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RESEARCH ARTICLE

Validation of Passive Islanding Detection Methods for Double Line-to-Ground Unsymmetrical Fault in a Three-Phase Microgrid System

Bangar Raju Lingampalli, K. Subba Rao

Department of Electrical and Electronics, Koneru Lakshmaiah Educational Foundation, Guntur, Andhra Pradesh, India

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ABSTRACT

Microgrid islanding detection has become challenging with the penetration of distributed generation (DG). IEEE-1547-2018 specifies that islanding is to be detected in less than 2 seconds if voltage $0.88 \leq V \leq 1.1$ *p.u.* (per unit) and frequency $49 \leq f \leq 51$ Hz (for 50 Hz) exceed these limits. The available methods of islanding detection are active, passive, hybrid, and communication. The active methods affect power quality due to injections; passive methods have a larger non-detection zone (NDZ); and communication type methods are expensive. The hybrid approach is a combination of the active and passive methods, which also deteriorate the power quality. To obviate all this, this paper proposes the rate of change of voltage phase angle (ROCOVPA) method, a passive islanding detection method which reduces NDZ and detection time when compared to other methods. The methodology is based on retrieving the voltage phase angle at the targeted output of DG first. Then, the phase angle is differentiated to get ROCOVPA to detect islanding and to isolate the microgrid seamlessly from the main grid during unintentional unsymmetrical fault. In this paper, the islanding condition is tested for double line-to-ground fault, which occurs when two lines are grounded. The non-islanding condition is also tested in MATLAB/Simulink with capacitor load connection and disconnection. The simulations are carried on ROCOVPA and compared with the widely used rate of change of frequency (ROCOF) at zero percent mismatch power. The analysis of the results depicts that ROCOVPA is effective and better than ROCOF.

Index Terms—Distributed generators (DG), double line-to-ground fault (L-L-G-Fault), non-detection zone (NDZ), point of common coupling (PCC), rate of change of frequency (ROCOF), rate of change of voltage phase angle (ROCOVPA).

I. INTRODUCTION

The microgrid is meant to feed the loads and import the mismatch power from the grid, which is the normal operation. Based on the load demand, the mismatch power is supplied by the grid. To achieve this, the inverters are designed to operate in constant current control during grid mode and droop control in islanding mode. The microgrid is to be seamlessly islanded from the main grid during unintentional, unsymmetrical, and symmetrical faults and is to be stable during non-islanding periods like load connection and disconnection. To detect these faults, many islanding detection methods already exist. These are active, passive, hybrid, and communication methods. The active methods are good but the power quality is affected due to injections. Passive islanding detection methods are good in view of the power quality as there are no injections; however, they leave behind a large NDZ. The hybrid method is a combination of passive and active methods. The communication methods are good but expensive, and the cost depends on the size of the microgrid and criticality of the loads. To obviate all these drawbacks, a simple passive islanding detection method, ROCOVPA is proposed, to detect faults even at 0% mismatch power. The detection time of ROCOVPA is less than that of ROCOF, according to the results analysis in Section 6.

In this paper, the passive islanding detection method ROCOVPA is tested for detecting unsymmetrical L-L-G fault [1]. This method can also be extended to all unintentional faults. Double line-to-ground unsymmetrical faults occur in the system due to two lines short circuiting and grounding to the earth. This occurs due to the line snapping, falling on another line, and earthing to the ground. This type of fault leads to unequal currents with unequal phase shifts in a three-phase system. The IEEE-1547-2018 standards prescribe that these unintentional faults are to be detected in less than 2 seconds and the microgrid is to be islanded from main grid for stability and to feed power to local loads without interruption [2].

Corresponding author: Bangar Raju Lingampalli, lsmlbr@yahoo.in

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The methodology suggested in this paper is to first retrieve the voltage signals at the targeted DG and estimate the phase angle. Then, the rate of change of phase angle is calculated to detect the fault condition. In the normal condition, the values are within the threshold. However, during fault conditions, the phase angle variations are sufficient to exceed the threshold values and trip the circuit breaker to isolate the microgrid from the main grid. The simulation results obtained during fault conditions, and sudden load connection and disconnection are discussed elaborately in Section 7. The simulation results prove the purpose for which the method is intended. The methodology suggested is justified with the results and comparison with ROCOF [3].

The advantages and disadvantages of the proposed phase angle variation method over the other two methods, ROCOF and ROCOV, are as follows:

A. Advantages

- It is simple to implement.
- It is effective, accurate, and reliable.
- It detects islanding at zero percent power mismatch (0% NDZ).
- It discriminates between islanding and non-islanding, thus avoiding nuisance tripping.
- The detection time is 10 ms, which is lower compared to other methods, and does not depend on frequency and voltage.
- The detection time is almost consistent irrespective of percentage of mismatch power.
- The method does not affect power quality as there are no injections during testing.

B. Disadvantages

- The ROCOVPA method is not suitable for microgrid with hybrid DGs, as proportional load sharing becomes a problem.
- The inverter control topologies have to be designed specially to suit DGs.
- High quality factor loads will have more problems in detecting the islanding condition.
- Loads with resonance frequency which are nearly equivalent to system frequency will also have difficulty in islanding detection.
- This method is not suitable for unbalanced loads.

