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Detection of islanding condition in medium voltage network with distributed generations penetration: A review on various techniques

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ABSTRACT

With the increased growth rate of population their demand of electrical power usage in terms of basic necessities to keep their successful life style also increases. To fulfill this requirement distributed generation (DG) play a vital role in the generation of electrical power. Distribution network which usually consist of medium as well as low voltage networks on the basis of research analysis which mainly focus on medium voltage network. The main fundamental objectives in this research work are to support the increased load growth, enhancement of reliable power operation, better quality of power, network prevention from contingencies and line losses in the power system. One of the main issues in this research work is islanding detection, a situation in which a portion of the network is detached from the central main network yet to be energized by the distributed generation. To detect such situation under different load conditions a case study is done in which different techniques are commonly used that uses different relays which are under and over for voltage, current, frequency, vector surge and rate of change frequency (ROCOF). To analyze the performance of these techniques for the non-detective zone (NDZ) and time of operation MATLAB / Simulink software's are used to perform the simulation.

Keywords— *Distributed generation, Rate of change of frequency, Non-detective zone, Islanding detection*

1. INTRODUCTION

A situation called as Islanding occurs in the utility grid either due to disturbance or due to some internal planned switching at the interface or location in the power distribution system where harmonic distortion is to be measured known as Point of Common Coupling (PCC). The small-scale matured technologies generations usually consist of renewable energy resources (RER) referred to as Distributed Generation or Disperse Generation, located locally and the rest of the power system.

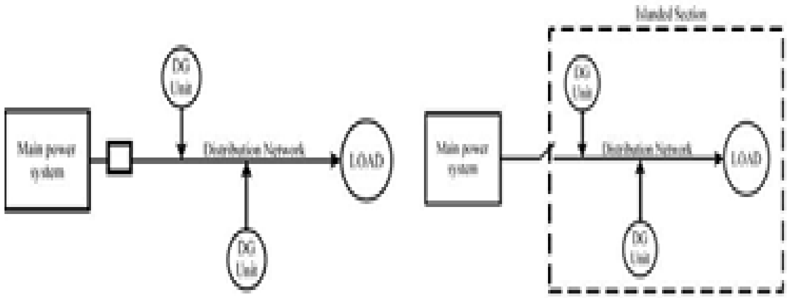


Fig. 1: Islanding Phenomena

2. CENTRAL POWER NETWORK

In Pakistan two specific constant and well-known transmission voltages 220KV and 500KV are used, before coupling with central power network each generating power station is first stepped into any of that specific voltage. Such electrical power system has bulk generation units usually of MVA ratings greater than 100 MVA.

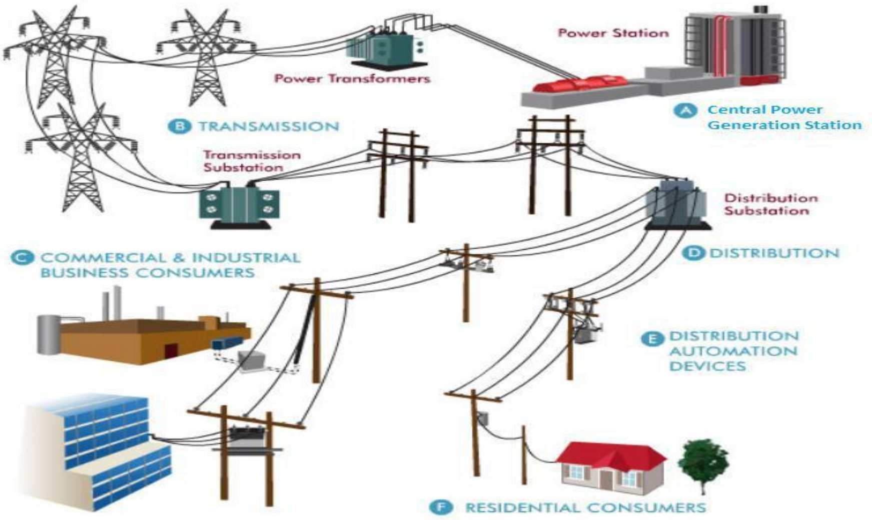


Fig. 2: Centralized Power System

Table 1: Network Switching

Traditional Network	Modern Network
Central power generating networks consisted primarily of coal gas powered that used fossil fuels, nuclear, large solar power plants and hydro power plants that turned high inertia turbines to generate. 1. Electric power 2. Environmental concern (Negatively) 3. Electric power transmitted long distances	Increase electricity demand and globalization of electric power industry having properties 1. Clean 2. Safe 3. More flexible

3. DISTRIBUTED GENERATION SYSTEM

These generators are distributed throughout the power system closer to the loads as shown in figure below.

