AN IMPLEMENTATION OF MAXIMUM POWER TRANSFER TRACKING THEOREM FOR PV CELL: A REVIEW

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***Abstract*: Photovoltaic (PV) is the name of the method of converting solar energy into direct current using a semiconductor material with photoelectric effect, which is usually taught in physics, photochemistry and electrical chemistry. Solar systems use solar panels made up of many solar cells to provide usable solar energy. This process is physical and chemical by nature because the first step involves a photoelectric effect in which a second electrochemical process involves the ionization of the crystalline atoms in a chain to produce an electric current. Photovoltaic products are best known for using solar cells to convert energy from the sun into a stream of electrons to produce electricity. The photoelectric effect is the photon in which the electrons are injected in a higher energy state, allowing them to act as current carriers. Arizona - Edmund first observed the photoelectric effect in 1839. The term photovoltaic refers to an unbiased mode of optical diode operation in which the current across the entire device is attributed to the light energy of the power adapter.**

***Keywords*: Photovoltaic, photovoltaic effect, photochemistry, electrochemistry, solar power.**

I. Introduction

Photovoltaic (PV) is the name of a method of converting solar energy into direct current electricity using semiconducting materials that exhibit the photovoltaic effect, a phenomenon commonly studied in physics, photochemistry and electrochemistry A photovoltaic system employs solar panels composed of a number of solar cells to supply usable solar power. The process is both physical and chemical in nature, as the first step involves the photoelectric effect from which a second electrochemical process take place involving crystallized atoms being ionized in a series, generating an electric current. Power generation from solar PV has long been seen as a clean sustainable energy technology which draws upon the planet's most plentiful and widely distributed renewable energy source the sun. The direct conversion of sunlight to electricity occurs without any moving parts or environmental emissions during operation. It is well proven, as photovoltaic systems have now been used for fifty years in specialized applications, and grid-connected PV systems have been in use for over twenty years. They were first mass-produced in the year 2000, when German environmentalists including Euro solar succeeded in obtaining government support for the 100,000 roofs program. Driven by advances in technology and increases in manufacturing scale and sophistication, the cost of photovoltaic has declined steadily since the first solar cells were manufactured, and the leveled cost of electricity from PV is competitive with conventional electricity sources in an expanding list of geographic regions Net metering and financial incentives, such as preferential feed-in tariffs for solar-generated electricity; have supported solar PV installations in many countries.

With current technology, photovoltaic recoups the energy needed to manufacture them in 1.5 to 2.5 years in Southern and Northern Europe, respectively. Solar PV is now, after hydro and wind power, the third most important renewable energy source in terms of globally installed capacity. More than 100 countries use solar PV. Installations may be ground-mounted (and sometimes integrated with farming and grazing) or built into the roof or walls of a building (either building-integrated photovoltaic or simply rooftop). In 2014, worldwide installed PV capacity increased to at least 177 giga-watts (GW), sufficient to supply 1 percent of global electricity demands. Due to the exponential growth of photovoltaic, installations are rapidly approaching the 200 GW mark – about 40 times the installed capacity of 2006 China, followed by Japan and the United States, is the fastest growing market, while Germany remains the world's largest producer, with solar contributing about 7 percent to its annual domestic electricity consumption.

II. Background

Zakzouk et al. (2016), introduced Variable-step incremental conductance (Inc. Cond.) technique, for photovoltaic (PV) maximum power point tracking (MPPT), has merits of good tracking accuracy and fast convergence speed. Yet, it lacks simplicity in its implementation due to the mathematical division computations involved in its algorithm structure. Furthermore, the conventional variable step size, based on the division of the PV module power change by the PV voltage change, encounters steady-state power oscillations and dynamic problems especially under sudden environmental changes. In this paper, an enhancement is introduced to Inc. Cond. algorithm in order to entirely eliminate the division calculations involved in its structure. Hence, algorithm implementation complexity is minimized enabling the utilization of low-cost microcontrollers to cut down system cost. Moreover, the required real processing time is reduced, thus sampling rate can be improved to fasten system response during sudden changes. Regarding the applied step-size, a modified variable-step size, which depends solely on PV power, is proposed. The latter achieves enhanced transient performance with minimal steady-state power oscillations around the MPP even under partial shading. For proposed technique's validation, simulation work is carried out and an experimental set up is implemented in which ARDUINO Uno board, based on low-cost Atmega328 microcontroller, is employed.

Ricco et al. (2017), introduced the way of implementing an adaptive maximum power point tracking algorithm for photovoltaic applications in a Field Programmable Gate Array is described in this paper. A dual Kalman filter allows estimating the settling time of the whole system, including the PV source and the dc/dc converter controlling the operating point thereof, so that the tracking algorithm self-adapts its parameters to the actual weather conditions. The real-time identification need of this application requires a FPGA platform, so that the intrinsic algorithm parallelism is exploited and the execution time is reduced. The tradeoff solutions proposed in this paper, accounting for the algorithm complexity and the limited FPGA hardware, as well as some solutions for optimizing the implementation are described. The proposed adaptive algorithm is implemented in a low-cost Xilinx Spartan-6 FPGA and it is validated through experimental tests.

