European Research Infrastructure supporting Smart Grid Systems Technology Development, Validation and Roll Out

TRANSNATIONAL ACCESS
USER PROJECT FACT SHEET

USER PROJECT	
Acronym	**IsDHDG**
Title	Islanding detection in integrated hybrid DG system
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TA Call No.	5

HOST RESEARCH INFRASTRUCTURE			
Name	TECNALIA - Smart Grid Technologies Laboratory (SGTL)		
Country	Spain		
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USER GROUP	
Name (Leader)	Ruchita Nale
Organization (Leader)	National Institute of Technology Raipur, India
Country (Leader)	India
Name	Nand Kishor
Organization	MNNIT Allahabad, India
Country	India

1. USER PROJECT SUMMARY (objectives, set-up, methodology, approach, motivation)

1.1 Objectives

The objective of the research is to implement the proposed islanding algorithm in a developed microgrid system integrated with hybrid distributed generation (DG), nonlinear loads, storage devices and capacitors.

- To overcome the drawback of conventional islanding detection technique having large non detection zone and detection time by utilizing the voltage and current information from both local and remote ends, so as to improve the reliability of the detection technique.
- To validate the already proposed islanding algorithm by us on large DG system having hybrid resources (inverter & turbine).

- To develop multi resolution signal decomposition methods for detailed investigation for following conditions: (1) with nonlinear dynamic changes in the operation of generation resources at the time of islanding event, and (2) effect of different control schemes in generation resources at the time of islanding event.

1.2 Test set-up

Testing of IsDHDG requires microgrid set up with two distributed energy resources and the voltage and current measurement at DG and point of common coupling (PCC) end. In the offline set up for validation of proposed algorithm, two converters are used to emulate the behaviour of DGs connected. The laboratory experimental set up for detection of islanding condition is illustrated in Fig. 1. The testing of IsDHDG can be carried out in two steps.

First the real time voltage and current signals from the microgrid set up are retrieved using OPAL-RT with a sampling frequency of 1 kHz. This signals are recorded and stored in MATLAB in .mat format. In the next stage, this saved sampled data is utilized for validation of algorithm run in MATLAB. Subsequently the islanding detection indices (transient index value and positive sequence superimposed current phase angle)are computed and the algorithm is verified for islanding and no-islanding conditions.The grid is operating at 400 V, 50 Hz. The converters are connected to grid through line impedance and isolation transformer at PCC. A microgrid management system controls the operation of the infrastructure to run according to certain strategy, physically connects/disconnects the elements, and changes the microgrid topology, by means of a switching cabinet.

1.3 Methodology

To distinguish islanding and non-islanding scenario two criterions are utilized.

1. Peak of transient index value (TIV), which is computed from measured three phase voltages, and
2. Positive sequence superimposed current angle (PSSC) determined from three phase currents injected at PCC.

Fig. 1. Schematic of experimental test set

TIV identifies the events which causes severe transients in the microgrid leading to islanding and PSSC angle is used to confirm the presence of islanding. Islanding is detected when magnitude of TIV exceeds the threshold and PSSC angle is positive. Different islanding and non-islanding scenarios are performed to observe its effect on IsDHDG: (1) capacitor switching event (non-islanding scenario), (2) Islanding event with low power mismatch.

1.4 Motivation

Recently, the penetration of distributed energy resources has increased significantly due to consumer demand for higher reliable electricity, reduced transmission and distribution line losses and environmental issues. However, the incorporation of DG creates technical problems which includes frequency stabilization, voltage stabilization, intermittency of the renewable resources, and power quality issues. The formation of the microgrid (MG), which is cause by the disconnection from the main grid without stopping the energy generation from the DG sources, can also be considered as a drawback of DG.The disconnection of the main source is called islanding, which can be either intentional or unintentional. Unintentional islanding gives rise to major issues which includes: 1) maintenance of voltage and frequency within standard acceptable limits, 2) hazard to line worker security by DG units feeding the loads, and 3) out of phase reclosure of DG unit as a result of instantaneous reclosing. Hence in IEEE 1547–2003 standard, it is recommended to isolate all the DG units from the main grid as soon as islanding condition occurs and disconnection is persisting till the normal grid supply is restored so as to give protection to the generators and loads connected to the system. The motivation of the research stands on the observation of dynamic behaviour and transients of a distribution subsystem with multiple distributed energy resources to pre-planned and/or accidental switching events. The switching events may lead to islanding of the subsystem and formation of an autonomous microgrid. After disconnection from the main grid, micro-grid experiences transients. The severity of the transients is highly dependent on (i) the pre islanding operating conditions, (ii) the type of the event that initiates islanding, and (iii) the type of the DG units within the microgrid. In this work, the islanding condition is detected by investigating the transient events and defining two new criterions i.e. TIV at DG terminal and positive sequence superimposed impedance angle (PSSC) at PCC.

2. **MAIN ACHIEVEMENTS** (results, conclusions, lessons learned)

2.1 Results

The main goal is the offline validation of IsDHDG for fast and accurate detection of islanding condition utilizing real-time signals obtained from OPAL-RT as depicted in Fig. 2. For that, we have created different test cases and few of the test cases are described below.

