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Analysis of Microgrid

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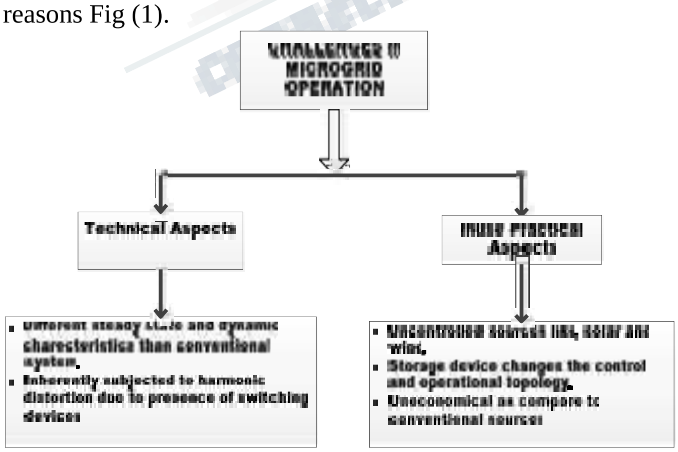
Abstract: **- Solar energy is a green energy and nearly no carbon traces are present. Hence, the growing demand and challenges to meet the electricity requirement even in remote places can be achieved with a solar microgrid. A microgrid when coordinately controlled can be operated both in grid-connected mode and intentional islanding condition. In this paper control scheme for intentional islanding of utility, the microgrid is analyzed. Also, reviews on various strategies to develop HIL for fast and accurate islanding and coordination control are presented. To overcome generation and demand mismatch study of various centralized adaptive load shedding scheme is investigated.**

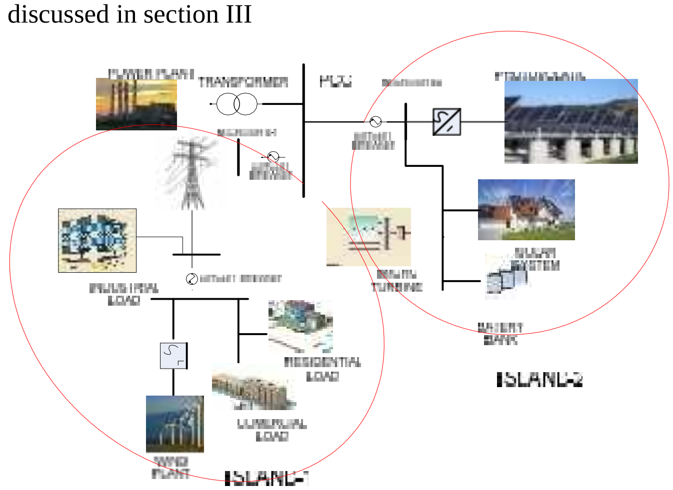
Keywords**— Intentional islanding, Islanding Detection Method (IDM), centralized load shedding scheme, Synchro phasor technology, Distributed Energy Resources (DER), Supervisory-control and data-acquisition (SCADA) system, Wide Area Monitoring, Protection and Control (WAMPC) system.**

I. INTRODUCTION

The yield of electricity from the conventional sources of energy is very convenient as compared to the renewable energy due to the ease of technology. Conventional resources also possess some disadvantages like; scarcity in the availability, high carbon traces, availability far away from the load centers, high transmission cost involve in transportation of produced electricity to the load locations etc. Due to these disadvantages, there has been an increase in penetration of Distributed Energy Resources (DER). All types of DERs can be easily synchronized with the utility grid using high rating power electronic converter, but the operation and control of DER are different from the conventional utility system due to the below mentioned reasons Fig (1).



