Islanding Detection Scheme for Grid-Connected PV System Using AI Technique

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Abstract.

In recent days, the solar photovoltaic (PV) system is one of the utmost renewable energy systems in the existing power system which will improve grid dependability. There is an adverse effect on the PV system on the grid, when the main grid power supply to the local/remote loads is interrupted and then there is a percentage of the load is supplied through the PV system. This paper presents the detection of the islanding state using the DWT-ANN approach. The voltage signals and current signals at the point of common coupling (PCC) bus and load bus are considered to detect the condition. Simulation study has been performed using MATLAB / Simulink software, and the results indicate that the proposed DWT – ANN based scheme is reliable.

Keywords. Photo Voltaic (PV) System, Artificial Neural Network Method (ANN), Islanding detection.

1. INTRODUCTION

Distributed generation (DG) connections such as solar plants, wind turbines, fuel cells, etc., to a system that has greatly increased the demand for clean energy is increasingly found. A few problems arose before the DG became part of the most important grid [1].

The unintentional discovery of an island in a connected DG grid is one of the biggest challenges that event events can be relied upon. It explained, "A situation in which a specific component system includes both distributed power resources (DER), and loads that remain dynamic while separated from the rest of the system in use" [2]. Unexpectedly, existing on the islanding causes serious problems, including:

- Maintenance of power and frequency range within acceptable limits of normal standards,
- Supplying loads in DG units will create threats on the line of personnel safety, as well,

- DG unit reset is out of phase which results in immediate reset. Therefore, in the most important energy system to find the occurrence of an islanding.

The means of finding an island are broadly divided into 2 types namely remote islanding scheme and local islanding scheme. Additionally local methods, distinguishing between active and passive: Passive routes have a lot of uninspected territory (NDZ) and depend on the unfavourable situation to identify the island. Effective methods have low NDZ [3], apart from that it causes addition of harmonics.

2. POWER SYSTEM EXPLANATION

This proposed scheme, must classify or discriminate islanding conditions with non-islanding conditions in order to obtain reliable islanding conditions. Non-island conditions such as faults [1] etc.

It has been recorded the desired three-phase voltages and currents on the grid bus and PV bus distinctively each/every simulation event. Generated for each case a data set of 50 cases each and a total of 200 cases of data set from PV bus and also at grid bus under fault condition, and islanding condition separately. These 200 cases of dataset have been processed through lowpass filter to reduce the noise from electrical signals, and are Extracted feature by DWT. Input dataset has been trained with corresponding targets using DWT-ANN modules. So, then the DWT-ANN modules have been designed based on Levenberg-Marquardt (LM) algorithm to reduce learning error.

3. FAULT DETECTION SCHEME FOR GRID-TIED PV SYSTEM

There is different type of faults like LG, LLG, LLLG, LLL, open-circuit etc. Assumed LG's fault for this proposed approach to discriminate faults and islanding conditions. To produce 50 sets of data by changing the fault inception time and by varying islanding situations in the power system network. For each and every case such as islanding situation or/and fault situation, measured voltage and current signals at the PV bus and grid bus. Fig.1. shows the voltage and current signals on the grid bus (B120) and Fig.2. shows current voltages and signals on PV bus (B25) at fault condition at 1.25 seconds respectively.

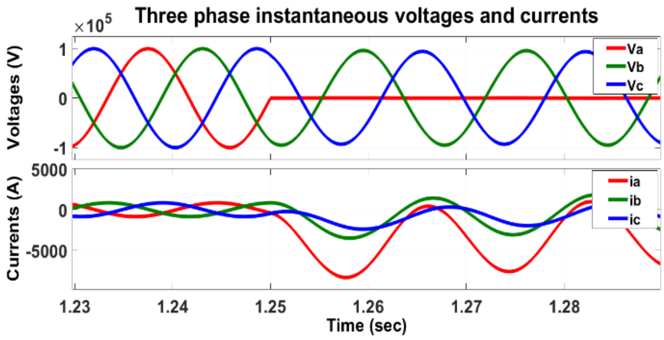


Fig.1. 3-phase signals at fault inception time-1.25sec at Grid bus (B120): (a). voltage waveform (b). current waveform

The LG fault has been applied between phase A and the ground which is the reason why the phase A power becomes zero and the current phase A raises its peak to at the grid bus after the fault shown in Fig. 1. In the PV bus, the three-phase voltage and current signals are replaced by the amplitude of the voltage signals decreases and the magnitude of the current signals increases as shown in Fig.2.

