

# An Anti-islanding Technique for Protection of Distribution Generation

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**Abstract**—This paper presents distribution generation (DG) different size and technology connecting to distribution networks in a system, and perturb associated with out-of phase reclosing operation, anti-islanding sustained to be an cause where no clear solution exists. This concept shows an auto ground approach that is proposed in the DG protection. An exemplification system is constructed by using the standard distribution apparatus and a recluse controller and the distributed generators were tripped through the high-speed communications circuit and were blocked from closing back it is tested on the utility's distribution test line model to a protection. The operation shows anti-islanding detection time is approximately a cycle longer than the delay associated with the application of the auto ground. Once the auto ground is applied, the DG is disconnected within 4 cycles on over current protection and applies to all DG types, the concept is inherently scalable, is confiscable to various reclosing operations and does not require additional equipment or setting changes at the producer's site, and reduces the cost of equipment.

**Index Terms**— Distributed generation, perturb, recloser, auto grounding, islanding.

## NOMENCLATURE

DG	Distributed generation
AG	Auto Grounding
SS	Sectionalizing switch
AS	Auto ground switch
AC	Auto ground control
BK	Substation Breaker
RCL	Recloser logic
RE/CL	Inline Recloser
T	Synchronizing torque
Ni	Neutral current
Sg	Synchronous generator
T <sub>G1</sub>	Step-down transformer
T <sub>G2</sub>	Step up transformer
Σ	Distribution operation
NDZ	Non detective zones

## INTRODUCTION

THE fast acting of distributed generator has grown over the past decade and some utilities have reached very high penetration levels. Despite this experience the debate between utilities and private producers still rages on a number of technical issues. Possibly the

most contentious is that of anti-islanding protectio, a reliable high speed communication based transfer-trip scheme and a local passive approach methods, that relies only on the measurements of the voltage wave form is represent islanding respectively, the most conservative and modern approaches. The anti-islanding system and line protection are the two fundamental protection requirements that need to be met by all distributed generation

(DG) installations, as detailed in the DG interconnection standardsLine protection consists of being able to detect all faults on the distribution feeder to which the DG is connected, while not disconnecting for faults on an adjacent feeder. Generally over current relaying is sufficient to meet this requirement, although in power electronic based generators, other strategies may be necessary due to the limited contribution to short circuits by these installations.

Anti-islanding has been the subject of a number of studies these approaches can be typically divided into the following two classifications: passive approaches using the local measurements of voltage and current, and variables derived from using these quantities, to delineate between islanding and grid connected operation and active approaches where by the DG perturbs the grid voltage or frequency, an approach intended to be benign while the grid is present, and to destabilize the system when the substation is open. A third approach is in fact a variant on communication based approaches, whereby using thyristor valves connected to ground, a disturbance is periodically injected at the substation-its presence at the DG's location indicates a normal condition, whereas its absence is indicative of an islanded grid have also suggested these thyristor based devices for fault identification in. Similar to active islanding techniques, this approach could be criticized alone on the impact on power quality. Additionally, in noisy grids or feeders that are particularly long, the issue of nuisance tripping is an issue.

This paper presents an approach to anti-islanding protection that is based on applying a three-phase short circuit to the islanded distribution system just prior to reclosing or re-energization. Provides the theory and methodology for construction of this utility-owned equipment. Anti-islanding protection is required of any distributed generator connecting to the Distribution network, in order to protect against the case that DG

continues to energize the feeder when the utility has opened-creating an unintentional island. An unintentional island, although rather unlikely in real life, could be created by one of two scenarios.

