NON-DETECTION INDEX OF ANTI-ISLANDING DEVICES

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Abstract— **In order to get the better power quality and the reliability and to satisfy the customer requirements, the protection of the power system is very much important. So the power industry should go for the advance methods to ensure the protection there by the reliability of the power distribution. Since distributed generator seems to be given a high momentum to the industry it has been used to improve the quality of the power distribution. An important requirement to interconnect a DG to the power system is the capability of the DG to detect the islanding. If the portion of the power system is electrically isolated then it is said to be islanded. If the DG failed to detect the system is been islanded it will affect the protection of the power system. So it is important to use the better detecting device in the DG in order to detect the islanding in the appropriate time. Hence it is called Anti-islanding devices. The effectiveness of the Anti-islanding device decides the fast detection of the islanding .This helps the power system engineers to decide which Anti-islanding protection scheme can be used for the power system at various conditions and at various load conditions.**

Keywords— **Distributed Generator, Intentional islanding, Anti-islanding, Non-Detection Index, Passive Anti-Islanding Devices.**

I. INTRODUCTION

IN power system networks the load is been supplied by the utility via the Distributed Generator. When the DG is connected to the power system it is important to resolve its protection issues. The DG may be commonly affected by short circuit voltage variations, transients, islanding conditions etc. Islanding is the main phenomena which seriously affects the DG thereby the total power system. The islanding condition occurs, when the Distributed Generator is electrically isolated from the utility but still it continues to supply the loads. This situation is called islanding. To prevent the DG from this situation, protective devices must be used in the power system. These devices used to detect the islanding condition. These devices find out the islanding according to the variations of the system parameters. Hence it is called as Anti-Islanding devices.

(i) Active techniques
(ii) Passive techniques
(iii) Hybrid techniques.

Among these techniques, passive islanding techniques seems to be give a better performance [1,2]. Passive techniques, works on the variations of active power, voltage, frequency etc.

Following are the some of the passive anti-islanding techniques.

(i) Rate of change of power
(ii) Rate of change of frequency
(iii) Rate of change of frequency over power
(iv) Harmonic distortion

Among these techniques frequency based relays gives the better performance [3,4].

In this work two of the passive anti-islanding techniques are used to detect the occurrence of the islanding. The performances of the devices are compared at various conditions using the EMT simulations. This will be useful for the power system engineers to choose the appropriate Anti-islanding Devices for the power system networks.

After the occurrence of the islanding the distributed generators must be disconnected within 100 to 200 ms [5,6]. So there may exist a time period at which the islanding situation is not detected by the Anti-islanding devices. This time period is called as the Non-Detection Zones [7,8]. So to find out the accurate non-detection period, it is important to find out the Non-Detection Zones.

II. ANTI-ISLANDING DEVICES

Frequency based Anti-Islanding devices are used to detect the islanding in the Distributed Generator.

(i) Frequency relays: The frequency relays calculate the absolute frequency and compared with the under frequency and over frequency ranges and according to the difference in the frequency the device gets activated.
(ii) Rate of Change of Frequency Relays:

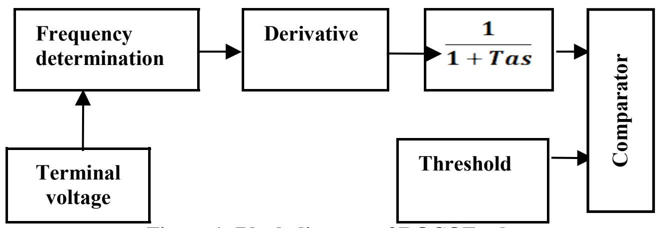

Figure 1: Block diagram of ROCOF relay

Here the islanding is detected using the Rate of Change of Frequency df/dt , the Rate of Change of Frequency is calculate for few cycles . If a loss on the system occurs, the initial rate of change of frequency is determined by the amount of stored rotational kinetic energy on the system. The initial RoCoF is inversely proportional to the stored kinetic energy on the system. The islanding has been intentionally created at various timings using the reclosers. Frequency relay and the ROCOF relays have been used as the Anti-Islanding devices. The performances of the two devices are compared.

