A Novel Approach for Power Management with Power Quality Enhanced Operation in Off-Grid Hybrid Power Systems

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Abstract--Hybrid Power System (HPS)s are considered as a reliable and viable option for the electrification of rural villages which are beyond the reach of grid electricity. This project proposes a Novel method for an efficient power management, power quality enhancement and regulation in Off-Grid Hybrid Power System(OG-HPS)s.The proposed method uses an Intelligent Module Distribution Generation (IMDG) units, which internally uses the Phasor Measurement Units(PMUs) and Power Quality Regulation Unit(PQRU) as its processing core ,with an aid of which they will detect the line faults and fluctuations in the power quality of the OG-HPS and corrects them to their rated level. As the core internal components of the IMDG units, the PMU detects the spurious fluctuations in the quality of power flowing through the associated bus line branch and measures the fluctuations with respect to its rated counter-parts. It issues an alert including the power fluctuations calculated so far to the PQRU which consists of variable winding transformers to step-up or to step-down the line voltage based on the calculated fluctuations. The PQRU not only intended to maintain the rated power quality on the Power Distribution Bus(PDB) of the Off-Grid system, but also protects it from the frequent physical faults due to natural disasters, birds and animals.The IMDG unit internally comprises a dedicated circuitry with bi-directional breakers to detect, locate and isolate the line faults of the OG-HPS.The fault detection circuit of IMDG compares the instantaneous parameter values of input and output breaker lines to detect the fault and isolate the faulted line. The IMDG regulates the power quality with protected fault free operation of OG-HPS. The proposed algorithm is designed,implemented and simulated in MATLAB environment

Key words--HPS,OG-HPS,IMDG,PDB,PMU,PQRU,Fault Isolation,Power Quality Regulation.

INTRODUCTION

Electrical energy is the most efficient and popular form of energy and the modern society is heavily dependent on the electric power supply. The life cannot be imagined without the supply of electricity. A major part of world population lives in villages where the extension of grid electricity is difficult and uneconomical. Off-grid power system which uses a hybrid combination of different renewable energy sources are found to be an alternative for the electrification of these areas. In India, hundreds of off-grid biomass power plants are set up under village energy security programme (V ESP) implemented by Ministry of new and renewable energy (MNRE), India. The aim of this program is to deploy various renewable resources based systems to meet total energy requirements of villages, in an efficient, reliable and cost effective manner. The improved quality and reliability in the supply definitely results in an increase in the power demand and hence the reduction in cost of electricity from these off-grid power systems. At the same time the quality and continuity of the electric power supplied is also very important for the efficient functioning of the end user equipment. Most of the commercial and industrial loads[21] demand high quality uninterrupted power. Thus maintaining the qualitative power is of utmost important. The quality of the power[23] is affected if there is any deviation in the voltage and frequency values at which the power is being supplied. This affects the performance and life time of the end user equipment. Whereas, the continuity of the power supply is affected by the faults which occur in the power system. So to maintain the continuity of the power being supplied, the faults should be cleared at a faster rate and for this the power system switchgear should be designed to operate without any time lag. The power quality is affected by many problems which occur in transmission system and distribution system. Some of them are like-harmonics, transients, sudden switching operations, voltage fluctuations, frequency variations etc. These problems are also responsible in deteriorating the consumer appliances. In order to enhance the behavior of the power system, these all problems should be eliminated.

Distributed Generation (DG) is an electrical power generation unit that is directly connected to a distribution network[8] or placed as nearly as possible to its consumer. The technologies adopted in distributed generation vary in methods of generation including small-scaled gas turbines, wind-farms, fuel cells, solar energy and hydro power plants, etc [1]. DG is both beneficial to the consumers and utilities[6], much so in places where centralized generations are unfeasible or where deficiencies can be found in transmission systems[11]. One of the challenging and vital issues for the customer is the reliability of the provided electrical energy. At the same time electrical utilities wish to decrease the revenue loss caused by outage. For this reason, the DPS has to be more reliable and efficient under not only routine conditions but also under emergency conditions. Under the situation that DPS consisting of a number of radial feeders[7] are normally subjected to the various types of faults caused by storm, lightening, snow, freezing, rain, insulation breakdown, and short circuit faults caused by birds and other exterior objects, desired reliability cannot be achieved easily. In order to improve the reliability of the DPS, utility should be able to detect and recognize the fault location[2] and type immediately after the fault is occurred. The faster the fault location is identified or at least estimated with reasonable accuracy, the more accelerated the maintenance time to restore normal power supply.

Benefit-wise, DG unit may offer solutions to the majority of power systems crave. However, installation of a DG unit at a non-optimal place may have the reverse effect instead to the system; such as increases in system losses followed by an increase in cost [5-8]. With that in mind, selecting the most appropriate place for installation paired with the ideal size of a DG unit is of utmost importance in a large power system. Nevertheless, the optimum choice and allocation of DG is a complex integrative optimization method for which common or older optimization method falls short in implementing such a concept in the system [9].