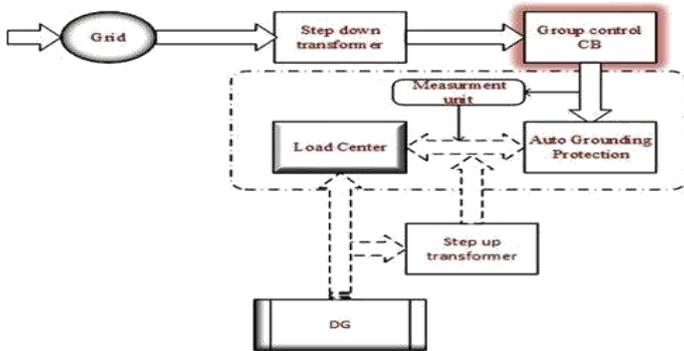


Fig.1. Block diagram of Proposed Schem

**THEORY AND METHODOLOGY**

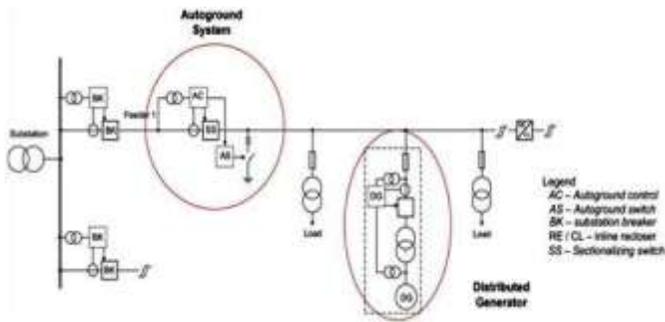


Fig.2. Illustration of the proposed autogrounding system

DG sets / TG sets are finding more and more applications as captive power sources in modern day industrial plants. A DG set owner may decide to connect his DG to the local Electricity Grid supply (ie) the DG will be synchronized to the grid. The main objective here is to feed the plant load will both by the grid as well as the DG set. Whenever a DG is connected to the local grid, there can be two modes of operation as shown in DG is shown connected in parallel to EB power. Plant load is connected to the same bus where both DG and EB are present.

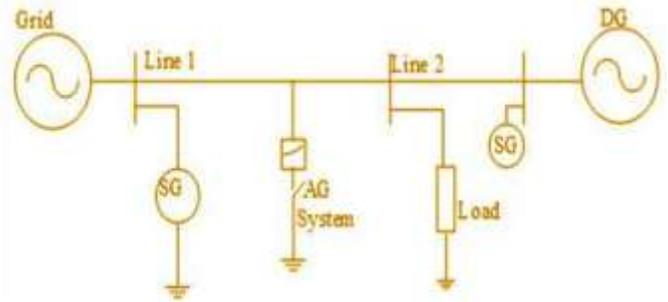


Fig.3. Single line diagram of the simulation system

The first case is a result of the inadvertent opening of the substation feeder breaker/recloses are one of the protection devices further down the feeder. This could be done in error or as a planned operation where the utility personnel do not realize that there is a DG present on the line. Eventually the line is re-energized and the risk of out-of-phase reclosing exists, if the DG remains online. The second, even less likely situation would be a temporary fault that leads to operation of the utility protection device, but the DG’s protection does not operate before the self-clearing fault extinguishes, creating the temporary island. For example a tree branch might touch the line and it is clear at the moment the vacuum bottle interrupter of a Recloser operates. Although less likely, the latter of the two cases is generally used to define the anti-islanding requirements, which links the requirement to first period relaxing time of the local utility typical first operation releasing time off, although some are as fast as 0.5 s. This defines the speed at which the DG’s anti-islanding protection must detect the island. Provides a comparison of the different types of anti-islanding approaches and the implications in terms of equipment, the installation site, relative cost, and pros and cons of each. The solution proposed in the present work, termed an auto ground, is seen as a compromise in terms of cost and performance between the transfer-trip and local passive measurements. Presents the autoground concept, where the autoground system is installed just down the line of the utility protection device (substation breaker or in-line Recloser). In this configuration, following the opening of the utility breaker, the autoground opens the substation side device, denoted sectionalizing switch (SS) and closes the auto grounding switch (AS) effectively applying a three phase to ground fault.

All DGs that have not already disconnected based on their anti-islanding protection will be forced to disconnect based on online protection. Here it is assumed that the DG’s line protection has been properly configured in order to detect all faults, as required by In the case of inverter based DG, over current protection alone may not be sufficient and more advanced functions such as over current with voltage restraint may be required. However, the focus of the present work is on the validation of the concept. Following application of the autoground for the predefined time, it then flips states, opening AS following by closing of its SS. The utility breaker, then re-energizes the system, without a risk of out-of-phase reclosing.