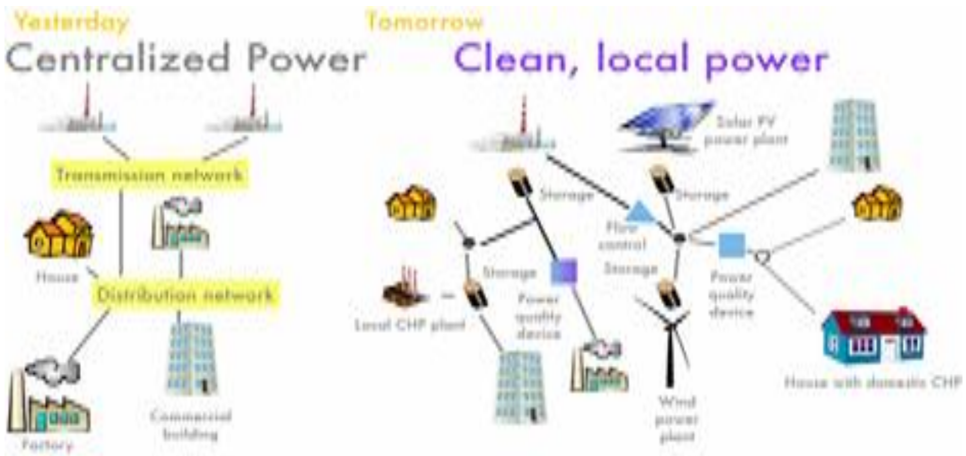


Fig. 3: Past Vs. Future Power Network

Table 2: Renewable Energy Resources

Distributed Generation Approach	
Small scale matured technologies to generate electric power	• Close to end users • Reduce transmission losses • Environmental impacts • Improved security of supply
Renewable Energy Resource (RER)	• Photovoltaic • Wind turbines • Tidal • Fuel cells • Geothermal
Challenges	***Problems***
To fulfill the power demand	• Significant impact on system & equipment • Reliability • Power quality Safety Stability

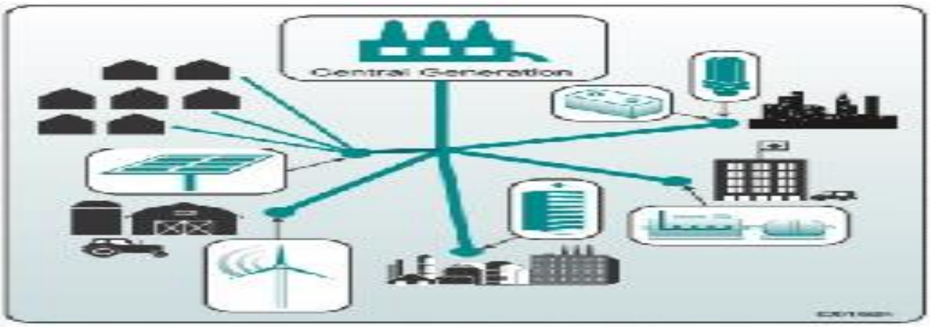


Fig. 4: Distributed Power Generation

4. KEY ISSUE

In the current research project, a problem related to the interference of some unknown operating situations in the power distribution system at Point of Common Coupling (PCC). Distributed Generation and the rest of the main network creates technical issues of electrically isolated part of the network from the utility feeder but will continues to power by the microgrid through DG units, connected to the isolated subsystem as shown in Figure 5. The isolated part has the capability without losing its stability as not allowed according to the Principles which is said to be unintentional islanding in the Distributed Generations unit interconnection.

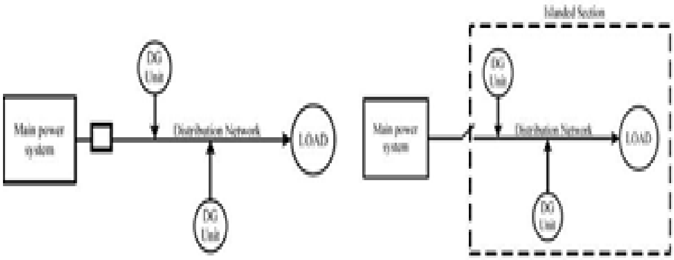


Fig. 5: Islanding Pre and Post Scenario

5. UNPREDICTABLE BEHAVIOURS ISLANDING

If the desire generation fulfill the load requirements hence said to be matched then there is no problem because it is clean, combustion free and environment friendly. To operate the control parameters such as voltage and frequency under rated values for smooth and normal operation of the power system in islanding condition it is vice versa due to its unpredictable and unregulated behavior of the power system.

Table 3: Islanding features and associated issues

Islanding Features	**Issues associated with Islanding**
Network Prevent network contingencies	**Personnel Safety** Line or general public workers safety can be threatened due to islanding because the line yet to be energized by the distributed generation interconnection.
Loads Certain critical loads tripping can be avoided.	**Protected Customers equipment** Variation in frequency and voltage rapidly occur if regulation to limits the control parameters under rated protective relaying properly not provided, may create customer's equipment damage by distributed generation in islanded system.
Fast restoration Once unwanted disturbance cleared Island section to grid connectivity restored fast.	**Synchronization protect systems** When generators not synchronized with systems would damage distributed generators in the islanding at the instant said to be reconnection such out of phase reclosing can inject large current to generators may result in re-tripping in the supply system.
	Transients creativity Out of phase reclosing at peak voltage occurrence will generates severe capacitive switching transient in a light damped system, that are the potential sources to damage utility system and the consumer appliances, the crest over voltage can approach three times rated voltage.
	Interference Islanding process can also affect and interfere to the normal operation on the neighboring customers in the context of system manual or automatic restoration process.
Core research objectives	• Enhancement of Reliable power operation • Small scale matured technologies reduce economical capital cost factor in terms of transmission • Network prevention from contingencies • Line losses in the power system • Better quality of power

6. SCOPE OF STUDY

Overview on the summarize breakup of the Malakand division as a case study project which is rich in natural resources like the two main rivers named as swat and panjkorra. To utilize these rivers government starting small power stations which are Jabban power station, Timergara Warrai power station and Bahrain power station to generate electric power and fulfill the energy crisis demand of the division for smooth and reliable operation.