II.1.DF/dt minimum & maximum setting:

The dF/dt setting range is dependent on the sample time setting are taken from the references [11,12]. Outside the specified setting range the rated accuracy is not met.

II.2.Df/dt function logic options:

Two global logic options are available in the relays.

The OR logic function requires either the frequency step element OR the dF/dt element to time out for the stage output relay to operate. The AND logic function requires both the frequency step element AND the dF/dt element to time out for the stage output relay to operate. Then the signals are being filtered and used to calculate the islanding. Normally the ROCOF relay senses the Stability factor of the frequency. Hence it is important to connect the ROCOF relay for the fastest detection. Usually the ROCOF relays gives the better performance when it is connect adjacent to the Distributed Generator.

III. PROPOSED TECHNIQUES

The following system is used for this study. Here reclosers are used to make the intentional islanding.

This power system model for islanding detection is developed with the PSCAD/EMTDC simulation. To generate the islanding situation number of reclosers has been connected between the buses, various loads have been served by the utility. The distribution generator is connected to the system and the breaker is used between the utility and the DG for the islanding purpose. There is a rate of change of frequency standard of 0.5Hz/s defined in the Grid Code in Ireland for all plant connected to the power system.

Figure 2: Single line diagram for the power system used

3.1. Recloser operations:

The reclosers RC1,RC2, RC3, RC4 and the breaker settings are changed at various timings and the performance of the system is absorbed. The intentional islanding is made by open the breaker at 4ms. The graphs are obtained at various load conditions.

3.2. Non-Detection Zones:

Non detection index is defined as the time period during which the islanding is not been detected. The non detected portion is called as the non detection zones. The period and the non detection area can be calculated using formulas.

Simulation can also be used to find the Non-Detection Index and the Non-Detection Zones. But comparatively it consumes more simulation time. The following formulas have been used to find out the Non-Detection Zones.

$$\Delta t_{p-G} = \Delta t_{p-RC01} \cup \Delta t_{p-RC02} \cup \Delta t_{p-RC03} \quad (1)$$

Δt_{p-G} is the total time period that the system is unprotected

Δt_{p-RC01} is the time period at the which the system is unprotected due to RC1. The non detection index can be estimated using the formula,

$$I_{ND} = (\Delta t_{p-G} / T) \times 100\% \quad (2)$$

This given index I_{ND} expresses the percentage of time over a period T that the system is unprotected against the islanding due to the operation of ay islanding.

The non detection zones are found out using the following formulas. Here the upper limit and the lower limit for the load for the generator are derived. Using that as a reference the time period is been calculated.

$$\Delta_P = (P_g - P_{load}) / P_{rg} \quad (3)$$

Where,

P_g is given as the generator load

P_{rg} is the rated load of the generator

$$t_{de} = (2 \times h \times R_{s2}) / (abs\Delta_{pi} \times 60) + t_r + t_{id} \quad (4)$$

$$t_{davg} = t_{dvag} + t_{de} \quad (5)$$

$$P_{g1} = P_g - abs(\Delta p_1) \quad (6)$$

$$P_{g2} = P_g + abs(\Delta p_2) \quad (7)$$

Where,

t_{id} intentional time delay,

R_{s2} over frequency time delay.

Using the equations the non detection time period is been calculated. The above equations used to find out the limits of the load to the generator. The curve lies between these limits is termed as the non detection period.

IV. RESUTS AND DISCUSSIONS

4.1. Recloser 1 (RC1):

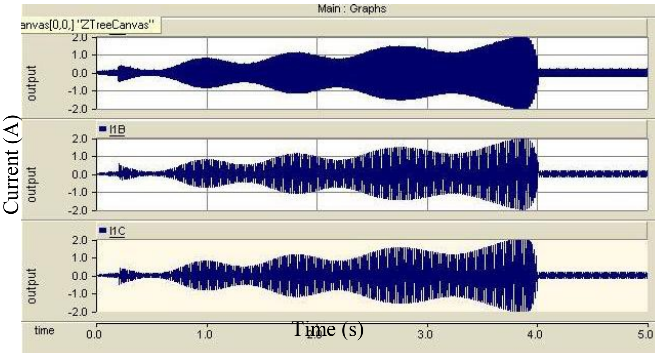

Figure3: Output of Recloser 1

The recloser1 is connected between the source and the bus1. The recloser RC1 is closed at 0s, so the power flow is normal till the bus1. The load of 1MW is connected in the bus1.The current curve at the moment of the RC1 operation is given in the figure 3.