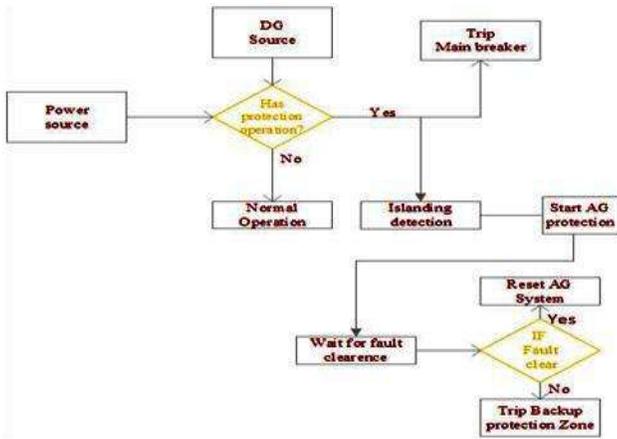


Fig.4. Flow chart of the anti-islanding protection

Distribution Apparatus

The autoground system consists of three main components: the sectionalizing switch the autoground switch, and the controller, which can be implemented using a variety recloser or breaker controls. Here we describe each of these components in turn the SS is required only to mirror the state of the substation breaker. It is preferable to have the SS as a separate device for the simple reason that costs escalate when work within the substation is required. Any savings associated with the integration of the SS function into the feeder breaker would be outweighed by the cost of linking it with the AS. In this case, it is not required to interrupt fault current so any device that can provide automated sectionalized capabilities would be sufficient. For applications where the outgrown is paired with an in-line Recloser, the SS is not required as its functionality can simply be integrated into the Recloser it.

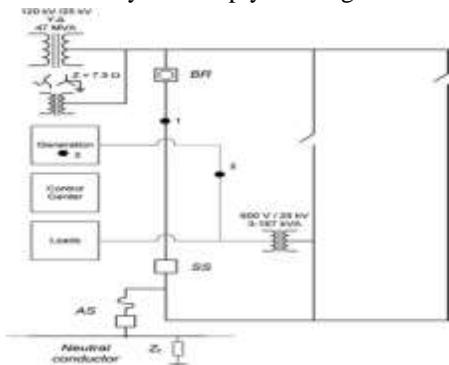


Fig.5. Distribution test line model of Autogrounding operation

Illustrates the vacuum bottle based recloser used in the experimental set-up as the SS. As the AS is connected in parallel with the distribution network only in order to apply the fault, it does not need to interrupt fault current either. As a result, the apparatus is even simpler, and is realized by a slight modification to an automated capacitor bank assembly. It automatically detects the absence of a power line carrier signal

when the distributed generator becomes electrically isolated (i.e. islanded) from the utility grid due to, for example, the opening of a breaker in the grid. With the knowledge of this situation, distributed generators are automatic disconnected from the grid in a timely manner for safe operation

Analysis of the corresponding equations

$$X_{fmr} FLA = (KVA * 1000) / (E_{L-L} * 1.732)$$

$$*3\text{-Ph } I_{sc \text{ at } X_{fmr}} = (((KVA/1000) * MVA) / (1.732 * E_{L-L})) * 100 / Z \%$$

$$3\text{-Ph } I_{sc \text{ at fault}} = I_{sc \text{ at } X_{fmr}} *$$

Where:

$E_{L-L}$  = phase to phase voltage

$Z$  = transformer nameplate impedance

$I_{L-L}$  = available 3-phase SC current

III. SIMULATION RESULTS

A. AG and opening and closing operation

Test Condition	Select Range	AS Opening & Closing Time (S)	Consideration
Feeder	25 KV	10, 11.1	4 times faster operation & closing time <(1.1) S
DG	600V/ 25KV	10, 11.1	

Autoground sectionalizing switch closing and opening logic.

The technique is conducted on proposed distribution test line model, configured according to The autoground system is installed at the end of the first feeder. The synchronous generator is connected to the second feeder through a 600 V/25 kV transformer, as indicated.

