CHAPTER 4

SIMULATION RESULTS AND ANALYSIS OF MPPTs

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4.1 INTRODUCTION

In this chapter, the simulation of P&O, Increment Conductance, and Decrement Resistance MPPT algorithm are done in the MATLAB to find out the maximum power tracing curve. In the last the results of these MPPTs are compared and find out the tracking efficiency with respect to theoretical energy.

4.2 SIMULATION CURVES OF P&O ALGORITHM

Many MPPT algorithms had been proposed in the past. The most common algorithms nowadays are the P&O [75]. This method offers the main advantage of providing high efficiency under rapidly changing atmospheric conditions, so it has been employed in the proposed model also. Figure 4.1 and 4.2 show the P-V, and I-V characteristics respectively of the BP SX 150S PV module using P&O MPPT at various irradiance levels. Figures 4.3, 4.4, and 4.5 show the tracking maximum power (simulation power) vs. time, tracking maximum voltage vs. time, and tracking current vs. time curves respectively. The P&O MPPT algorithm is implemented using MATLAB.

![Figure 4.1: P-V curves of P&O Algorithm at various irradiances and a tracking of MPPs.](image-url)
Figure 4.2: I-V curves of P&O Algorithm at various irradiances and a tracking of MPPs.

Figure 4.3: Tracing Power vs. Time curves of P&O Algorithm at various irradiances.
Figure 4.4: Tracking Voltage vs. Time curves of P&O algorithm at various irradiances

Figure 4.5: Tracking Current vs. Time curves of P&O algorithm at various irradiances
4.3 TRACKING ENERGY AND EFFICIENCY OF P&O ALGORITHM

The tracking power of PV module is the power which achieved by tacking the maximum power points at various irradiances (tracking energy = tracking power × time). From the figure 4.3 the total tracking energy of PV module for a day (12 hrs) can be calculated as:-

Tracking Energy for .9011 hour

\[
= (0.5 \times 149.9 \times 0.9011)
\]

\[= 67.54 \text{Wh} \quad (4.1)\]

Tracking Energy for 11.0989 hours

\[
= (149.9 \times 11.0989)
\]

\[= 1663.725 \text{Wh} \quad (4.2)\]

By adding the equations (4.1) and (4.2), the total tracking energy of the PV module can be calculated

Total Tracking Energy for a day (12 hrs)

\[= 67.53 + 1663.73 \]

\[= 1731.3 \text{Wh} \]

\[\sim 1731.6 \text{Wh} \text{ (by MATLAB Program)} \quad (4.3)\]

The tracking efficiency of the MPPT is defined as the ratio of total energy received by tracking maximum power points to theoretical energy

Tracking Efficiency % = \[
\frac{\text{Tracking Energy}}{\text{Theoretical Energy}}
\]

\[= \frac{1731.6}{1732.3} \times 100\]

\[= 99.96\%\]

Please refer to Appendix 1.6 for this MATLAB program.
4.4 SIMULATION CURVES OF INCREMENT CONDUCTANCE ALGORITHM

Here the MPPT Increment Conductance algorithm is simulated in the MATLAB. The results are given below. Figures 4.6 and 4.7 show the P-V, and I-V characteristics respectively for the BP SX150S module using Increment Conductance algorithm with maximum power tracking at various irradiance levels. Figures 4.8, 4.9, and 4.10 show the tracking maximum power (simulation power) vs. time, tracking maximum voltage vs. time, and tracking current vs. time curves respectively.

Figure 4.6: P-V curves of Increment Conductance algorithm at various irradiances and a tracking of MPPs.
Figure 4.7: I-V curves of Increment Conductance Algorithm at various irradiances and a tracking of MPPs.

Figure 4.8: Tracking Power vs. Time curves of Increment Conductance Algorithm at various irradiances.
Figure 4.9: Tracking Voltage vs. Time curves of Increment Conductance algorithm at various irradiances.

Figure 4.10: Tracking Current vs. Time curves of Increment Conductance algorithm at various irradiances.
4.5 TRACKING ENERGY AND EFFICIENCY OF INCREMENT CONDUCTANCE ALGORITHM

The tracking power is the power which achieved by tracing the maximum power point at various irradiances (tracking energy = tracing power × time). From the figure 4.8 the total tracking energy for a day (12 hrs) can be calculated as:-

Tracking Energy for 54.03 minutes

\[
= \frac{0.5 \times 149.9 \times 54.03}{60} = 67.49 \text{ Wh} \quad (4.4)
\]

Tracking Energy for 665.97 minutes

\[
= \frac{149.9 \times 665.97}{60} = 1663.82 \text{ Wh} \quad (4.5)
\]

By adding the equations (4.4) and (4.5), the total tracking energy of the PV module can be calculated

Total Tracing Energy for a day (12 hrs)

\[
= 67.49 + 1663.82 = 1731.3 \text{ Wh} \approx 1731.6 \text{ Wh (by MATLAB Program)} \quad (4.6)
\]

The tracking efficiency is defined as the ratio of total energy received by tracking maximum power points to theoretical energy.