In Technical perspective a terminology used Single line diagram for the transmission of generated electric power from the main central Power House used here as Tarbela Power House through high voltage transmission lines (T/L) of 220KV to the main Grid Station or Sub Station known as Chakdara Grid Station which feed the load in Swat and Dir while the power stations called as distributed generation are Jabban, Timergara and Bahrain power stations.

Islanding condition occurs when the main Chakdara Grid Station circuit breaker is open and it does not supply any electric power to the islanded section containing Jabban, Timergara Warrai and Bahrain power stations due to faults or forced disconnect, but part of the disconnected loads will still be feed locally through Distributed Generations. To identify the unintentional islanding condition different analysis are carried out using the equivalent circuit of the isolated system as well as the interconnected system with the main utility system through single line diagram. Which is further used in Simulations using MATLAB/Simulink.

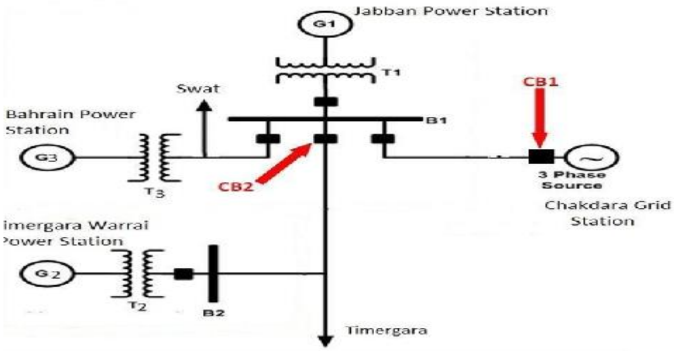
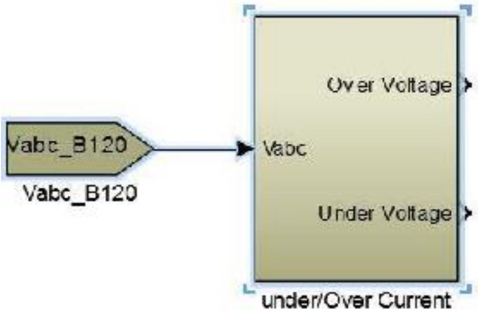


Fig. 6: Single Line Diagram

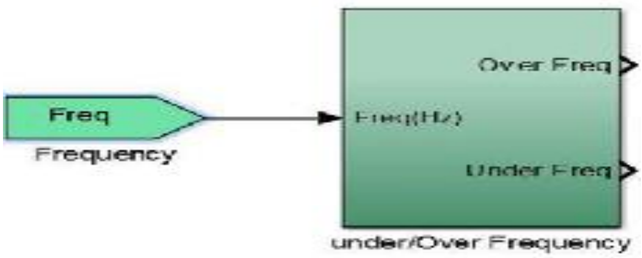
There are numbers of Anti islanding relays some of them are implemented in practice for reliable speed, simplicities and sensitive tripping under fault or abnormal condition by constantly measuring the electrical parameters such as voltage, current and frequency in order to secure the critical loads, devices and personnel while others are still in research level which are to be discussed as:

Under voltage relay due to its inverse characteristics operating time reduces with the reduction in voltage necessary for voltage and reactive power control usually connected to the system through potential transformer(PT) while given protection for AC circuits, bus-bars, motors, rectifiers and transformer set.



Over current relay due to its inverse characteristics connected to system through Current transformer while given protection when current magnitude exceeds the threshold value and responds to phase faults also applicable for motor, transformer, line and utility equipment protection.

Under current relay designed to operate when certain amount of current decreases from its specified limit i.e. in coil whereas used in unloaded condition.



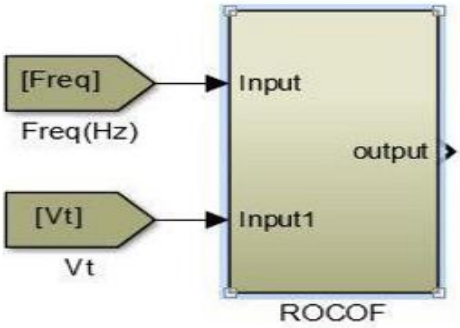
Over frequency relay connected to the system through potential transformer while given protection to AC machines such as power generators in terms of prime mover due to over/under speeding conditions and synchronous motors when the relay isolate the motor from the main network due to outage or unsynchronized connection from possible damage.

Under frequency relay used and protect from severe damaging to shed some part of the load and electrical circuits when the frequency rated in 60Hz reduces to 55Hz and in 50Hz to 46Hz operation.

Vector surge and rate of change of frequency (ROCOF)

Relay due to its property of most sensitive based frequency device known as vector surge or rate of change of frequency relay to detect anti islanding and protect the generator, transformer and alternator due to immediate decoupling in the main parallel operation in case of grid failure usually preferred for the reliable operation so as to maintains the power factor of the system due to inductive loads by the industries.

The Model consist of the above mentioned anti islanding relays and to simulate for evaluation under a preplanned or intentionally islanding condition to determine these relays performance in terms of electrical protection after selecting for the best suitable protective devices with its coordinated system settings for Distributed Generation Systems by the Electrical Protection Engineers.



