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Comparative Analysis of Anti-Islanding Prevention Technique in Grid Connected PV System

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Abstract: This paper presents a novel islanding prevention scheme of Grid-Connected PV Systems in Matlab/ Simulink based on monitoring the dc-link voltage of the PV inverter. A 100kW PV System equipped with islanding protection like frequency relays, a ROCOF relay, and respectively the proposed dc-link voltage relay are simulated under the conditions of islanding and the detection time for all these AI techniques are compared.

Keywords: Anti-Islanding, Distributed Energy Resources, Frequency Relays, ROCOF Relay, Dc-link Voltage Relay, Grid Connected PV Array

I. INTRODUCTION

Islanding also known as loss of grid or Loss-of-Mains–LoM represents "a condition in that a portion of the power system that contains both load and distributed energy resources (DER) remains energized while isolated from the remainder of the power system". Also, island represents a condition where a portion of an area electric power system (EPS) is energized solely by one or more local DER through the associated point of common coupling (PCC) while that portion of the area EPS is electrically separated from the rest of the area EPS. Development of sensitive and reliable AI protection is very important to encourage medium scale integration of DER into the electrical network and avoid unnecessary tripping of DER. The PV inverter design will be influenced by the power grid requirements, including the anti-islanding (AI) requirement which is considered the most technically challenging. One of the most challenging aspects of protection of DER is the sensitivity of islanding detection, which makes the system stable to external faults and frequency excursions. Islanding for PV Power Systems appears when the power grid is tripped and the inverter does not disconnect quickly enough and continues to operate with the local load. To perform islanding protection in some specific circumstances (impossibility of forming a stable island) it may be sufficient to use a combination of under/over frequency/voltage protection. In most cases, the islanding must be quickly detected and the PV System must be immediately disconnected from the power grid.

II. THE GRID CONNECTED PV SYSTEM AND ITS ISLANDING PREVENTION SYSTEM

The Simulink model of the 100kW Grid-Connected PV System is depicted in Fig.1. The PV Array, formed by330 SunPower modules provides in standard test conditions (STC) a maximum power of 100.7kW and 273.5V. The 100kW PV Array is connected to a 20kV power grid (Fig.2) with the main frequency of 50Hz through a 100kVA260V/20kV three-phase coupling transformer.