4.2. Recloser 2 (RC2):

Recloser2 is connected between the bus1 and the bus2. The bus2 is serving the load of 2MW. The RC2 is opened at 2ms. And the output is been observed.

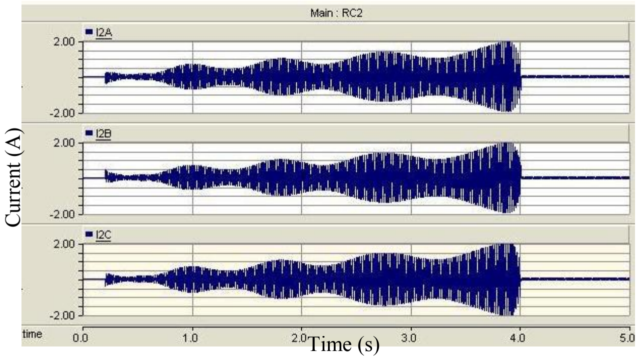

Figure4: Output of the Recloser 2

4.3. Recloser 3 (RC3):

The islanding is created intentionally in the recloser3 which is connected between the bus3 and bus4. The islanding is created at the time of 4s after the utility is been started to serve the system. After 4s the recloser opened and the bus4 is islanded from the utility and is been served by the Distributed Generator. The frequency variation of the system during the islanding condition is given in the figure 5.

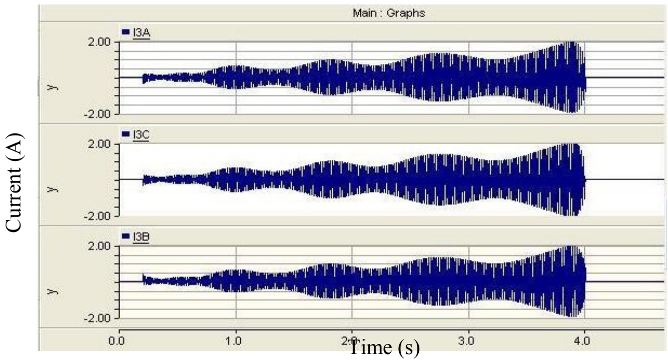

Figure5: Operation of Recloser 3

4.4. Breaker:

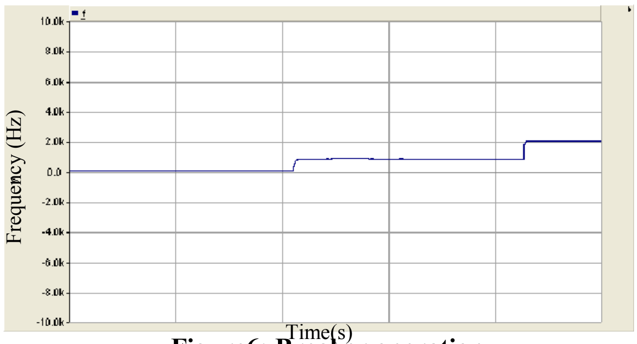

Figure6: Breaker operation

The DG is been intentionally islanded using the breaker which is connected to the DG and the utility. Here the breaker is opened at 4s and the DG is made islanded from the utility. Now the local loads are served with the DG. From the figure6 the performance of the breakers at the time of islanding can be seen.

4.5. Results with frequency relay:

The detection time of the frequency relays is given in the figure7. The islanding is occurred at the time of 4s, and the Anti-islanding device is detected the islanding condition after 1.06s. The time, at which the status of the relay changes from "0 position to 1" position because of the islanding, is shown in the graph.