7. METHODOLOGY

To review the techniques used for detection of islanding condition by continues observation to check and balance the output parameters of the main network with the distributed generation for making the decision of island situation as occur from the parameter's changes. Islanding detection are classified into two main categories.

(a) Remote techniques

(b) Local techniques

Local techniques further divided into the following as shown below in the flow chart.

i. Passive technique

ii. Active technique

iii. Hybrid technique

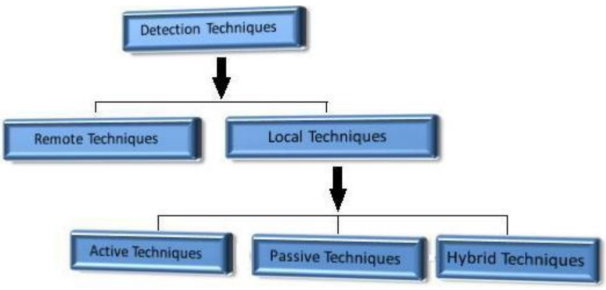
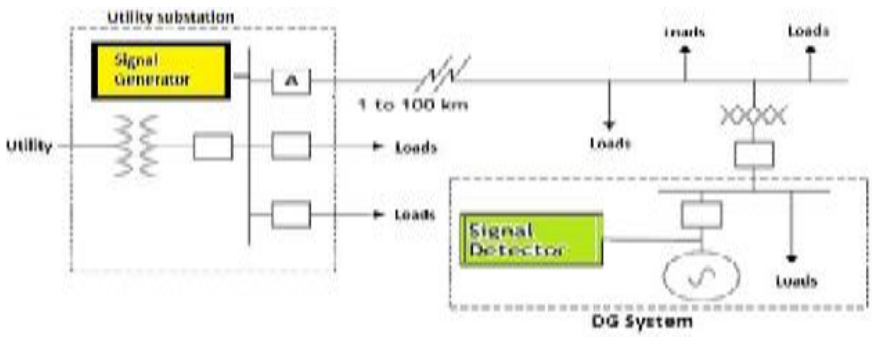


Fig. 7: Islanding Detection Technique

Table 4: Features

1. Environment friendly	Cleaner due to Greenhouse gas emission by using the renewable energy resources like fuel cell, wind turbines and biomass etc.
2. Better quality of power	Investment cost on transmission and distribution reduced
3. Reliability for smooth operation	Prevention from Global warming



Remote Techniques

Fig. 8: PlCC signal generation & detection

8. SIGNAL PRODUCED BY DISCONNECT

To transfer technical data special protocols are used by the technique said to be signal produced by disconnect(SPD) which mainly consist of different communication methods to transform information on communication medium that are to be discussed given below.

Table 5: PLCC main features

<table>
<tr><th colspan="2">Features</th><th colspan="3">Using</th></tr>
<tr><td colspan="2">To Transform Information</td><td colspan="3">1. Using Existing high voltage power lines
2. Over medium & long distances</td></tr>
<tr><td colspan="2">Reliable method</td><td colspan="3">Due to high mechanical strength</td></tr>
<tr><td colspan="2">Communication</td><td colspan="3">Via Signal generator and Signal detector</td></tr>
<tr><td colspan="5">PLCC Application</td></tr>
<tr><td>Telemetry</td><td>Tele-signal</td><td>Tele-control</td><td>Tele-printer</td><td></td></tr>
<tr><td colspan="5">Supervision and Alarm</td></tr>
</table>

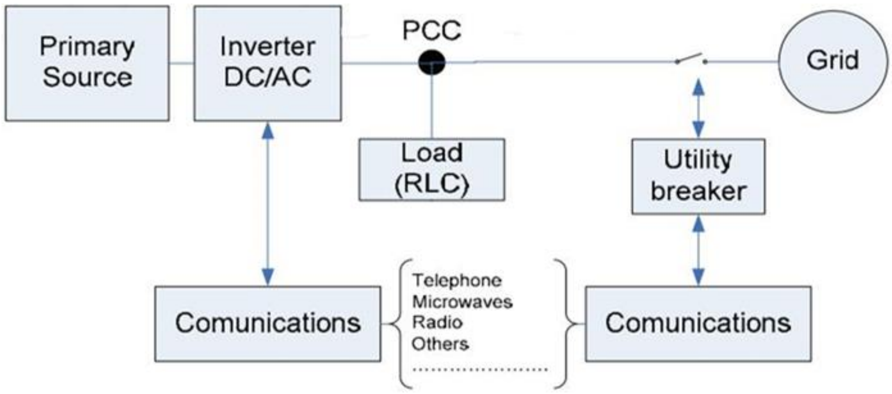


Fig. 9 Communication methods

Table 6: SPD Network Strategies

<table>
<tr><th colspan="3">Signal Produced by Disconnect</th></tr>
<tr><td>To Manage different network strategies</td><td colspan="2">1. In order to avoid inconvenience
2. Under certain unexpected Scenario</td></tr>
<tr><td rowspan="2">Sudden Unforeseen Disconnection</td><td colspan="2">Reason of unexpected Scenario</td></tr>
<tr><td>Signal Strength Drop</td><td>Noise</td></tr>
<tr><td>Slow Connected Session</td><td colspan="2">Slow session maintained in active state</td></tr>
</table>