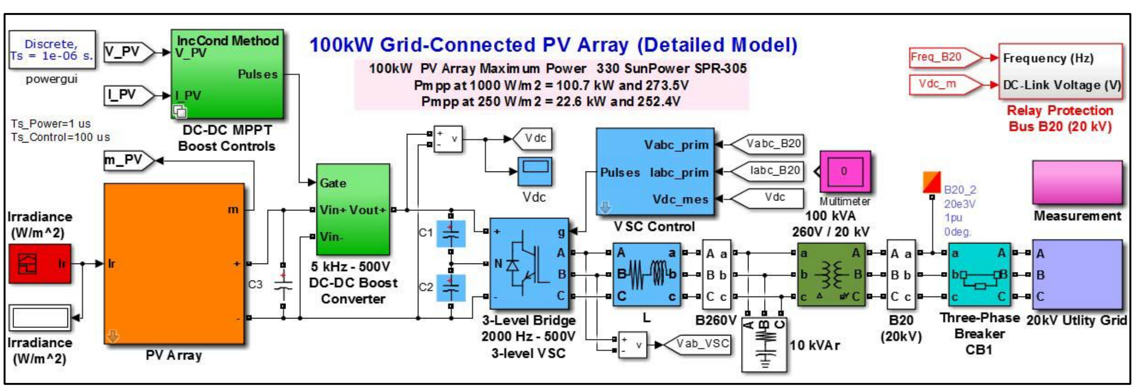

Fig. 1 The Simulink model of the 100kW Grid-Connected PV System

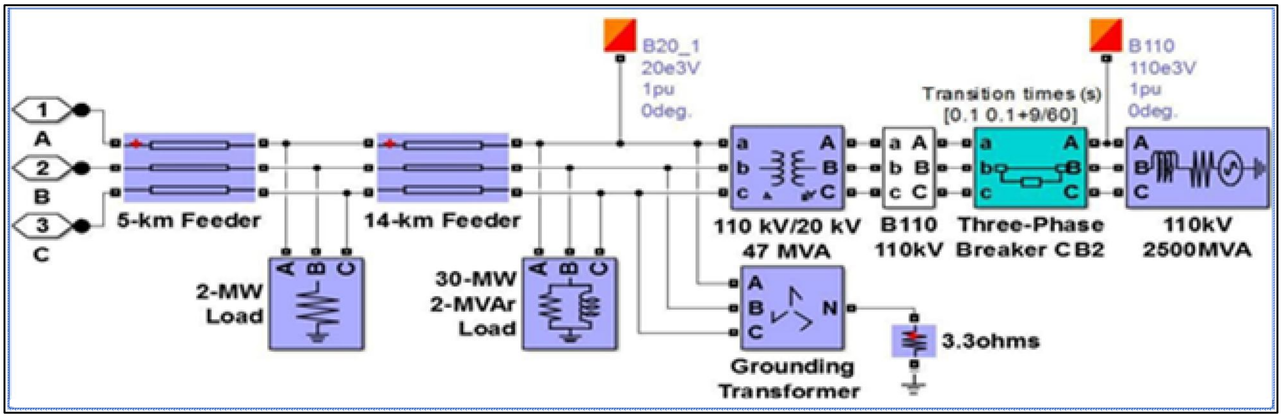

Fig. 2 Utility 20kV grid model in Simulink environment.

III. SIMULATION RESULTS OF ISLANDING CONDITIONS

The 100kW Grid-Connected PV Array from Fig. 1 is equipped with islanding protection methods like under/ over frequency relays, a ROCOF relay, and respectively the proposed dc-link voltage relay. This model is simulated using Simulink in various islanding scenarios. The islanding conditions occur in the studied network from Fig. 2 when the three- phase circuit breaker CB2 is opened at time (t) = 0.1 seconds (s). The circuit breaker CB2 disconnects the utility grid from the rest of the network during 150ms. As can be noted from Table I, the AI technique using dc link voltage relay has the fastest detection time. During islanding condition, the dc-link voltage decrease with the increase of the connected load. A small variation of inductive power does not influence much the detection time of the AI relays.

TABLE I
DETECTION TIME OF ANTI-ISLANDING METHODS

Scenarios	Detection Time (s) of Anti-Islanding Relays			
	UF	OF	ROCOF	DC-Link Voltage
Local load greater than local generation	0.0536	-	0.0149	0.0135
Local load matches with local generation	-	0.0632	0.0280	0.0212
Local load less than local generation	-	0.0623	0.0276	0.0222

The frequency relays have the limits of preset thresholds imposed by grid codes, leading to late detection of island conditions of PV systems. The detection times of islanding conditions of Grid-Connected PV System for the ROCOF relay are comparable with the detection times of frequency relays. The simulation results with detection time of different AI methods on various islanding scenarios of a PV System are depicted in Fig. 3

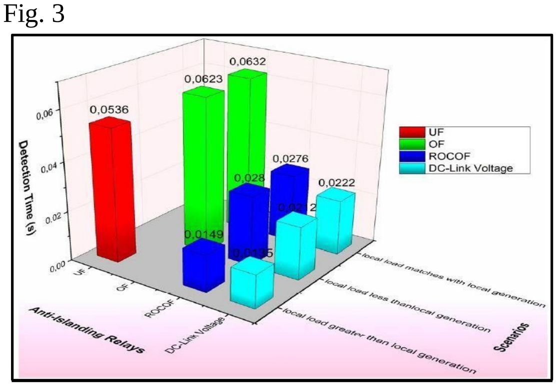

Fig. 3 Performance of different AI methods for a 100kW Grid-Connected PV System.

