SMC approaches for MPPT operated PV system under ON GRID

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ABSTRACT

How to design a grid connected photovoltaic system, including modeling of photovoltaic cells DC-DC Cuk design. The maximum power point tracking is superior other techniques. Maximum power point tracking is implemented in grid-connected photovoltaic system based on Perturb and Observation (P&O) algorithm. sliding mode controller is best for maximum power point tracking system. Due to non-linear nature of the system, the use of sliding mode method can sustain the stability of the converter in wide range of variations in radiation, load, sliding mode method, only input voltage and capacitive filter current are utilized as a feedback and the design process is completed without the converter model inclusion. The effectiveness of the proposed photovoltaic system is evaluated by simulations conducted on MATLAB/SIMULINK.

Keywords :MATLAB, SIMULINK.Photovoltaic,Wind Turbines

I. INTRODUCTION

Maximum power point tracking is a technique used commonly with *wind turbines* and photovoltaic (PV) solar systems to maximize power extraction under all conditions. Although solar power is mainly covered, the principle applies generally to sources with variable power: for example, optical power transmission and thermophotovoltaic.The use of maximum power of photovoltaic systems considering their high cost is an important necessity. The output power drawn from photovoltaic cells is highly influenced by peripheral factors including radiation, ambient temperature, and load amount. If photovoltaic cells are not controlled appropriately, they will rarely operate in maximum power point. Thus, maximum power point tracking (MPPT) plays a key role in improving the system efficiency. In many grid-connected applications, a dc/dc switching converter is usually connectedbetween the PV modules and the inverter.

While, a new maximum power point tracker (MPPT) for a grid connected photovoltaic system without solar array current sensor is proposed. The solar array current information is obtained from the sliding-mode observer and fed into the MPPT to generate the reference voltage. The parameter values such as capacitances can be changed up to 50% from their nominal values, and the linear observer cannot estimate the correct state values under the parameter variations and noisy environments. The structure of a sliding-mode observer is simple, but it shows the robust tracking property against modeling uncertainties and parameter variations.In this method the controller adjusts the voltage by a small amount from the array and measures power; if the power increases, further adjustments in that direction are tried until power no longer increases. This is called the perturb and observe method and is most common, although this method can result in oscillations of power output.It is referred to as a hill climbing method, because it depends on the rise of the curve of power against voltage below the maximum power point, and the fall above that point. Perturb and observe is the most commonly used MPPT method due to its ease of implementation. Perturb and observe method may result in top-level efficiency, provided that a proper predictive and adaptive hill climbing strategy is adopted.

A novel method by P&O algorithm based on sliding mode is proposed in order to track and extract operating point current for MPPT in Cuk DC-DC converter. Regardless of step-up/step-down converters in which currents are highly no-continues, the advantage of this converter over other standard converters is that both input current and feeding current of output level have low ripple. This issue obviates the need for separate filters. However, to best of our knowledge, because of the complexity of Cuk converter model, there have been no reports on MPPT by employing this converter and sliding mode control. It is tried in this paper to provide step-by-step simulation and modeling of photovoltaic system in order to illustrate this method effectiveness. The most significant merit of Cuk converter for MPPT is its small input-output ripple of currents and no need for filters. All simulations are carried out inMATLAB/SIMULINK.

A. Temperature and Radiation Effects on Photovoltaic System

Array V-I characteristic changes with variations in solar radiation and ambient temperature. Temperature rise affects cells performance and, in turn, their efficiency declines. The amount of cells' open-circuit (OC) voltage drop is roughly0.3-0.4% for one centigrade increase. However, short-circuit (SC) current increase is only 0.025-0.075% per one-degree temperature increase. Therefore, cell efficiency is decreased by 0.05% for each one-degree increase in ambient temperature

The PV module is the interface which converts light into electricity. Modeling this device, necessarily requires taking weather data (irradiance and temperature) as input variables. The output can be current, voltage, power or other. However, trace the characteristics $I(V)$ or P(V) needs of these three variables. Any change in the entries immediately implies changes in outputs. That is why, it is important to use an accurate model for the PV module.