Table 7: SPD Communication Networks

<table>
<tr><th rowspan="2">Communication Technique</th><th colspan="4">To transform Technical Information</th></tr>
<tr><th colspan="3">Advantages</th><th>Disadvantages</th></tr>
<tr><td rowspan="3">Power line carrier communication</td><td colspan="3">Popular & reliable method</td><td>Transmitter & Receiver cost are high</td></tr>
<tr><td colspan="3">Does not have non detective zone</td><td>Noise introduced in power lines is far more than in case of telephony</td></tr>
<tr><td colspan="3">No separate wires required</td><td>To guard carrier proper care has to be taken</td></tr>
<tr><td></td><td colspan="4">Advantages in terms of transmission</td></tr>
<tr><td>Radio communication</td><td colspan="4">• Use frequency within the electromagnetic spectrum
• Which has range of all possible electromagnetic radiation
• Using 802.11 technology known as wireless networks
• Gamma rays, x-rays, visible light & radio waves
• That move in a perfect medium with a speed of light or free space in unpredictable manner</td></tr>
<tr><td rowspan="2">Microwave communication</td><td colspan="4">Current communication method</td></tr>
<tr><td colspan="4">• Frequency range from 3GHz to 30GHz
• Low operational cost
• Short construction period
• Easy maintenance
• Frequency license required
• Limited transmission capacity
• Transmission quality greatly affected by climate</td></tr>
<tr><td rowspan="6">Transfer Trip Scheme</td><td colspan="4">Approach</td></tr>
<tr><td rowspan="5">To detect Islanding</td><td colspan="3">SCADA System used (Supervisory Control for Data and Acquisition)</td></tr>
<tr><td colspan="3">SCADA</td></tr>
<tr><td colspan="2">Control</td><td>System parameters</td></tr>
<tr><td>Monitor</td><td rowspan="2">Circuit breakers</td><td rowspan="2">Reclosers</td></tr>
<tr><td>Supervise</td></tr>
</table>

	To detect disconnection	**Phenomena at Substation in power network**		
		Whether Island part	**DG Operation**	
			Remain	Dis-continue
	Radial topology	**Limited Numbers of**	• DG • Breakers	
		Continuously	• Supervise • Monitor • Observe	
		Status send	• Through power signaling of each • Monitoring point	

9. LOCAL ISLANDING DETECTION TECHNIQUES

Table 8: Passive techniques

To Detect Islanding Condition Set Threshold Limit			
System Parameters variation measured	***System Interference***	***Draw Backs***	***Methods***
1. Voltage			
2. Frequency	1. Fast	Fail due to small natural effect of Islanding	Large NDZ
3. Harmonic Distortion	2. Don't introduce Disturbance		
Passive Techniques Categorization	**Key Features**	**Key Advantages**	
Rate of Change of Output Power **(ROCOP)**	For the same Rate of Load on DG side		
	Post Scenario of Islanding	**Pre-Scenario of Islanding**	
	Greater	Smaller	
	An Effective Method In Load Mismatching		
	Between		
	Demand	Generation	
Rate of Change of Output Frequency (**ROCOF**)	**1.** i. Highly reliable method ii. To detect Islanding iii. By using relay to monitor waveforms iv. Triggers if certain setting reach threshold		
	2. Algorithm States during the failure as load matches, any condition from the load side changes would unbalance the generation and demand would be followed by the islanding detection and form an islanded condition.		
	3. Mathematical Equation $df/dt = \frac{\Delta P}{2HG} * f$ **ΔP…** represents change in power between generation and capacity at the DG side**, H** shows the moment of Inertia**, G** represent the rated Generation of the DG System		
	4. Moment of Inertia(H) **Rated Generation(G)**		
	Large System	**Small System**	
	High	Low	
Rate of Change of Frequency Over Power **(ROCOFOP)**	Utilize Concept of Power Mismatch		
	Between	DG Local Loads	**To Determine Whether Island has Occur**
	ROCOFOP (df/dp)		
	In small Generation System	In Large Generation System	
	Large	**Small**	
Voltage Unbalance **(VU)**	**Distribution Network**	Usually Consist of Single Phase Load	
	If Change in Load Rate created by DG	**Large**	Islanding occur easily Phase Displacement Voltage Magnitude Frequency Change
		Small	Voltage Unbalance
Harmonic Distortion (**HD**)	**Load Configuration Changes**		

<table>
<tr><td rowspan="8"></td><td colspan="2">Creates</td><td colspan="2">In large Generation System</td></tr>
<tr><td colspan="2">Harmonic Distortion</td><td colspan="2">Small</td></tr>
<tr><td colspan="4">Total Harmonic Distortion (THD) Approach</td></tr>
<tr><td colspan="4">To Detect Condition of Islanding at DG</td></tr>
<tr><td colspan="2" rowspan="2">By Monitoring</td><td colspan="2">THD Terminal Voltage</td></tr>
<tr><td>Before Island</td><td>After Island</td></tr>
<tr><td rowspan="2">Note:</td><td colspan="3">Change in 3rd Harmonic</td></tr>
<tr><td colspan="3">Gives a good pics of when DG is Islanded</td></tr>
<tr><td rowspan="6">Phase Jump Detection
(PJD)</td><td colspan="4">Use Phase Lock Loop Technique (PLL)</td></tr>
<tr><td colspan="4">To Detect Error</td></tr>
<tr><td colspan="2" rowspan="3">As a result of Phase difference B/W</td><td rowspan="2">O/P Current</td><td>Said to be</td></tr>
<tr><td>Feedback Signal</td></tr>
<tr><td>Power Grid Voltage</td><td>Reference I/P Signal</td></tr>
<tr><td colspan="4">PLL used in Communication
For Synchronization of Signals the main feature offered by PJD is its implementation and ease in the design. The voltage phase at the PCC may change with reference to its current during islanding condition.</td></tr>
</table>

10. ACTIVE ISLANDING DETECTION TECHNIQUE

A technique used for detection of islanding condition, which introduces disturbance intentionally at the output of the inverter, is known as Active Detection Techniques.