Tracking Efficiency % = \frac{\text{Tracking Energy}}{\text{Theoretical Energy}}

\[
= \frac{1731.6}{1732.3} \times 100 = 99.96\%
\]

Please refer to Appendix 1.7 for this MATLAB program.
4.6 SIMULATION CURVES OF DECREMENT RESISTANCE ALGORITHM

Here the MPPT Decrement Resistance algorithm is simulated in the MATLAB. The results are given below. Figures 4.11, and 4.12 show the P-V, and I-V characteristics respectively for the BP SX150S module using Decrement Resistance algorithm with maximum power tracking at various irradiance levels. Figures 4.13, 4.14 and 4.15 show the tracking maximum power (simulation power) vs. time, tracking maximum voltage vs. time, and tracking current vs. time curves respectively.

Figure 4.11: P-V curves of Decrement Resistance algorithm at various irradiances and a tracking of MPPs.
Figure 4.12: I-V curves of Decrement Resistance algorithm at various irradiances and a tracking of MPPs.

Figure 4.13: Tracking Power vs. Time curves of Decrement Resistance algorithm at various irradiances.
Figure 4.14: Tracking Voltage vs. Time curves of Decrement Resistance algorithm at various irradiances.

Figure 4.15: Tracking Current vs. Time curves of Decrement Resistance algorithm at various irradiances.
4.7 TRACKING ENERGY AND EFFICIENCY OF DECREMENT RESISTANCE ALGORITHM

The tracking power is the power which achieved by tracking the maximum power point at various irradiances (tracing energy = tracing power × time). From the figure 4.13 the total tracking energy for a day (12 hrs) can be calculated as:-

Tracking Energy for 54.3 minutes

\[ \text{Tracking Energy} = \frac{0.5 \times 149.9 \times 54.3}{60} = 7.82 \text{Wh} \]  
(4.7)

Tracking Energy for 665.7 minutes

\[ \text{Tracking Energy} = \frac{149.9 \times 665.7}{60} = 1663.14 \text{Wh} \]  
(4.8)

By adding the equations (4.7) and (4.8), the total tracking energy of the PV module can be calculated

Total Tracking Energy for a day (12 hrs)

\[ = 67.49 + 1663.82 = 1731 \text{Wh} \]

\[ \approx 1731.4 \text{Wh (by MATLAB Program)} \]  
(4.9)

The tracking efficiency is defined as the ratio of total energy received by tracking maximum power points to theoretical energy

\[ \text{Tracking Efficiency} \% = \frac{\text{Tracking Energy}}{\text{Theoretical Energy}} \]

\[ = \frac{1731.4}{1732.3} = 99.95\% \]

Please refer to Appendix 1.8 for this MATLAB program
4.8 COMPARE AND ANALYSIS OF MPPTs EFFICIENCY

From the above results of P&O, Increment conductance (IncCond.), and Decrement Resistance (DecRes.) algorithm (Algo.), the observation values are given in the comparative table 4.1:-

Table 4.1: Comparative table of three algorithm

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Power (Pmax)</td>
<td>149.92W</td>
<td>149.86</td>
<td>149.92W</td>
</tr>
<tr>
<td>Maximum Voltage (Vmp)</td>
<td>34.15V</td>
<td>34.45V</td>
<td>34.15V</td>
</tr>
<tr>
<td>Maximum Current (Imp)</td>
<td>4.39A</td>
<td>4.35A</td>
<td>4.39A</td>
</tr>
<tr>
<td>Tracking Energy</td>
<td>1731.6W</td>
<td>1731.6W</td>
<td>1731.4W</td>
</tr>
<tr>
<td>Theoretical energy</td>
<td>1732.3W</td>
<td>1732.3W</td>
<td>1732.3W</td>
</tr>
<tr>
<td>Tracking Efficiency</td>
<td>99.96%</td>
<td>99.96%</td>
<td>99.95%</td>
</tr>
<tr>
<td>Tracking Time of MPP</td>
<td>42-43 seconds</td>
<td>45-46 seconds</td>
<td>45-46 seconds</td>
</tr>
</tbody>
</table>

From the analysis of comparative table, the maximum power at the irradiance of 1000W/m² of Increment Conductance algorithm is better than P&O algorithm but similar to Decrement Resistance algorithm for the same irradiance. The efficiency of Increment Conductance algorithm is equal to P&O algorithm but greater than Decrement Resistance algorithm.

4.9 CONCLUSION

From the comparative table and simulation curves of three algorithms, it is concluded that for better efficiency the P&O and Increment conductance are better than Decrement Resistance algorithm. From the analysis of maximum power (Pmax) and maximum voltage (Vmp) the Increment Conductance and Decrement algorithm can work at partly cloudy whether while P&O algorithm can exhibit erratic behavior in case of rapidly changing atmosphere.