B. Maximum power point tracking(MPPT)

Maximum power point trackingis a technique used commonly photovoltaic (PV) solar systems to maximize power extraction under all conditions. One of the methods used for MPPT in solar cells is chaos algorithm. This method is the most conventional controlling maximum power point tracker. It is based on creating chaosin voltage and observing output power. If the generated power increases, chaos will be maintained in the route otherwise, if it decreases, the next chaos will be reversed.

Solar cells have a complex relationship between temperature and total resistance that produces a non-linear output efficiency which can be analyzed based on the I-V curve.It is the purpose of the MPPT system to sample the output of the PV cells and apply the proper resistance (load) to obtain maximum power for any given environmental conditions.The performance of photovoltaic system ,that is output voltage/current curve (I-V curve),is usually studied using an equivalent circuit model .This equivalent circuit consists of a current source with one or two diodes connected in parallel and upto two resistors one connected in parallel another is series ,to take into account energy losses in this model base on these electronics components basic configuration are normally used when studying photovoltaic system.

The 1 diode model ,whose equation to relate the outputcurrentI,output voltage V is given,

$$I = I_{pv} - I_{D1} = I_{pv} - I_0 \left[exp\left(\frac{V}{NaV_T}\right) - 1 \right] \quad (1)$$

Where,
I_{pv} - Photocurrent delivered by the constsnt current
I_0 -Reverse saturation current corresponding to the diode
V_T - Thermal voltage

$$V_T = \frac{KT}{q}$$

k-Boltzmannconstsnt
T-Temperature expressed in Kelvin

q-Electron change

a-identify factor

N-No of series connected cell in the photovoltaic system to be analyzed.

MPPT devices are typically integrated into an electric power converter system that provides voltage or current conversion, filtering, and regulation for driving various loads, including power grids, batteries, or motors.Solar inverters convert the DC power to AC power and may incorporate MPPT: such inverters sample the output power (I-V curve) from the solar modules and apply the proper resistance (load) so as to obtain maximum power.

Figure 1.V-I characteristics of solar array in light radiation intensity variation

Figure 2.pv characteristic of solar array in light radiation intensity variation.

The perturb and observe (P&O) maximum power point tracking algorithm is the most commonly used method due to its ease of implementation. The reason is in the fact that P&O can be implemented in cheap digital devices by assuring high robustness and a good MPPT efficiency. The low hardware resources required by the P&Oalgorithm are especially useful in distributed MPPT architectures, where the cost makes the difference. The performances of the P&O algorithm implemented in a digitaldevice are affected by the quantization effect and numerical approximations. In this paper the basic P&O algorithm is suitably improved in order to compensate for these effects. A design recipe for choosing the best values of the P&O parameters is also given. The conclusions of the theoreticalanalysis are validated through simulations and experiments .Incremental Conductance method that operates based on zero-derivative of power to voltage and/or current in maximum power point. Open-loop method in which a fraction of short-circuit current is used according to an approximately linear relationship with power point is used in   Open circuit method that is based on presence of anapproximate function between operating point voltage andopen circuit voltage is proposed in However, it is obvious that periodical interruption leads to lost power in photovoltaic system; thus, a base cell is proposed as a guide to detectoverall panel behavior. This also results in uncertainty in basecell measurement with respect to overall panel
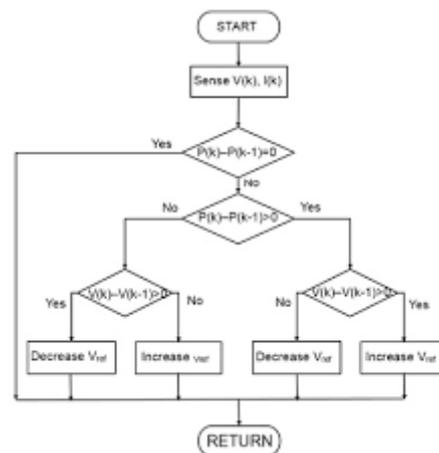

Figure 3.P&O Algorithm

II. SLIDING MODE CONTROL (SMC)

Sliding mode control, or **SMC**, is a nonlinear control method that alters the dynamics of a nonlinear system by application of a discontinuous control signal (or more rigorously, a set-valued control signal) that forces the system to "slide" along a cross-section of the system's normal behavior. The state-feedback control law is not a continuous function of time. Instead, it can switch from one continuous structure to another based on the current position in the state space. Hence, sliding mode control is a variable structure control method. The multiple control structures are designed so that trajectories always move toward an adjacent region with a different control structure, and so the ultimate trajectory will not exist entirely within one control structure.