(a) In active detection techniques that potentially disturbed the output intentionally at the inverter output.
(b) Active method can reduce the NDZ size. However, reduce the grid power quality.

Classification of active Detection Techniques

On the basis of intentional disturbance active islanding detection techniques are classified into the following methods which are given below.

Table 9: Active Islanding Detection Techniques

<table>
<tr><td colspan="9">In these Methods</td></tr>
<tr><td>A. Active Classification</td><td>B. Operation Principle</td><td colspan="3">C. Main Advantage</td><td colspan="2">D. Weak Areas</td><td colspan="2">E. Need Improvement</td></tr>
<tr><td rowspan="11">A. Impedance measurement</td><td rowspan="3">Impedance can be measured</td><td colspan="3">Place Inductive Load</td><td colspan="2">Parallel with</td><td colspan="2">Power source</td></tr>
<tr><td colspan="3" rowspan="2">Due to which</td><td colspan="2">Short circuit current</td><td colspan="2" rowspan="2">Can be Calculated</td></tr>
<tr><td colspan="2">Open circuit voltage</td></tr>
<tr><td rowspan="3">2.Islanding</td><td colspan="7">Can Occur</td></tr>
<tr><td colspan="3" rowspan="2">Under the Perfect Match</td><td colspan="4">Between</td></tr>
<tr><td colspan="2">Generation</td><td colspan="2">Load</td></tr>
<tr><td colspan="8">3. Note:
Which is not possible according to a technique known as passive technique which detect the change occur at the output of the inverter due to the low impedance of electric distribution grid hence disconnect from the system.</td></tr>
<tr><td colspan="8">4. Mathematical Equation:
$$i_{DG-inv} = I_{DG-inv} \sin(\omega_{DG} t + \phi_{DG})$$
Intentional disturbance induces to the inverter output current, IDG-inv, which causes the output voltage to suffer from changes when the grid is disconnected</td></tr>
<tr><td colspan="4">C. It has small</td><td colspan="4">NDZ</td></tr>
<tr><td colspan="4">D. When Number of Inverter increases</td><td colspan="4">Its effect decreases</td></tr>
<tr><td colspan="8">E. Impedance threshold is essential to establish in order to predict when grid is integrated.</td></tr>
<tr><td rowspan="12">B. Harmonic Injection</td><td colspan="8">Impedance Detection Technique</td></tr>
<tr><td rowspan="5">When the Grid is connected</td><td colspan="7">Intentionally injecting</td></tr>
<tr><td rowspan="4">specific Current Harmonic</td><td colspan="6">At the PCC</td></tr>
<tr><td rowspan="3">IF</td><td>Grid Impedance</td><td rowspan="3">Don't Matched</td><td colspan="3">At Harmonic frequency</td></tr>
<tr><td rowspan="2">Load Impedance</td><td rowspan="2">Then</td><td colspan="2">Injected Harmonic Current</td></tr>
<tr><td colspan="2">Will flow into the Grid</td></tr>
<tr><td rowspan="6">After Grid Disconnection</td><td colspan="7">Harmonic Current</td></tr>
<tr><td rowspan="5">Will Flow</td><td colspan="6">Through the Load</td></tr>
<tr><td colspan="2" rowspan="4">Generating</td><td colspan="4">A Specific Harmonic Voltage</td></tr>
<tr><td rowspan="3">Amplitude of harmonic Voltage</td><td colspan="3">Proportional to Load Impedance</td></tr>
<tr><td rowspan="2">At</td><td colspan="2">Frequency of Injected</td></tr>
<tr><td colspan="2">Harmonic Current</td></tr>
</table>

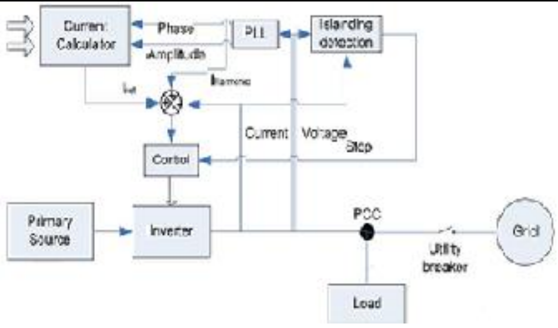
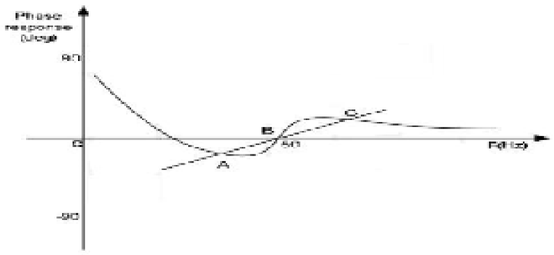
<table>
<tr><td rowspan="5"></td><td colspan="4">Disturbances size that occurs at the voltage level be influenced by the nominal values of the grid impedance.</td></tr>
<tr><td colspan="2">C. Change in 3rd Harmonic</td><td colspan="2">Gives a good pic</td></tr>
<tr><td colspan="2">D. If Sub harmonic signals are injected</td><td colspan="2">Instead of high order harmonics</td></tr>
<tr><td colspan="2">E. Unfortunately, problems are not definitively solved</td><td colspan="2">Unless the amplitude of the injected harmonics is very small</td></tr>
<tr><td colspan="4">

