# Detection of Islanding and Power Quality Disturbance in Micro Grid Connected Distributed Generation

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***Abstract*** **- Micro grid (MG) is becoming a very good substitution for traditional grid. It is capable of supply DC or AC power with the help of hybrid distributed generator. These are capable maintain good power quality (PQ) and reliable supply with full control over voltage and current. MG could optimize capital resource by reducing maintenances and operating cost. This reduces loss and generation cost and increases efficiency of the power system. MG works in standalone mode and interconnected mode. In standalone mode it operated without any grid connection but in interconnected mode it is coupled with main grid. In case interconnected mode when it operate alone due to grid failure, it is called islanding. It results number of power quality issues and human safety concern. Large variation in frequency, voltage, current and harmonic distortion some time become very harmful for utility and inverter .Non detection zone (NDZ) is a very dangerous condition during islanding. So it is necessary to detect islanding as fast as possible and disconnect the DG from the system. Many different methods have been proposed to detect island previously. In this paper discrete wavelet transform technique (DWT) is used for detection of island and various power quality problem.**

***Keywords- Distributed generation, micro-grid, Hybrid distribution generation system, discrete wavelet transform Power quality.***

## I. INTRODUCTION

Land allocation and environment clearance are the main challenge for installing a power plant, transmission and distribution lines. Micro-grid (MG) is becoming a good alternative to the above problems, as it mainly depends upon renewable sources. Advantage of a renewable source is that, power can be generated at the load site which eliminates huge power losses and increase total power generation at low generation [4]. MG playing a key role in maintaining power quality (PQ) and reliable power supply. When connected with main grid, it introduced issues [8] that should be taken care during the when designing MG. Transient is a very harm full for power quality, for this it should be detected and classified as first as possible. Modern technology in electronic devices and advancement in renewable resources is clearing the path for MG. A MG can be work in grid connected mode and as well as island mode. It can supply power to customer as per their demand through a continuous communication with a micro-grid. Hybrid system (HS) [12] of renewable sources make sure reliable power supply and maintain (PQ) irrespective of environment condition in a MG. But there are number of challenges with integration of MG with main grid, such as PQ disturbances like voltage swell and sag and islanding of renewable source. Some time Island condition become very dangerous for local load, inverters and other power system equipment. Especially a condition called Non Detection Zone (NDZ) [3] [15] during island is very dangerous for the MG, DG and utility connected to them. There should be proper methods to detect it just after an island occur.

IEEE Std. 929-2000, states that an islanding is a situation when a part of the utility containing both the DG setup and utility continue to operate while other part is electrically disconnected from the main grid supply . According to nature there are two category of islanding condition: (1) intentional islanding and, (2) unintentional island. In maintenances of power network, optimal use of DG, enhance the power quality (PQ) and maintaining reliable supply intentional island is needed. But in the other hand unintentional island occurs when there is a fault in the main grid side. Second type of island some time result dangerous consequence [5], [6] and [7]. So it is very important to detect it and disconnect the DG from the system before the grid side circuit breaker closed [8], [9]. There are number of consequence of an unintentional island like (a) safety issue, (b) voltage phase shifting, (c) possible damages to utility, (d) damage inverter in DG side, (e) negative impact or malfunction of protective device operation.

According to demand of load connected to DGs of a MG and power supply by the particular DGs there are three conditions possible under unintentional island,

**1)**If the demand of the load is significantly higher than the DG generation, the mechanical input fall behind electrical energy demand resulting in reduction in generator frequency and speed.

**2)** If the demand of the load is less than the DG generation, the DG frequency and speed rise above acceptable range.

**3)** But, if the plant generation matches with the load demand, then there is no change in frequency and speed. This abnormal condition termed as "non detection zone" (NDZ) [3]. Non detection zone (NDZ) plays an important role in fast detection

To detect island there are many method has been proposed .broadly we can divide them in to three main categories, i.e.