1. 1.The first step in SMC is sliding surface that represents the desired close behavior .
2. 2.The second step in SMC is design a control lawthat drives the system output untill it reaches the sliding surface and keep it there.

$$\sigma(t) = \left(\frac{d}{dt} + \gamma\right) \int_0^t e(t) dt \qquad (2)$$

We are selecting as an integral-differential equation acting on some tracking error,that is linear and stable. A process used to design a controller should guarantee system stability, settlement time of interest as well as minimum overshoot. In this paper, sliding Surface is described as follows. The main benefit of such switching function is PV voltage adjustment without the need for extra controller and linearized model. IC in is current of capacitor in converter input and K1 and K2.

$$\varphi = (V_{pv} - V_{ref}) K_1 + i_{pv} K_2 \qquad (3)$$

Where,

V_{pv} is pv instantaneous output voltage

v_{ref} is reference value implement switching function in which is v_{ref} a reference voltage calculated by P & O algorithm.

Dynamic behavior of DC-DC converter is expressed by Eqs. (4) and (5), where i_{pv} and denote PV current and bulk voltage, respectively. The parameter u is semi-conductor switches' switching function.

$$i_{cin} = C_{in} \frac{dvpv}{dt} = i_{pv} - i_L \qquad (4)$$

$$v_L = L1 \frac{d}{dt} = v_{pv} - v_L(1 - u) \qquad (5)$$

The block diagram of the control system is provided, in which u is produced through a hysteresis loop. In designing of a sliding mode controller, three requirements should be met: Transversality condition, equivalent control, and reachability condition
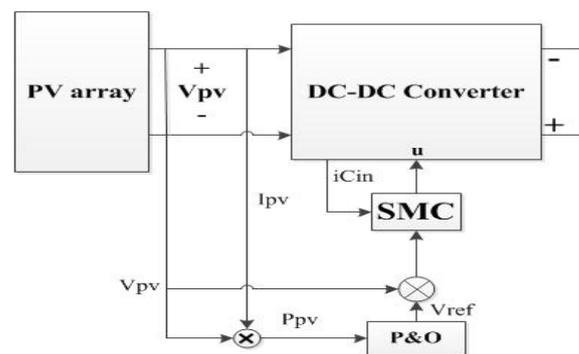

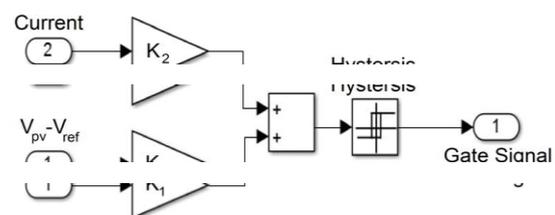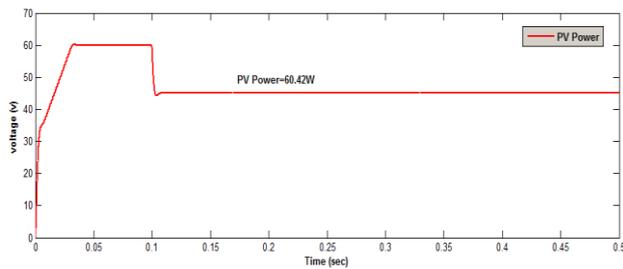**Figure 4.**smc design based on voltage error and input capacitive current block diagram
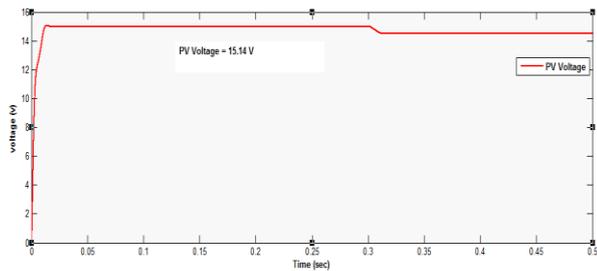

