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ABSTRACT

The appearance of microgrids created challenges such as microgrid protection and due to the presence distributed generation in microgrid network fault currents basically are variable.protection projects based on constant current must be upgraded.one of the major challenges, changes of microgrid frequency in islanded mode.in this paper a new protection system have provided to monitor microgrids and update current errors use extensive communication network. This system has been designed to respond to the dynamic changes in the system like connection/disconnection DG sources and changing microgrid user condition from connected network mode to islanded mode. the protection system Provided takes over control frequency microgrid in islanded mode and prevents microgrid instability. To control frequency central protection unit changes one of the distributed generators to busbar slack. Studies for the provided network sample have been done and show how the proposed protection system can run these models.

Keywords: Frequency control, smart microgrid, protection, fault currents, distributed generation, power system communication.

1. INTRODUCTION

Given the recent developments in Power engineering technology and the growing concerns for global warning, the new tendency is to generate electricity from cleaner energy sources and closer to the consumption areas [1].Subsequently, power industry is inclined toward DG such as renewable energy source (RE) This also decreases the burden on transmission lines which already operate close to their limits [2], [3]. Microgrid is a collection of loud and small producers behaving like a citizen [4] from grid side thanks to intelligent control [5]. Although a microgrid consists of many producers and consumers, it works like a generator [6]. Micrigrids behave dynamically. At any time DG connection or disconnection may occur in microgrid. It occurs anytime, in production of electronic energy load sharing, and protection and control strategies will be incorrect. To operate properly microgrid parameters should follow any changes in microgrid [7], [8]. This requires a centralized management system which implements an algorithm to determine the structure of the system and yields the relay hierarchy at all branches of the network [9], [10]. Because two principles of traditional distribution network, radial structure network and passive nature,can no longer be valid [11]-[13]. In this case, a series of reforms in the system of the old protection is not enough and requires fundamental changes [14]-[16]. In [17] a novel microgrid protection system is proposed with extensive communication. The system reacts to using a network line under consideration and dynamic changes in system [18]. In [19] a stable control project of microgrids has provided in this project by using passing power, we diagnose microgrid islanded. Stabilizer units can reduce transients between generators. In [20] stabilization of different modes of short connection and microgrid have been discussed.

In this reference, the benefits of each connected method have to be examined.

Finally, microgrid performance and general network in connected mode have better stability than islanded performance. In the case of severe error by changing mode we can maintain the stable operation of the system and report the reliability of central unit the reliability.

In this paper, a protection system and smart control are provided that have the ability to protect network microgrid. This is an updated system, because compared to the previous proposed method it has high speed performance and the reliability is higher than the previous method.

This paper is organised as:
1) The proposed adaptive protection system is briefly stated.
2) Described microgrid modeling and central protection system.
3) Described microgrid frequency control in islanded mode.
4) Conclusion.

2. PROPOSED PROTECTION SYSTEM WITH MICROGRID CENTRAL SECURITY

Dynamic structure security. The communication system can be an Ethernet network based on TCP/IP. To isolate the errors, it is necessary to update relay operational current and current faults detection. MICROGRID CENTRAL PROTECTION UNIT continuously of microgrids and their adaptive operation develop conservation strategies. To connect with all relays and DG the proposed system requires microgrid central checks the status of DGs. In this model, DG status it is rated currents (IratedDGx) and shares of faults.

For a particular relay, the operating fault current (the current level that causes the relay to trip) is calculated as shown in (1): [21]

$$I_{relay} = (I_{faultGRID} \times \text{Operating Mode}) + \sum_{i=1}^{m} (k_i \times I_{faultDGi} \times \text{Status}_{DGi}) \qquad (1)$$

Where m is the total number of DGs in the microgrid, Ki is the impact factor of distributed generator on thefault current of the relay,and Ifault$_{DGi}$ and status are as described before. If the microgrid is operating in islanded mode, then the grid's fault contribution will be multiplied with the "Operating Mode" bit which will be equal to zero. Likewise, the fault contribution of a DG which is not in operation will be annulled by its status bit. The impact factor, namely k, is introduced to calculate the fault contribution of DGs at distant points in the microgrids. It takes a value between 0 and 1 and represents the decrease in the fault current due to inductance and resistance of low voltage distribution lines. The relays closer to the DG under consideration will have higher "k" levels whereas those which are further downstream or upstream will have lower coefficients.

3. MICROGRID MODELING AND CENTRAL PROTECTION SYSTEM

Fig.1. shows a single line diagram of the distribution 13.8 kv system for microgrid examination. The microgrid consists of a DG common unit (1.8 MVA) DG1 attached to feeder1, two units with electronic interface (EI-DG): it means DG3 (2.5 MVA) and (1.5 MVA) DG2 are attached to feeders 3-4.