(a) Active methods.

(b) Passive methods.

(c) Hybrid methods.

(d) Communication based methods.

Active methods depend upon injecting small signals or disturbance into the line to detect grid failure by observing the signal nature. Different active methods are (1) variation in active power and reactive power (2) frequency jump (3) sandia frequency shift (4) active frequency drifts (5) impedance detection (6) sliding mode frequency shift (7) sandia frequency jump (8) impedance measurement (9) general electric frequency scheme (10) mains monitoring unit etc.

Passive method mainly depends on transient changes of the grid parameters. This information helps in determine grid condition. Different passive methods are (1) under and over voltages (2) under and over frequency (3) current and voltage harmonics detection (4) detection based on state estimation (5) phase jump detection etc.

Active method has a smaller NDZ as compare to passive method. But the continuous injection of signal in to the grid, introduces disturbance in the system at a definite time intervals. It results in very poor quality power. That is why a combination of active and passive method is required for proper and fast detection.

Hybrid technique includes methods like (1) voltage imbalance and positive feedback technique (2) voltage and reactive power shift etc. Communication method has least effect on power quality and with small period of NDZ. But the installation cost of this method is very high then other two.

The IEEE Standard 1459–2000 [10] provides some clear dentitions for the power components by extending the established sinusoidal concepts to no sinusoidal situations. But reformulation of power definition [11] helps us in calculating the approximation and detail components.

Using DWT, we can reformulate voltage and current RMS value as:

$$V = \sqrt{\frac{1}{T}\sum_{0}^{T} v^2(t)dt} = \sqrt{V_{J0}^2 + \sum_{J \ge J0} V_J^2} \ldots.(1)$$

$$I = \sqrt{\frac{1}{T}\sum_{0}^{T} i^2(t)dt} = \sqrt{I_{j0}^2 + \sum_{j \ge j0} I_j^2} \ldots..(2)$$

Here,$V_{j0}$ and $I_{j0}$ : are the RMS values of the voltage and current of the lowest frequency band j0 , also called approximated voltage ($V_{app}$) and approximated current ($I_{app}$) , respectively.

$V_j$ and $I_j$ : are the sets of RMS values of the voltage and current of each frequency band or wavelet-level higher than or equal to the scaling level j0 , and are called detailed voltage ($V_{det}$) and detailed current ($I_{det}$) , respectively.

$c'_{j0,k}, c_{j0,k}$ **:** Are the Voltage and current discrete wavelet coefficients at the scaling level j0 and Sample k .

$d'_{j,k}, d_{j,k}$ : Are the voltage and current discrete wavelet coefficients at any other level that the scaling level j0 and sample k.

**TOTAL HARMONIC DISTORTION**

$$THD_V = \frac{V_{det}}{V_{app}} = \frac{\sqrt{\sum_{j \ge j0} V_J^2}}{V_{j0}} \ldots..(1)$$

$$THD_I = \frac{I_{det}}{I_{app}} = \frac{\sqrt{\sum_{j \ge j0} I_J^2}}{I_{j0}} \ldots..(2)$$

**ACTIVE POWER:**

The approximation active power is defined as,

$$P_{app} = P_{j0} = \frac{1}{T}\sum_{K} c'_{j0,k} c_{j0,k} \ldots\ldots.(3)$$

The details active power is defined as,

$$P_{\det} = \sum_{j \ge j0} P_j = \frac{1}{T} \sum_{J \ge J0} \sum_{K} d_{j,k}^2 d_{j,k} .....(4)$$

The total active power is defined as

$$P = P_{app} + P_{\det} ........(5)$$

**APPARENT POWER:**

The approximation apparent power canbe defined as,

$$S_{app} = V_{app} I_{app} = V_{j0} I_{j0} ......(6)$$

The details apparent power can be defined as,

$$S_{\det} = V_{\det} I_{\det} = (\sqrt{\sum_{j \ge j0} V_j^2})(\sqrt{\sum_{j \ge j0} I_j^2}) .......(7)$$