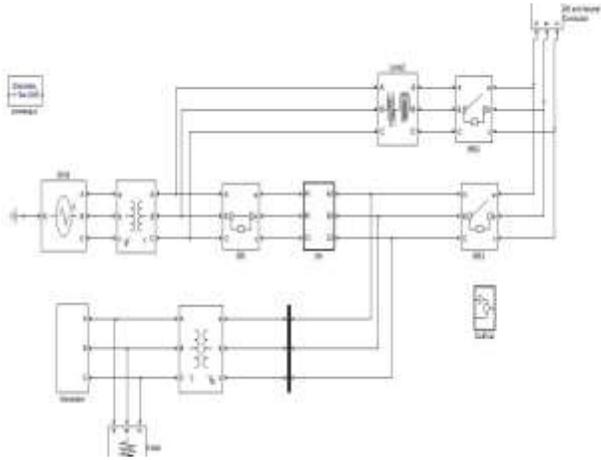


Fig.6.The Monitoring of Proposed anti islanding technique

The parameters of the synchronous generator and the overcurrent protection are provided in the Appendix.Switches on feeders 2 and 3 were opened in order to feed them both from feeder 1.The testing consisted of first synchronizing the generator, balancing its output power with the 150 kW load and then initiate opening of the SS for three different configurations of the autoground with all three fuses in service; with one fuse removed;and with two of the three fuses removed.

**SYNCHRONOUS GENERATOR PARAMETERS**

SG (KVA)	PG (KW0)	VG (V)	IG (A)
250	200	600	240

**RESULTS FOR SYMMETRICAL ASYMMETRICAL OPERATION OF THE AUTOGROUND**

Test Conditions	Peak current at 600V [A <sub>peak</sub> ]	Step Vtg at 1m [V <sub>peak</sub> ]	Neutral Current [A <sub>peak</sub> ]
Three phase	3500	0.729	92
Two Phase	3900	3.608	394
Single phase	4100	3.438	856

Synchronized data were acquired using the data Acquisition system, monitoring the following parameters: three phase currents and voltages at 25 kV (point 1), 600 V (point 2) and the generated torque (point 3). Additionally, measurement of the ground voltage at 1 m, 5 m and 75 m (taken to be the zero reference) is performed in order to investigate the earth voltage rise during operation of each of the cases. The paper

further investigated the characteristics of the anti-islanding signal. Key factors that can affect the signal strengthen, attenuation and frequency are identified.Based on the findings, three signal detection algorithms are proposed.The algorithms are tested using simulated waveforms.

**B. Results**

The simulation results for the three cases are summarized in The magnitudes of the peak current (which includes the DC component) are given, along with step voltage measured at 1 meter, and the neutral current. Torque measurements were taken but they are not presented as the reading saturated in each case at 45 N m.

As can be noted, the magnitude of the phase current is roughly equivalent for the three cases; however, the neutral current is much higher, as expected, for the unbalanced autoground cases. This is reflected in the step voltage measurement, are the measured value represents no issue. illustrates the case for balanced operation of the autoground that is,with the three fuses in operation. The SS is opened at roughly 11.1 s and the AS is closed less than 90 cycles later (1.1 s) (As can be noted, there is little change in the magnitudes of the voltages and currents of the synchronous generator due to the fact that load and generation are well balanced.Three phase voltages (top) and

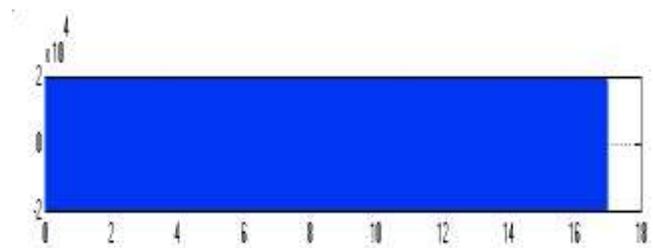


Fig. 7a. Substation voltages (top ) during opening of SS and application of the AS.