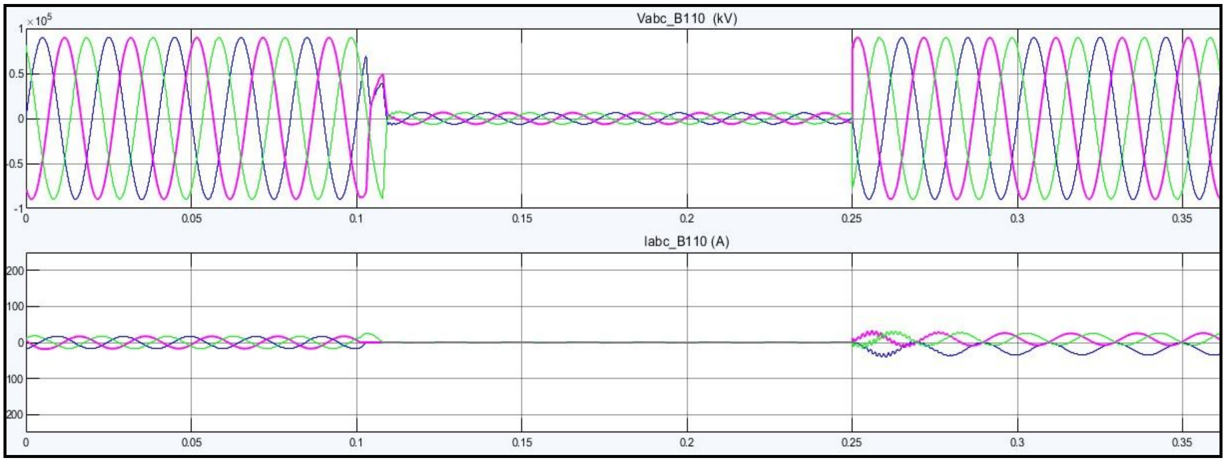

Fig. 4 Voltage & current waveform at Bus B110 grid side

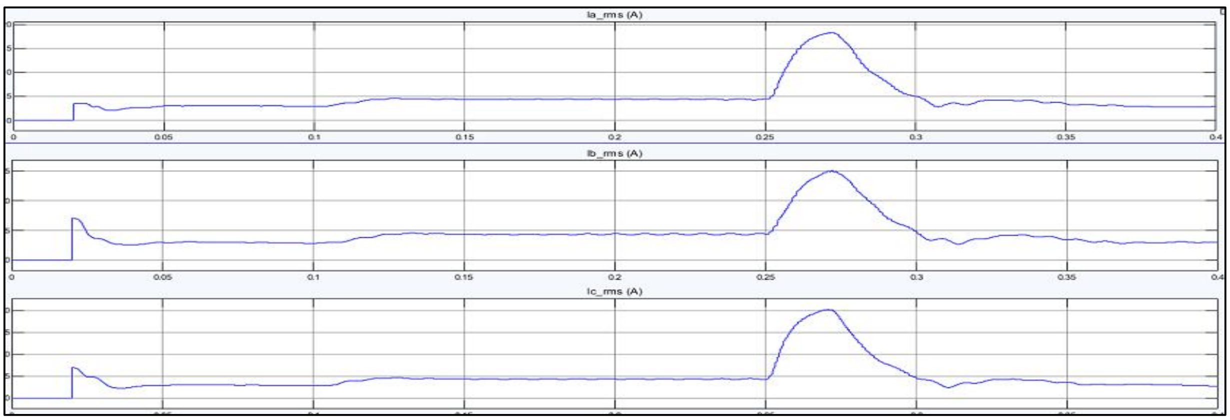

Fig. 5 Current waveform at bus B20 at solar PV generation SIDE Performance of different AI methods for a 100kW Grid-Connected PV System.

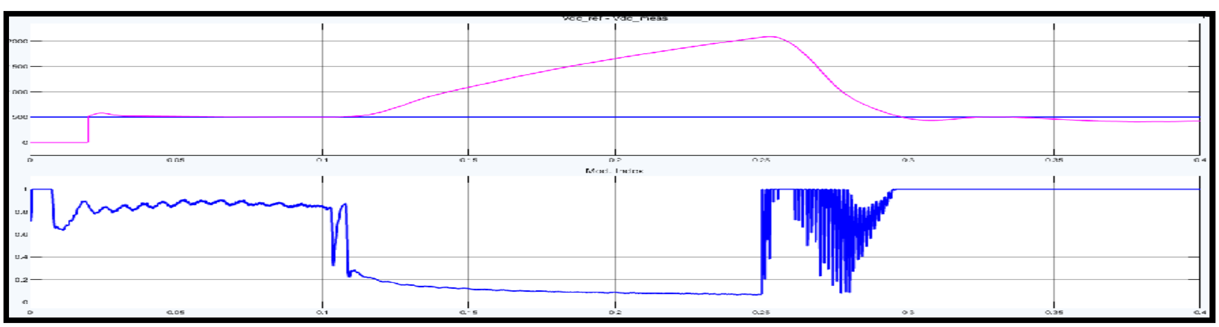

Fig. 6 (a) - DC voltage at the solar side local generation, (b) - mode of index solar generation with respect to time.