Figure 5.SMC structure

III. SIMULATION RESULT AND DISCUSSION

The proposed approach's results based on study of SMC in PV system will be given in detail in this section. Radiation range is assumed with maximum continues radiation derivative. PV array with given parameters in maximum voltage in power point
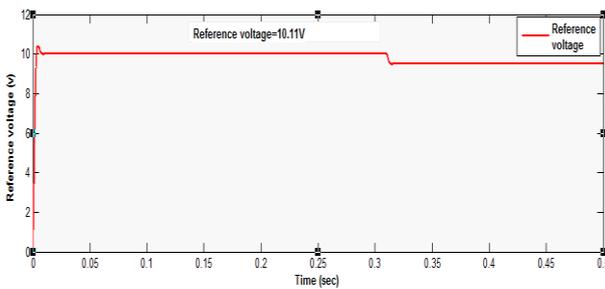
within 16.39-18.13 V. DC-DC converter parameters are provided in PV voltage.
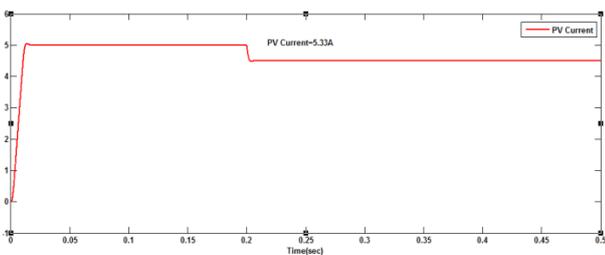

(a)

(b)

(c)

(d)

Figure 6. Simulation results (a) voltage,power and current Waveforms of PV module (c) reference voltage waveform by P & O algoritham.
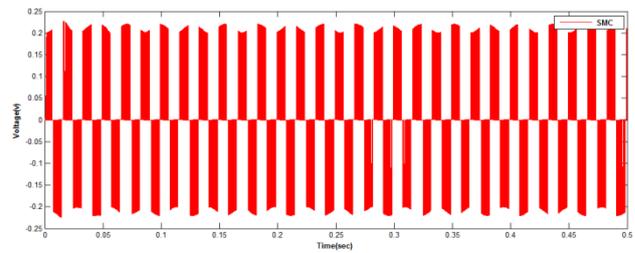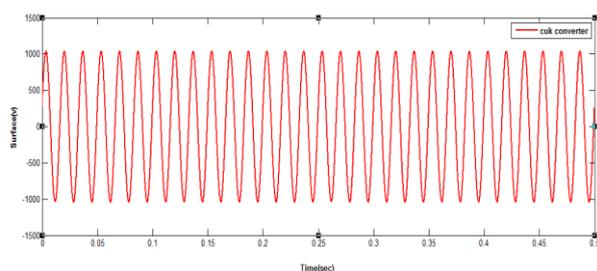

Figure 7. SMC Simulation cuk converter

Figure 7 shows SMC simulation for up-step and down-step reference changes. Simulations given in Fig. 6 are related for a block diagram Obviously, PV array voltage can satisfactorily track the reference *Vref* and is in sliding regime stability condition illustrates sliding mode control vs. upper step and lower step of reference various radiation levels in different temperatures. It can be seen that despite step and extreme changes in nominal parameters, output voltage and reference voltage are exactly equal, validating the effectiveness of the sliding mode in wide operating range.

IV. CONCLUSION

A novel and straightforward method was proposed for maximum power point tracking (MPPT) in a PV system using Cuk DC-DC converter based on sliding mode control (SMC) in step-by-step fashion. It was observed that with changes in peripheral conditions including solar radiation or thermal temperature in the proposed system, it can appropriately track the reference values. The selection of switching level based on a linear combination of input capacitorcurrent and PV voltage error was completed as a unit control loop. This approach was different from the other methods reported in the literature in several ways such as avoiding the need for extra consecutive controllers based on internal current control loop and voltage loops. Controller parameters are obtained by solving a set of non-linear equation system. In addition, constraints required to maintain it in sliding mode of PV array and DC-DC converter operating point are also obtained.

V. REFERENCES

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