The total apparent power is,

$$S^2 = (V1)^2 = S_{app}^2 + D_I^2 + D_v^2 + S_{\det}^2 ......(8)$$

The non-approximation apparent power can be defined as, $S_N^2 = D_I^2 + D_v^2 + S_{\det}^2 ........(9)$

**DISTORTION POWER:**

The current distortion power can be defined as

$$D_I = V_{app} I_{\det} = V_{j0} (\sqrt{\sum_{j \ge j0} I_j^2}) .......(10)$$

The voltage distortion power can be defined as

$$D_v = V_{\det} I_{app} = (\sqrt{\sum_{j \ge j0} V_j^2}) I_{j0} ........(11)$$

## II. MICRO GRID

A micro-grid is a smaller version of energy systemconsisting number of distributed generation. It includes distributed energy sources (solar PV cells, wind turbine, geothermal, small hydro, combined heat and power and waste to energy etc) with storage, demand management through digital communication. In a micro grid some part of load and generation are able to operating in parallel with or without the help of the main power grid. The primary purpose of a micro grid is to make sure of reliable supply in an affordable price in local region (rural or urban).

Like presently used power grid a micro grid have generation system, distribution network and control over voltage, current magnitude and phase and frequency. But the factor which make it superior than a normal electric grid is, it brings the grid and consumer very close to each other so that they communicate freely with each other about power usages and its quality. Its dynamic control over different sources, made it automatically self healing. During grid failure a micro-grid can supply power to it. As it is independent of main grid it never affects grid's integrity.

## III. HYBRID DG SYSTEM

Now a day Renewable energy resources, such as wind energy and solar PV [12],[13] cells are very good alternative to generate power without polluting or affecting the nature and atmosphere. But the main drawback of wind or solar is, wind flow and intensity of sunlight is highly unpredictable and it is greatly changing with disturbance in nature. So it is difficult to get a continuous and reliable supply. To solve this issue engineers are come up with a hybrid system of two different renewable sources. For example a combination of solar PV cell with a wind energy generator. So that in a rainy day solar PV may not work properly but a wind turbine still produce energy in this climate. so using hybrid system is a better option than using a single renewable source. This hybrid system is coupled with main grid to overcome the power shortage in certain area. But unfortunately the coupling of renewable sources with the main grid system makes the power system complex and complicated which creates power quality problem [14] and islanding problem. These problems are very dangerous for entire power system. Figure-1 shows the hybrid renewable sources coupled with main grid system.

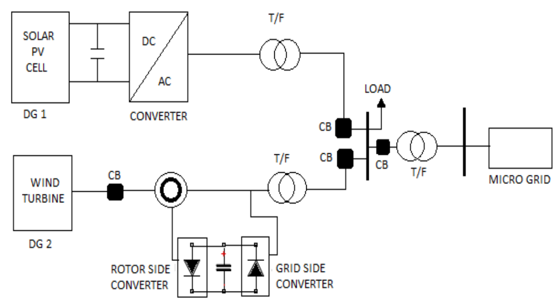


Fig. 1 schematic diagram of a micro grid's DG sources coupled with main grid

## IV. PROPOSED METHODS FOR DETECTION OF PQ DEVIATION AND ISLANDING

This section presents technique that is used in determining the PQ disturbance and island. DWT applications are rapidly increasing in the fields of signal processing. DWT is a fast and efficient means of analyzing signals in both frequency and time domain simultaneously .Because PQ disturbance information most of the time a combination of frequency and time and called stationary signal.