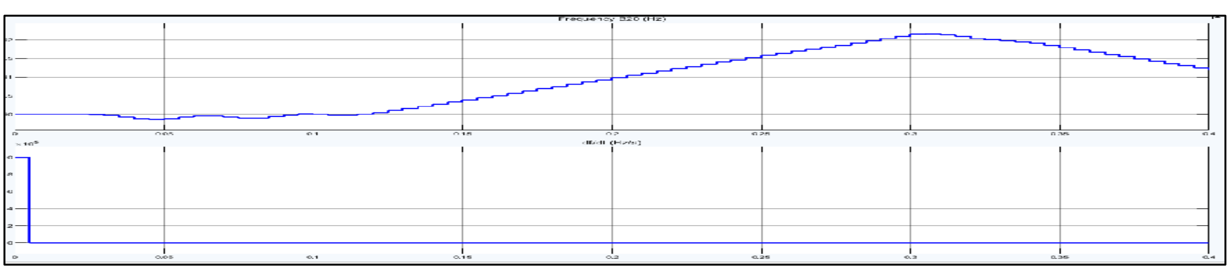

Fig. 7 (a)- Frequency at Bus B20 (Hz), (b)- df/dt at Bus B20mode of index solar generation with respect to time

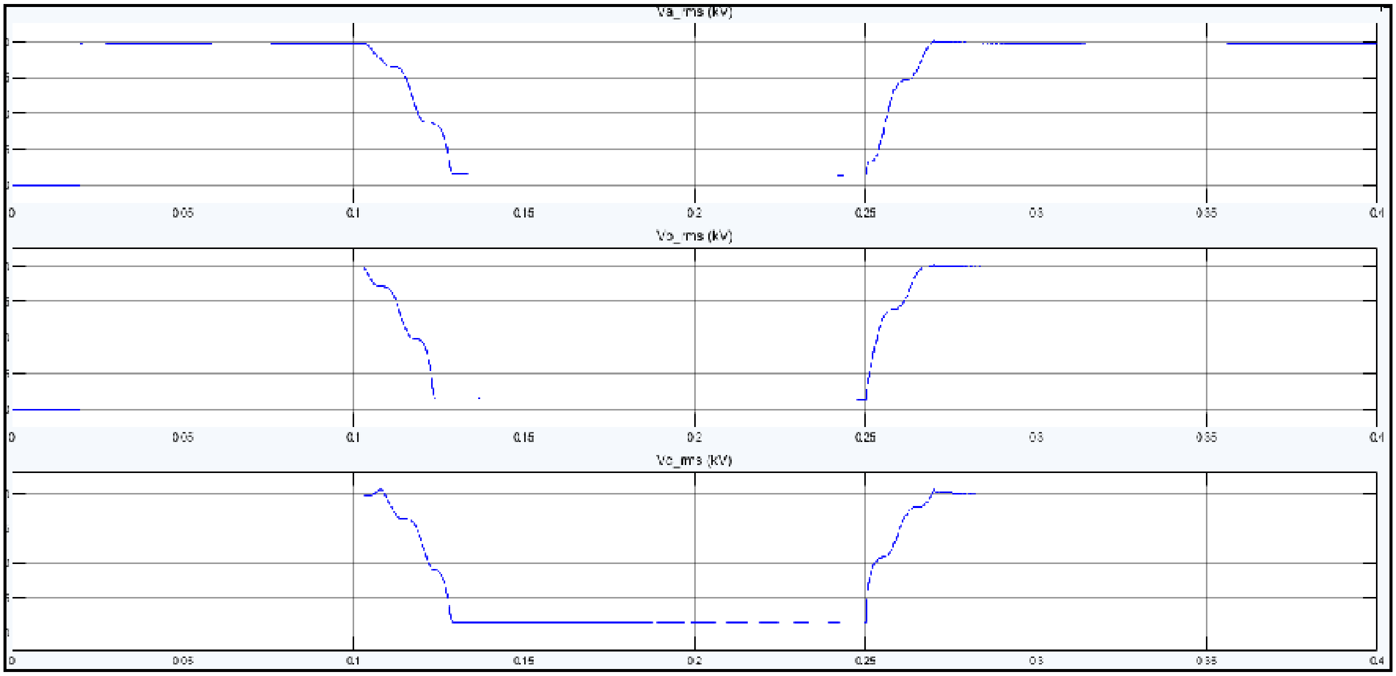

Fig. 8 Current at bus B110 Irms grid side.