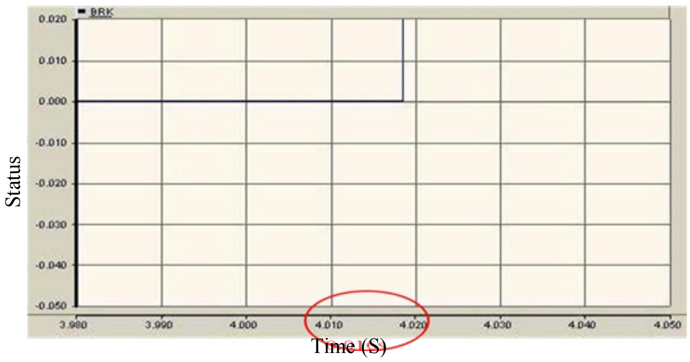

Figure 7: Performance of frequency relay

4.6. Results with Rate of Change Of Frequency Relay:

The figure 8 shows the detection time of the ROCOF the relay. The islanding is occurred at 4s. And the device detected the islanding at 4.007s.That is within 0 .007 seconds. This is faster than the normal frequency relay.

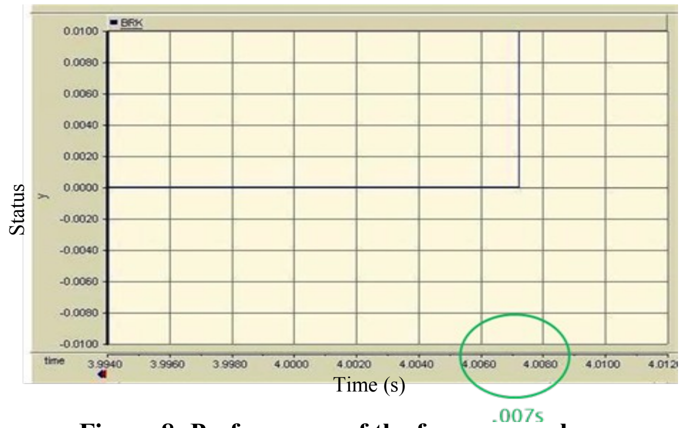

Figure 8: Performance of the frequency relay

4.7. NON-DETECTION ZONE:

Non detection zone is the time period during which the islanding situation is not detected by the Anti-islanding devices. This time period is calculated using following formulas. The graphs are drawn using the MATLAB programming.

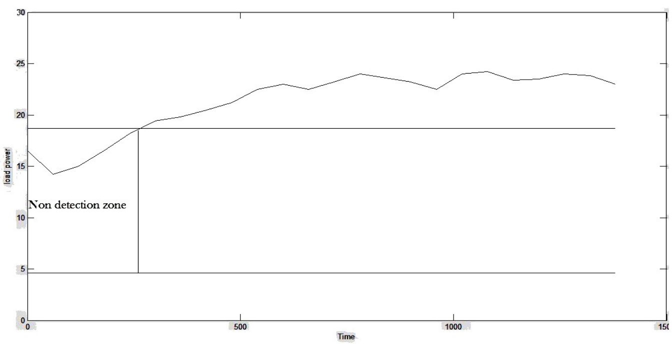

Figure 9: Non detection zone for the load of 10MW

The figure9 shows the Non-Detection Zones of the Anti-islanding devices at various load conditions. Figure represents the Non- detection zone while the load of 10MW connected to the bus. At the intersection point of the curve the system is working in the normal condition, i.e., the islanding is been found at that time so the load and the demand is been satisfied. Before the intersection point, the DG is in islanding condition and it not been found out by the Anti-islanding devices.

V CONCLUSION

The work concluded that , when comparing the two Anti-islanding devices used to detect the islanding, the device with Rate of change of frequency relay having the faster detection time when compared with the normal frequency relay. Since the DG may often get islanded due to the faults, this is very important to provide better protection schemes for the better reliability and quality and also to protect the Distributed Generator. The Non detection zones that are found by the formulas are useful to the power system engineers to provide the proper protective schemes for the power system. This work can be extended for the Large power system networks and various Anti-islanding Schemes and devices can be analysed for various conditions of the power system.

REFERENCES:

[1]. Prakash K. Ray, Student Member, IEEE, NandKishor, Member, IEEE, and Soumya R. Mohanty,Member IEEE. *"Islanding and Power Quality Disturbance Detection in Grid-Connected Hybrid Power System Using Wavelet and –Transform"* , IEEE TRANSACTIONS ON SMART GRID, VOL. 3, NO. 3, SEPTEMBER 2012.

