Islanding Detection of Integrated System using Hybrid ROCOF and Current Injection Technique

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Abstract- Renewable distributed generation (RDG) has become prior now a days due to the insufficient availability of fossil fuels and to reach the global wide energy demand. The other side of Renewable distributed generation systems is breakdown from the power grid can be incurred later being connected to it. Islanding incurs into the system once there is abnormal electrical parameters into the system until then the RDG sustains energy flow to the added load. IEEE 1547 explains time range for the accomplishment of DG interconnection job and one of these jobs is the identifying of islanding, which must be done within two seconds of the job start. This paper gives innovative and effective islanding identifying algorithms for a hybrid DGS connected to the grid. These techniques depend on reactive power injection with positive feedback and the rate of frequency change (ROCOF). In addition, this Non Detection Zone (NDZ) is readily identified using this technique on compared with standard approaches. These techniques depicts a better improvement in their ability to categorise events into islanding and non-islanding cases. The MATLAB/Simulink tool gives a settings to the suggested methods those can be implemented.

Keywords: Islanding-detection, ROCOF, Non islanding, Non-detection zone.

1. Introduction

Scientists are being forced to look at easily accessible renewable energy alternatives as the world's energy supplies continue to run out at an alarming rate and environmental pollution levels climb [1]. Numerous people are thinking about alternative forms of energy, such as fuel cells, hydropower, tidal power, and solar power. Such renewable energy sources are commonplace in the energy harvesting realms of homes and businesses [2]. Because of its many positive attributes—including being environmentally friendly, pollution-free, getting cheaper every year, being readily available in nature, and having a longer lifespan—In the battle against global warming and the production of electricity, distributed generating, or D.G., has become a significant participant [3–4]. Renewable energy sources (RES) are appealing due to their ease of grid synchronization and cheap maintenance costs. In order to meet consumer demands, cogeneration employing renewable energy sources (RES) like solar and wind is common in many businesses [5]. These integrated systems can be connected to the live system or run independently. In the event of a power loss, the loads might be hardwired into the system. To increase efficiency and overcome power quality issues, distributed energy sources require innovative power electronic coherence and regulatory techniques [6–9]. A distributed generation system that uses only one form of renewable energy is unreliable when there are frequent variations. Combining D.G. sources within the same area may allow for the most effective utilization of the numerous scattered energy sources while ensuring a steady supply of electricity [10–11].

Protecting scattered producing units from electrical-islanding and also the major current challenges is connecting with the utility system. This Islanding is a series of steps that which D.G. unit is disconnected from the live system during breaker's isolation, is required by IEEE standard 1547-2018 [12–18]. Islanding leads to the presence of the factors below:

- Suppose the live system has an issue, then gadget will get into turnoff automatically and this is unintentional activation of the usual grid supply.
- Using grid equipment, can be due to human mistakes or intentional troubleshooting.
- Natural calamities such as lightnings, thunderstorms, flooding etc
- Various causes for Islanding identification and prohibition are seen when DG inverters are connected to the grid. Personal safety, sustaining power improvement are the most important factors to avoid islanding. Utilities are meant for reliable power supply. Because of this, anti-islanding is wanted for DG inverters due to following causes:

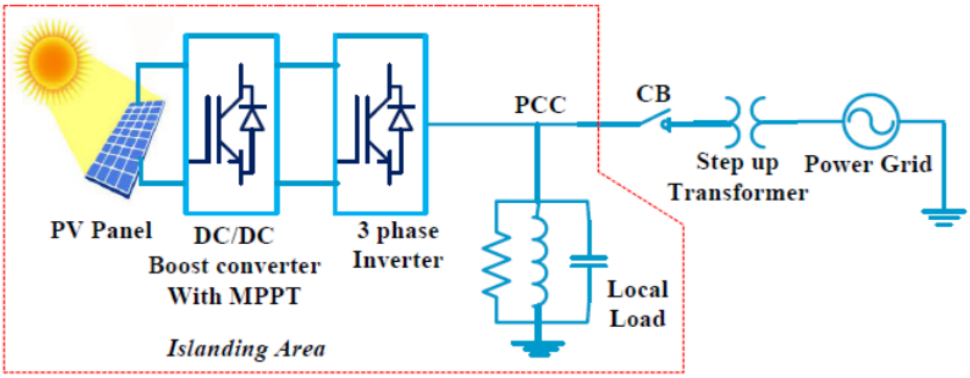

Fig.1: Test system under study

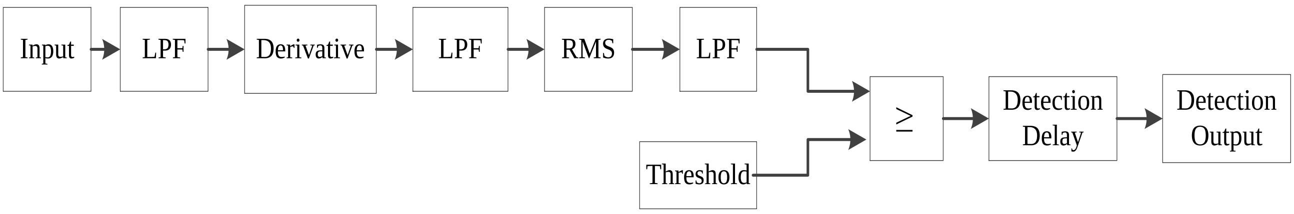

Fig. 2: Identifying islands with a passive ROCOF relay

- Reclosing with an island condition may leads to line restriping, havoc to DG system, havoc to other added equipment because of out of phase reclosing.

Currently, RDGs are the most viable alternative for satisfying the world's total energy demand. DG refers to the RDG system that is linked to the residential power grid. Islanding occurs when an RDG powers a load without grid power [19]. The service staff's ignorance puts field personnel and equipment at risk during the islanding. A tripped circuit breaker (CB) for maintenance, grid difficulties, human error, or a natural disaster are major reasons of unintended islanding [20]. The basic grid interface specifications specifies, include removing the DG supply before two seconds of islanding. Voltage, frequency, active, and reactive powers that depart from norms might affect consumer loads and DG. Methods for detecting islands may be further subdivided into local, remote, and local, active, passive, and hybrid. Active methods can identify islanding by adding a brief perturbation at PCC and monitoring the ensuing fluctuations in the output signal. A system tied into the grid may absorb minor variations without experiencing any major consequences. When the system is separated, however, the output signal varies more. Active solutions that have a lower NDZ are superior to passive options in terms of efficiency, but they degrade power quality. The term "non-effective detection zone" (NDZ) refers to the region or value range that lies outside of the scope of islanding detection methods.

2. The DG Islanding Test Setup

This experimental setup (shown in Figure. 1) was utilised to verify the proposed method of islanding detection. It's a 100 kW solar DG system that uses three-phase power to connect to utility grid at the distribution level [21]. To promote islanding, the CB is triggered at the PCC. Complete IEEE 1547-compliant validation procedure for the suggested technology is here. The first stage in installing a 100 kW system involves linking the photovoltaic system, the use of MPPT boost converters, the inverter, loads, and network [22]. The inverter has a UPF of 1 and is feeding power into the grid while the CB is closed.

Second, the solar DG will automatically shut off the inverter if the voltage or frequency deviates from the IEEE 1547 norms. Third, the CB is intentionally opened at PCC, plots are recorded, and islands are created. Finally, if frequency fluctuations are observed after islanding, RP injection with the opposite sign is used to verify islanding.

3. Method for Identifying Islanding

Active and passive aspects validate IS and NIS occurrences in hybrid islanding detection systems. The passive ROCOF approach can detect islanding if its research state deviates. Active approaches like reactive power injection validate islanding.

3.1 ROCOF Passive Islanding Detection Scheme

A passively ROCOF relay is seen in Fig. 2. At PCC, the voltage signals are decoded using three phase-locked loops (PLLs), which provide the basis for establishing a frequency. Using a measurement window of 500 ms, computes ROCOF and triggers the CB with an alarm signal [23]. If ROCOF" exceeds a threshold. One of the many benefits of this approach is that it rarely necessitates actual physical travel. The ROCOF relay is triggered by frequency shifts and imbalances between PCC's load and generation.

