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Overview of Technical Issues Related to the Connection and the Islanding Operation of Distributed Generation to the Ditribution Grid in the Islands of Vietnam

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***Abstract* – Distributed generation (DG) in simple term can be defined as a small-scale generation. It is an active power generating unit that is connected at distribution level. IEEE defines the generation of electricity by facilities sufficiently smaller than central plants, usually 10 MW or less, so as to allow interconnection at nearly any point in the power system, as Distributed Resources [1]. The advancement in new technology like fuel cell, wind turbine, photo voltaic and new innovation in power electronics, customer demands for better power quality and reliability are forcing the power industry to shift for distributed generations. Connecting the distributed generation to the grid will carry significant benefits to the environment and the liberalization of the electricity market. However, when connecting DG to the grid it will occur some issues on distribution networks such as: power quality, stability and reliability of power supply, protection, voltage regulation and islanding operation. This paper presents the influence of distributed generation on the operation of distribution grid in Vietnam's islands.**

Keywords— Impact of distributed generation, Islanding, islanding detection, distributed generation, sequence components

I. INTRODUCTION

The structure of a traditional power system is the electricity produced by large power plants. Before the electricity is transmitted away, the voltage is raised to the appropriate level at the turbocharger. After being transmitted to the consumer, the voltage drops at the low voltage stations to suit the load requirements and is distributed to the loads through the distribution grid. Schematic of the traditional power system as shown in Figure 1.

So, in the structure of a traditional power system, currents can be viewed only from the power plant to the transmission grid and from the transmission grid to the distribution grid and supply to the load. For a distribution network in a traditional power system, there is only one source. That is the intermediate transformer which connecting the transmission grid and the distribution grid. In the design of control and protection systems for distribution grid, it is common to see the current or power flow as having a same direction.

However, when connecting the distributed generation to the distribution grid, the current flows not only in one direction, but also in the direction of the load from the DG to the load or from the DG to the transmission grid as shown in Figure 2. This has some impact on distribution networks such as: power quality, power supply stability and reliability, protection, voltage regulation, isolation and isolation operation.

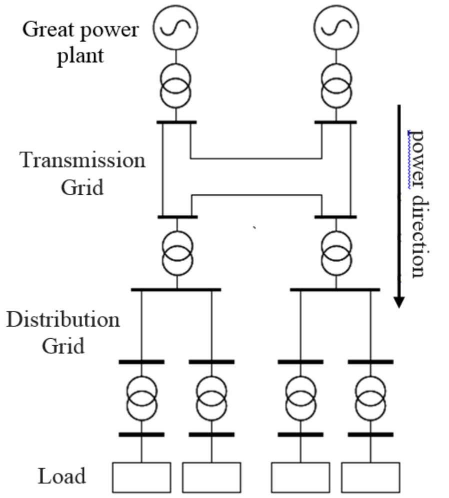

Figure 1. The structure of a traditional power system

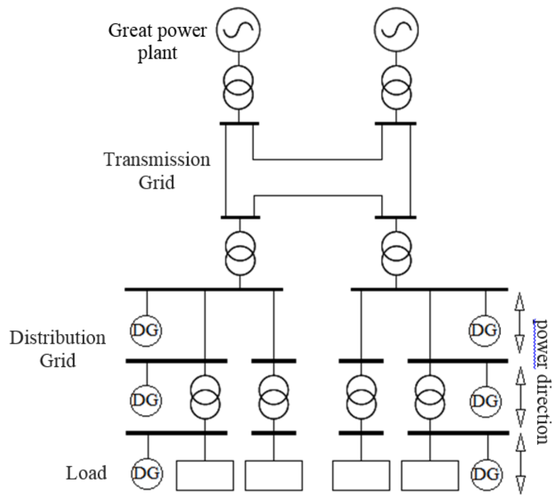

Figure 2. Distribution grid when connecting to DG

The following are the technical issues involved when connecting the DG to the distribution grid [2]:

1.1. Protection issue

a. The co-ordination of recloser (Rec) – fuse (FCO)