Xiao et al. (2015), presents a modular cascaded H-bridge multilevel photovoltaic (PV) inverter for single- or three-phase grid-connected applications. The modular cascaded multilevel topology helps to improve the efficiency and flexibility of PV systems. To realize better utilization of PV modules and maximize the solar energy extraction, a distributed maximum power point tracking (MPPT) control scheme is applied to both single-phase and three-phase multilevel inverters, which allows the independent control of each dc-link voltage. For three-phase grid-connected applications, PV mismatches may introduce unbalanced supplied power, leading to unbalanced grid current. To solve this issue, a control scheme with modulation compensation is also proposed. An experimental three-phase 7-level cascaded H-bridge inverter has been built utilizing 9 H-bridge modules (3 modules per phase). Each H-bridge module is connected to a 185 W solar panel. Simulation and experimental results are presented to verify the feasibility of the proposed approach.

Du et al. (2018), introduced a maximum power point tracker (MPPT) should be designed to deal with various weather conditions, which are different from region to region. Customization is an important step for achieving the highest solar energy harvest. The latest development of modern machine learning provides the possibility to classify the weather types automatically and, consequently, assist localized MPPT design. In this study, a localized MPPT algorithm is developed, which is supported by a supervised weather-type classification system. Two classical machine learning technologies are employed and compared, namely, the support vector machine (SVM) and extreme learning machine (ELM). The simulation results show the outperformance of the proposed method in comparison with the traditional MPPT design.

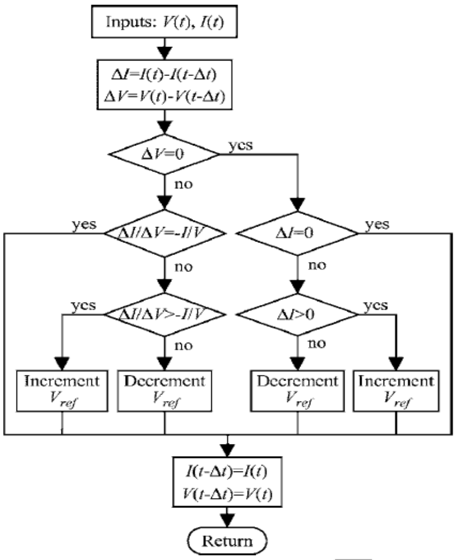
Renaudineau et al. (2015), introduced Photovoltaic systems are one of the main actors in distributed power generation. Especially in urban contexts, the photovoltaic generators can be subjected to mismatching phenomena, due to the different orientation of the modules with respect to the sun rays or due to shadowing. In these cases, the maximum power point tracking function must be designed carefully. In this paper an architecture including one dc/dc converter for each photovoltaic generator is considered. The converters' output terminals are series-connected to a high voltage dc bus, where also a bi-directional dc/dc converter managing the power from/to a storage device is plugged. The functional constraints deriving from the dc/dc converters' connection, the mismatching phenomena, the MPPT capabilities of the inverter, connected with its input terminals at the dc bus, are taken into account in order to determine the best operating point of the system as a whole. The real time constrained optimization problem is solved by using the particle swarm optimization method, which needs the knowledge of the actual current vs. voltage curve of each photovoltaic generator. The practical impact of this need is also discussed in the paper. The feasibility and the performances of the proposed approach are experimentally validated by using a laboratory prototype.

Wang et al. (2016), introduced the photovoltaic (PV) string under partially shaded conditions exhibits complex output characteristics, i.e., the current-voltage (I-V) curve presents multiple current stairs while the power-voltage (P-V) curve shows multiple power peaks. Thus, the conventional maximum power point tracking (MPPT) method is not acceptable either on tracking accuracy or on tracking speed. In this paper, two global MPPT methods, namely, the search-skip-judge global MPPT (SSJ-GMPPT) and rapid global MPPT (R-GMPPT) methods are proposed in term of reducing the searching voltage range based on comprehensive study of I-V and P-V characteristics of PV string. The SSJ-GMPPT method can track the real maximum power point (MPP) under any shading conditions and achieve high accuracy and fast tracking speed without additional circuits and sensors. The R-GMPPT method aims to enhance the tracking speed of long string with vast PV modules, and reduces more than 90% of the tracking time that is consumed by the conventional global searching method. The improved performance of two proposed methods have been validated by experimental results on a PV string. The comparison with other methods highlights the two proposed methods more powerful.

Sundareswaran et al. (2016), introduced the perturb and observe (P&O) algorithm is a simple and efficient technique and is one of the most commonly employed maximum power point tracking (MPPT) scheme for photovoltaic (PV) power generation systems. However, under partially shaded conditions (PSC), P&O method miserably fails to recognize global maximum power point (GMPP) and gets trapped in one of the local maximum power point (LMPP). This paper proposes ant colony based search in the initial stages of tracking followed by P&O method. In such a hybrid approach, the global search ability of ant colony optimization (ACO) and local search capability of P&O method are integrated to yield faster and efficient convergence. A theoretical analysis of the static and dynamic convergence behavior of the proposed algorithm is presented together with computed and measured results.