### A. Discrete Wavelet Transform (DWT)

It is a Passive method approach. In this method, the current and voltage signal data from multi meter are used as input parameter to the DWT algorithm and daubechies 10 (dB10) is used as mother wavelet, since it perform very good in determine P and Q as well as issue related islanding. The input signal (S) is break into 2 types of parameter, i.e. Detail (D) and Approximation (A) parameter. The detail is high frequency and low scale signal where as approximation is low frequency and low scale signal. For analyze the high frequency the input signals are allowed to pass through a number of high pass filters, and for low frequency analyze through a number of low pass filters.

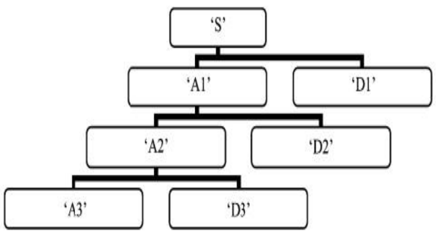


Fig. 2 Discrete wavelet decomposition tree

## 8 BUS SYSTEM UNDER STUDY

The below figure is a representation of the system under study, with a generator meant for a main grid and a generator for DG.

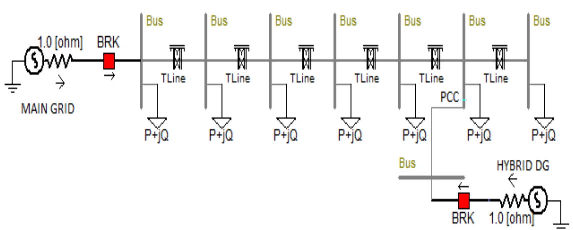


Fig. 3 Distribution system network using PSCAD

I. TABLE Line data

| | |
|---|---|
| Positive Sequence R | 6.76e-8 [pu/m] |
| Positive Sequence L | 9.6e-7 [pu/m] |
| Positive Sequence C | 5.78e5 [pu x m] |
| Zero sequence R | 6.86e-7 [pu/m] |
| Zero sequence L | 2.5e-6 [pu/m] |
| Zero sequence C | 8.14e5 [pu x m |

Table I showing the positive and zero sequence line data of line resistance, inductance and capacitance. Main grid of 300 MVA rating and Distributed generator of 30 MVA rating. Loads are of 100 MVA, 25 MVAR each.