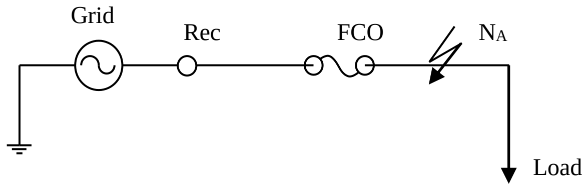

Figure 3a. Before connecting DG

Figure 3a shows a branch of the power supply line for a load. For a failure occurring at position A, if the problem is temporary, it will be eliminated after the recloser is cut and the power supply restored after the recloser closes. If it is a permanent problem, after the recloser cuts out two times at rapidly mode, it will switch to a slower cut-out mode and the fuse will then cut off the fault circuit from the grid. At the same time, the recloser's low cut-out mode also provides for the fuse if the fuse fails [3].

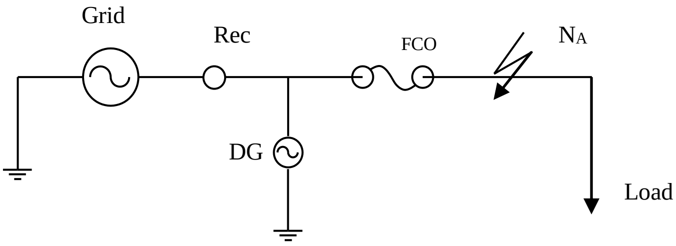

Figure 3b. After connecting DG

For Figure 3b, DG is installed between the recloser and the fuse. At the time of the fault, first the recloser closes, the DG can compensate for the current that is large enough to disconnect the fuse. Therefore, even in the case of transient, fuses may cut-off the circuit behind the fuse.

b. The co-ordination of relay – relay

Depending on the position of the DG on the grid, it will vary considerably with the combination of the relays. In the case of only one DG installed at the end of the route, it is shown in Figure 4.

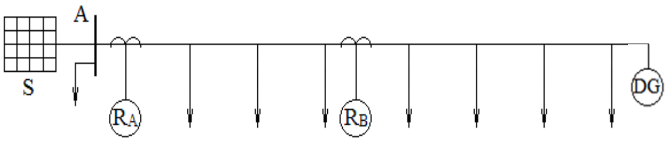

Figure 4: Relay-Relay Coordination when the grid connected to DG

If the fault occurs behinde RB block, the short-circuit current passing through the RA and RB is equal and is the short-circuit current from the source S to. This short circuit will be smaller than not having the DG so it will reduce the protection area of the two RA and RB protection. Therefore, if the fault occurs at the end of the feeder, the RB protection can not be detected until the DG is cut off the grid. This means that the cut time of protection relay will increase when connecting DG to the grid. Similarly, if an incident occurs in the preceding segment of the RB protection, it also increases the time taken to eliminate the fault of RA protection relay.

c. Voltage and frequency issues

When the unintended islanding (UI) occurs, it must be detected within 2 seconds [4]. Once this happens, islanding or a small grid is formed, in which part of the grid is only provided by the DGs. The basic thing is that the frequency and voltage of this small grid need to be restored quickly after disconnection from the grid. Transfering the frequency and voltage in the limits as quickly as possible and remain them is a technological challenge being studied globally.

d. Operation issue

In the case of small grids that consume a significant amount of power from the Utility, if the fault occurs, DGs may not have enough power to supply all loads connected to this grid. In such cases, some loads must be sacked selectively to ensure the quality of power supply to the important loads. On the other hand, if this small grid has DGs generating extra power to, the voltage and frequency of this small grid may increase after occuring the islanding. In such a case, the reduction of power generated by the DGs will be required.

e. The issue of improving the distribution grid system when connecting to DG

The addition of new power generated by DGs may have the following major effects on the electrical system [5].

- The unintended islanding (UI)
- Increase the fault current, which may require replacement of the switching equipments.
- Power system upgrade: The appearance of the DG on the grid may be required upgrading some elements of the power system.
- Distributes the switch/control
- Relay protection system and protection setting

Amongst the above issues, islanding is the greatest concerned because it regard to the operation of DGs.