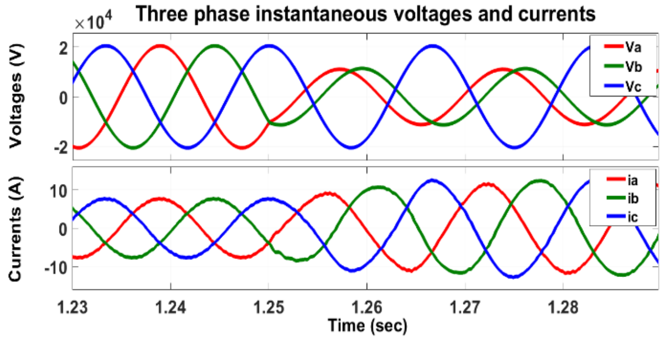


Fig.2. 3-phase signals at fault inception time-1.25sec at PV bus (B25): a) voltage waveform b) current waveform

4. Islanding Detection Scheme for Grid-Connected Solar PV System

There are different methods to identify an islanding condition in which is an effective and passive method [4]. Functional methods are Sandia frequency shift [5], Active slip frequency [6], Active Frequency Drift [7-8], DG voltage variation [9], and a mixed analysis method with current d injection -axis [10]. The passive islanding method is proposed in [11]. In this proposed scheme a grid side power turned off in the system using a circuit breaker, and produced 50 cases of dataset by changing the switching times of the circuit breaker. For each/every islanding case, measured the electrical voltage and current signals at the PV bus and grid bus. Fig.3. shows the voltage and current signals on the grid bus (B120), and Fig.4. shows the electric current and current signals on the PV (B25) bus during the island's first 1.25 seconds consecutive.

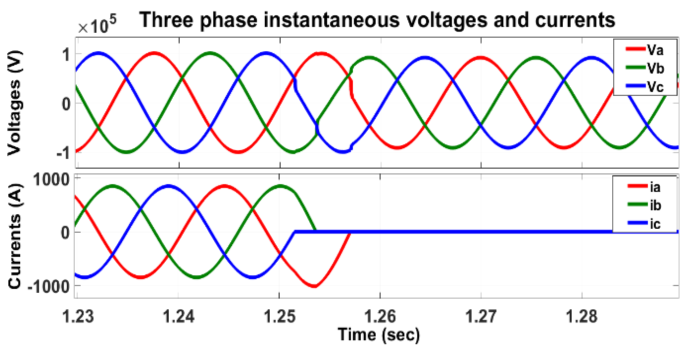


Fig.3. 3-phase signals at islanding situation with inception time -1.25sec at Grid bus (B120): a) voltage waveform b) current waveform

The grid disconnection to the PV system has been done by using the circuit breaker and noticed that the magnitude of the three-phase voltage signals decreased and the current three-phase signals became zero on the grid bus respectively shown in Fig.3. In the PV bus, the three voltage and current signals are altered as shown in Fig.4.

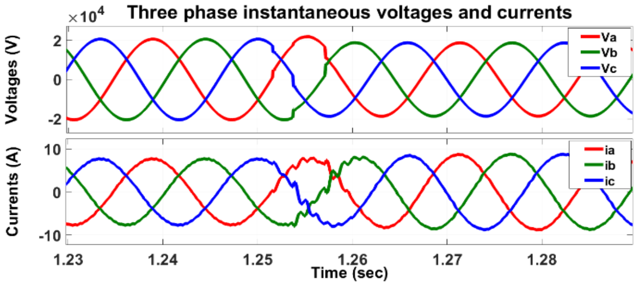


Fig.4. 3-phase signals at islanding situation with inception time-1.25sec at PV bus (B25): (a) voltage waveform (b) current waveform

5. PROPOSE DWT-ANN SCHEME

This proposed model consists of a DG (PV system), grid and conventional loads are connected with different type of loads in the power system network. Fig.5. shows a grid-connected SPV system block diagram where voltage/current signals are recorded at PCC. If any alteration or disruption occurs, and then it has been detected by the DWT-ANN module. Then, it should detect the islanding situation, and issues a trip signal to the circuit breaker to avoid damage caused by disturbance in the PV system and local loads.

