Modeling and Simulation of Incremental Conductance Algorithm basedSolar Maximum Power Point Tracking System

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ABSTRACT:This paper deals with simulation/modelling, controlling of maximum power point tracking (MPPT) used inPV systems to maximize the output power of photovoltaic system, irradiation conditions irrespective of thetemperature of VI characteristics of load.Among many MPPT algorithms available,Incremental Conductance Algorithm is highly efficient as it has Steady State accuracyand it gets easily adjustable for the changing environmental conditions thus increasingthe efficiency of PV system. Additionally if the Solar radiation is also modelled usingslope of the panel, latitude the temperature of the place where the solar panel isinstalled the panel can be installed in such a way it can produce maximum powerthroughout the day. In this paper, the solar radiation and the PV module is modeled using basic equations of solar cell and implemented in Simulink. IncrementalConductance Algorithm is implemented using m- files of MATLAB.

KEYWORDS: Solar radiation, Photovoltaic Module, Maximum Power Point Tracking,Incremental Conductance Algorithm.

I. INTRODUCTION

As sun is the prime source of energy, the ultimatesolution of energy problem rests specially with theproper utilization of the solar energy.The fact that theoutput of the solar PV system is dependent upon thesolar irradiance and temperature. In order to getmaximum power from the solar panels the MaximumPower Point Tracking (MPPT) controllers can play animportant role in photovoltaic systems; they have tooperate at their maximum power point (MPP) despitethe changes in the environment conditions. MaximumPower Point Tracking (MPPT), which significantlyincreases the efficiency of the solar photovoltaicSystem.

Solar power is fast growing and one of the most important renewable energy; this hugely increases globalenergy consumption rate in India [1]. Photovoltaics (PV) system is belonging to research and technology relatedapplication of solar cells. The solar energy is the energy converting sun energy with sun light and ultraviolet radiationconvert directly into electricity using solar cell [2].The aim of this work is to increase the power output and efficiency of the PV system. It is also needingof the constant voltage be supplied to the load irrespective of the variation in solar temperature and irradiance. Paralleland series combination of PV arrays are used to generate electricity depending upon the environmental effects (e.gtemperature and solar irradiation) [3].

In solar PV module the efficiency is low [4]. It is necessary to operate on peak power point so that the maximumpower can be delivered to the load. The effects of varying temperature and solar irradiation conditions [4].To increase theefficiency of the system and tracking the maximum power point (MPP) of a photovoltaic (PV) array. The by MPPTtechniques is to automatically find the maximum voltage point or maximum current point at which a PV array shouldobtain the maximum power output under the effects given by temperature and irradiance [5].The many MPP tracking(MPPT) methods have been developed and implemented. MPPT is a fully electronic system that varies the electricaloperating point of the module it capable to deliver maximum available power to the load [6]

II. MAXIMUM POWER POINT TRACKING (MPPT)

A. Selection of MPPT Algorithm

MPPT is the only way of increasing the efficiency of the solar cell by extracting themaximum power from the solar panel and delivering constant voltage irrespective ofvariation in solar radiation. In direct coupled method i.e without MPPT solar power isdelivered directly to the load the voltage will quickly collapse to zero. This can beunderstood from the I-V curve obtained from the solar panel. Hence a system withMPPT presents the collapse of the voltage by keeping the operating point near theMaximum Power point. A wide range of MPPT Algorithms are available. Of all theavailable algorithms Incremental Conductance Algorithm lends itself well to the DSPand Microcontroller [1]. A comparison between the Perturb & Observe (P & O) andthe Incremental Conductance Algorithm (INC) reveals that the efficiency of P & Omethod is 95 % and INC Algorithm is 98.2 % [2] The drawback of using PI controllerin the Maximum Power Point Tracker due to Nonlinear nature of the PV cell [3] isovercome by using Direct control method in this paper.