I. THE ISLANDING OPERATION

As shown in Figure 5, a fault occurring in the power distribution system is generally cleared by the protective relay that is located closest to the faulty spot (B1 opens). As a result, a distributed generation tries to supply its power to part of the distribution system that has been separated from the utility's power system.

In most cases, this distributed generation assumes an overloaded condition, where its voltage and frequency are lowered and it is finally led to stoppage. However, though this is a rare case, a generator (or a group of generators) connected to this islanded system is provided with a capacity that is large enough to feed power to all the loads accommodated in the islanded system. When the loads are fed power only from the distributed generations even after the power supply is suspended from the power company, such a situation is called an "islanded operation" or "islanding".

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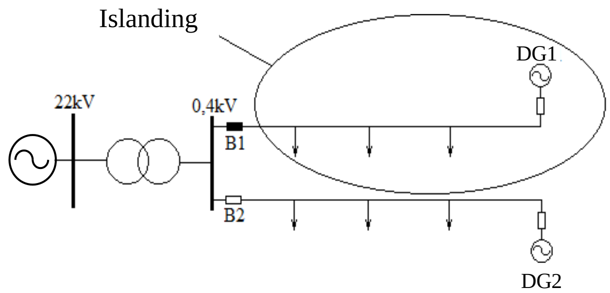

Figure 5. A part of the grid is islanded when the B1 opens

An unintended islanding is not expected because it can cause a large variation in voltage and frequency in the isolated area. At this moment, electrical power supplied to the customer under unnormal conditions can lead to complete collapse of the power system. In order to operate the electrical system safely when connecting to DG, the islanding must be detected accurately. This function is referred to as the "islanding detection" or "loss-of-mains protection."

III. APPLICATION OF ISLADING DETECTION TECHNIQUES IN DISTRIBUTION GRID IN THE ISLANDS OF VIETNAM

The main philosophy of detecting an islanding situation is to monitor the DG output parameters and system parameters and decide whether or not an islanding situation has occurred from changes in these parameters. Islanding detection techniques can be divided into remote and local techniques and local techniques can further be divided into passive, active techniques as shown in Figure 6.

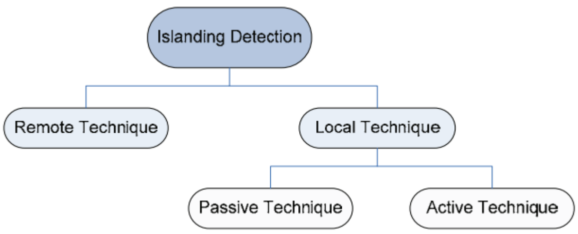

Figure 6. Islanding detection techniques

Table 1. Summarize the islanding detection techniques, their advantage and disadvantage, and examples [6].

Islanding Detection Techniques	Advantages	Disadvantages	Examples
1. Remote Techniques	• Highly reliable	• Expensive to implement especially for small systems.	• Transfer trip scheme • Power line signaling scheme
2. Local Techniques			
a. Passive Techniques	• Short detection time • Do not perturb the system • Accurate when there is a large mismatch in generation and demand in the islanded system.	• Difficult to detect islanding when the load and generation in the islanded system closely match • Special care has to be taken while setting the thresholds • If the setting is too aggressive then it could result in nuisance tripping	• Rate of change of output power scheme • Rate of change of frequency scheme • Rate of change of frequency over power scheme • Change of impedance scheme • Voltage unbalance Scheme • Harmonic distortion scheme
b. Active techniques	• Can detect islanding even in a perfect match between generation and demand in the islanded system.	• Introduce perturbation in the system • Detection time is slow as a result of extra time needed to see the system response for perturbation • Perturbation often degrades the power quantity and if significant enough, it may degrade the system stability even when connected to the grid	• Reactive power export error detection scheme • Impedance measurement Scheme • Phase (or frequency) shift schemes

Through the above methods of islanding detection, the local detection methods are chosen to apply in Vietnam because it is situable with Vietnam's economic conditions.