Though the operation and control of DER is difficult since it require Deployment of new infrastructure and technology, but due to advantages like freely available, green and clean form of energy, and most importantly, it can be operated either autonomous mode or grid connected mode, there is an increase in incorporation of microgrid in the power network as shown in Fig (2). In this paper a short review on performance analysis of utility microgrid when operating in both intentional islanding and grid connected mode is present. In section II, a thorough review on various islanding detection techniques available in literature is presented. When microgrid is operating in islanded condition intelligent load shedding has to be applied, so as to bridge the gap between generation and demand. Various intelligent load shedding techniques to remove mismatch between load and generation in the condition of intentional islanding is discussed in section III



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II. ISLANDING DETECTION TECHNIQUE

A. Islanding in utility grid

When the system is subjected to sever disturbances like faults or abnormal operating conditions, some part of the network gets disconnected but is powered by one or more DERs is called as "islanding" . Islanding can be both "intentional" and "unintentional". Intentional islanding is done to construct a power island to prevent power interruption of some important loads. Undetected islanded MG is generally called "unintentional islanding" . Unintentional Islanded operation of utility grid is always undesired since it is followed by threads to operational security like unorderly service restoration, degradation in power quality, harmonic injection, endangering lives of utility personnel etc, . When islanding is done in a controlled manner, it can improve the reliability of utility grid. Therefore IEEE Standards Coordinating Committee 21 (SCC21) have lay down rules for the development of IEEE P1547, as part of the further development of IEEE 1547-2003 Standard for Interconnecting Distributed Resources with Electric Power Systems . Hence controlled intentional islanding is advisable since it maximizes the benefits from DG. The successful implementation of islanding detection algorithm is the disconnected of the affected region, as soon as islanding is detected. According to IEEE 1547 standard, an efficient islanding detection algorithm is one which detects the islanding condition disconnect it with utility system within 2 s from the disturbance . Islanding detection techniques can be broadly classified as; local and remote techniques .

Local technique rely on monitoring of power system parameters like voltage, rate of change of voltage, frequency, rate of change of frequency. Remote methods depend upon communication between DGs and power grid. Local methods are further sub-divided into active, passive and hybrid technique. Various communication based methods are intertriping, PLCC based, SCADA based etc. A comprehensive literature on all these methods is present in .The following figure explains in short about above mentioned islanding detection methods advantages and disadvantages. Fig (3)

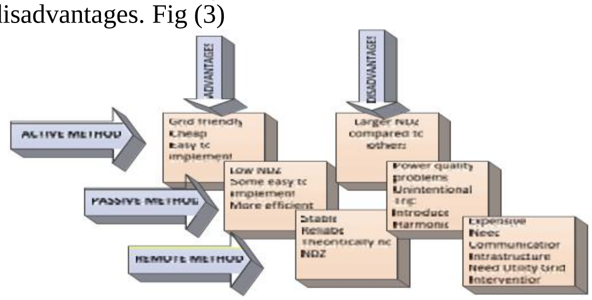

Fig (3) Islanding detection methods; advantages and disadvantages

In constant current control mode also termed as grid connected mode, incessant current for the set value of power is supplied by the inverter. In constant voltage control mode also termed as islanded mode of operation, output of the inverter is incessant voltage for the set value of frequency. The transition between grid connected and islanded mode is performed by islanding detection algorithm. In literature numerous paper are there who discusses about islanding detection methods for inverter based microgrid systems . With the advent of development in smart grid technology, the implementations of IDMs are becoming easier since smart grid supports communication infrastructure. All remote technique can be easily implemented in smart grid architecture. Though local IDMs are simpler to implement but have the drawback of large NDZ, therefore remote IDMs are most reliable. Remote techniques monitors the status of the breakers in the network and if any of the contact of breaker is open, so with the help of communication channel like PLCC, a trip signal is generated for the concerned power system. For the existing power system, deployment of communication infrastructure is very expensive so a compromise has to be made by employing local techniques. In Table-1 comparison between various IDMs is presented.