Since Micro-Grid[10] Networks (MGN) are considered as the giant class Distributed Power Systems (DPS) which will cover a large area, a fault occurred at one corner part of such network shows a serious impact on the entire network by causing a severe deviation in its operation and remarkable variations in the power quality of the network there by leading to shut-down of the entire network until or unless the fault was detected and isolated. All the times these huge complex MGNs[21] cannot spread their roots to the remote areas due to the geographical conditions and discontinuities of these areas. Under these conditions the Off-Grid -Hybrid Power Systems (OG-HPS) are considered as a reliable and viable option for the electrification of remote rural villages which are beyond the reach of grid electricity. Many such renewable based off-grid power systems working mostly in India are generating power which is not at par with grid power[22]. The control of power among different renewable sources while maintaining the power quality of supply is important for the reliable and sustainable operation of these OG-HPS.For this purpose many algorithms are proposed in the literature but their performance was not up to the satisfactory level, that is demanded by the real time applications. Hence as an attempt to provide an eternal solution to this ever teasing limitations of OG-HPS we developed this project to enable the robust fault free and power quality enhanced operation of OG-HPS.In this project We proposed a novel method for an efficient power management, power quality improvement and regulation in Off-Grid Hybrid Power Systems (OG-HPS) using Intelligent Module Distribution Generation (IMDG) unit as the DG unit.