Fig. 10</td></tr>
<tr><td colspan="5">Active Islanding Detection Techniques</td></tr>
<tr><td colspan="5">In these Methods</td></tr>
<tr><td>A. Active Classification</td><td>B. Operation Principle</td><td>C. Main Advantage</td><td>D. Weak Areas</td><td>E. Need Improvement</td></tr>
<tr><td rowspan="6">B. Sliding Mode Frequency Shift(SMS)</td><td colspan="4">1. On the principle of varying frequency of inverter output by controlling the phase of the inverter cure
2. Usually, DG operates with unity power factor
3. In normal operation the inverter output current-voltage phase angle of the inverter, instead to be controlled to be zero
4. Is made to be a function of the frequency of the PCC voltage</td></tr>
<tr><td colspan="4">Response Curve
In inverter, the response curve is design in the region in such a way that with a unity power factor inverter phase enhanced rapidly than load phase such as RLC load close at the grid connection thus creates line frequency for inverter an unstable and abnormal operating point. To stabilize line frequency at the operating point by providing solid phase and reference frequency. However, after the island is formed, the phase-frequency operating point of the load and inverter must be at an intersection on phase response curve.</td></tr>
<tr><td colspan="4">
</td></tr>
<tr><td colspan="4">1. Easy to Implement
2. Shows very effective while operating in parallel connection with multiple inverters
3. Deals acceptable compromise between Islanding Detection
4. Modified form of Phase Locked Loop(PLL)</td></tr>
<tr><td colspan="4">It has relatively small NDZ compared to other methods</td></tr>
<tr><td colspan="4">SMS approach need to compromise on the quality of output power at DG inverter.</td></tr>
<tr><td rowspan="5">Reactive power Export Error</td><td rowspan="3" colspan="2">Reactive power flow generates by DG</td><td colspan="2">At PCC</td></tr>
<tr><td rowspan="2">Between</td><td>Distributed Generation site</td></tr>
<tr><td>Main grid</td></tr>
<tr><td colspan="2">Reactive power flow is Maintained</td><td colspan="2">When the grid is connected</td></tr>
<tr><td colspan="2">If the level of reactive power flow is not maintained</td><td colspan="2">Island is detected</td></tr>
<tr><td rowspan="4">Active Frequency Drift (AFD)</td><td colspan="4">1. Intentionally injecting a current Into the PCC
2. That vary frequency slightly on the output current
3. For the short period of dead or zero time</td></tr>
<tr><td colspan="4">Used to reduce the non-detective zone (NDZ)</td></tr>
<tr><td colspan="4">Phase error appear at PCC between inverter current and voltage as a result of Grid Disconnection</td></tr>
<tr><td colspan="4">1. Phase error detected by inverter can be compensated by enhancing generated current frequency
2.This process continues until the frequency exceeds the limits and is detected by OFP/UFP</td></tr>
<tr><td></td><td colspan="4">Active Islanding Detection Techniques</td></tr>
</table>

<table>
<tr><td></td><td colspan="4">In these Methods</td></tr>
<tr><th>A. Active Classification</th><th>B. Operation Principle</th><th>C. Main Advantage</th><th>D. Weak Areas</th><th>E. Need Improvement</th></tr>
<tr><td rowspan="4">A. Sandia Frequency Shift(SFS)</td><td colspan="2">B. The accelerated version of Active frequency drift</td><td colspan="2">1. With Positive feedback
2. That increases dead time of inverter current
3. Corresponding to increase deviated frequency from nominal</td></tr>
<tr><td colspan="4">C. Most effective method to detect Islanding</td></tr>
<tr><td colspan="4">D. In RLC dependency of phase angle on operating frequency due to which Islanding being not detected</td></tr>
<tr><td colspan="4">E.
1. To get rid of this an Automatic Phase Shift(APS)
2. A modified form of SMS method
3. In this method frequency variation detected by Sandia frequency Shift (SFS) via amplification
4. Due to the frequency variation error produce said to be phase error, hence its value is positive in an iterative method given by;
Mathematical Equation:
$f(n+1) = f(n) + K(f).\Delta f$
f(n+1) is the reference frequency in n+1cycle
fn is the frequency in each cycle
Kf is a constant that allows to accelerate the islanding detection
Δf is the frequency variation in each cycle</td></tr>
<tr><td rowspan="4">A. Sandia Voltage Shift(SVS</td><td colspan="2">B. Similar to technique of Active power variation</td><td colspan="2">1. That uses a close loop or a positive feedback over the voltage at PCC.
2. Values of quantities are measured in r.m.s values.
3. If its values decreases the inverter output would be forces to limits the current or output power.</td></tr>
<tr><td colspan="4">C. 1. Implementation is easy
2. Effective method among the above discuss are through, using a Positive feedback loop.</td></tr>
<tr><td colspan="4">D. Quality of power reduces due to simultaneously disturbing PCC voltage</td></tr>
<tr><td colspan="4">E. 1. In order to safeguard the component at the system.
2. Decrease of the system voltage is preferred as with increase of voltage at PCC.</td></tr>
<tr><td rowspan="4">A. Phase Shift Method</td><td colspan="2">B. Is an Approach with the following features</td><td colspan="2">1. Used by inverter-based DG To Detect Islanding
2. Intentional disturbance induces in the form of phase shift
3. When the DG is grid connected, the frequency will be stabilized
4. When the system is islanded, the small perturbation will result in significant change in frequency</td></tr>
<tr><td colspan="4">C. Used in system when more than one inverter-based Distribution Generation</td></tr>
<tr><td colspan="4">D. Islanding can go undetected If slope of phase load is greater than SMS line.</td></tr>
<tr><td colspan="4">E. The unstable zone encompasses the stable operating point.</td></tr>
</table>