Unit DG1 is a unit with response (like a generator diesel) or a gas unit with the governor and excitation control system. DG2 and DG3 units are rapid control resource. It is assumed that the DG2 and DG3 both have the capacity to provide active and reactive power of the system. These 3 systems are used to investigate the possible interaction.

1) Between units (EI-DG).
2) Between units (EI-DG) and common units.
3) Between units DG and network.

Table.1. Loads parameters.

Parameters	L1	L2	L3	L4	L5	L6
Configuration	Yg	Yg	Yg	Yg	Yg	Yg
Nominal phase-to-phase voltage Vn (Vrms)	480	480	480	2400	2400	480
Nominal frequency fn (Hz)	60	60	60	60	60	60
Active power P (W)	0.9e6	1.5e6	1.5e6	1.21e6	0.6e6	1.21e6
Inductive reactive power QL (positive var)	0.6e6	0.95e6	0.95e6	0.81e6	0.42e6	0.81e6
Capacitive reactive power Qc (negative var)	0	0	0	0	0	0

Table.2. Trans parameters.

Parameters	T(a)	T(b)	T(c)	T(d)	TL
Nominal power and frequency [Pn(VA), fn(Hz)]	[15e6, 60]	[3e6, 60]	[3e6, 60]	[2e6, 60]	[1.25e6, 60]
Winding 1 parameters [V1 Ph-Ph(Vrms), R1(pu), L1(pu)]	[69000 0.0050 0.0400]	[13800 0.0105 0.0547]	[13800 0.0105 0.0547]	[13800 0.0021 0.00109]	[13800 0.0035 0.0300]
Winding 2 parameters [V2 Ph-Ph(Vrms), R2(pu), L2(pu)]	[13800 0.0050 0.0400]	[4140 0.0105 0.0547]	[4140 0.0105 0.0547]	[2400 0.0021 0.00109]	[480 0.0035 0.0300]
Magnetization resistance Rm (pu)	500	500	500	500	500
Magnetization inductance Lm (pu)	500	500	500	500	500

Table.3. Data Maps in the Central Protection Unit.

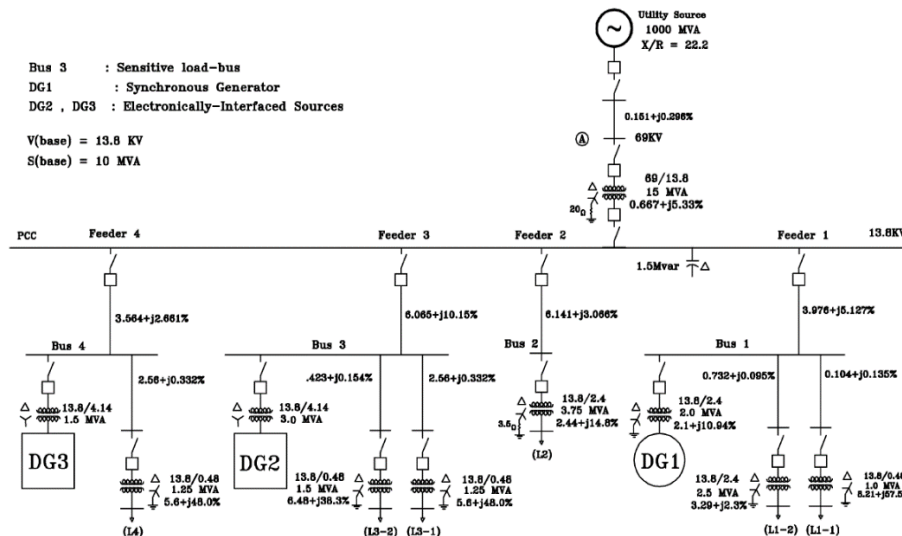|	Grid-Connected	Islanded	
Operating Mode	1	0	
Grid Fault Contribution	Ifault$_{Grid}$	——	
Relays	Operating Fault Current	Fault Detection (1 – Y, 0 – N)	Time delay for Selectivity
R1	I_{R1}	1	t_1
R2	I_{R2}	1	t_2
R3	I_{R3}	0	t_3
DG$_s$	Irated	Ifault$_{DGs}$	Status (1-ON, 0-OFF)
DG$_1$	I_{DG1}	Ifault$_{DG1}$	1
DG$_2$	I_{DG2}	Ifault$_{DG2}$	1
DG$_3$	I_{DG3}	Ifault$_{DG3}$	0

Fig.1. Single line diagram of microgrid under study of protection unit and central control.