III. Algorithms

$$\begin{cases} dP/dV = 0, & \text{at MPP} \\ dP/dV > 0, & \text{left of MPP} \\ dP/dV < 0, & \text{right of MPP.} \end{cases}$$



Since

$$\frac{dP}{dV} = \frac{d(IV)}{dV} = I + V\frac{dI}{dV} \cong I + V\frac{\Delta I}{\Delta V}$$

(1) can be rewritten as

$$\begin{cases} \Delta I/\Delta V = -I/V, & \text{at MPP} \\ \Delta I/\Delta V > -I/V, & \text{left of MPP} \\ \Delta I/\Delta V < -I/V, & \text{right of MPP.} \end{cases}$$

IV. Proposed Work

1. Several MPPT techniques taken from the literature are discussed and analyzed herein, with their pros and cons. It is shown that there are several other MPPT techniques than those commonly included in literature reviews. The concluding discussion and table should serve as a useful guide in choosing the right MPPT method for specific PV systems.
2. Since Perturb and observe algorithm is quite simple and easy to implement but this is slow as compared to Incremental conductance. Implementation complexity of P&O low as compared to IncCond algorithm. Because we have to use complex circuitry like.-Comparator, integrator, differentiator etc.

VI. Conclusion and future Scope

The model is simulated using Simulink and MATLAB. The plots obtained in the different scopes have been analyzed. The simulation was first run with the switch on no MPPT mode, bypassing the MPPT algorithm block in the circuit. It was seen that when we do not use an MPPT algorithm, the power obtained at the load side was around 95 watts for a solar irradiation value of 85 Watts per sq. cm. It must be noted that the PV panel generated around 250 Watts power for this level of solar irradiation. Therefore, the conversion efficiency came out to be very low. The simulation was then run with the switch on MPPT mode. This included the MPPT block in the circuit and the PI controller was fed the V_{ref} as calculated by the P&O algorithm. Under the same irradiation conditions, the PV panel continued to generate around 250 Watts power. In this case, however, the power obtained at the load side was found to be around 215 Watt, thus increasing the conversion efficiency of the photovoltaic system as a whole. The loss of power from the available 250 Watts generated by the PV panel can be explained by switching losses in the high frequency PWM switching circuit and the inductive and capacitive losses in the Boost Converter circuit. Therefore, it was seen that using the Perturb & Observe MPPT technique increased the efficiency of the photovoltaic system by approximately 126% from an earlier output power of around 95 Watts to an obtained output power of around 215 Watts. Finally this research concludes as below.

References

[1] Zakzouk, N. E., Elsaharty, M. A., Abdelsalam, A. K., Helal, A. A., & Williams, B. W. (2016). Improved performance low-cost incremental conductance PV MPPT technique. IET Renewable Power Generation, 10(4), 561-574.
[2] Ricco, M., Manganiello, P., Monmasson, E., Petrone, G., & Spagnuolo, G. (2017). FPGA-based implementation of dual kalman filter for PV MPPT applications. IEEE Transactions on Industrial Informatics, 13(1), 176-185.
[3] Xiao, B., Hang, L., Mei, J., Riley, C., Tolbert, L. M., & Ozpineci, B. (2015). Modular cascaded H-bridge multilevel PV inverter with distributed MPPT for grid-connected applications. IEEE Transactions on Industry Applications, 51(2), 1722-1731.
[4] Du, Y., Yan, K., Ren, Z., & Xiao, W. (2018). Designing localized MPPT for PV systems using fuzzy-weighted extreme learning machine. Energies, 11(10), 2615.
[5] Renaudineau, H., Donatantonio, F., Fontchastagner, J., Petrone, G., Spagnuolo, G., Martin, J. P., & Pierfederici, S. (2015). A PSO-based global MPPT technique for distributed PV power generation. IEEE Transactions on Industrial Electronics, 62(2), 1047-1058.
[6] Wang, Y., Li, Y., & Ruan, X. (2016). High-accuracy and fast-speed MPPT methods for PV string under partially shaded conditions. IEEE Transactions on Industrial Electronics, 63(1), 235-245.
[7] Sundare swaran, K., Vignesh kumar, V., Sankar, P., Simon, S. P., Nayak, P. S. R., & Palani, S. (2016). Development of an improved P&O algorithm assisted through a colony of foraging ants for MPPT in PV system. IEEE Transactions on Industrial Informatics, 12(1), 187-200.
[8] Miyatake M., Inada T., Hiratsuka I., Hongyan Zhao, Otsuka H., Nakano M. "Control characteristics of a Fibonacci-search-based maximum power point tracker when a photovoltaic array is partially shaded**".** Power Electronics and Motion Control Conference, 2004. IPEMC 2004. The 4th International Volume 2, 14-16 Aug. 2004 Pages: 816 - 821 Vol.2
[9] Miyatake M et al: "A simple maximum power point tracking control employing Fibonacci search algorithm for photovoltaic power generators". EPE-PEMC'02, No. T6-003, 2002