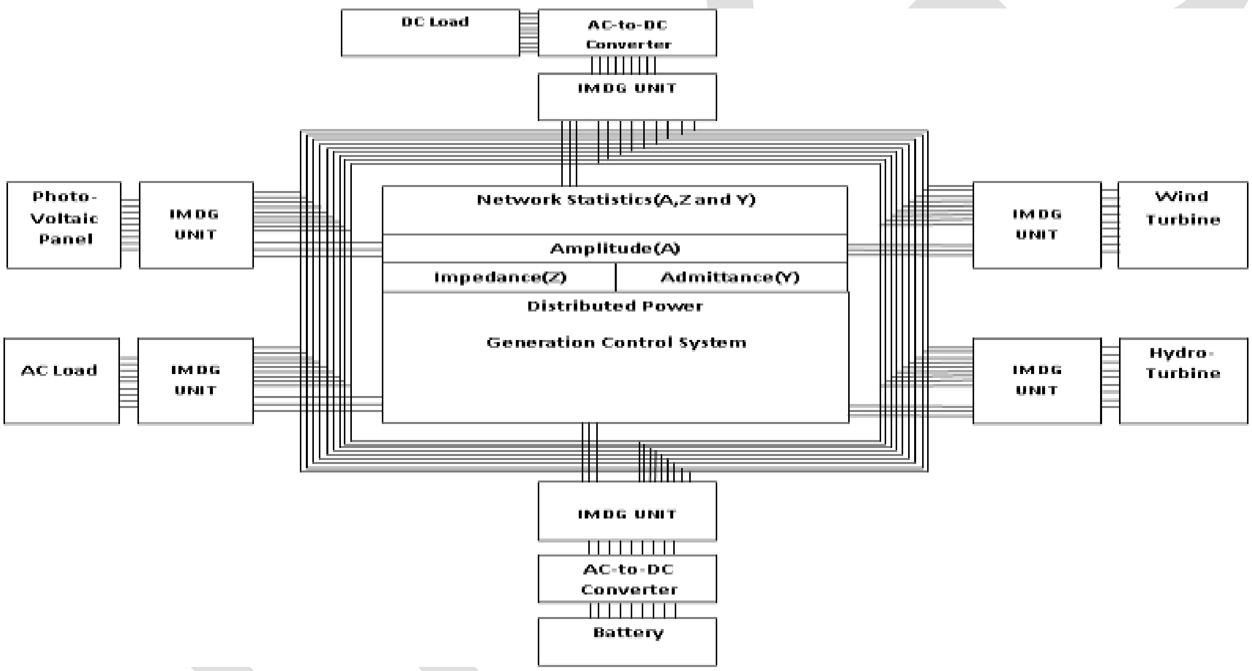
II.PROPOSED METHOD

In this project we proposed and developed a novel method for an efficient power management ,power quality improvement and regulation in the distributed generation based Off-Grid Hybrid Power Systems (OG-HPS) using an Intelligent Module Distributed Generation(IMDG).IMDG unit internally implements a very efficient and widely accepted technique called the Phasor Measurement Unit(PMU) and Power Quality Regulation Unit(PQRU) for fault monitoring and power quality enhancement of the OG-HPS.An IMDG unit with PMU and PQRU as its core internal components is designed to act as a Distribution Generation (DG) Unit which can reduce the power loss and improve the voltage profile. With an aid of these core processing units it maintains the power quality of supply with perfectly isolated line faults. Generally the Distributed Power Systems (DPS) are a small scale power generation and distribution units in located in the remote geographic regions to where the grid electricity cannot reach. DG[5] is a renewable energy in small scale located near to the load in the DPS[20].Generally a Micro –Grid system is a large scale power distribution system which is employed to cover a relatively a large geographic area with its power. In this project we intended centrally to develop a novel method to design and implement an efficient IMDG units to use with OG-HPS for effective Observability [3], detection and isolation of line faults that occur frequently and also for an efficient power management, power quality improvement, power quality regulation, to improve the voltage profile and to reduce the power loss. Generally HPS are considered as a reliable and viable option for electrification of rural villages and geographically remote areas, where there is a huge scarce for Grid Power. In such remote areas the renewable energy resources such as solar energy, water resources and wind energy are the most dependable means. These renewable energy resources[14] are employed as raw inputs to generate the power using the power generation units such as Photo-Voltaic Cells[13], Hydro-Power Plants and Wind mills. Thus the generated power is distributed to the rural village and geographic remote areas using the power distribution network employing power distribution units. The Generated Power of the renewable energy driven power generation units is called a hybrid power which is not coming from conventional grid system. The generated hybrid power[19] is routed efficiently from generation units[15] to the distribution units using a highly efficient loss less power coupling circuit which will maintain the perfect impedance matching between the power generation and distribution units called the IMDG unit as DG Unit. Normally these IMDG units will act as an interconnection unit between the power generation and distribution units. The IMDG units will perform the function of the distributed generation along with the power generation and distribution units. The overall arrangement including the power generation units, DG units and power distribution units are collectively named as HPS which is aimed at generation and distribution of the hybrid power in remote areas using the renewable hybrid energy resources based on the principle of DG[5]. Hence the name DG-HPS. .These DG-HPS are also called as Off-Grid Hybrid Power System (OG-HPS)s. Many such off-grid power systems working mostly in India are generating power which is not at par with grid power. Due to high penetration of Distributed Generation(DG) in the OG-HPS ,the transmission networks are no longer responsible for security issues in OG-HPS.All the control of power among different renewable sources while maintaining the power quality oriented supply is very important for the reliable and sustainable operation of OG-HPS[12].IMDG units may also participate in security as well as power generation and distribution activities depending on their locations .Installation of IMDG units in the OG-HPS can reduce the power loss and improve the voltage profile.

In order to improve the reliability, utility should be able to detect and recognize the fault location and type immediately after fault occurs. The faster the fault location[4] is identified or at least estimated with reasonable accuracy, the more accelerated the maintenance time to restore normal energy supply. Since the DG based OG-HPSs are the only possible means to electrify the remote villages and regions of irregular geometric structures and unfair atmospheric conditions. The reliable and sustainable operation of these OG-HPS systems is of great importance to ensure an uninterrupted renewable power generation and distribution to the remote geographic areas for which the grid electricity[16] cannot fulfill the need of their electrification. The most sophisticated and effective algorithms are required for practical realization of the aforementioned task. Real time fault protection without operational disturbance of the OG-HPS is a challengeous and almost impossible task for which we developed a new Distribution Generation (DG)unit[5] called the IMDG unit using the novel most efficient and widely accepted techniques called the Phasor Measurement Units[17]. The technique exploits the close relationships between the voltage and current phasors of power lines using the mesh voltage and node current analysis and uses these universally accepted relationships to detect the deviations in the line parameter values such as line amplitude, impedance and admittance levels. Using this analysis as the core processing unit, an IMDG unit performs the real time fault detection and isolation with regulated power quality enhancement[18] without causing any disturbance to the normal operation of the OG-HPS.A detailed implementation procedure and operational structure of the IMDG unit based OG-HPS is provided in section III.