4. DESCRIBED MICROGRID FREQUENCY CONTROL IN ISLANDED MODE

4.1 CENTRAL PROTECTION ALGORITHM OF MICROGRID

Microgrid central protection unit use an algorithm based on send and receive, when a message is received by microgrid central protection unit new error current in relay will be updated. To open separate connections relays are used when the current value exceeds the limit, relay sends a signal to adjust the error detection bit. If the error did not clear in another

relay in delay time to open the circuit, that specific relay isolates the error. The time delay is set in the system to ensure appropriate selectivity. It is clear that central relays such as R1 and R2 have more delay than those on splits R4 and R8. Connection or disconnection in complicated system may change the structure of network and relay procedure. In this case relay rearrangement procedure may be required and time delay setting must be updated in current operational error, if any error occurred and was not resolved by supporting relay. Microgrid central protection unit and the task of identifying the error and sending orders to cut off realy. Is related to where the error is and automatically detects which should be a priority relay and which one should operate as a supporter.

4.2MICROGRID FREQUENCY CONTROL IN ISLANDED MODE

If the microgrid is on connected mode, the network takes over the role of frequency control and the microgrid frequency is determined by the network but if the microgrid is in islanded mode, other network frequency is not microgrid frequency and one of generators must take over the role of frequency control.

It means that we must assume one of generators as busbar slack. In this proposed project we assume DG3 as a busbar slack. Speed sample will be sent to the control system DG3. There is a real power management block and control frequency for EI-DG units.

Local frequency is the input block and is speed sample when the microgrid is connected to the network, DG3 acts as busbar PQ and islanded mode should take over busbar slack role. In connected mode network takes over control frequency and microgrid so that microgrid remains stable in islanded mode. One of the DG resources must take over control frequency role and microgrid voltage.

By using Intelligent system and protection unit and central control, microgrid mode is diagnosed and to change control mode a signal is sent to DGs. When the microgrid turns to islanded mode to change control mode status to DGs, central protection unit sends a signal in which in this case, DG3 takes over voltage frequency control role in microgrid. Finally, frequency measurement entering the DG3 control system as microgrid frequency in islanded mode is controlled.

Fig.4. is shows an active power management and frequency control block diagram of a smart grid EI-DG unit. The input of this block diagram is local frequency (Wn) that is estimated by PLL with bus voltages. The block diagram output is reference current of x axis internal current controller that is contradicted with active power reference (P reference). Gain parameters of this block diagram are shown in table.5.

This structure is a reactive power strategy control based on voltage-droop characteristic that consists of a v-q characteristic to determine reactive power reference (Q_{ref}) and PI controller to determine q axis reference current (i_{qn} (ref)). The block diagram input is rms voltage at the point of common coupling (PCC) of a DG unit.

Table.4. DGs role in both microgrid operational mode.

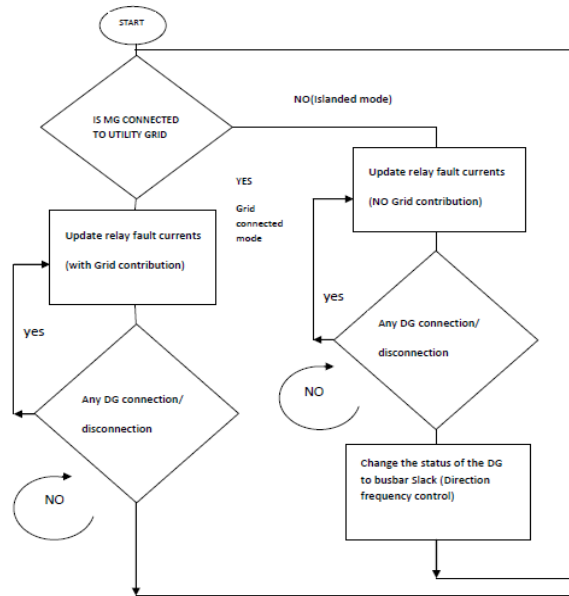| Operating Mode Microgrid	Grid-Connected	Islanded
DG_s	Operating Mode	Operating Mode
DG_1	Shane PV	Shane PV
DG_2	Shane PQ	Shane PQ
DG_3	Shane PQ	Shane Slack

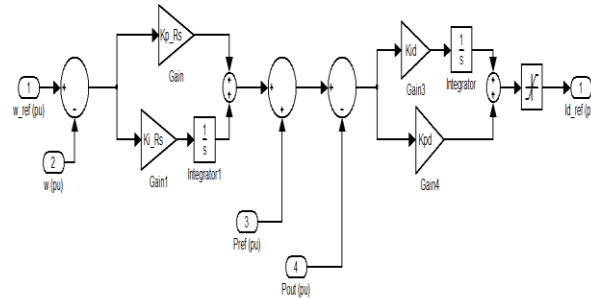Fig.3. Central protection algorithm of microgrid.

Fig.4. Block diagram of the frequency control.

Table.5. Gain parameters of frequency control scheme.

Gain parameter	Value
Kp_rs	5
Ki_rs	200
Kpd	0.05
Kid	30
Idn_max	3
Idn_min	-3

This is a scenario to show different aspects of protection project.