## V. ANALYSIS RESULTS

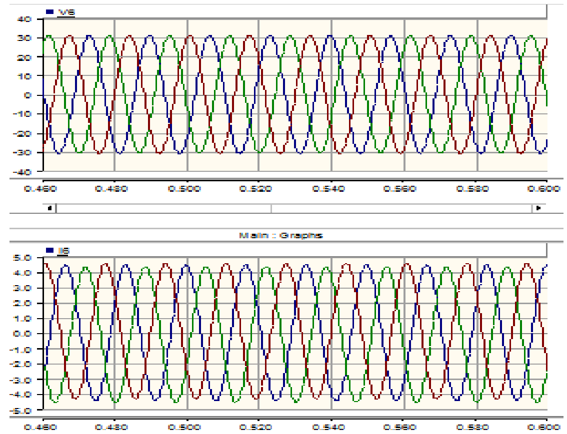


Fig- 4: Normal condition waveform

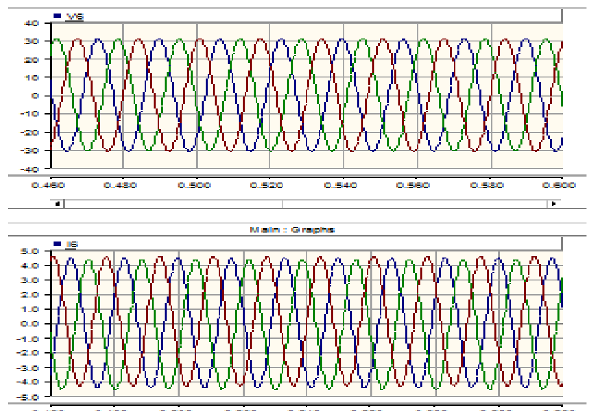


Fig 5: Faulty phase 1-2 of section 1

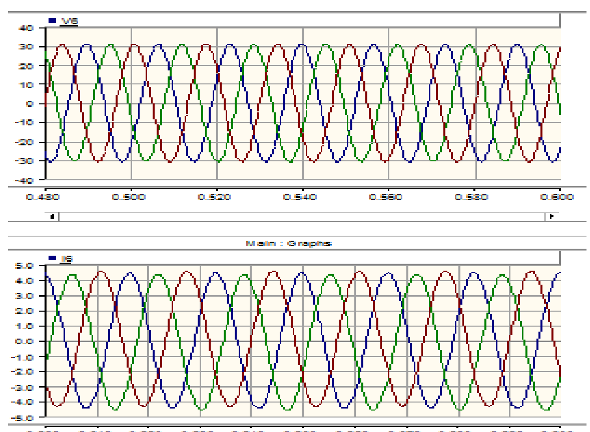


Fig 6: Faulty phase 1-2 of section 2

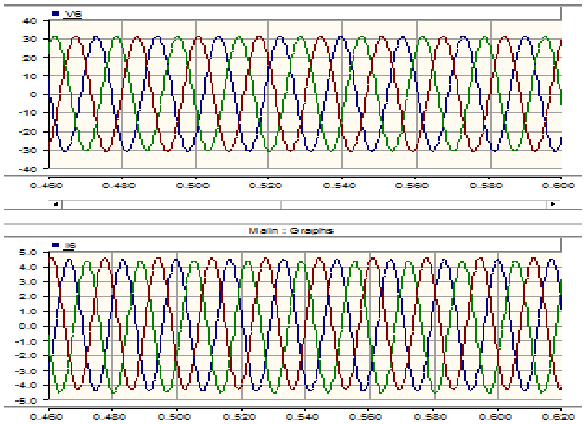

Fig 7: Faulty phase 1-2 of section 3

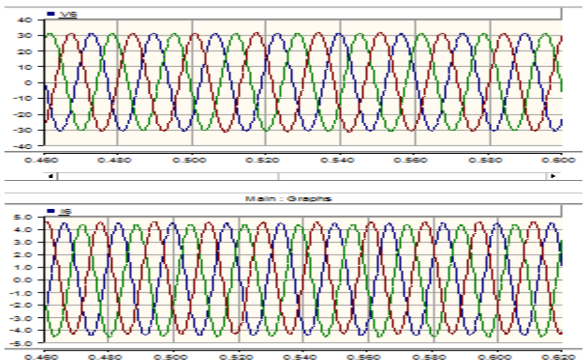

Fig 8: Faulty phase 1-2 of section 4

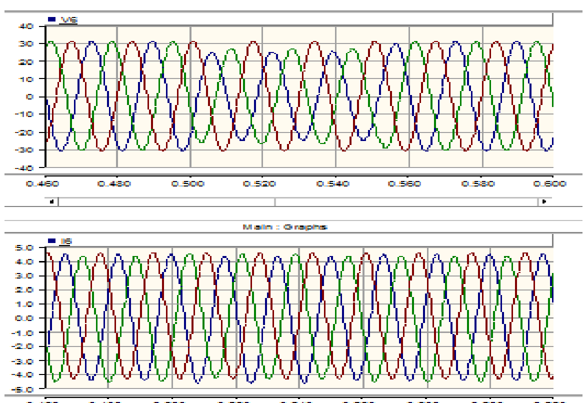

Fig 9 Faulty Phase 1-2 of section 5

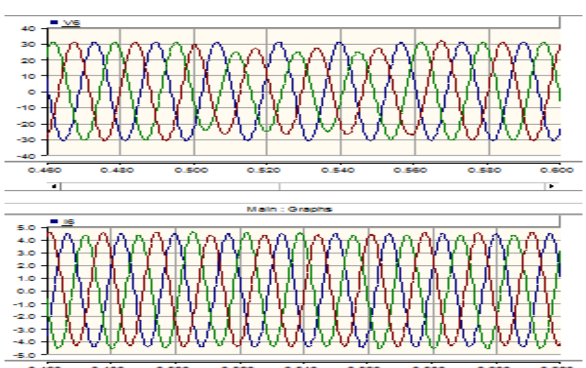

Fig 10 : Faulty phase 1-2 of section 6

We have simulated the fault condition for a phase 1-2 fault (LLG) in different section. All six figures shown above are representing different voltage and current fault situation. It is clearly shown that figure from 5 to 8 has a little change in waveform from figure 1. Whereas figure 9 and 10, has a clear deviation from the normal situation waveform. It is because fault at section 9 and 10 has clear impact on DG section where as all other section fault are not showing any detectable change in the waveform. To detect the fault, we have calculated very sensitive parameter like $D_I$, $D_V$, $THD_I$, $THD_V$ changes . If the graph are not able to show the change then by butting a thresh hold limit to these parameter variation one can easily detect.

Table. II shows different $D_I$ $D_V$, $THD_I$, $THD_V$ for same LLG fault in different section of the transmission line. The value has been calculated from entering the faulty data in a MATLAB program. The output is according to the new redefine formula [10].Then by taking a thresh hold limit for every sensitive parameter we can detect an island situation. Block diagram shown in figure 11 represent steps of complete detection process.

