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

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ABSTRACT

In the present power system with distributed generators (DGs), there are some issues that are not resolved yet. One of these issues involves a fast and very accurate detection of islanding. The number of DGs introduced into electricity distribution systems is increasing day by day, and it is the most challenging concept in modern power system scenarios, since DG islanding can cause degraded proficiency, excellence, reliability and quality of supply. Hence, anti-islanding with fast response time is essential for a DG connected grid system. To overcome the challenges from islanding DGs, researchers proposed a numerous model that deals with the consequences of intentional islanding, and clears it as fast as possible.

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

I. INTRODUCTION

The concept of Distributed Energy Resources (DER) is moving from being a local issue towards a system issue. The issue of unintentional islanding in DGs grid interconnection still remains a huge challenge in grid-connected systems, since the system may not succeed at activating the protective devices during the islanded condition.

This result in the issues related to the power quality, protection, and reverse power flow and system stability. Hence, the condition of islanding must be detected and cleared as fast as possible as per the recommendation of grid codes.

Anti-islanding protection involves the use of relays or controls to prevent the existence of an unintentional island. The inverter must be able to detect an island, and take appropriated measure in order to protect people and equipment.

II. THE SIMULINK MODEL OF THE GRID-CONNECTED PV SYSTEM

A 100-kW PV array is connected to a 20-kV grid via a DC-DC boost converter and a three- phase three-level

Voltage Source Converter (VSC). Maximum Power Point Tracking (MPPT) is implemented in the boost converter by means of a Simulink model using the 'Incremental Conductance + Integral Regulator' technique .In this average model the MPPT controller is based on the 'Perturb and observe' technique.

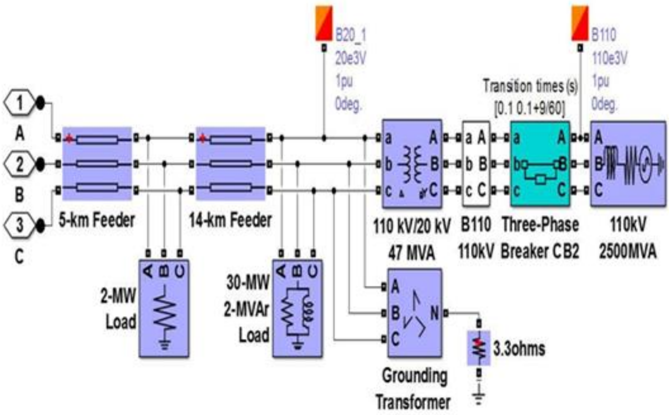

Fig. 5.1: The 20kV utility grid model in Simulink environment.

The Simulink block diagram of the AI protection relays on the 20kV bus are depicted in Fig.5.2.

The trip signals of these AI relays are disconnected from the three-phase circuit breaker on the 20kV distribution feeder at the PCC of the PV System in order to activate all relays and compare the detection times of these AI techniques. During simulation, the relays are activated only once.

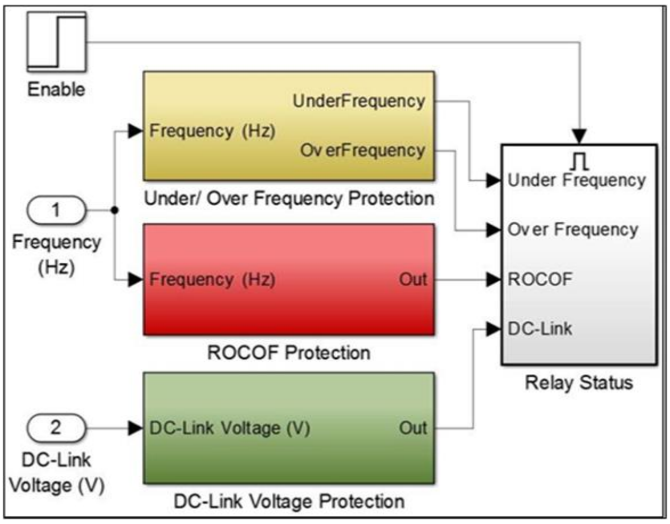

Fig. 5.2: The Simulink model of AI relays protection bus 20kV.

This model is simulated using Simulink in Local Load Greater than Local Generation islanding scenarios. The values of local connected feeder loads for this scenario are shown in the utility grid model from Fig.5.1.

III.RESULTS AND DISCUSSION

Different configurations of the connected feeder loads have different effect on dc-link voltage as shown in Fig. 5.3.

The frequency variations and their ROCOF or df/dt, during island conditions for the same configurations of connected feeder loads from Fig.5.4 are depicted in Fig. 5.5 and Fig. 5.6, respectively. As it can be observed, for defaults loads and for the resistive loads these two quantities are quite close. For capacitive reactive loads, the PV inverter loses control of the frequency.

Fig. 5.7 presents together the frequency and ROCOF during island condition of PV system with default loads of utility grid from Fig.5.2. From Fig. 5.7 it can be observed the effect of frequency on the islanding of PV system.

During islanding condition, the frequency decreases in a very short time. Rapid change in frequency implies a certain variation of ROCOF.

The islanding conditions are detected when a ROCOF threshold of 12Hz/s is exceeded. The minus sign indicates the frequency decrease.