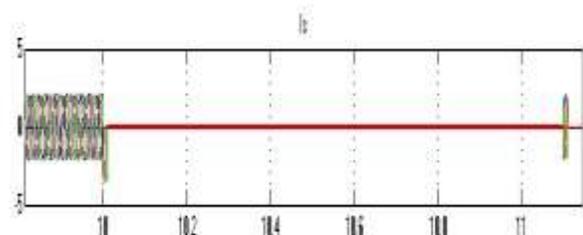


Fig. 7b. Substation currents (bottom) during opening of SS and application of the AS.

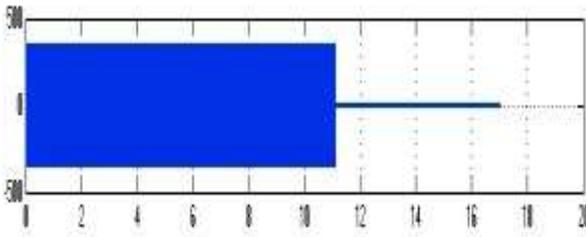


Fig. 8a. . Three phase voltages (top) of synchronous generator during opening of SS and application of the autoground

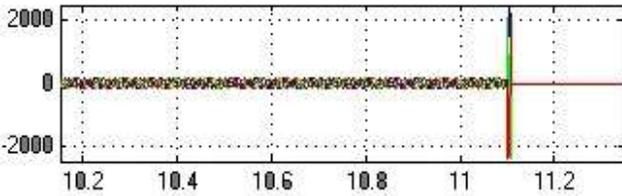


Fig.8b. Three phase voltages (top) and currents (bottom) of synchronous generator during opening of SS and application of the autoground.

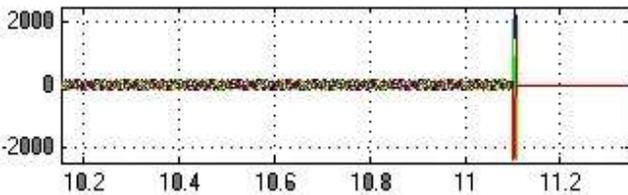


Fig.9.Current waveforms of the synchronous generator during application of the autoground.

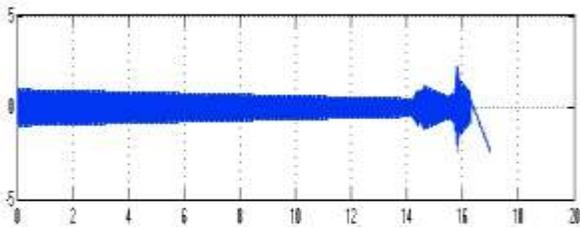


Fig. 9. Torque measurement of the synchronous generator shaft during operation (expressed on the base of the real power prior to the islanding event).

### C. Recommended Practices

The above tests validated that the concept works and that the autoground system can be constructed with readily available distribution apparatus. However, many practical considerations are necessary prior to deploying the solution. First and foremost would be analysis of the impact of the

autoground technology on the local distribution protection philosophy. This would include ensuring that the autoground is compatible with the number and duration of reclosing operations.

This could mean adjusting the various delays mentioned above, or in certain cases, requiring different delays for different reclosing operations. That the autoground should only need to be applied during the first reclosing period. To avoid equipment issues, it would be the best selection of the autoground apparatus. The scheme is also economically attractive to DG owners and utilities, especially for systems with multiple DG installations.

This paper investigated the design considerations for the signal generator. A set of design formulas is established. Typical signal generator parameters are illustrated using actual system data. The proposed scheme can be implemented using other signalling techniques. Developing a signalling technique that can take advantage of the simple requirement of anti-islanding signalling to reduce the cost of signal generator is still opening of any components. This has resulted in a significantly simplified \_Auto grounding scheme. In addition, a subject worth research.

### CONCLUSION

This paper is presented a new and powerful anti-islanding protection concept and associated scheme for Utility and DG applications. However, the signal is sent through power line, which makes the scheme applicable to any distribution systems regardless the availability of signal detection means. More importantly, since the signal passes through any switches, breakers and other open able components connected between the substation and DG sites; the scheme is able to detect automatically.

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