Table. II : Showing variation in different parameter.

| SEC-TION | FAULT LOCA-TION | $D_I$ | $D_V$ | $THD_I$ | $THD_V$ |
|---|---|---|---|---|---|
| NO FAULT | NO | 11.191 | 25.2557 | 0.1455 | 0.3284 |
| 1 | PHASE 1-2 | 9.0479 | 24.8546 | 0.1202 | 0.3301 |
| 2 | PHASE 1-2 | 11.1848 | 25.2541 | 0.1454 | 0.3284 |
| 3 | PHASE 1-2 | 11.1765 | 25.2506 | 0.1454 | 0.3284 |
| 4 | PHASE 1-2 | 11.1883 | 25.2526 | 0.1455 | 0.3283 |
| 5 | PHASE 1-2 | 9.0479 | 24.8546 | 0.1202 | 0.3301 |
| 6 | PHASE 1-2 | 11.2195 | 25.2619 | 0.1458 | 0.3284 |

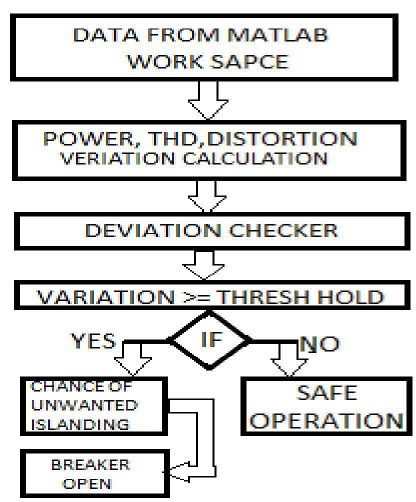


Fig: 11 Block diagram showing detection of unwanted islanding

## CONCLUSION

This paper represents the importance of micro grid and need of hybrid renewable system in present power scenario. At the same time try to resolve issue like PQ disturbance and unwanted islanding detection due to DG and grid tied up. Discrete wavelet analysis technique is used for detection of variation in sensitive parameter like voltage and current THD, voltage and current distortion. A simulation of an 8 bus system is done to verify the situation. By taking a threshold limit one can easily detect variation in different parameter, when waveform unable to show the changes during any fault. Here we have taken a common LLG fault for each section in same phase. This helps in detection of unwanted islanding and PQ disturbance. This method is also very much effective for harmonic content identification in power analysis. As it showing approximate and detail component at different level. One can analyze different number harmonic content by the help of this method. The results from DWT have a better performance and error less analysis in detecting islanding.

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