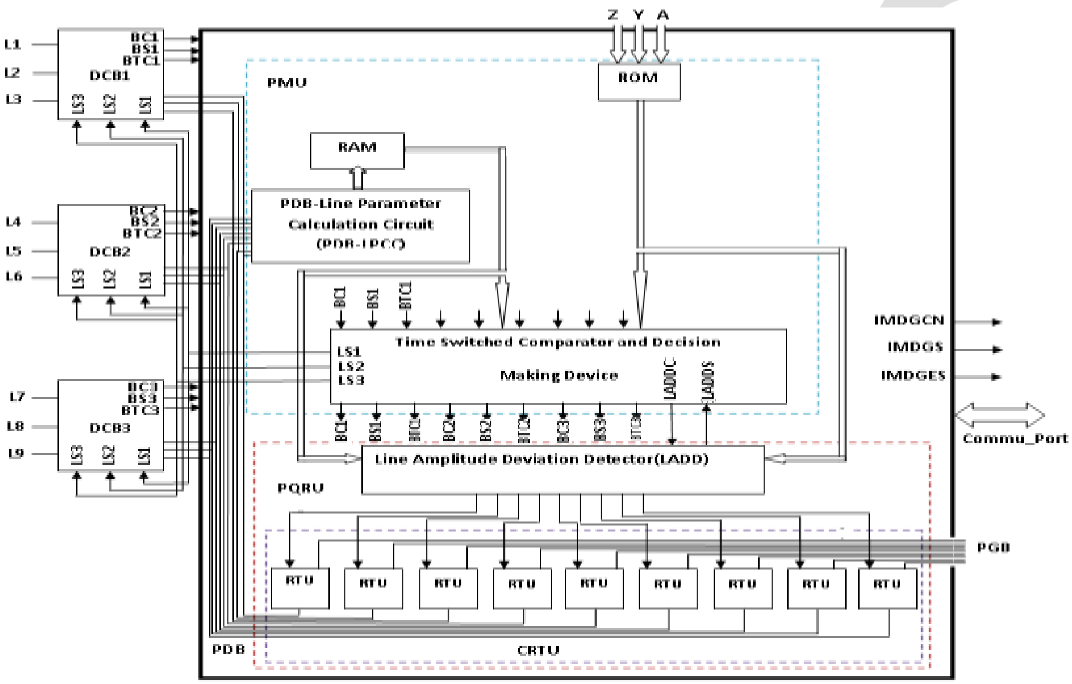
III.PROPOSED WORK

In this project we designed ,developed and implemented an Intelligent Module Distribution Generation(IMDG) unit with a novel procedure which uses the most efficient and widely accepted technique called the Phasor Measurement Units and employed as a DG unit in the emerging OG-HPS systems to ensure the real time fault protection with the regulated power quality enhanced operation of OG-HPS.We constructed IMDG unit to act as an efficient DG units for fault free operation and power quality regulation of OG-HPS.The schematic block overview of the proposed OG-HPS system is shown in figure(1)



Fig(1): Schematic block diagram of the proposed DG-HPS System.

The proposed system consists of a Off-Grid Hybrid Power System(OG-HPS) which is implemented using a ring bus architecture as shown in figure(1).The ring bus architecture enables the OG –HPS to serve the regions surrounding it with its power. The OG-HPS supplies the power to all regions or zones around it .One identical bus branch is drawn to each and every region or zone. Each power distribution bus branch is put under the control of an unique IMDG unit as shown in the figure(1).Each IMDG unit will control and monitors the assigned bus branch for faults and acts accordingly to detect and isolate the faults without showing any impact on the distributed power quality and operational effectiveness of the OG-HPS.The OG-HPS maintains the data base of the rated values of line parameters of individual lines of Power Distribution Bus(PDB) of the OG-HPS.The rated line parameter values are used as basis for fault detection, isolation and power quality regulation in a OG-HPS.OG-HPS also consists of a Distributed Power Generation Control System(DPGCS),which will control and regulates all operational activities of OG-HPS.DPGCS simply serves as a control system for OG-HPS.All the IMDG units are put under the control and direction of DPGCS.The DPGCS controls all the IMDG units through three control signals such as IMDGCN to control the enable/disable status of the IMDG unit,IMDGS to check the operational activeness of the internal components of the IMDG unit and IMDGES to check the IMDG operational fault(error) status. The internal architecture of the IMDG unit is shown in figure (2), which consists of two major operational core processing blocks such as a Phasor Measurement Unit(PMU) which is identically meant for fault protection and a Power Quality Regulation Unit(PQRU) which is meant for power quality improvement and regulated power quality management. The IMDG unit based DG unit will consist of an IMDG unit and its associated breakers. Among these two internal functional blocks of the IMDG unit, the PMU block is intended for an adaptive fault security of OG-HPS with an intelligent detection of spurious power quality fluctuations caused by various PDB line faults and to isolate the line faults. Whereas the PQRU is dedicated to regulate the deviated power quality with power fluctuations caused by several natural and atmospheric conditions which are detected perfectly in quantity and supplied as feedback input to the PQRU block by the PMU block. The internal architecture of the PMU block is shown in fig(2),which consists of a ROM unit, a RAM unit, a mini processor (Line Parameter Calculation Circuits(LPCC)),and a Time Switched Comparator and Decision Making Device(TSC-DMD) units.

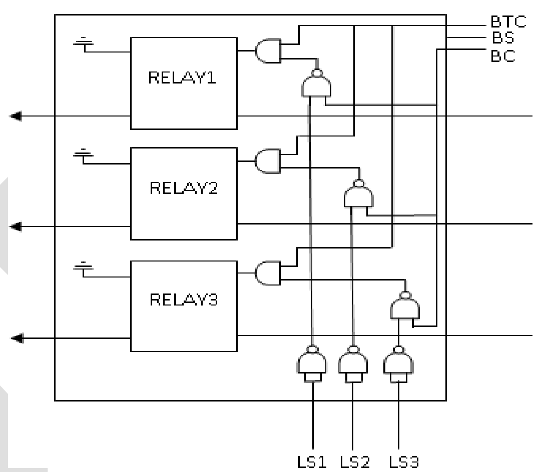


Fig(2):Schematic block diagram of the proposed DG unit

A devoted mini-processor (Line Parameter Calculation Circuit) is used to calculate the instantaneous line parameter values of PDB.The objective of ROM unit is to store the rated parameter values from data base unit of OG-HPS.The TSC-DMD unit accepts the instantaneous line parameter values and rated line parameter values along with the control, status and trip signals of the individual breakers as input and processes them accordingly to issue the necessary control signals to all breakers to ensure the fault free and power quality regulated operation of the proposed OG-HPS.A single PMU block inside the IMDG unit controls all the breakers of PDB lines. Each IMDG unit is put under the control of the DPGCS unit which will control them with a specialized set of three control signals they are: IMDGCN (IMDG Control), IMDGS (IMDG Status) and IMDG Error Status(IMDGES). The Control signal logical definitions are given as

IMDGCN→IMDG control signal; If IMDGCN=1;IMDG unit is enabled, otherwise disabled.IMDGS→ IMDG unit Operational Status. If IMDGS=1; all the internal components of the IMDG unit are working perfectly and the IMDG unit is active at this instance of operation, otherwise there is an error in the operational condition of internal components of the IMDG unit.IMDGES→IMDG unit Error Status. If IMDGES=1; there is a fault in the lines of the bus branch being monitored by this IMDG unit. Otherwise there is no fault in the lines of the bus branch being monitored by this IMDG unit.