11. HYBRID ISLANDING DETECTION TECHNIQUE

Table 10: Hybrid Islanding Detection Techniques

<table>
<tr><td colspan="5">Hybrid Islanding Detection Techniques</td></tr>
<tr><td rowspan="6">Classification</td><td rowspan="2">a. That Uses</td><td colspan="3">Both</td></tr>
<tr><td>b. Active Technique</td><td>c. Concern</td><td>d. Passive Technique</td></tr>
<tr><td colspan="4">i. Combined techniques</td></tr>
<tr><td colspan="4">ii. As change in system parameters is large
Due to which large non detective zone (NDZ)</td></tr>
<tr><td colspan="4">iii. Has been Raised on
Note: This approach is executed at the condition that the islanding is alleged and assumed by the passive technique.</td></tr>
<tr><td colspan="4">iv. That reduce the large non detective zone (NDZ)
To retain the fixed output power quality</td></tr>
<tr><td rowspan="2">Methods based on Voltage Umbalance (VU) or positive</td><td rowspan="2">To Monitor</td><td>3-phase Voltage</td><td rowspan="2">Positive feedback (PF)</td><td rowspan="2">Voltage imbalance (VU)</td></tr>
<tr><td>To determine voltage unbalance</td></tr>
</table>

feedback (PF)	**Mathematical Equation:** VU= V+Sq V-Sq **Voltage Spikes** V+Sq…. Positive Sequence V-Sq…. Negative Sequence **iii. Voltage Spike Observed** 1. Load Change 2. Islanding 3. Switching Action Voltage Spike | IF | Greater | Than Threshold Value | Island Occur		
Technique based on voltage & Reactive power shift	i. Adaptive Reactive power Shift **(ARPS) Algorithm** Vary Voltage over time to get Co-variance Value **Mathematical Equation:** **Co-variance(Tav',Tv)=E.Tav(n)-UavTv(n)-Uv** **Tav'………Average of previous four voltage periods** **Uav………Maen of Tav'** **Tv………...Voltage periods** **Uv………..Mean of Tv** **Note:** The choice of the islanding detection technique will largely depend on the type of the DG and system **characteristics**	ii. **Reactive Power Shift**	iv. **Voltage**
Wavelet-Based Islanding Detection	**Key Features** 1. Technique used to detect islanding of distributed generation on the basis of hybrid is known as Wavelet-based islanding detection 2. To detect islanding by removing discriminative characteristics from the acquired voltage signals 3. Islanding can be detected from local measurements of PCC voltage and current signals 4. To obtained time localization of islanding condition applied Wavelet analysis 5. Wavelet analysis by proposing time-frequency detection algorithm **Wavelet Transform Classification** **Continuous Wavelet Transform(CWT)** Continuous wavelet transform coefficient shows how the original signal well match with the scaled or translated mother wavelet. **Inverter** i. Injecting suitable reactive power ii.That control active power output of Distributed Generation to reduce power quality problems. **Solved many System Problems** [1] Fault detection [2] Power quality [3] Event localization [4] Preserve both time and frequency by handling non stationary signals [5] Suitable for low-voltage low-power PV systems	**Discrete Wavelet Transform(DWT)** Set of all wavelet coefficient associated with specific signal is the wavelet showing of the signal with respect to mother wavelet i. According to IEEE standard 1547 ii. DG should be provided with an anti-islanding detection algorithm, which could be performed utilizing the inverter interface control.	
Average Rate of voltage Change and Real power Shift	**i. Key Features**	**ii. Real Power Shift (RPS)**	**iv. Average rate of voltage Change (ARVC)**

	1. For efficient island detection under different load scenarios mentioned hybrid is suited. 2. Intentional injected disturbance can be eliminated by this hybrid technique. 3. Real Power Shift (RPS) satisfied the condition for operation of Distributed Generation at unity power factor. 4. Only one DG changes the real power in contrast to positive feedback techniques. 5. Furthermore, islanding can be detected even when the load and the generation closely match.	Initiated RPS due to which distributed generation real power changed	Cannot clearly discriminated between grid connected and islanding condition

12. FUTURE WORK

One of the major key issue of islanding seems to be detected in distributed generation network. Ongoing research work on advanced renewable energy resources shifts the traditional central power network to modern network. Further research work needs to develop reliable islanding detection schemes for fast and proper isolation of distributed generations in large non detective zones (NDZ) that gives unwanted trips.

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