IV. CONCLUSIONS

As it can be noted from Table and graphs, the AI technique using dc-link voltage relay has the fastest detection time. During islanding condition, the dc-link voltage decrease with the increase of the connected load. A small variation of inductive power does not influence much the detection time of the AI relays. System outfitted with islanding protection such as frequency relays, a ROCOF relay, and the proposed dc-link voltage relay are simulated under islanding conditions, and the detection time for all of these AI approaches is compared.

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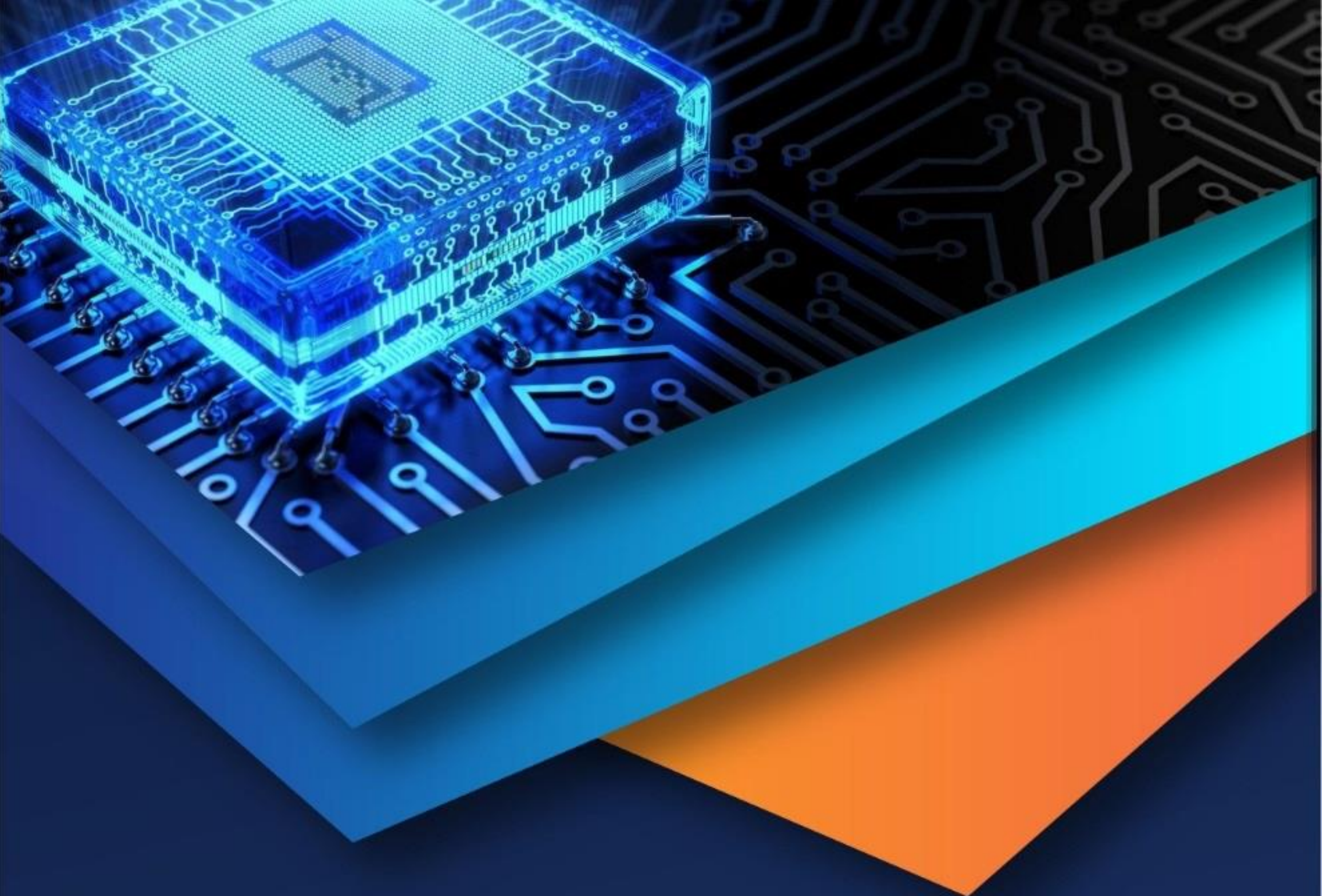

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