At every instant of its operation, the instantaneous operational status of the IMDG unit is informed in terms of a detailed text message format to the DPGCS unit. The DPGCS unit receives the operational status messages from all the IMDG units to examine their operation condition and to act accordingly. If the DPGCS unit receives a message stating an error in the operational condition of a particular IMDG unit, the DPGCS unit passes the messages received from the corresponding IMDG unit which is monitoring the faulted bus branch for faults to the technical department. Since this message from the DG unit consists of a detailed information about the operational conditions of the region to which it is assigned as an independent region monitoring device, if any line fault is occurred in a region, then that fault condition is precisely identified by its type, location and number of the line suffering from the fault and the same information is informed to the technical department so as enable faster recovery of faults with negligible amount of delay and man power. Thus the PMU block will detects the line faults of the power distribution bus, which are the root causes for the power quality fluctuations. These PMU blocks will sense the line fault conditions and isolates them immediately and calculates the power quality differences between the instantaneous and rated power levels and informs the same to the PQRU for instantaneous power quality correction. The second core processing block of the IMDG unit is the PQRU which is shown in fig(2),which internally consists of a Line Amplitude Deviation Detector(LADD),which will detects and calculates the power quality fluctuations in quantitative terms and a Cascaded Reconfigurable Transformer Unit(CRTU)s,which is meant to restore the fluctuated power levels on the PDB lines with a suitable step up/step down action of the transformer units. The CRTU unit consists of a cascade connected Reconfigurable Transformer Unit(RTU)s,one for each PDB line. The computed power quality fluctuations of each PDB line by the LADD unit are supplied as the feedback input to the corresponding RTU in the CRTU,so as to regulate the power quality fluctuations and to ensure the power quality enhanced operation of the OG-HPS .If there is no fluctuation in the power quality of a particular PDB line, no step up /step down process is carried by an associated Reconfigurable Transformer Unit(RTU) of the line, but it will just acts as an auto transformer without any step up/step down process, there by maintaining the same power quality on the line without any change. The PQRU block is internally put under the control of the PMU block with an aid of two control signals such as LADDC and LADDS.LADDC stands for Line Amplitude Deviation Detector Control(LADDC),where as LADDS stands for Line Amplitude Deviation Detector Status(LADDS).If LADDC=1;then the LADD is enabled, otherwise disabled. If LADDS=1; then all the internal components of the LADD are active, otherwise inactive. The internal architecture of the breaker circuit is shown in below figure (3), which consists of three relay circuits to control three lines one for each line and the associated control circuitry. Each relay will control and monitor the close or open status of one particular line. Each breaker has three control pins such as BC,BS and BTC with access of which the associated IMDG unit controls its operation. Thus the PQRU will acts as the Power Fluctuation Regulator (PRF).If a fault is occurred in a particular breaker lines, then it will get tripped by making its BTC=1 and based on the logic levels on Line Status (LS)pins such as LS1,LS2 and LS3,the relay of the particular faulted line will be discharged. When LS1=1;then the first line of the breaker will be faulty and hence isolated from the network. Similarly, if LS2=1, second line of the breaker will be isolated and if LS3=1 then the third line of the breaker will be isolated.



Fig(3):Internal architecture of the breaker circuit

IV.RESULTS AND DISCUSSION

To test the operational efficiency of the proposed OG-HPS, the computer simulations have been performed using MATLAB.The algorithm is designed, programmed with six operational zones for simplicity, which can be extended further to any number of regions or zones with relatively less operational overhead costs and simulated using Matlab.As a first task after starting its operation the OG-HPS initializes all its IMDG Units for rated fault free operation of the OG-HPS. This initialization includes loading the rated parameter values of line voltage, line currents and associated phase deviations by individual IMDG Units from the OG-HPS as given in table(1),table(2) and table(3).The initialization data of the OG-HPS is given as follows.

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Intializing The Network Rated Line Voltages..........

SNO	BUS LINE	RATED VOLTAGE LEVELS(in V)
1	LINE1	400
2	LINE2	400
3	LINE3	400
4	LINE4	400
5	LINE5	400
6	LINE6	400
7	LINE7	400
8	LINE8	400
9	LINE9	400

Table(1): Network Rated Line Voltages

Intializing The Network Rated Line Currents..........

SNO	BUS LINE	RATED CURRENT LEVELS(in A)
1	LINE1	50
2	LINE2	50
3	LINE3	50
4	LINE4	50
5	LINE5	50
6	LINE6	50
7	LINE7	50
8	LINE8	50
9	LINE9	50

Table (2): Network Rated Line Currents.