B. Incremental Conductance Algorithm

The equation for implementing the INC algorithm can be easily obtained from thebasic power equation.The equation for power is given as

$P = V * I$ ……(1)

Differentiating the above equation with respect to voltage yields,

$$\frac{dP}{dV} = \frac{d(V*I)}{dV}$$

$$\frac{dP}{dV} = I + V*\frac{dI}{dV}$$

The condition for the maximum power point tracking is that the slope dP/dVshould be equal to zero.

Substituting in the above equation,

$\frac{dI}{dV} = -(\frac{I}{V})$…… (2)

The above equation is implemented in Matlab m-files to track the maximumPower point of the PV panel. The flow chart describing the INC Algorithm isshown in the fig. 1

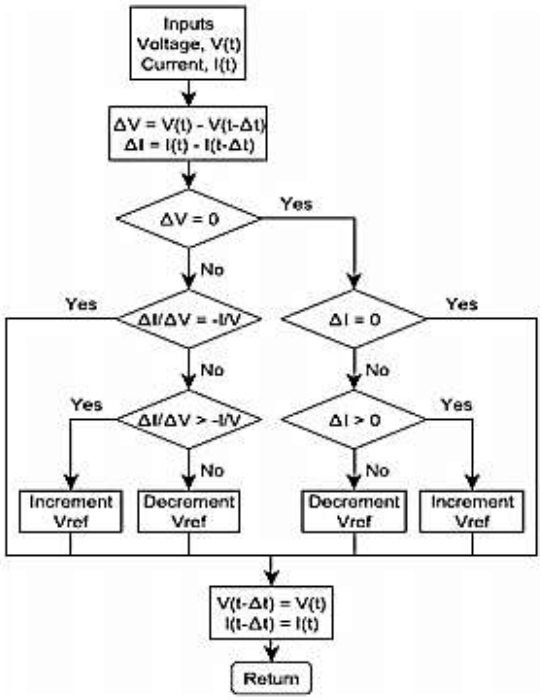

Figure-1. Flow chart of the INC algorithm

C. MPPT Control strategies

In the conventional MPPT Systems there are two independent control loops to makethe operating point of the Panel to be at the maximum power point. The first loop isthe MPPT algorithm and the second one is the PI controller. INC Algorithm isentirely based on the Instantaneous and Incremental conductance to generate an errorsignal which is the made zero at the MPP point. But due to the nonlinearity nature ofthe PI controller in this paper Direct control strategy is applied. The main objective ofselecting this method is to eliminate the second control loop and to provide a simplecontrol circuit only with the tracking algorithm.

DC-DC CONVERTER: The mainobjective of using DC-DC converter in MPPT is (i) Regulating the input voltage at thePV MPP and (ii) for providing load matching for the maximum power transfer. DCDC converters are of many types. Basically there are two types (i) Isolated and NonIsolated topologies. Isolated topologies provide DC isolation between input andoutput. They find application in switch mode DC power supplies. In PV applicationsthis type of topology is used in grid tied system for safety reasons. Isolationtransformers are not present in Non-isolated type. The main topologies are (i) Buck(ii) Boost (iii) Buck – Boost (iv) Cuk converters. Buck topology is used in chargingbatteries and in LCB for water pumping systems. In MPPT buck converter is notsuitable when the maximum power point goes below the charging voltage of thebattery and also at low irradiance time. Boost converter can provide a mediumtracking of the MPP because when the maximum power point is at a very lowoperating point Boost converter will not be suitable. But Boost converter has thecapability to increase the overall efficiency by boosting the voltage.

III. SYSTEM CONFIGURATION

A single phase inverter and boostconverter using modelling. The panel output is given to the boost converter after boosting the voltage is connected toinvert and then supply to load. In this MPPT algorithm switching pulse generated and given to the boost converter forvarying the duty cycle of the boost converter. The interfacing with renewable energy sources is also possible for differentsolar panels can be feed to the inverter as a dc source [8]. The power coming from battery backup is given to inverterthrough a bi-directional dc-dc converter; the controlled flow of electrical power in either direction is possible by varyingduty cycle.