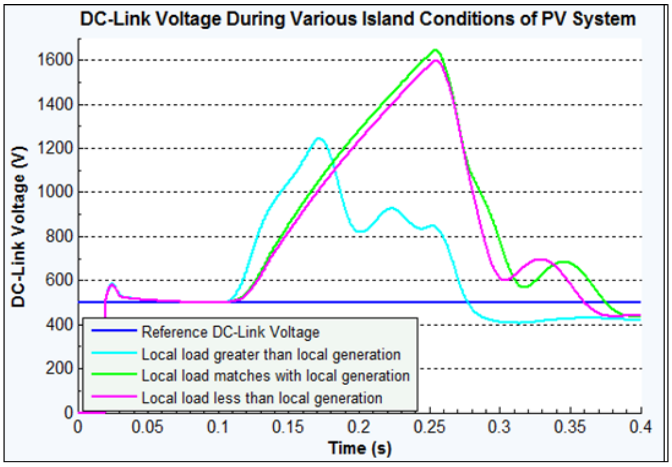

Figure. 5.3: The dc-link voltages in various islanding scenarios of PV System

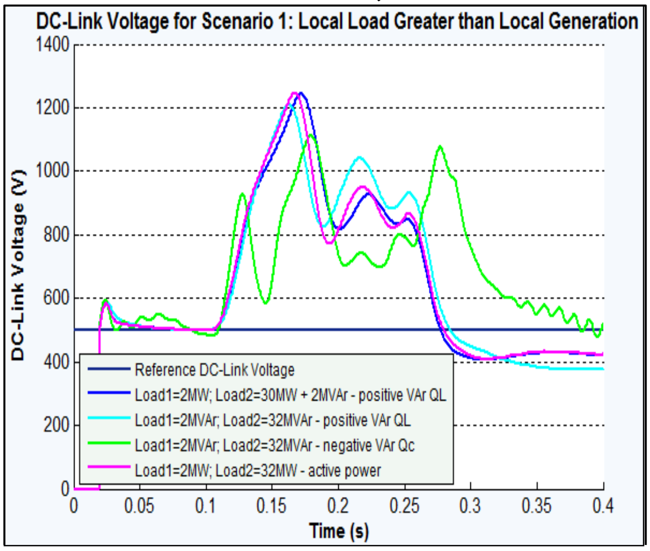

Figure. 5.4: DC-Link Voltage during island conditions of scenario 1 in different configurations of the connected feeder loads.

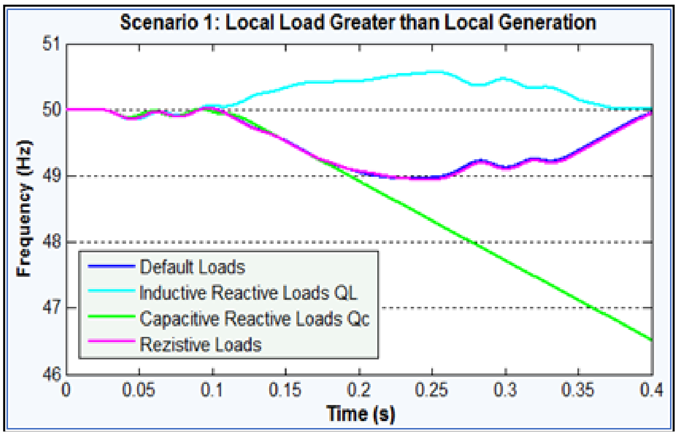

Figure. 5.5: Frequency variations during island conditions of scenario 1 in different configuration of the connected feeder loads

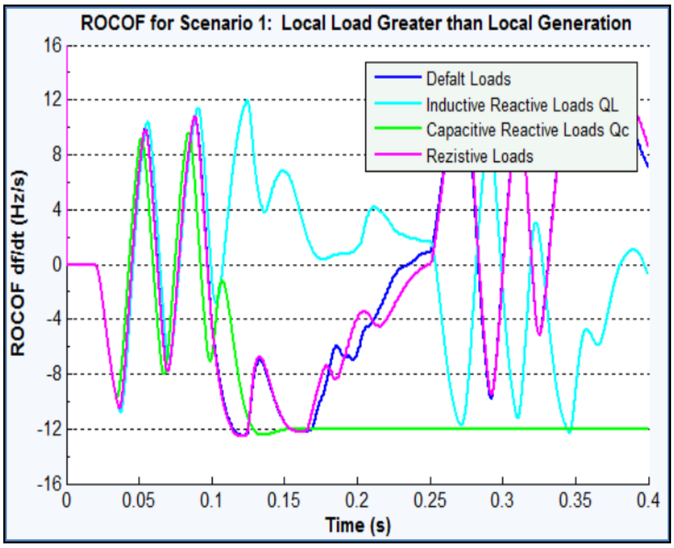

Figure. 5.6: The rate of change of frequency (ROCOF) during island conditions of scenario 1 in different configuration of the connected feeder loads

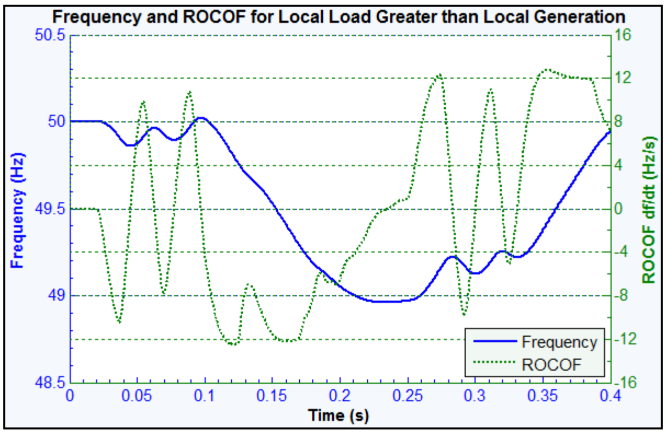

Figure. 5.7: The Frequency and its rate of change of frequency (ROCOF) during island condition with default loads

As it can be noted from Table 1, the AI technique using dclink 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 1
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

IV. CONCLUSION

The frequency relays have the limits of preset thresholds imposed by grid codes, leading to late detection of island conditions of PV systems. This thesis 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. The study shows dc- link voltage AI relay is the most efficient in this case.

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