Unfortunately, this approach does not detect balanced islanding.

3.2 Active Islanding Detection via RP Injection

The shape of the RP injection influences the frequency shifts at PCC as the system switches from grid-connected to islanding mode. The current method is injecting a square wave with a duty cycle of 5%. The available power, power quality, and power factor are all suffering as a result of this. Reactive power is injected as a triangle wave at a rate of 1% of the rated current to fix the power quality problems [24-25]. As a result, the amount of reactive power injected is negligible, therefore, it won't affect power quality. PCC has a power factor in (1).

$$P.f = P_{DG} / \sqrt{P_{DG}^2 + Q_{Injected}^2} \quad (1)$$

It is highly unlikely that the system will achieve a power factor of 0.9999 when operating at rated power. When reactive power is injected, either positively or negatively, the frequency deviations go up or lower, respectively.

3.3 Proposed Hybrid ROCOF Relay for Islanding Detection

Both the active approach (discussed in Section 3.2) and the use of a passive ROCOF relay (discussed in Section 3.1) are incorporated into the suggested hybrid island identification system. The test system is connected to the grid while the CB is closed, as shown in Fig. 3, and operates in island mode when the CB is open.

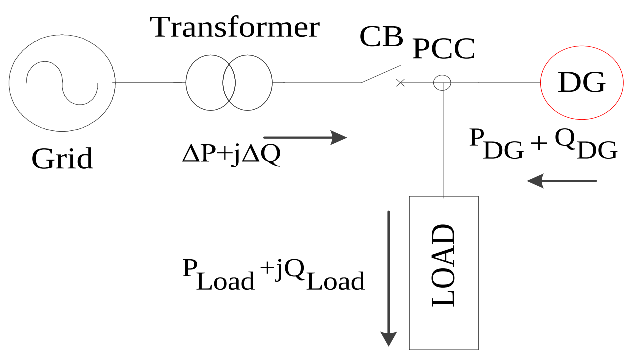

Fig.3: Grid-connected vs. islanding for active (AP) and reactive (RP) powers

The load receives AP and RP in grid-connected mode.

$$P_{Load} = P_{DG} + \Delta P \quad (2)$$

$$Q_{Load} = Q_{DG} + \Delta Q \quad (3)$$

Where P_{Load}, Q_{Load}, P_{DG}, Q_{DG}, ΔP and ΔQ are the AP and RP of the load, the generating set, the distribution grid, the generating set, and the load, respectively. Load AP (4), RP (5), and load impedance (6) at UPF can be expressed as V and f, the grid voltage and frequency, respectively.

$$P_L = \frac{V^2}{R} \quad (4)$$

$$Q_L = V^2 \left(\frac{j}{\omega L} - j\omega C \right) \quad (5)$$

$$|Z_L| = \frac{V^2}{|\Delta P + P_{DG} + j\Delta Q|} \quad (6)$$

The voltage (7) and frequency (8) changes during islanding state, when the CB is opened, can be expressed as

$$V' = \frac{V}{\sqrt{\left(1 + \frac{\Delta P}{P_{DG}}\right)^2 + \left(\frac{\Delta Q}{P_{DG}}\right)^2}} \quad (7)$$

$$R\sqrt{\frac{C}{L}} \left(\frac{\omega'}{\omega} - \frac{\omega}{\omega'} \right) = \frac{\Delta Q}{\Delta P + P_{DG}} \quad (8)$$

The suggested approach must be flexible enough to accommodate these differences if it is to yield credible findings. The suggested hybrid islanding technique incorporates both the reactive power injection and ROCOF passive approaches. By monitoring the minute frequency change brought on by islanding, reactive power may be injected in the correct direction. The d-q controller cannot degrade power quality while connected to the grid since it injects reactive power at UPF. This controller injects reactive power to correct islanding situations The controller injects positive RP when ROCOF grows, and the phase locked loop (PLL) calculates frequency changes (Figure. 4). After stopping at point C, the q controller injects RP in the opposite direction at point D, reducing ROCOF to zero. Under the dot "D" is the islanding.