The system starts operation with a full load. DGs are (on) and MG operates in connected network.

In t=0.6 s error occurs on network and network will be cut and MG turns islanded.

Fig.5. shows relay current setting as a sample. As seen in this figure, by changing circuit to islanded mode the level of current setting is

reduced which means that the term IfaultGrid is removed from equation.1.

It is a response to dynamic changes in system and shows system performance of central protection. If the proposed method is not used all relay current settings will remain stable in all scenarios.

Fig.6. microgrid frequency, shows network connected mode and islanded mode. It is seen that microgrid t=0.6 s changes to islanded mode and microgrid frequency will remain stable in both microgrid modes.
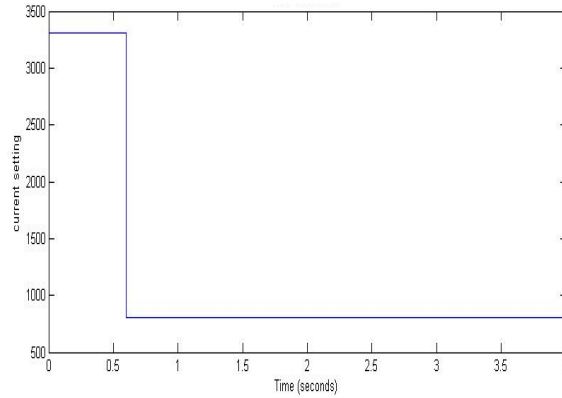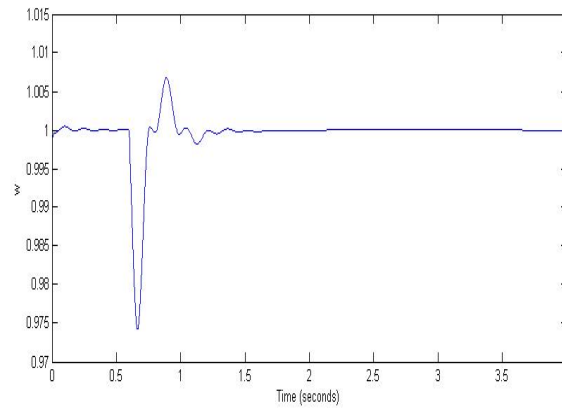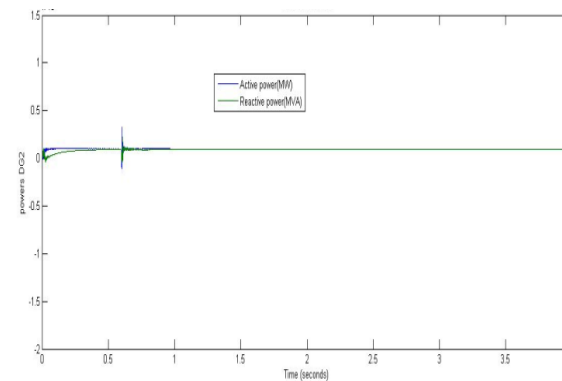

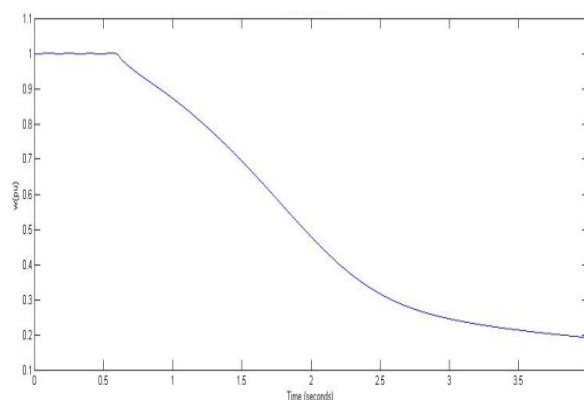Fig.5. Load relay current setting (L3-1).

Fig.6. microgrid frequency in network connected mode and islanded mode in protection scenario.

Figure(7)-power active and reactive of DG2

Figure(8)- microgrid frequency in network connected mode and islanded mode in protection scenario (Without control unit)

5.CONCLUSION

In this paper a novel protection system is provided for microgrids with DG high permeability. To monitor all endocrine equipment there is a central unit and new operation status is calculated for each received connection or disconnection by controller. Relay model and DG models are very versatile and can be used in different microgrid modeling. Regardless of their model and their producers, DGs global modeling, is important to have a global concept of DG connectivity.

Implementing the concept of connection has a fundamental role in microgrid. To verify the proposed project maps of sample data on a predetermined scenario, They are simulated in MATLAB software. which highlights different aspects of the proposed protection projects. The obtained results show full protection in connected network and islanded mode and also stable frequency and voltage in islanded mode. The proposed project is flexible and can be developed in future projects.

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