As shown in figure 7, phase voltage of the DG to change an instant way [7]. This change happened on the voltage waveform at different times for each phase. With regard to the unbalance between the phase of the voltage as figure 2, the negative sequence component of voltage will exist during islanding. Inverse order components of the voltage signal are separated from the voltage in the location of DG connection on.

The method of detecting the fault suitable isolation is to compare the value negative sequence component of voltage value is defaulted. A method based on negative sequence component of voltage combined with a damping characteristic of this component has the ability to distinguish the condition happens the islanding with the other operators in the case of the grid even when the problem is not symmetric.

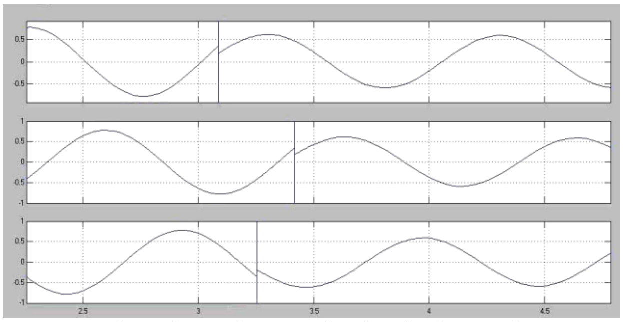

Figure 7. Three-Phase voltage signal under Islanding Condition retrieved at the target DG location

The Grid shown in figure 8 is in the CuLaoCham's island of Vietnam. Application of local detection method using negative sequence component of voltage combined with a damping characteristic of this component is to detect the islanding in this island.

The grid is presented in figure 8 include 110 kV power transmission system and 50 Hz short circuit capacity of 100 MVA is illustrated by a voltage source and resistor. Grid system is connected to a distribution system through a transformer 110/22 kV. DG is scattered source, including 3 generator has a capacity of 0.590 MW. Capacitors have a capacity of 0.12 MVAr. Load: P = 1 MW, Q = 0.6 MVAr. L is the submarine cable under the sea. It is 15.444 km long.

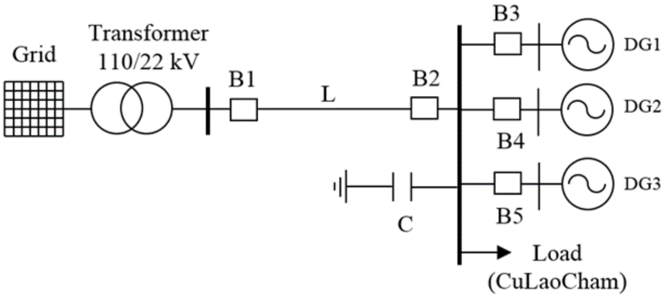

Figure 8. The studied Power Distribution network with multiple DG

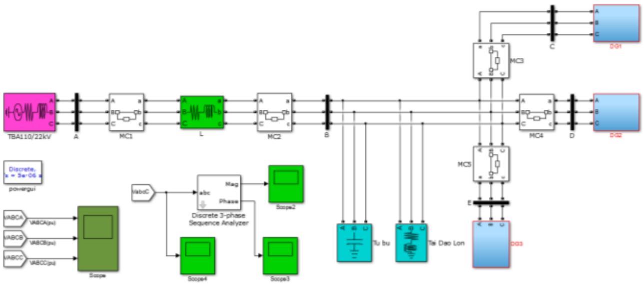

Figure 9. MATLAB/SIMULINK MODEL

To distinguish the islanding condition with the other conditions, we analyze the case of the following operators:

+ Disconnect/connect DGs to the grid
+ Change the load in power system
+ Disconnect/connect the capacitor
+ Asymmetric load
+ Short circuit asymmetry
+ Disconnect the DG with the distribution grid, this case is islanding operation

1. Disconnect/connect DGs to the grid

Suppose that at the time of 0.5s we trip a distributed generation (DG3) out of the system by opening the breaker B5. Figure 10 shows that at the time of 0.5s the value negative sequence component of voltage begins to rise and its characteristic off gradually over time. Continue measuring the value negative sequence component of voltage at the moment that way voltage components reaches the maximum value after 0.1s (5 cycles) and then get this value.