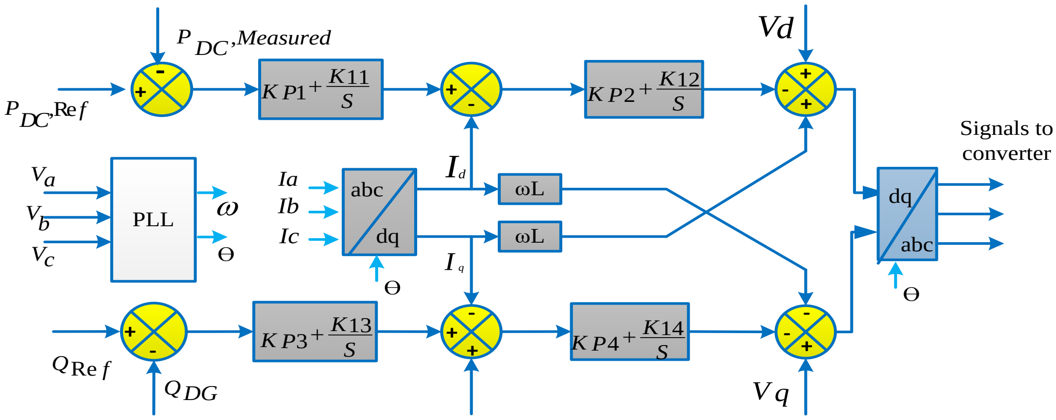

Fig.4: Grid integration and reactive power injection controller circuit

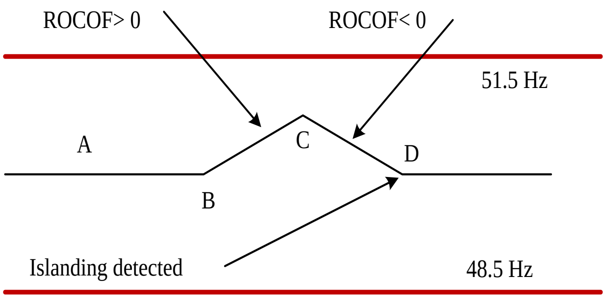

Fig.5: Method for Identifying Hybrid Islanding

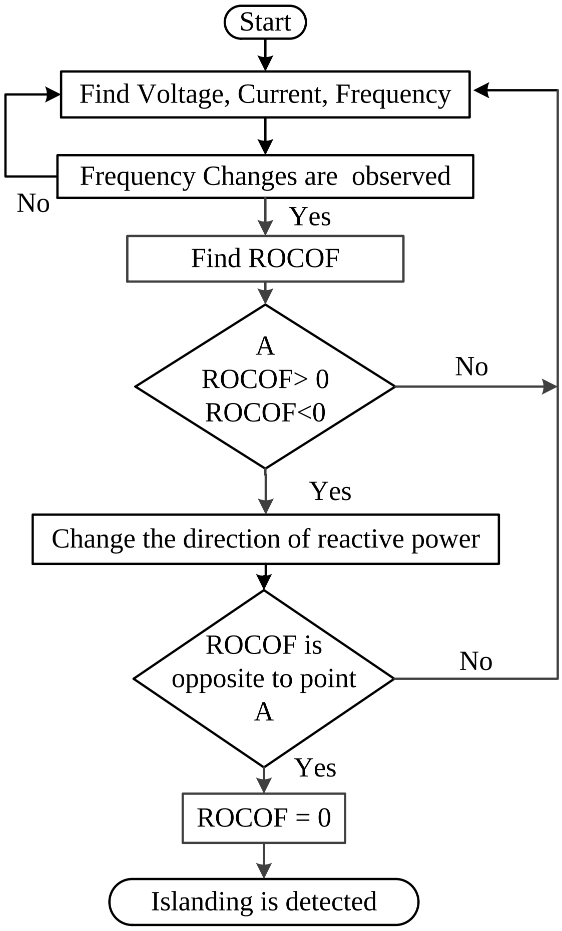

Fig. 6: The proposed hybrid island identification technique illustration.