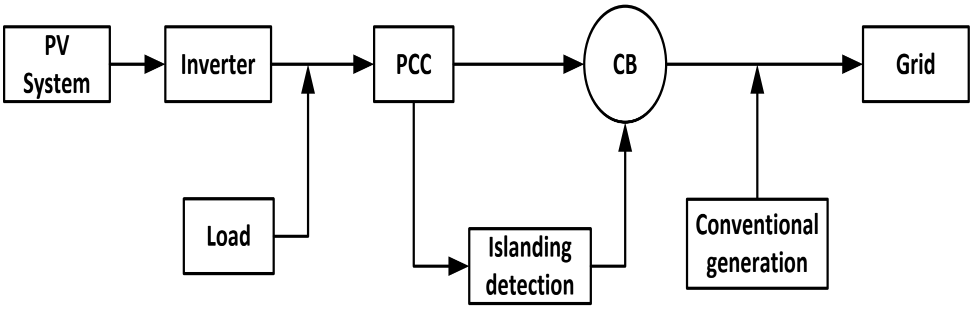


Fig.5. Block diagram of Grid-connected SPV system

6. DWT-ANN FOR THE GRID-CONNECTED SOLAR PV SYSTEM

The DWT-ANN has been trained using the feedforward network with Levenberg – Marquardt (LM) [12] with the input data set consisting of 200 cases. This dataset is also processed thereby considering a 2-cycle data window in which 1-cycle samples of the pre-fault and/or pre-islanding, and additionally 1-cycle samples of the post-fault and/or post-islanding situations. However, the standard deviation [13-14] of 2-cycle data window of three-phase voltage/current signals, at grid bus and PV bus for fault, and islanding situations of power system network have been taken as an input to train DWT-ANN module, and also considered the target vector '0' for fault scenario, and '1' for the islanding scenario during the training, testing, and validation cases with training of 70%, testing and validation of 15% of dataset considered respectively.

Fig.6. demonstrates the flow diagram of the proposed DWT-ANN approach. Total cases of 200 simulated and three voltages/current signals are recorded, and further, it is processed with the help of lowpass filter to eliminate the noise in the signals. Then after voltage/current signals have been pre-processed using DWT to extract features. An input dataset used to train/test DWT-ANN to detect the islanding condition. Numerous constraints have been used to produce input datasets for training/testing as reported in Table.1. The constraints particularly inception time, type of fault and islanding scheme, number of cases for islanding, and fault at the grid bus and PV bus are used for the training and testing of DWT-ANN modules.