Intializing The Network Rated PHASE Voltages..........

SNO	BUS LINE	RATED PHASE VOLTAGE LEVELS(in V)
1	LINE1	230
2	LINE2	230
3	LINE3	230
4	LINE4	230
5	LINE5	230
6	LINE6	230
7	LINE7	230
8	LINE8	230
9	LINE9	230

Fig (3): Network Rated Phase Voltages.

The Network Rated Power Levels..........

SNO	BUS LINE	RATED POWER LEVELS(in W)
1	LINE1	11500
2	LINE2	11500
3	LINE3	11500
4	LINE4	11500
5	LINE5	11500
6	LINE6	11500
7	LINE7	11500
8	LINE8	11500
9	LINE9	11500

Fig (4): Network Rated Power Levels

The control signal definitions of the IMDG unit for its fault free and faulty operational conditions are given in the table 5 and 6 respectively.

Initializing The Network IMDG Units..........

SNO	IMDG Unit	IMDG CONTROL	IMDG STATUS	IMDG ERROR STATUS	OPERATIONAL STATUS
1	IMDGU1	Enabled	Active	No Error	Fault Free
2	IMDGU2	Enabled	Active	No Error	Fault Free
3	IMDGU3	Enabled	Active	No Error	Fault Free
4	IMDGU4	Enabled	Active	No Error	Fault Free
5	IMDGU5	Enabled	Active	No Error	Fault Free
6	IMDGU6	Enabled	Active	No Error	Fault Free

Table(5): Control signal definitions of the IMDG unit for fault free operational conditions

Initializing The Network IMDG Units..........

SNO	IMDG Unit	IMDG CONTROL	IMDG STATUS	IMDG ERROR STATUS	OPERATIONAL STATUS
1	IMDGU1	Disabled	Inactive	Error	Faulty
2	IMDGU2	Disabled	Inactive	Error	Faulty
3	IMDGU3	Disabled	Inactive	Error	Faulty
4	IMDGU4	Disabled	Inactive	Error	Faulty
5	IMDGU5	Disabled	Inactive	Error	Faulty
6	IMDGU6	Disabled	Inactive	Error	Faulty

Table(6): Control signal definitions of the IMDG unit for faulty operational conditions.

The operational results of the proposed algorithm under fault free conditions of the OG-HPS are

The operational results of the proposed algorithm under fault free conditions of the OG-HPS are presented primarily as follows. Under fault free condition the operational and performance summary of the proposed IMDG unit are given in table (7) and table (8) respectively. These definitions are common for all IMDG units.

IMDG OPERATIONAL SUMMARY

SNO	Control Variable	Operational Status
1	IMDG Control	Enabled
2	IMDG Status	Active
3	IMDG Error Status	No Error
4	BR1 Control	Enabled
5	BR2 Control	Enabled
6	BR3 Control	Enabled
7	BR1 Status	Active
8	BR2 Status	Active
9	BR3 Status	Active
10	BTC4 Status	Untrip
11	BTC4 Status	Untrip
12	BTC4 Status	Untrip

Table(7):The operational summary of the IMDG unit for fault free operation.

IMDG PERFORMANCE SUMMARY

SNO	IMDG_BUS_LINE	LINE_STATUS	AMPLITUDE	IMPEDANCE	ADMITTANCE
1	LINE1	Closed	Rated	Rated	Rated
2	LINE2	Closed	Rated	Rated	Rated
3	LINE3	Closed	Rated	Rated	Rated
4	LINE4	Closed	Rated	Rated	Rated
5	LINE5	Closed	Rated	Rated	Rated
6	LINE6	Closed	Rated	Rated	Rated
7	LINE7	Closed	Rated	Rated	Rated
8	LINE8	Closed	Rated	Rated	Rated
9	LINE9	Closed	Rated	Rated	Rated

Table(8): The performance summary of the IMDG unit for fault free operation.

The status and variational characteristics of breaker currents of the IMDG unit breakers with respect to the operational conditions are illustrated in fig(4)

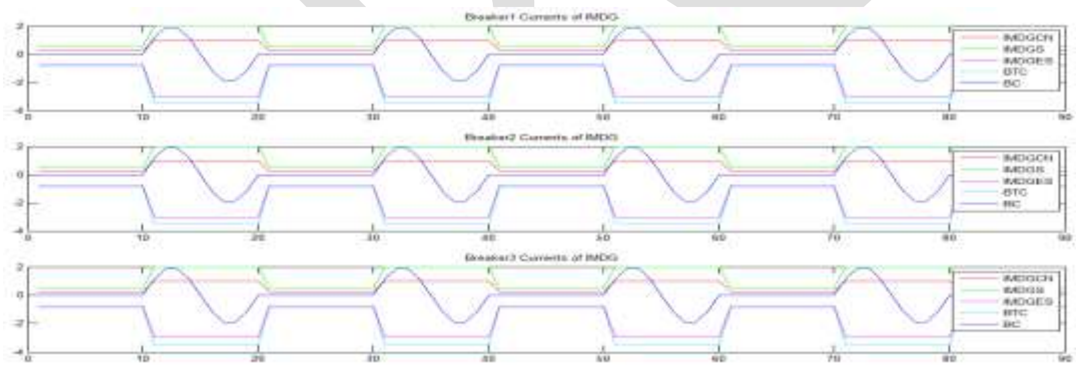
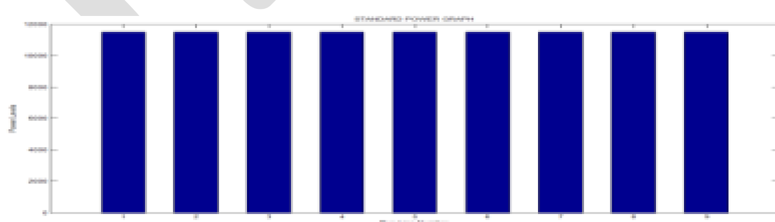