The proposed hybrid strategy is depicted in a simplified form in Figure. 5. The PCC PLL detects frequency variations. If linked to the network, frequency is constant. The reactive power injection and frequency modulation capabilities of the d-q controller make it a useful tool even in non-coupled systems. Reactive power flows anticlockwise when ROCOF decreases and clockwise when rises RP reversed will zero the ROCOF at the detection position (D). Among the many benefits of this strategy are

- Even when the forces are evenly balanced, it can detect islanding.
- Power quality is not degraded because it cannot continuously inject reactive power.
- it can be simply implemented using a d-q controller, this method has several advantages.
- When compared to other active approaches, the reactive power used is less.

4. Outcomes of a Computer Simulation

Examine a variety of islanding scenarios, giving equal weight to both proactive and RPs. The suggested hybrid tropology uses ROCOF study to detect islanding as well as ROCOF analysis with reactive power injection. Within the conventional ROCOF relay framework, the proposed approach can see balanced islanding with very little power. Fig.7 shows a simulated ROCOF relay's voltage, current, frequency and ROCOF. By injecting negative reactive power, ROCOF is reduced for a capacitive load; conversely, infusing positive reactive power causes ROCOF to rise, revealing islanding.

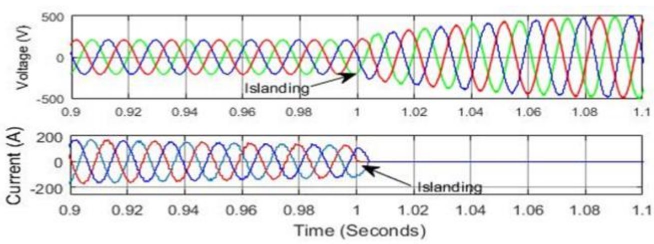

Fig.7: Conventional ROCOF relay voltage, current, frequency, and ROCOF simulation results

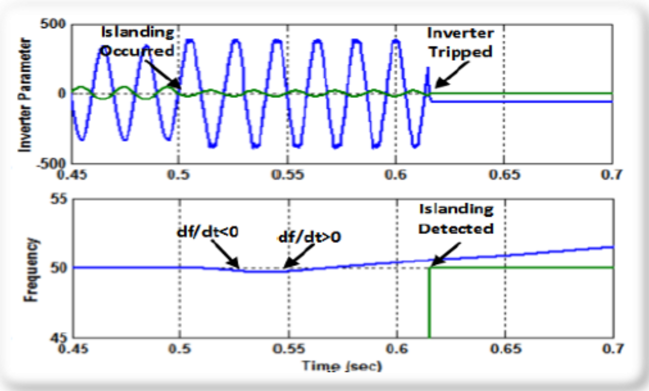

Fig.8: Active power of 33% and capacitive reactive load of 5%, as calculated by computer simulation

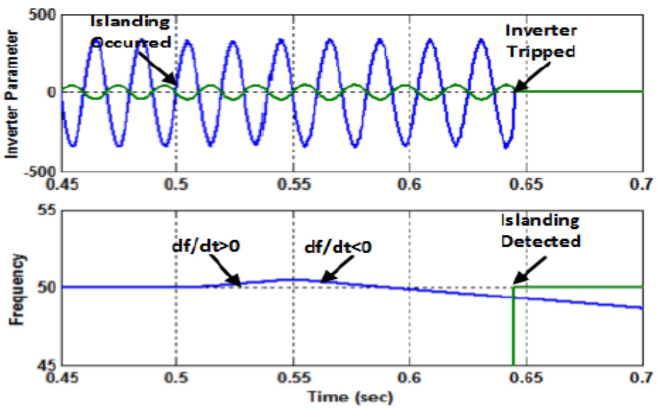

Fig. 9: Active power load simulations at 100% and RP load simulations at 0%

Figure.8 and 9 shows the results obtained for 33% active, 5% capacitive load and for 100% AP power with 0% RP. This shows that the technique can detect islanding even with little or no electrical supply

5. Conclusion

An innovative RP injection-based ROCOF analysis hybrid PID method for grid-integrated solar PV systems is presented in the present section. An active reactive power injection approach proves islanding after passive ROCOF analysis shows post-islanding frequency variations. ROCOF varies positively with capacitive loads because reactive power enters the system favourably. The controller injects reactive power to combat growing positive ROCOF.

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