NAME OF IDM	SUITABILITY WITH INVERTER BASED DG
Communication Based Methods	Very High. Depends on the communications network.
Passive Methods	Low: Difficult to predict behavior with multiple inverters without simulation, low reliability with single inverter.
General Electric Frequency Shifts (GEFS) [24]	Very High, but not unlimited. More research is required.
Automatic Phase Shift [25]	High, but not effective for non-linear loads.
Sandia Frequency and Voltage Shift [26-30]	Medium: Can be used, but impacts power quality and MPP controls.
Robust Islanding Detection Algorithm for Distributed Fuel-cell Powered Generation (DFPG) [30]	Low: May fail for the case of multiple DFPGs with small power ratings operating independently.
Current injection Method [30][21]	Low: The measured frequency changes at the PCC can be caused by other inverters.
Slip Mode Frequency Shift (SMS) [31-35]	Low: Cannot handle concurrent detections.
Impedance Detection [26], [32], [36]	Low: Not reliable with multiple inverters.
Detection of Impedance at Specific Frequency [26], [36]	Low: Prone to nuisance tripping with multiple inverters.

B. Islanding Detection in Inverter based Microgrid

When an unscheduled outage occurs in the centralized electric grid, the micro grid may continue to supply to the local load forming an island. A microgrid is deliberately constructed to support local load. Inverter designed for microgrid operates in two modes ;

1. Constant current control mode.
2. Constant voltage control mode.

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Table-1 comparison between various IDMs

An active, passive & remote technique has high NDZ, so hybrid techniques were introduced.These techniques diminish non-detection zone (NDZ) to a very lower level, also improves power quality because perturbations are only introduced when islanding is suspected. However, this combination increases the cost of the system, along with the islanding detection time. The above mentioned limitations can be overruled with signal processing techniques of islanding detection. Safdar Raza, et al. discusses signal processing techniques, the application of which can enhance the performance of passive islanding detection techniques.

III. LOAD SHEDDING IN ISLANDED MICROGRID SYSTEM

While creating an island at the time of system disturbances or blackout or any situation of abnormal operation, system always faces voltage or frequency stability related issues. As mentioned before, microgrid can be operated in grid connected or isolated condition. During the transition from grid connected to islanding mode, there is a threshold condition of voltage and frequency caused due to the mismatch between load and generation in microgrid.

During islanded operation, either system frequency rises up due to redundancy in generation or it will fall to a value lower than normal value due to redundant load connected. In either case system will become unstable. To restore stability for high frequency, generated output can be controlled. For low frequency level proper load shedding scheme has to apply to maintain frequency to normal value.

Optimal load shedding has always been a hot spot of research especially in smart grid environment. In early days fixed steps of load or frequency based load shedding scheme was used in industries .This is a blind type of UFLS, since without properly analyzing the system at some fixed point of distribution an amount of load is shedded. The limitations of the conventional decentralized scheme can be overcome by implementing fast centralized load shedding scheme at the system control station.With the development of Supervisory-control and data-acquisition (SCADA) system, accuracy of load shedding scheme is increased. The adaptive load shedding scheme implemented centrally senses the value of voltage and frequency at various buses and send them to the processing unit at system control station, where all the data are analyzed and according to the situation of operation required corrective action can be taken. With the advent of smart grid technology there has been an improvement in the application of centralized adaptive load shedding scheme. Smart grid supports synchrophasor measurement technology (SMT), communication network within the smart grid helps in the transfer of data packets which are collected by phasor measurement units (PMU) located at various busses in the system under study. Centralized load shedding scheme has become an exhaustive area of research in wide area monitoring, protection and control (WAMPC) system. PMUs are time synchronized with GPS clock, uses the communication infrastructure of smart grid technology to send the data measured to central processing unit. These synchrophasor data helps in online analysis of dynamic behavior of the system and present a complete scenario of at various operating states of power system. Hence, there is an increase in stability of power system operation and reliability to. Another adaptive load shedding scheme based on decay curve of frequency in mentioned in also an integrated df/dt scheme to calculate load to be shed is discussed in. With the increase in penetration of DERs system inertia resists to calculate the amount of load to be shed. Proposed a load shedding which is not depends upon the parameters of microgrid. The islanded microgrids have different perspective to develop load shedding scheme, since different DER units connective have small inertia hence frequency decays rapidly. In addition to this, economical reasons also govern the choice of load shedding scheme with technical aspects. In a deregulated structure ,there is an obligation on operators to supply the load to a customer who is paying high, irrespective of the demand size. There is a load shedding scheme for a DG connected distribution system based on Willing To Pay condition and Rate Of Change Of Frequency (ROCOF). To account multiple DGs the concept of equivalent inertia considering center of inertia of all DGs.