Fig (4): Breaker currents of the IMDG Unit breakers under fault free condition.



Fig(5):The Rated Power levels of the OG-HPS under fault free operation.

The operational results of the proposed algorithm under faulty conditions of the OG-HPS are presented primarily as follows. Under faulty conditions the operational and performance summary of the proposed IMDG unit are given in table (9) and table (10) respectively.

IMDG1 OPERATIONAL SUMMARY

SNO	Control Variable	Operational Status
1	IMDG Control	Enabled
2	IMDG Status	Active
3	IMDG Error Status	No Error
4	BR1 Control	Enabled
5	BR2 Control	Enabled
6	BR3 Control	Enabled
7	BR1 Status	Active
8	BR2 Status	Active
9	BR3 Status	Active
10	BTC1 Status	Trip
11	BTC2 Status	Untrip
12	BTC3 Status	Untrip

Table(9): The operational summary of the IMDG unit for faulty operation.

IMDG1 PERFORMANCE SUMMARY

SNO	IMDG_BUS_LINE	LINE_STATUS	AMPLITUDE	IMPEDANCE	ADMITTANCE
1	LINE1	Closed	Rated	Rated	Rated
2	LINE2	Opened	Change	Change	Change
3	LINE3	Opened	Change	Change	Change
4	LINE4	Closed	Rated	Rated	Rated
5	LINE5	Closed	Rated	Rated	Rated
6	LINE6	Closed	Rated	Rated	Rated
7	LINE7	Closed	Rated	Rated	Rated
8	LINE8	Closed	Rated	Rated	Rated
9	LINE9	Closed	Rated	Rated	Rated

Table (10): Performance Summary of the IMDG unit for faulty operation.

The status and variational characteristics of breaker currents of the IMDG unit breakers under faulty operational conditions are illustrated in figure(6).

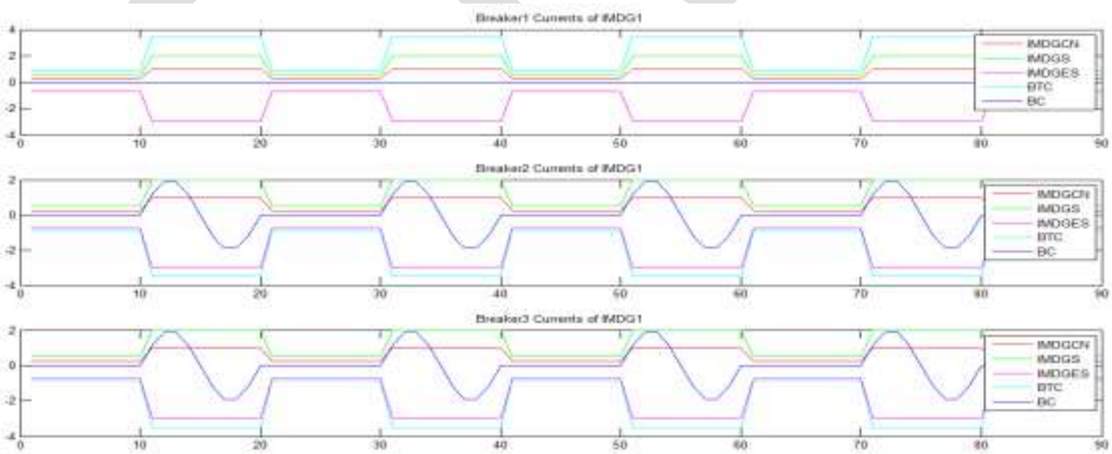


Fig (6): Breaker currents of the IMDG Unit breakers under faulty condition.

The power quality checking of the OG-HPS is done as follows.

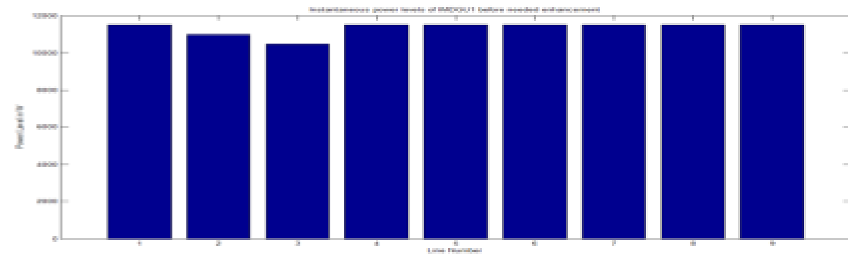


Fig (8): Instantaneous power levels of PDB lines before the needed enhancement.