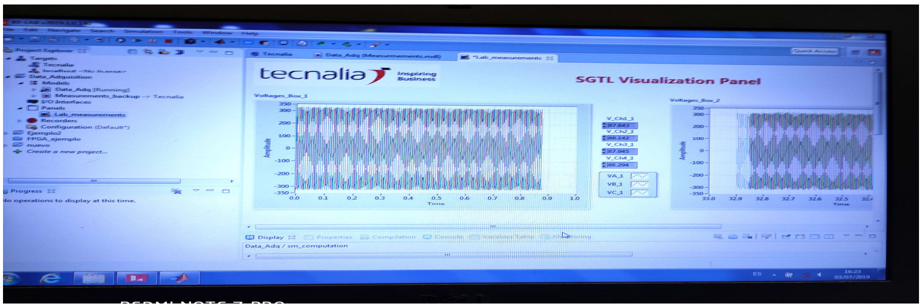

Fig. 2. Real time monitoring of voltage and current signals at DG and PCC end using real time simulator OPAL-RT.

<u>*Case 1*</u>: Non-islanding event (capacitor switching): To create this scenario, the power flow through the tie line, connected in between grid and PCC, is fixed at 4 kW and the power delivered by each converter is maintained to 8 kW. The total load connected in the system is 20 kW and 25 kVAr. Further, to improve the power factor in the system, a 20 kVAr capacitor is switched ON and the signals at DG and PCC end are stored.

<u>*Case 2*</u>: In this scenario, an islanding event is created with approximately 12% active power mismatch. First, the power delivered by each converter is set to 8 kW and the tie line power flow is fixed at 2 kW. The total load connected to the system is 18 kW. Next, the switch connected in between grid and PCC is opened to create an islanding condition. The delivered power and

frequency are monitored and the real time plots are depicted in Fig. 3 during islanding condition.

Further, the measured signals at both DG and PCC end are plotted by utilizing the real time saved data in .mat files. The voltage signals plotted offline during islanding condition are shown in Fig. 4. The islanding detection index i.e. TIV and PSSC is depicted in Fig. 5. From Fig. 5(a) it is noted that, the magnitude of TIV is much higher during islanding condition than during capacitor switching event (non-islanding scenario). Also, the variation in PSSC angle (Fig. 5(b)) is positive during islanding and negative during non-islanding scenario. Hence, discriminating both the events accurately and reliably.

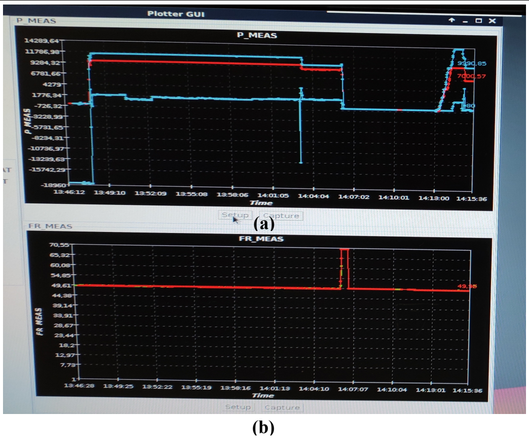

Fig. 3. Real time monitoring of (a) Active power supplied by converter-1, converter-2 and grid (b) frequency at PCC.

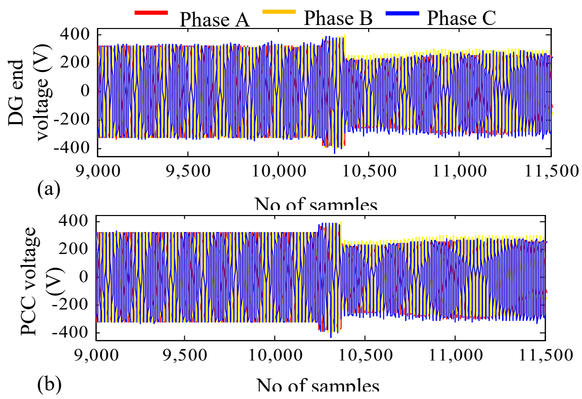

Fig. 4. (a) DG end voltage signal (b) PCC end voltage signal during islanding condition.

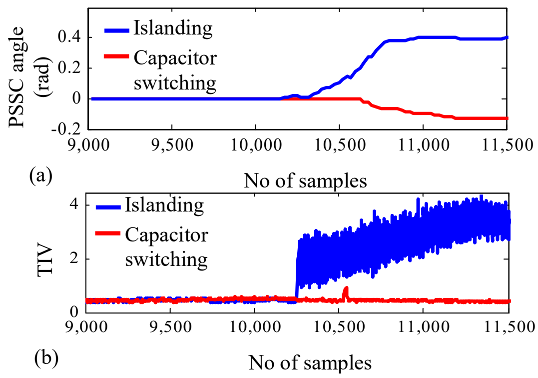

Fig. 5. Response of technique during islanding and non-islanding scenario (a) TIV (b)PSSC.

2.2 Conclusions

- IsDHDG is effective and accurate in discriminating the islanding and non islanding events.
- With the proposed approach, the non-detection zone had reduced and hence the reliability of the operation was assured.
- Because of faster detection capacity (less than one cycle) and simple computational procedure, more reliable and secured way to detect islanding phenomenon is possible in the digital platform using the proposed integrated technique.

3. PLANNED DISSEMINATION OF RESULTS (journals, conferences, others)

Results will be published in the form of journals with the collaboration of user group members, including the project manager and his team mates.

4. PLANNED DISSEMINATION OF RESULTS THROUGH ERIGRID CHANNELS

Contact erigrid-ta@list.ait.ac.at to organise promotion of your results

By the technical report and ERIGrid website.