$$\Delta P_i = \frac{2H_i}{f_n}\frac{df_i}{dt} \Leftrightarrow H_i = \frac{\Delta P_i * f_n}{2 * \left(\frac{df_i}{dt}\right)} \Rightarrow H_{COI} = \frac{\sum_i H_i}{i}$$

Where;
ΔPi = power mismatch of generator in per unit;
H = inertia constant of generator in seconds;
fn = system-rated frequency in hertz;
fi = generator frequency in hertz.

HCOI is center of inertia (COI), inertia constant.

In an islanded microgrid to, it is supposed that load is shared equally for satisfactory operation. Such a concept is used in frequency droop approach, where active power load sharing between multiple DG within an island is done . But in an inverter based micro grid system concept of COI is difficult to apply since inverter doesn't have its own rotor angle thus no inertia constant. An additional difficulty with inverter based islanded microgrid operation is that changing the generators' real power introduces a frequency disturbance and thus increase phase deviation. By introducing a ratelimit for any real power set-point adjustments can resolve this problem . For a Proportional Derivative (PD), phase difference controller and PID governor controlled DG system , a ramp of power output will introduce a steady-state phase difference error during the time of ramping. Thus a balance must be achieved between the desired rate-of-change of power and the acceptable steady-state phase difference error. This error signal can be utilized to initiate the islanded operation and mismatch in power will lead to load to implement load shedding algorithm. Geethi et al. presents a control strategy for grid connected and islanding modes of operation. In the beginning, DG system operates in a current controlled mode to provide the required power to the load. When the grid gets disconnected, a simple passive detection algorithm switches the system to voltage control mode. A priority based load shedding scheme, based on the measurement of the voltage at PCC, is used to neutralize the load generation mismatch. A phase locked loop (PLL) determines the frequency and angular reference at the Point of Common Coupling (PCC) and also synchronize the DG with the utility grid . I. J. balaguer et al. uses constant impedance based load shedding and in priority based algorithm is developed. The magnitude of the voltage at the PCC, obtained from the DQ PLL, is continuously measured. When it crosses the specified voltage level, signal is given to the circuit breaker to remove the load.

IV. CONCLUSION

This paper presents a comprehensive review on the performance analysis of micro grid when connected to the utility grid. In present day scenario when conventional resources based utility grid is fighting for the scarcity of resources and carbon emission related problems, renewable resources connected to the micro grid helps in maintaining load demand characteristics and it is also environment friendly. Under the condition of system contingencies properly coordinated micro grid presents a viable solution to the stability and reliability related issues. A micro grid is capable of working in both grid connected mode and islanded mode. A thorough review on various islanding detection techniques available in literature also presented. Hybrid techniques combining active methods and THD based islanding detection techniques are most suited to grid connected micro grid system. Control strategies that are used to implement grid- connected and intentional-islanding operations of distributed power generation have also been discussed. In most of the cases controller are designed in such a way that it automatically detects the islanding situation and run the various remedial action schemes for stable islanded operation. Literature review for such algorithms available for intelligent load shedding to remove mismatch between load and generation in the condition of intentional islanding is also discussed.

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