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# Islanding Detection Technique using Grid-Harmonic Parameters in the Photovoltaic System

Il-Song Kim*

*Department of Electrical Engineering, Chung-Ju National University, Republic of KOREA*
**Corresponding author: iskim@cjnu.ac.kr, Tel : 82-43-841-5142*

**Abstract**

Power Conditioning System (PCS) in the photovoltaic system requires reliable islanding detection function (passive or active) in order to know electrical grid status and operate the grid connected inverter properly. This paper proposes a passive islanding detection algorithm based on the grid harmonic components. It utilizes the fact that the equivalent harmonic components at the point of common coupling (PCC) are changed according to the grid connection status. This method shows reduced Non-Detection Zone (NDZ) and fast detection time compared to the conventional approach. The mathematical modeling is performed and verified by experimental result using high performance DSP controller



*Keywords : Islanding detection, PCS, photovoltac system, harmonic detection*

Photovoltaic (PV) energy is the most promising reusable energy source thanks to its features of pollution-free, abundance and even distribution through the world. A main issue associated to renewable energy sources connected to electrical grids through an active front-end is the proper operation of such grid interfaces in order to improve the power supply reliability and quality independently from the electrical characteristics of the renewable sources and the grid conditions at the PCC.

The islanding condition occurs when the utility system contains both load and photovoltaic system remain energized while it is isolated from the remainder of the utility system. When the islanding is happens, the PCS should be stopped less than 2 second in order to avoid possible damages to local electrical loads or guarantee the safety of workers during maintenance operation of the electrical system.[1]

There have been many researches for islanding detection methods. Passive and active detection methods have been proposed in the literatures. Passive methods monitor the voltage, frequency, current at the PCC in order to determine islanding conditions. The drawbacks of these methods must be considered that grid voltage disturbances can cause inopportune intervention of the island-detection algorithm during normal


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operation. Active methods are the alternatives to the passive methods. A controlled disturbance is introduced at the PCC, and when the islanding condition occurs, the disturbance force the detection method threshold. Several algorithms such as active frequency drift, slip mode frequency shift, active and reactive power variation are introduced in the literatures. [1-3]

In this paper, another way of passive method is introduced to detect islanding condition. It uses the variation of harmonic components of the grid voltage. The advantage of proposed method is the reduced NDZ compared to the conventional passive method when the generated power by PV is matched with the consumed power by load. The islanding detection can be failed in the conventional passive method when the sag, swell or transient conditions happen in the grid voltage. The robust detection capability can be obtained using the proposed method, because the harmonic variations are minimal in the grid disturbance conditions. It also has the increased power quality and efficiency compared to the active method because it does not introduce any intentional disturbance to the grid.

The mathematical harmonic model of the photovoltaic system is introduced in the first chapter and the theoretical analysis is developed in the next chapter and verified by experimental result using high performance DSP controller.

## 1. Harmonic modeling of PV system

The harmonic equivalent circuit for grid connected photovoltaic system is shown in fig. 1. The DC equivalent circuit for inverter side at PCC can be modeled sinusoidal current source whose contains harmonic components. As the harmonic model does not contain fundamental component (60Hz), it can be modeled as harmonic current source $I_{f\_h}$. The grid voltage is a harmonic source which can be expressed as $V_{g\_h}$ whose grid impedance is series value of $R_g$ and $L_g$. Local load at PCC is a resonant $R_L$, $L_L$, $C_L$ whose quality factor $Q_L$ = 1.5. The condition for the local load and anti-islanding test is followed IEEE standard 929-2000. The Total harmonic distortion (THD) of $V_{g\_h}$ can be changed a little bit when the switch *SW* is closed or opened. However, the transition time is short compared to detection time, it can be neglected.

The grid voltage harmonic equation which does not contain fundamental component can be written as

$$V_{g\_h}(grid) = V_{M2}\sin(2\omega t) + V_{M3}\sin(3\omega t) + ...V_{Mn}\sin(n\omega t) = \sum_{n=2}^{\infty} V_n \sin(n\omega t) \quad (1)$$

The Inverter side harmonic equation which has uni-polar sinusoidal modulation single-phase full bridge topology can be written.

$$I_{f\_h} = \sum_{n=2}^{N} \left( \left| \frac{I_n}{n} \sum_{i=1}^{k} (-1)^{i+1} \cos(n\alpha_i) \right| \right) \quad (2)$$

The equivalent circuit during islanding operation is shown in fig. 2. When the switch *SW* is changed, the harmonic voltage $V_{pcc\_h}$ at PCC will be changed. This can be expressed as complex impedance equation. The harmonic voltage at PCC is given as

$$V_{pcc\_h} = \frac{Z_L}{Z_s + Z_L} V_{g\_h} + Z_L I_{f\_h} \qquad (SW\ ON)$$

$$V_{pcc\_h} = Z_L I_{f\_h} \qquad (SW\ OFF) \quad (3)$$