IV. SIMULATION RESULTS

The overall simulation diagram is given in the fig.2. It contains four importantblocks. (1) Solar radiation block which is a subsystem containing the equations
modelling the solar radiation.

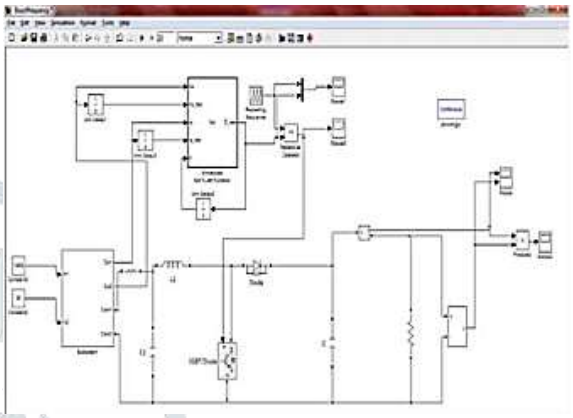

Table.1 solar module electrical specifications

Parameters	Ratings
Maximum Power	5 W
Open circuit voltage (Voc)	21.7 V
Short circuit current (Isc)	0.527 A
Voltage at maximum power Vmpp	17.39 V
Number of cells	36

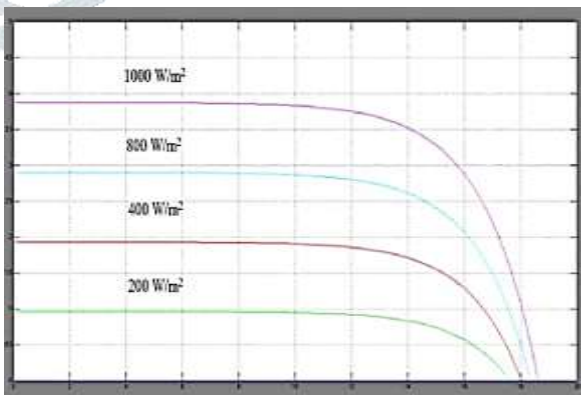

Fig.3 V-I Curves obtained for various radiation levels

The V-I curve shown in the fig. 3 is the input to the Incremental Conductancealgorithm. INC algorithm using the flowchart shown in fig, (1) computes the dutycycle required to product the maximum power at the output. The PWM pulse which isobtained from the INC Algorithm is shown in the fig. (3).

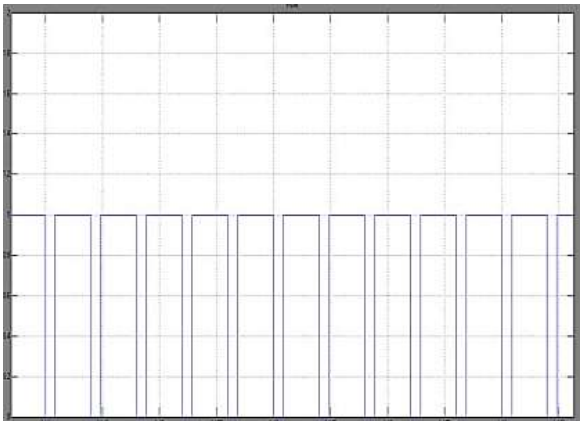

Fig. 4 PWM signal obtained from INC algorithm

The PWM pulse is then given as Gate signal to the IGBT used in the DC- DCconverters. In the DC-DC Converter sections, different dc-dc converters like Buck,Boost, Buck Boost and Cuk converters are analysed and the corresponding output ofeach converter.

V. CONCLUSION

This paper has offered a comparison of Buck, Boost, Buck-Boost and CukConverters used in a solar Maximum power point tracking. The P-V and I-V curveswere obtained from the simulation of the PV array designed in MATLABenvironment explains in detail its dependence on the irradiation levels andtemperatures. Among the converters used Boost and Cuk converter provide bestresults for the MPPT controller.

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