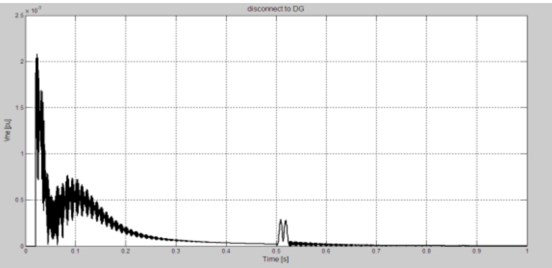

Figure 10. Negative sequence component values of the voltage and the characteristic of this component when disconnects DG with the power system

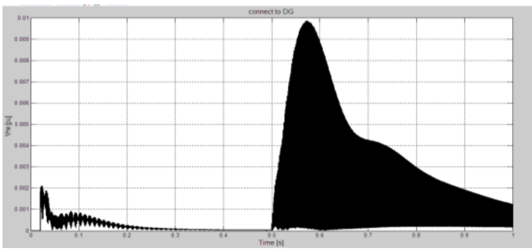

Figure 11. Negative sequence component values of the voltage and the characteristic of this component when disconnects DG with the power system

2. Change the load in power system

This is the sudden load change condition. Where suddenly load is changed up to 50%.

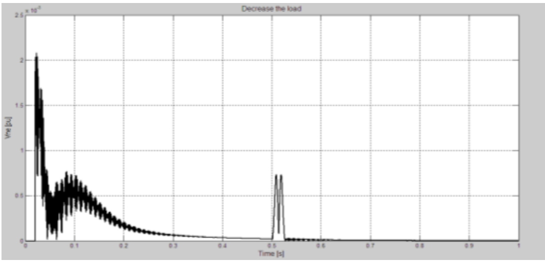

Figure 12. Negative sequence component values of the voltage and the properties of this component off when reduces the load to 50%

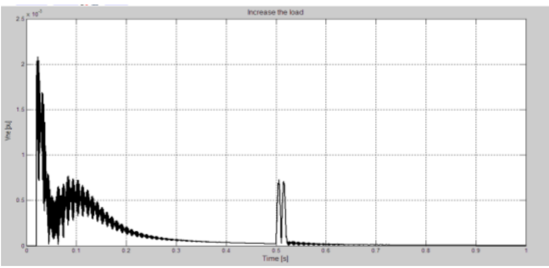

Figure 13. Negative sequence component values of the voltage and the properties of this component off when increases the load to 50%

3. Disconnect/connect the capacitor

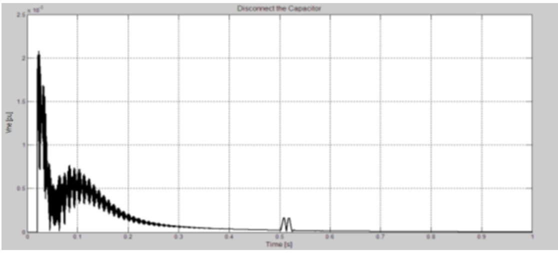

Figure 14. Negative sequence component values of the voltage and the properties of this component off when disconnects capacitor with the power system

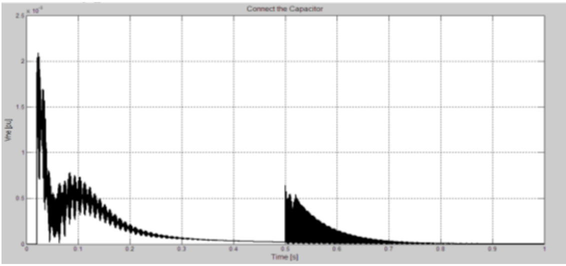

Figure 15. Negative sequence component values of the voltage and the properties of this component off when connects capacitor with the power system