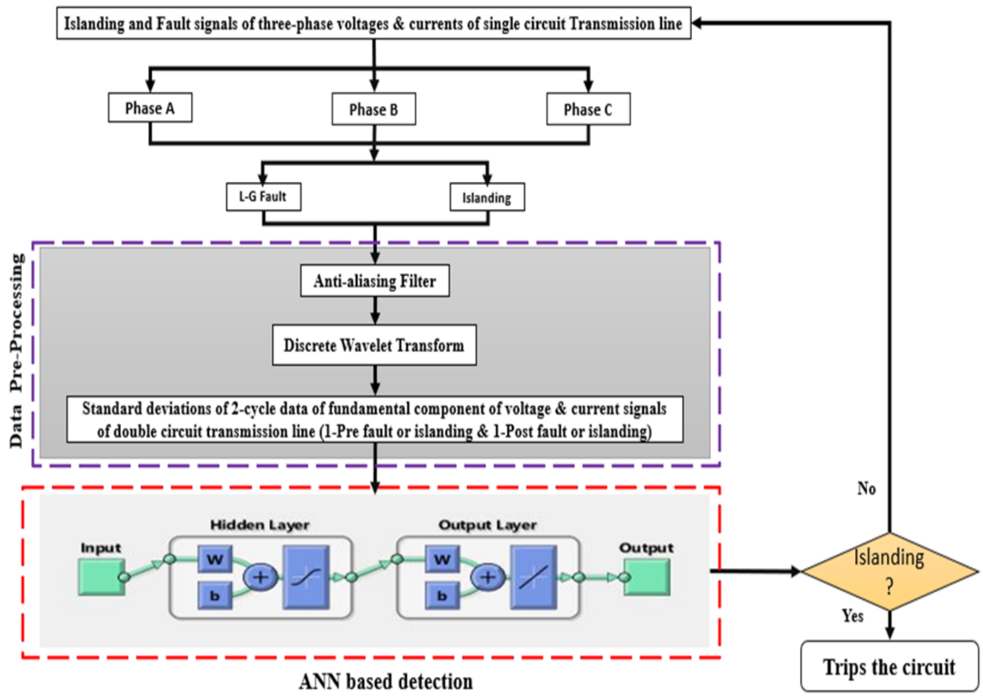


Fig.6. Flowchart of the Proposed ANN model

7. SIMULATION RESULTS

Subsequently designed the proposed DWT-ANN modules using the Levenberg – Marquardt (LM) algorithm in MATLAB software. Fig.7. shows a Simulink diagram of the PV system connected to the Grid.

The MATLAB code is used to train DWT-ANN which continues to use parameters such as performance goal, validation checks, number of neurons, number of layers in hidden layer, number of epochs (iterations) [15]. The training constraints which are reported to train the DWT-ANN network and recorded the (mean square error) MSE minimum. Performance of DWT-ANN module exhibits good response for the islanding detection.

For DWT-ANN module having one layer with 6 neurons, one outer layer with 6 neurons and one hidden layer with a different number of neurons that has provided to the feed-forward network at different situations. The DWT-ANN Feed-forward network has trained in the various architectures shown in Table.2 and its performance during training/testing with Epochs and MSE are illustrated in Fig.7.

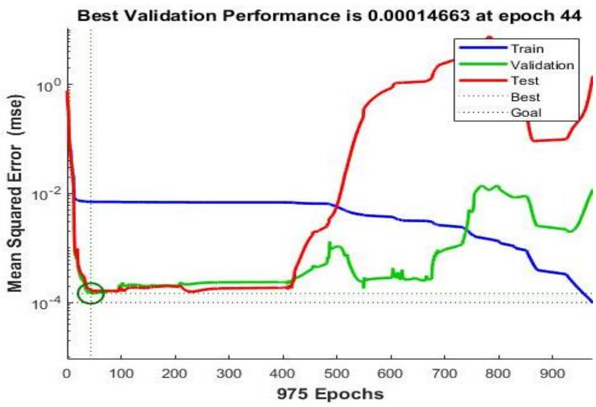
From the performance graphs, can yield the best case by considering at training/testing and validation, where case 2 is the best possible one because of its 3 training patterns (i.e., training, testing and validation) that justifies the detection of islanding situations properly.

Table.1 Fault & islanding situations considered to produce the datasets for training & testing

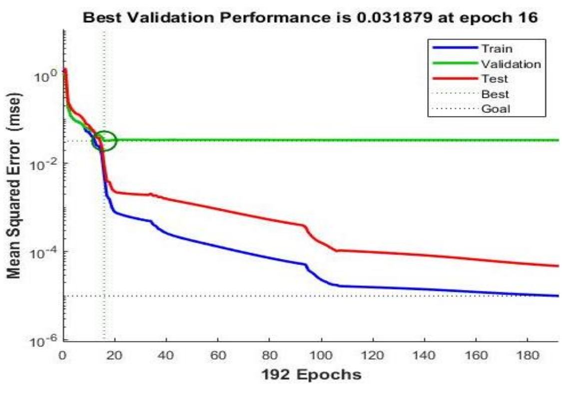
S. No	Condition	Parameters	Training & Testing data
1	Fault	Fault type	AG
		Fault resistance	0.001
		Fault inception time	0.9-1.88 (in steps of 0.02)
		Voltage and Current signals recorded	At PV bus & Grid bus
		Total no. of cases	Training cases =70, Testing cases =30, Total no. of cases = 100
2	Islanding	Islanding type	Passive
		Islanding resistance	0.01
		Islanding inception time	0.9-1.88 (in steps of 0.02)
		Voltage and Current signals recorded	At PV bus & Grid bus
		Total no. of cases	Training cases =70, Testing cases =30, Total no. of cases = 100

