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Performance Assessment of SMA Based MPPT Controller for PV System Considering Random PSC

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Abstract

Renewable energy sources such as solar photovoltaics are numerous, making them an ideal alternative to conventional energy sources. Due to their natural and environment-friendly properties, they are also more efficient than conventional energy sources. One of the most critical factors that can affect the efficiency of a PV system is the PV power extraction due to the Partial shaded conditions. Although the performance of a PV system is generally improved by implementing a maximum power point tracking technique, this technique is not ideal for every type of system. The classical methods are usually preferred due to the only peak in the P-V curve. However, when it comes to the multiple peaks of the P-V curve, the conventional methods are not able to achieve the optimal performance. Hence in this paper a novel Slime Mould algorithm (SMA) is proposed and its effectiveness is evaluated in comparison with Particle swarm optimization algorithm. The proposed algorithm is implemented on a test case of 200 W PV system of 5 X 5 size with S-P and T-T configurations. Parameters such as PV mismatch losses, fill factor efficiency are evaluated. Proposed SMA MPPT algorithms exhibits the superior performance in comparison with PSO MPPT algorithm.

Keywords. SMA, PSO, PSC, MPPT, S-P, T-T.

1. INTRODUCTION

Today, solar power is widely used in the world due to its high efficiency and cost-effectiveness. It is regarded as a promising renewable energy source. Compared with other sources such as fossil fuels and oil, it is very clean and has an abundance of environmental friendliness [1]-[3]. Due to the increasing concerns about the power generation efficiency of PV systems under different shading conditions, the need for more effective PV configurations has been increasing.

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Hence in this paper optimal MPPT control technique is implemented considering the configurations under random PSC [4].

A novel Slime Mould algorithm is proposed and its effectiveness is evaluated in comparison with Particle swarm optimization algorithm. The proposed algorithm is implemented on a test case of 200 W PV system of 5 X 5 size. Parameters such as PV mismatch losses, fill factor are evaluated. Proposed SMA MPPT algorithms exhibits the superior performance in comparison with PSO MPPT algorithm [5].

2. Slime Mould Algorithm

The concept of the slime mould algorithm is based on the oscillation style of the mould in nature. It takes into account the various feedbacks generated by the mould's propagation wave and generates a dynamic structure that can be used to improve the efficiency of the system. The SMA approach is illustrated in Fig. 1. Mathematical model is illustrated in Fig. 2. [6]

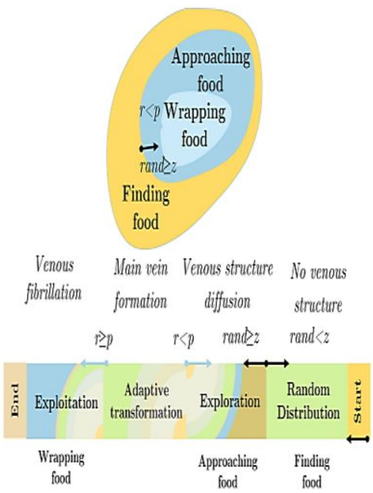

Fig. 1 SMA Approach

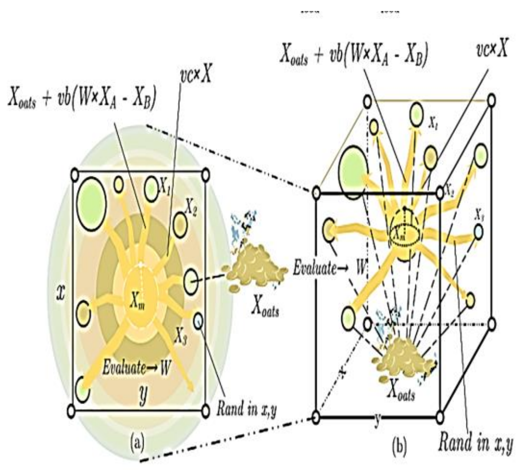

Fig. 2 Mathematical Model

3. Proposed System

In this paper SMA optimal MPPT control technique is implemented considering S-P and T-T configurations under random PSC. A test case of 54 cell, 200 W PV system with 5 X 5 configuration is considered as shown in Fig. 3.