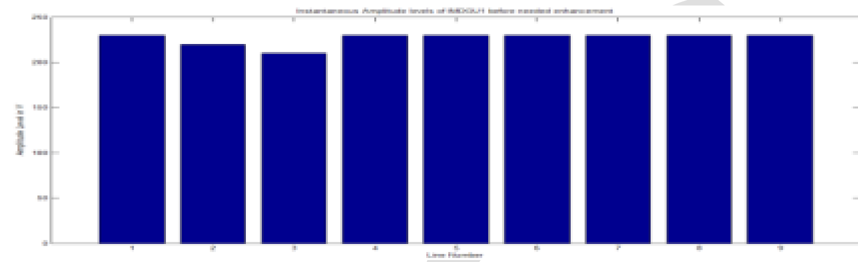


Fig (9): Instantaneous amplitude levels of PDB lines before the needed enhancement.

The power quality regulation and enhancement of the OG-HPS is done as follows.

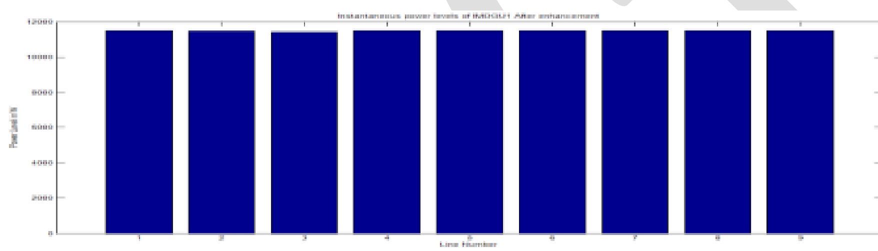


Fig (10): Instantaneous power levels of PDB lines after the needed enhancement.

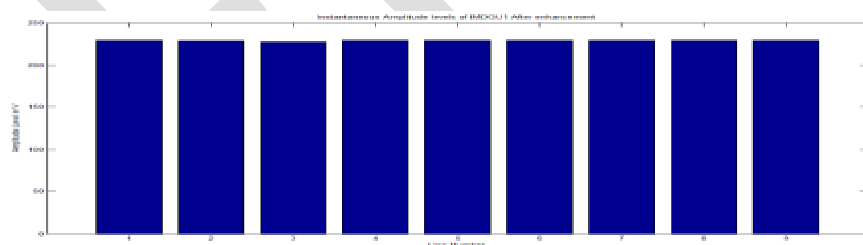


Fig (11): Instantaneous amplitude levels of PDB lines after the needed enhancement.

V.CONCLUSION

The Robust and regulated operation of an Off-Grid Hybrid Power System (OG-HPS) can benefit the power distribution company, network and also the consumers. Generally the spurious fluctuations in the quality of the power being supplied by the OG-HPS not only causes a disturbance to the normal operation of the electrical utilities or consumer industries, but also these power fluctuations may sometimes destroy the internal circuitry of the electrical machines. This leads to a huge production loss to the consumer industries. These power fluctuations may be resulted due to normal input and load variations, which can be tolerated with relatively less effort. But sometimes the power quality may get dropped due to line faults, which occurs because of natural disasters such as storms, thunders, snow, rain, birds and animals. Power fluctuations due to line faults cannot be tolerated easily, until or unless the fault is detected and isolated. Some years of research was dedicated to find an appropriate means for an efficient power management and power quality improved operation of the OG-HPS. As a result, many algorithms were proposed in the literature with fair performance characteristics which cannot meet the present application demands.In this effort in order to counteract to the challenges in the adaptive fault security and power quality regulation of the OG-HPS, we designed and implemented a Novel method for an efficient power management, power quality enhancement ,regulation and fault analysis in an Off-Grid Hybrid Power System(OG-HPS) which works on Distributed Generation(DG) principle with Intelligent Module Distributed Generation(IMDG)unit being employed as a core DG unit.The IMDG concept is new and practically very efficient. Each IMDG unit encapsulates two major processing units which are PMU and PQRU.These two units will work in coordination with each other to accomplish the task of sensing the power quality deviation ,quality regulation, fault detection, location and isolation activities in the OG-HPS.The proposed method is practically implemented and simulated in MATLAB software. The results of testing adjudge that the proposed algorithm is best in all aspects and outperforms all the existing methods and techniques for fault free and power quality enhanced operation of OG-HPS.

VI.FUTURE WORK

This algorithm is proven to be the best in performance in all aspects by its performance. In this project in order to reduce the complexity, the proposed algorithm is practically implemented with 9-line ring bus architecture. But there are no constraints on the size of the network and hence it can be extended to any large size OG-HPS with increased number of operational zones and any higher order bus. Increase in the physical size of the OG-HPS network doesn't cause any performance dissimilarities and extra limitations. As a consequence the physical size and processing capability of the internal components has to justified with the proper selection of internal components of matched capacity and efficiency.

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