Table.2. Training architecture of different cases of Feed forward ANN

Cases	1	2	3	4
Size of Input Dataset	6×200	6×200	6×200	6×200
Size of Architecture	6-15-6	6-20-6	6-25-6	6-30-6
No. of Epochs	975	192	446	391
Performance Goal	9.85e-5	9.98e-6	0.00199	0.00496
Training time(sec)	24	4	19	16
Mutation	2e-7	1e-5	5e-6	0.0001
Validation Checks	931	176	275	319



(a)



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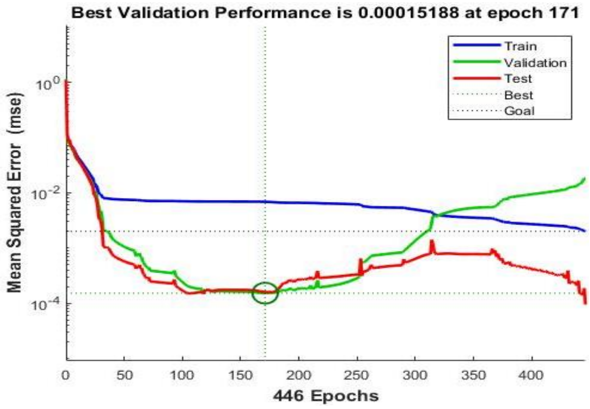
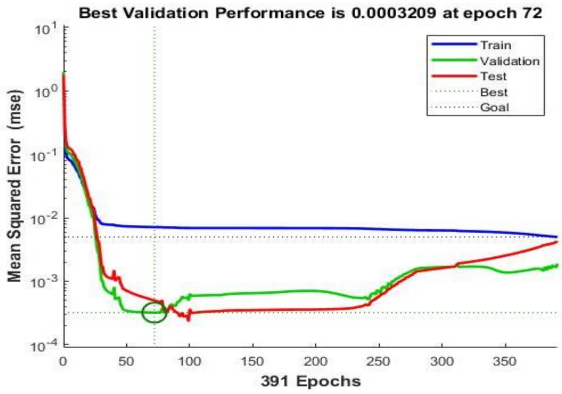


(c)



(d)

Fig.7. Performance Validation curves during ANN between Epochs and MSE (a) case 1 (b) case 2 (c) case 3 (d) case 4

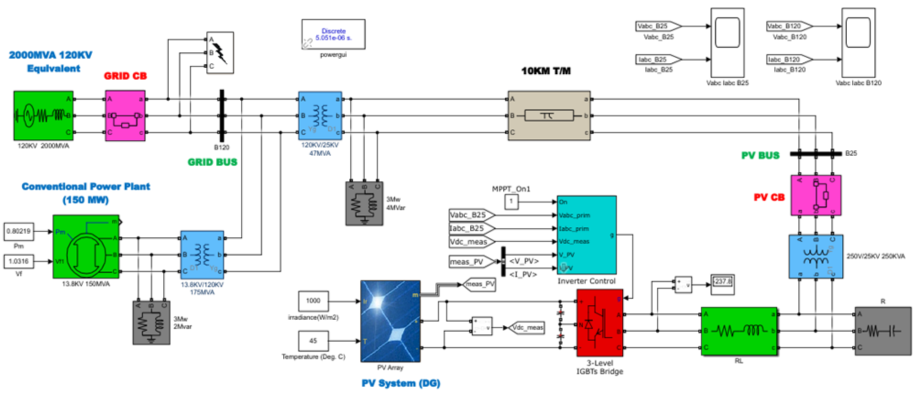


Fig.8. MATLAB Simulink diagram of Grid-Tied PV System

8. CONCLUSION

In this paper, proposed a DWT-ANN based islanding detection scheme by considering its current three-phase signals. The main purpose of DWT-ANN is that trained topology can be used in an effort to improve the performance and speed of the island detection system. To get the MSE is small, and the minimum MSE case should be given an additional process to get the system to get an accurate and quick response to finding an island situation reliably.

9. REFERENCES

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