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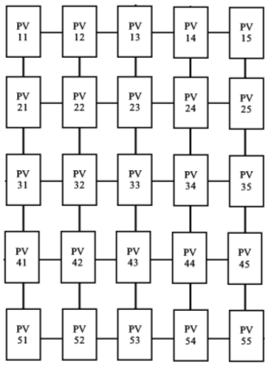

Fig. 3 Test Case Configuration

4. RESULTS AND DISCUSSION

In this paper the proposed algorithm is implemented on a test case of 200 W PV system of 5 X 5 size with S-P and T-T configurations. Parameters such as PV mismatch losses, fill factor efficiency are evaluated under the following cases.

- Performance Assessment Considering PSO Algorithm
- Performance Assessment Considering SMA Algorithm

4.1. Performance Assessment Considering PSO Algorithm

In this case PSO algorithm is implemented on a test case of 200 W PV system with 5 X 5 S-P and T-T configuration under random PSC condition. In the random PSC condition, the solar irradiance varies from 200 W/m^2 to 1000 W/m^2 at 25^{o}C temperature. Parameters such as PV mismatch losses, fill factor and efficiency are evaluated.

1. Series Parallel (S-P) Configuration

In this case the PSO algorithm is implemented on S-P configuration. Under PSO algorithm, the Max. voltage is 111.100 V, Max current is 35.312 A, Max Power is 3923.163 W. The O. C. voltage is 162.047 V, S. C. current is 41.101 A. The evaluation parameters are tabulated in Table 1.

Table 1. Performance evaluation with S-P Configuration

Type	Fill Factor (%)	PV Mismatch Losses (%)	Efficiency (%)
Conventional MPPT	58.886	27.676	11.086
PSO MPPT	58.904	27.546	11.098

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From the above evaluation table, it is clear that PSO MPPT exhibits the best performance than the conventional MPPT controller.

2. Triple Tie (T-T) Configuration

In this case the PSO algorithm is implemented on S-P configuration. The Max. voltage is 143.305 V, Max current is 31.399 A, Max Power is 4499.634 W. The O. C. voltage is 162.512 V, S. C. current is 41.101 A. The evaluation parameters are tabulated in Table 2.

Table 2. Performance evaluation with T-T Configuration

Type	Fill Factor (%)	PV Mismatch Losses (%)	Efficiency (%)
Conventional MPPT	67.460	11.429	12.703
PSO MPPT	67.366	11.206	12.728

From the above evaluation table, it is clear that PSO MPPT exhibits the best performance than the conventional MPPT controller.

4.2. Performance Assessment Considering SMA Algorithm

In this case SMA algorithm is implemented on a test case of 200 W PV system with 5 X 5 S-P and T-T configuration under random PSC condition. In the random PSC condition, the solar irradiance varies from 200 W/m^2 to 1000 W/m^2 at 25ºC temperature. Parameters such as PV mismatch losses, fill factor and efficiency are evaluated.

1. Series Parallel (S-P) Configuration.

In this case the SMA algorithm is implemented on S-P configuration. Under the SMA algorithm, the Max. voltage is 112.320 V, Max current is 36.706 A, Max Power is 4122.818 W. The O. C. voltage is 163.010 V, S. C. current is 43.980 A. The evaluation parameters are tabulated in Table 1.

Table 1. Performance evaluation with S-P Configuration

Type	Fill Factor (%)	PV Mismatch Losses (%)	Efficiency (%)
Conventional MPPT	58.886	27.676	11.086
SMA MPPT	57.508	21.370	11.662

From the above evaluation table, it is clear that SMA MPPT exhibits the best performance than the conventional MPPT controller.

2. Triple Tie (T-T) Configuration

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In this case the PSO algorithm is implemented on S-P configuration. The Max. voltage is 144.121 V, Max current is 32.411 A, Max Power is 4671.106 W. The O. C. voltage is 163.121 V, S. C. current is 44.012 A. The evaluation parameters are tabulated in Table 2.

Table 2. Performance evaluation with T-T Configuration

Type	Fill Factor (%)	PV Mismatch Losses (%)	Efficiency (%)
Conventional MPPT	67.460	11.429	12.703
SMA MPPT	65.064	7.123	13.213

From the above evaluation table, it is clear that SMA MPPT exhibits the best performance than the conventional MPPT controller.