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4. Asymmetric load

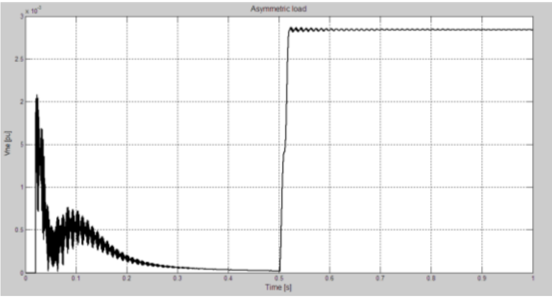

Figure 16. Negative sequence component values of the voltage and the characteristic of this component when the load is asymmetrical

5. Short circuit asymmetry

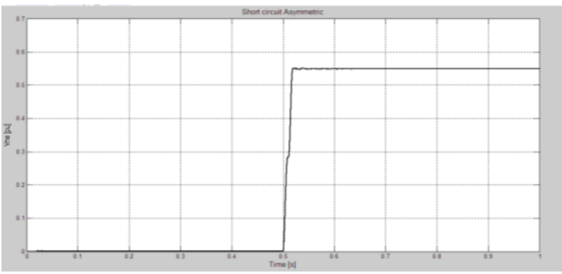

Figure 17. Negative sequence component values of the voltage and the characteristic of this component when the system occurs short circuit asymmetry

6. Disconnect the DG with the distribution grid, this case is islanding operation.

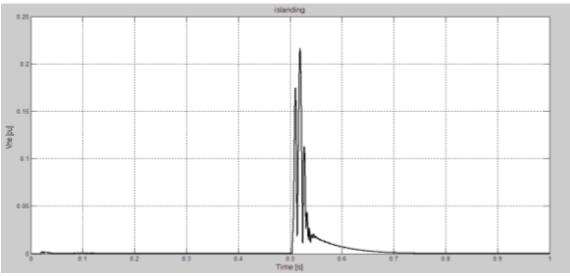

Figure 18. Negative sequence component values of the voltage and the characteristic of this component when during islanding

From the assumed the operation of the above condition, we have the general simulation results as table 2.

Table 2: General table the results measured after simulations

The cases of operation		The maximum value of negative sequence component of the voltage (pu)	The value negative sequence component of voltage at the moment that way voltage components reaches the maximum value after 0.1 s (5 cycles) (pu)
Disconnect/connect DGs to the grid	Connect DG3 with the power system	0.0099	0.0044
	Disconnect DG3 with the power system	0.0021	3.1705e-004
Change the load in power system	Increases the load to 50%	0.0021	3.1705e-004
	Reduces the load to 50%	0.0021	3.1705e-004
Disconnect/connect the capacitor to the grid	Disconnect the capacitor to the grid	0.0021	3.1705e-004
	Connect the capacitor to the grid	0.0021	3.0803e-004
Asymmetric load		**0.0029**	**0.0029**
The maximum value		**0.0099**	**0.0044**
Islanding condition	Disconnect the DG with the distribution grid	**0.2163**	**0.0053**
Short circuit asymmetry		**0.5518**	**0.5518**

From table 2, we see that the maximum value of negative sequence component of voltage is 0.0099 pu and the value of negative sequence component of voltage at the moment that way voltage components reaches the maximum value after 0.1 s (5 cycles) is 0.0044 pu (except the islanding operation case and the short circuit asymmetry case).

For the case of asymmetric short circuit, the value of negative sequence component of voltage is largest. This value is almost not reduced after 0.1 seconds since the power system occurs the asymmetric short circuit and the overcurrent protection relay will recognize this fault case. Therefore, to distinguish the islanding operation case with the case of asymmetric short circuit and these cases of another operation that has been in the simulation, we give the value threshold to detect the islanding condition as follows:

$$0.0099\text{pu} < V_{2set} \leq 0.2163\text{pu}$$

IV. CONCLUSION

This paper analyzed the effects of distributed generations on distribution grid in Vietnam. In particular, the islanding should be most concerned because this problem affects the quality of power electricity on the grid. Therefore, the islanding needs to be detected quickly.

The paper applied an islanding detection method using a negative sequence component of voltage combined with a damping characteristic of this component can detect the islanding condition exact and doesn't operate wrong when occurs the disturbance in power system on the distribution grid in the islands of Vietnam.

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