A New Active Method to Diagnose the Anti-Islanding Mode Protection for Photovoltaic System

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Abstract: Nowadays, renewable energies have taken special place in the world and most of the distributed generations (DGs) in the power system utilize these types of energy sources. Due to the DGs advantages, including the use of renewable energies which do not polluting environment and has endless nature, using these resources to produce electrical energy in the world are increasing. One problem with such generators is an unwanted islanding phenomenon. In this paper, a new method is proposed to diagnose islanding conditions for photovoltaic system which has been connected to the network through VSC converter. A photovoltaic system connected to the network is simulated in MATLAB software. The simulations results verify the effectiveness of the proposed method.

Key words: Renewable Energies · Anti-Islanding Protection · Current Control · Photovoltaic system

INTRODUCTION

Nowadays, mostly, countries’ energy consumption is supplied by fossil fuel resources. But, in this regard, they have encountered with many problems including environmental pollution and terminable fossil resources.

To solve this problem, countries are interested in renewable energies to supply their demanded energy consumption. Renewable energy mostly includes solar energy, wind energy, fuel waste due to urban, biomass and stream line water flow [1].

Bulk of distributed generations in power system is renewable energy. Depending on the distributed generations’ type, their production can be AC or DC. But, most of these products are connected through electronic power converter to the network [2].

But DGs by themselves will have affects in the network, which one of these affections is an islanding phenomenon. Islanding mode happens when one or more DGs are connected and supplied local loads without connecting to the network. In most cases this phenomenon may occur unwanted. This issue causes problems such as creating the hazard for line repair technicians, equipment damage due to instability in utilization voltage and frequency and inconsistency in the reconnection to the power system. Therefore, according to IEEE1547 standard, islanding mode should be diagnosed and disconnected in 2 seconds [3-5].

So far many methods to detect islanding mode have been proposed. These methods can be classified in two broad categories of active and passive classifications [4]. Active methods can include:

- Impedance measurement method [6]
- Frequency domain analysis [7]
- Changing voltage amplitude and reactive power method [8]
- The mid-harmonic method [9]

And passive techniques can be as followings:

- Voltage and frequency relays [10]
- Rate of change of frequency relay (df/dt) [11]
- Output power speed changes [10]
- Unbalanced voltage and Total current (or voltage) harmonic distortion (THD) [12]

In this paper, an active method is utilized based on 3rd harmonic component of output current to diagnose the anti-islanding protection in photovoltaic systems. At first, the system is controlled by the current controller which by the uses of this controller the amount of transferred power to the network is measured and when islanding mode is occurred this mode should be diagnosed by the proposed algorithm and the system generation should be disconnected.

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Table 1: Study system parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<tbody>
<tr>
<td>V&lt;sub&gt;DC&lt;/sub&gt;</td>
<td>350vDC</td>
</tr>
<tr>
<td>R&lt;sub&gt;s&lt;/sub&gt;</td>
<td>1Ω</td>
</tr>
<tr>
<td>L&lt;sub&gt;s&lt;/sub&gt;</td>
<td>7mHs</td>
</tr>
<tr>
<td>R&lt;sub&gt;t&lt;/sub&gt;</td>
<td>50Ωl</td>
</tr>
<tr>
<td>L&lt;sub&gt;t&lt;/sub&gt;</td>
<td>35mHl</td>
</tr>
<tr>
<td>V&lt;sub&gt;ref&lt;/sub&gt;</td>
<td>220v</td>
</tr>
<tr>
<td>f&lt;sub&gt;n&lt;/sub&gt;</td>
<td>50HZ</td>
</tr>
</tbody>
</table>

Nominal Power | 1KW |
Nominal Frequency | 50HZ |

In the next section, the studied system will be analyzed. In Section 3 the proposed algorithm to detect islanding state will be presented. Test results to diagnose islanding state will be come in Section 4 and in last section of this paper the conclusion will be presented.

**Study System:** Contributions Single line diagram of the study system in this paper is shown in Figure 1. As depicted in this figure, DG has been modeled by a DC source and a voltage source converter (VSC) which is connected to power network and local load through a low-pass filter. Total impedance of low-pass filter is represented by R<sub>t</sub> and L<sub>t</sub>. The system parameters are presented in Table 1.

When the system is connected to the network, mid-VSC will act like current controlled voltage source; in fact it works as the conventional controller for VSC. The output current of DG will be measured and the rms value of the current will be calculated and compared with reference value. Then, using conventional PI controller the output current will be controlled.

When islanding mode is occurred the system should act such that the islanding mode is diagnosed and system disconnected from the power network. Since the generated energy by the photovoltaic system is stored in the battery, then photovoltaic system could be modelled as voltage source with constant value.

**The Proposed Algorithm:** In the proposed method, output current of the photovoltaic system is measured and the 1st and 3rd harmonics are extracted and the rms value of the 1st harmonic will be calculated. This value is compared with reference value and then controlled using PI controller. The output of the controller is transformed into the sine wave value by the sume of the 1st and 3rd angles and by the use of which the sine voltage signal of gate is obtained.

When the system is work normally, the value of 3rd harmonic is low and as the system is connected to the network, presence of this harmonic will not cause any disturbances in the system.

When the islanding phenomenon is occurred, the 3rd harmonic value will be raised and this will cause disturbance in switching action and causes to increase 3rd harmonic value. This procedure will act like a positive feedback and causes change in frequency of the output current of load.

When the output frequency is more than nominal frequency of the network, frequency relays connected to the output of the DGs will diagnose this change which in turn the islanding mode is diagnosed and the DG will be disconnected. This algorithm is act based on a positive feedback and shown in Fig 2.

![Fig. 1: Photovoltaic system with battery, converter and load](image-url)
Simulation Results: In this section of the paper, the simulation results of the proposed method for the system simulated in MATLAB software is shown to verify the effectiveness of the proposed algorithm. At first the system is the network-connected state and its load is nominal and equal to 1000W. DG will supply this load. At $T=1$ sec CB is opened and in Fig 1, islanding condition took place and the DG is separated from the network. Simulation results for this load are shown in Figs 3, 4 and 5.
Fig. 5: Frequency changes of the output voltage before and after islanding

In Fig. 3, load voltage waveform is depicted which at T=1 sec the islanding is occurred. The load current before and after the islanding mode is illustrated in Fig 4. From the figure, it is clear that the system response is fast and in the event of islanding has a little drop and then return to the initial condition. In Fig 5, the frequency value is shown which confirm the correctness of the proposed algorithm.

CONCLUSIONS

In this paper, a new active method to identify islanding mode for DGs were proposed. This method is essentially active and makes decision based on the applied disturbances to the system. The shown results indicate good performance of the proposed method because it act based on 3rd harmonic and the increase in 3rd harmonic cause its performance in islanding mode and do not cause mistake in decision.

The system was simulated on MATLAB software and its results were shown for load worst condition, the algorithm is capable to identify islanding more from the other network conditions.

REFERENCES