5. PERFORMANCE COMPARISON

In this paper the proposed algorithm is implemented on a test case of 200 W PV system of 5 X 5 size with S-P and T-T configurations. Parameters such as PV mismatch losses, fill factor efficiency are evaluated under S-P and T-T configurations. Comparison analysis under S-P Configuration is illustrated in Fig. 3.

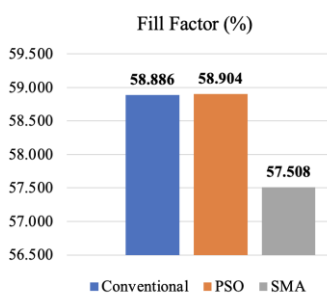

Fig. 3 (a) Comparison of Fill Factor

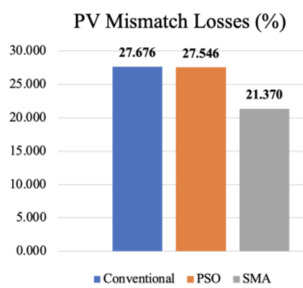

Fig. 3 (b) Comparison of PV Mismatch Losses

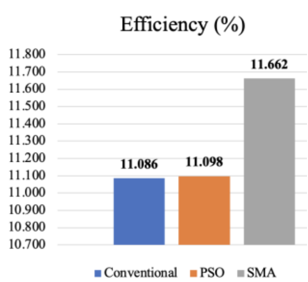

Fig. 3 (c) Comparison of Efficiency (%)

In the S-P Configuration Fill Factor is reduced, PV mismatch losses are minimized and the Efficiency is improved. Comparison analysis under S-P Configuration is illustrated in Fig. 4.

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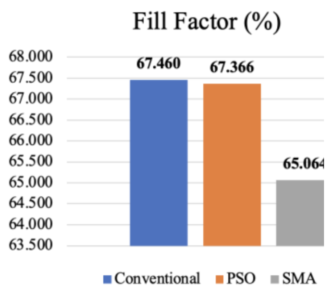

Fig. 4 (a) Comparison of Fill Factor

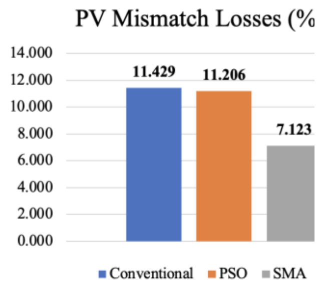

Fig. 4 (b) Comparison of PV Mismatch Losses

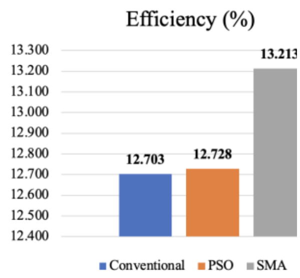

Fig. 4 (c) Comparison of Efficiency (%)

In the T-T Configuration Fill Factor is reduced, PV mismatch losses are minimized and the Efficiency is improved. Hence in all the cases the proposed algorithm exhibits the superior performance

6. CONCLUSION

In this paper a novel Slime Mould algorithm (SMA) is proposed and its effectiveness is evaluated in comparison with Particle swarm optimization algorithm. The proposed algorithm is implemented on a test case of 200 W PV system of 5 X 5 size with S-P and T-T configurations. Detailed literature review is presented. SMA algorithm approach si presented. Parameters such as PV mismatch losses, fill factor efficiency are evaluated considering conventional, PSO and Proposed SMA algorithm. Proposed SMA MPPT algorithms exhibits the superior performance in comparison with PSO MPPT algorithm. In S-P configuration Fill Factor is reduced from 58.886 % to 57.508 %, PV mismatch losses are minimized from 27.676 % to 21.370 % and the Efficiency is improved from 11.086 % to 11.662. Similarly in T-T configuration Fill Factor is reduced from 67.460 % to 65.064 %, PV mismatch losses are minimized from 11.429 % to 7.123 % and the Efficiency is improved from 12.703 % to 13.213.

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