[2]. Walid El-Khattam, Member, IEEE, Amirnaser Yazdani, Senior Member, IEEE, Tarlochan S. Sidhu, Fellow, IEEE, and Ravi Seethapathy, Senior Member IEEE*, "Investigation of the Local Passive Anti-Islanding Scheme in a Distribution System Embedding a PMSG-Based Wind Farm",*. IEEE TRANSACTIONS ON POWER DELIVERY, VOL. 26, NO. 1, JANUARY 2011,

[3]. Hua Geng, Member, IEEE, Dewei (David) Xu, Member, IEEE, BinWu, Fellow, IEEE,
and Geng Yang, Senior Member, IEEE. "*Active Islanding Detection for Inverter-Based Distributed Generation Systems With Power Control Interface"* IEEE TRANSACTIONS ON ENERGY CONVERSION, VOL. 26, NO. 4, DECEMBER 2011.

[4]. Josep M. Guerro, Ferde Blaabjerg, Toshko Zhelev., *" Distributed Generation Toward a New Energy Paradigm",* IEEE INDUSTRIAL ELECTRONICS MAGAZINE, MARCH 2010

[5]. Jose C. M. Vieira, Member, IEEE, Walmir Freitas, Member, IEEE, Wilsun Xu, Fellow, IEEE, and Andre Morelato, Member, IEEE. *"An Investigation on the Non detection Zones of Synchronous Distributed Generation Anti-Islanding Protection",* IEEE TRANSACTIONS ON POWER DELIVERY, VOL. 23, NO. 2, APRIL 2008.

[6]. Luiz A. C. Lopes, Senior Member, IEEE, and Yongzheng Zhang, Student Member, IEEE. *"Islanding Detection Assessment of Multi-Inverter Systems With Active Frequency Drifting Methods*" IEEE TRANSACTIONS ON POWER DELIVERY, VOL. 23, NO. 1, JANUARY 2008.

[7]. Jose C. M. Vieira, Student Member, IEEE, Walmir Freitas, Member, IEEE, Wilsun Xu, Fellow, IEEE, and Andre Morelato, Member, IEEE.*"Performance of Frequency Relays for Distributed Generation Protection",* IEEE TRANSACTIONS ON POWER DELIVERY, VOL. 21, NO. 3, JULY 2006.

[8]. Walmir Freitas, Member, IEEE, Zhenyu Huang, Member, IEEE, and Wilsun Xu, Senior Member, IEEE. , *"A Practical Method for Assessing the Effectiveness of Vector Surge Relays for Distributed Generation Applications"*, IEEE TRANSACTIONS ON POWER DELIVERY, VOL. 20, NO. 1, JANUARY 2005.

[9]. Zhihong Ye, Member, IEEE, Amol Kolwalkar, Member, IEEE, Yu Zhang, Pengwei Du, and Reigh Walling, Senior Member, IEEE., *"Evaluation of Anti-islanding Schemes Based on Nondetection Zone Concept"*, IEEE TRANSACTION ON POWER ELECRONICS. VOL.19, NO.5, SEPTEMBER 2004.

[10]. Fu-Sheng Pai and Shyh-jier Huang, Member, IEEE. *"A Detection Algorithm for Islanding- Prevention of Dispersed Consumer-Owned Storage and Generating Units".* IEEE TRANSACTION ON ENERGY CONVERSION, VOL.16, NO.4, DECEMBER 2001.

[11]. Diogo Salles*, Student Member, IEEE*, Walmir Freitas*, Member, IEEE*, Jose C. M. Vieira*, Member, IEEE*, and Wilsun Xu*, Fellow, IEEE," Nondetection Index of Anti-Islanding Passive Protection of Synchronous Distributed Generators",* IEEE TRANSACTIONS ON POWER DELIVERY, VOL. 27, NO. 3, JULY 2012.

[12]. R. A. (Reigh) Walling*, Fellow, IEEE*, Robert Saint*, Senior Member, IEEE*, Roger C. Dugan*, Fellow, IEEE*, Jim Burke*, Fellow, IEEE*, and Ljubomir A. Kojovic*, Senior Member, IEEE, "Summary of Distributed Resources Impact on Power Delivery Systems",* IEEE TRANSACTIONS ON POWER DELIVERY, VOL. 23, NO. 3, JULY 2008.