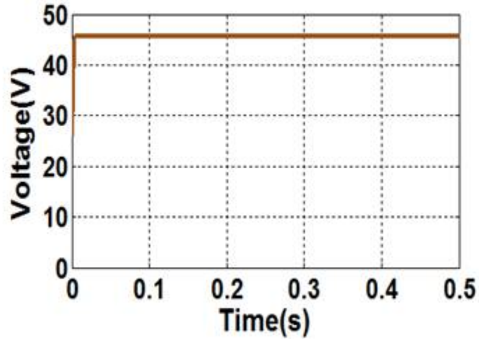

Fig 3: Potential Of Integrated System

The integrated output has been fed to the converter which is controlled with PID controller based MPPT controller whose voltage, current and power are given Fig.4

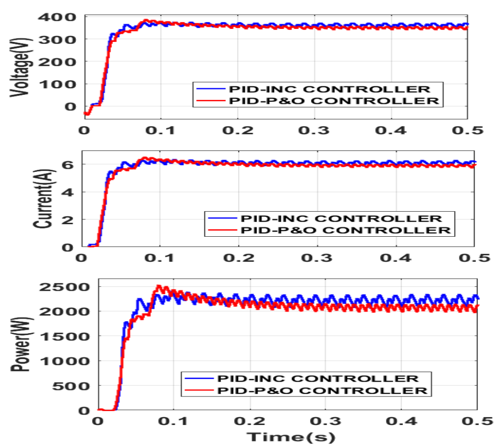

Fig 4: HGIBC Output Voltage, Current And Power With PID-INC And PID-P&O Controller

An output voltage of 360V has been produced from the HGIBC whose peak value is 385V and settled at t=0.21sec with PID-P&O controller as revealed in Fig.4 and also output voltage of 372V has been produced from the HGIBC whose peak value is 379V and settled at t=0.1sec with PID-INC controller . The current of 6.1A has been obtained from the boost converter whose peak value is 6.5A and settled at t=0.21sec with PID-P&O controller as revealed and also current of 6.28A has been obtained from the boost converter whose peak value is 6.1A and settled at t=0.1sec with PID-INC controller . The output power of the converter has been observed to be 2280W whose peak value is 2500W and settled at t=0.21sec with PID-P&O controller as revealed and also output power of the converter has been observed to be 2336W whose peak value is 2450W and settled at t=0.1sec with PID-INC controller .

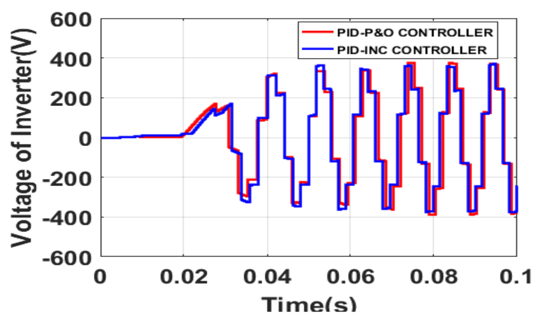

Fig 5: Voltage Of Inverter With PID-INC And PID-P&O Controller

The output of the converter has been directed into the inverter which generates AC output for driving the BLDC motor and shows the voltage generated from the inverter with PID-P&O and PID-INC controller.

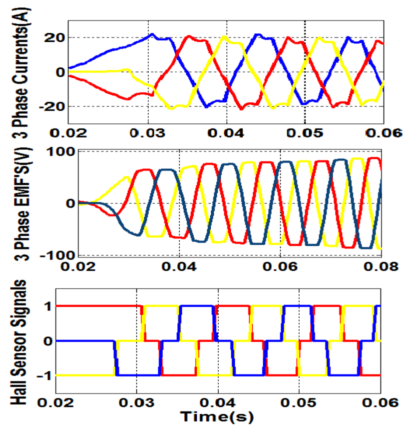

Fig 6:Currents, EMF's And Hall Sensor Of BLDC Motor With PID-P&O Controller

The output from the HGIB converter is passed to the three-phase inverter to produce AC output for the BLDC Motor whose value is 360V and the performance characteristics (Speed, Torque, EMFs' and Currents) of the Motor are as shown whose speed of BLDC motor is 1450RPM and torque obtained is 0.65N-m, three phase generated EMF whose magnitude is 85V, three phase currents whose magnitude is 19A with PID-P&O controller.

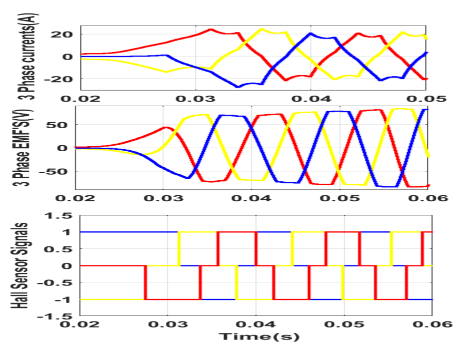

Fig 7:Currents,EMF's And Hall Sensor Of BLDC Motor With PID-INC Controller

The output from the HGIB converter is passed to the three phase inverter to produce AC output for the BLDC Motor whose value is 372V and the performance characteristics (Speed, Torque, EMFs' and Currents) of the Motor are as shown whose speed of BLDC motor is 1520RPM and torque obtained is 0.705N-m, three phase generated EMF whose magnitude is 87V, three phase currents whose magnitude is 20.3A with PID-INC controller.

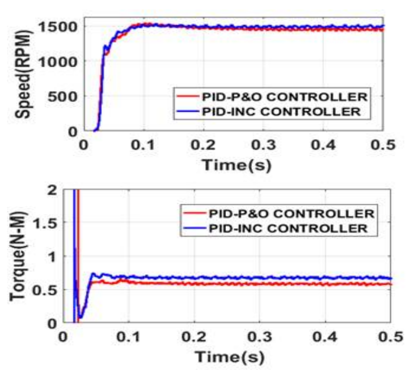

Fig 8: Speed And Torque Of BLDC Motor With PID-INC And PID-P&O Controller

TABLE I. ASSESSMENT OF DC LINK VOLTAGE, CURRENT AND POWER OF HGIBC WITH PID-INC, PID-P&O MPPT

Parameter	PID-INC MPPT	PID-P&O MPPT
DC voltage	372V	360V
DC current	6.28A	6.1A
DC power	2336W	2280W
Speed	1520RPM	1490RPM
Torque	0.705N-m	0.69N-m
Torque ripples	0.11N-m	0.15N-m

The comparison Table.1,2 with PID based INC and P&O MPPT technique has been provided in terms of dynamic, static where PID-INC MPPT shows the better performance than the PID-P&O MPPT.

TABLE II. COMPARISON TABLE IN TERMS OF STATIC AND DYNAMIC PERFORMANCES WITH PID-INC, PID-P&O MPPT

Performance	Parameter	PID-INC MPPT	PID-P&O MPPT
Dynamic	Response time (ms)	0.1	0.21
	Overshoot (W)	150	300
Static	Ripple (W)	180	200
Efficiency	Output power average value (W)	2336	2280

V. CONCLUSION

It presents the design of renewable source based electric vehicle with the use of the solar and fuel cell as the supply resources. Also, PID based MPPT tracking system has been designed in this paper with two trackers named as incremental conductance and perturb and observe method. The assessment of the performance of controller based maximum power point technique in terms of voltage, current, power, response time, torque ripples and efficiency of the system and also comparison has been made in between incremental conductance based MPPT system and also perturb and observe based MPPT system with designing the system using MATLAB simulink.

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