Main Points

- The main purpose of the microgrid is to supply uninterrupted quality power to loads.
- As per IEEE-1547-2018 standards, the microgrid is to be islanded in less than 2 seconds from the main grid and has to supply power to loads in autonomous mode.
- The proposed ROCOVPA method detects islanding at zero percent power mismatch and isolates the microgrid to feed connected loads, as the methodology is based on phase angle variation instead of frequency and voltage.
- According to the analysis of the results, the proposed method discriminates islanding during faults and is stable without nuisance tripping during non-islanding conditions, like capacitor load connection and disconnection at PCC.
- The proposed ROCOVPA method is compared with the widely used ROCOF method and is found to be a better alternative.

Because of its simplicity, reliability, and effectiveness over the active and communication methods, ROCOVPA, the passive method, is more preferable than other methods. It also avoids nuisance tripping as it distinguishes islanding and non-islanding very accurately. The islanding detection is perfect even at 0% power mismatch. This method seamlessly detects islanding and transfers the microgrid from grid to islanding mode in less than 1 cycle detection time with almost zero NDZ. This is verified with the MATLAB simulation results and proved to be as proposed. The paper is organized as follows: Section 2 explains the network and mathematical model. Section 3 discusses the NDZ. Section 4 deals with the proposed methodology. Section 5 gives the design parameters. Section 6 discusses and analyzes the results of MATLAB simulations. Finally, the paper is concluded in Section 7.

II. LITERATURE REVIEW

Dejan Milosevic et al. in [1] have used both voltage magnitude and phase angle at PCC, for obtaining balance between active power and reactive power to achieve stability in the microgrid. The proposed method considers only rate of change of phase angle for the protection during islanding. The phase angle variations will increase after a certain time, and hence, the islanding is detected. Thus, the method exactly caters to the need of the islanding detection without additional components.

Haidar Samet et al. in [2] used the voltage phase angle in their method. However, they used the energy involved in the phase angle by collecting five energy samplings. Although there may be an error in calculating energy samplings, the proposed method directly monitors rate of change of phase angle at output of the DG, and hence, is more reliable.

Ch. Rami Reddy et al. in [3] utilized the active method of injecting low-frequency current harmonics on the q-controller with the ROCOF method. It increases power quality issues and is ineffective at lower power mismatches.

Behrooz Bahrani et al. in [4] used the active method of injecting negative sequence current on the inverter, which raises power quality issues. However, the NDZ will of course be reduced considerably.

Min-Sung Kim et al. in [5] reviewed different islanding techniques including ROCOV and ROCOF. However, the proposed method ROCOVPA is better than all those methods, as it detects at zero percent power mismatch in less time, as per IEEE-1547-2018 standards.

Mehdi Hosseinzadeh et al. in [6] reviewed islanding methods and their merits and demerits. However, the proposed method is a better alternative to detect islanding

F. Namdari et al. in [7] considered the passive islanding detection method of rate of change of voltage over active power, which is good for power quality retention but not efficient at zero power mismatch.

Onkemetse Tshenyego et al. in [8] used artificial intelligence(AI) with wide-area monitoring protection and control (WAMPAC). This method is less reliable, as it uses communication support.

Hajir Pourbabak et al. in [9] used the variations in the phase angle of active and reactive powers. Though the method reduces NDZ, the variations are not consistent, leading to nuisance tripping.

Walid Ghzaiel et al. in [10] used phase shift between real and imaginary values of voltage, to detect islanding. The method depends on voltage, and nuisance tripping cannot be avoided; the NDZ is also large enough.

III. NETWORK AND MATHEMATICAL MODEL

The network model is shown in Fig. 1. The ROCOVPA islanding detection method is tested on a DG with 2.5 KW with an interfaced inverter. A parallel-connected Resistive, Inductive and Capacitive (RLC) load is connected to the DG with a quality factor of 1.8 at PCC. The DG inverter is connected to the main grid via PCC through a three-phase circuit breaker. The inverter is connected to the PCC with a series filter.

The mathematical model of the islanded microgrid in frame abc is given by the following equations,

$$V_{t,abc} = L_t di_{t,abc} / dt + R_t i_{t,abc} + V_{abc} \quad (1)$$

$$i_{t,abcc} = V_{abc} / R + i_{L,abc} + C \frac{d}{dt} V_{abc} \quad (2)$$

$$V_{abc} = L \, {}^{d}\!/_{dt} \, i_{L,abc} + R_L i_{L,abc} \quad (3)$$

where $V_{t,abc}$, $i_{t,abc}$, $i_{L,abc}$ are terminal three-phase voltages and currents, V_{abc} is PCC voltage,R_t, L_t are line resistance and inductance, respectively.

These three-phase instantaneous voltages and currents are to be transformed to a synchronous rotating frame dq0, due to the following reasons:

- to have control of active power (d-axis) and reactive power (q-axis)
- to keep mutual inductance constant
- to achieve the desired output
- to have infinite gain control on PI and PID, by adjusting integrators, and to make steady-state error to zero to enable ease of computations

$$X(t) = AX(t) + Bu(t) \quad (4)$$

$$y(t) = CX(t) \quad (5)$$

$$u(t) = V_{td}. \quad (6)$$

The A, B, C, and D are constants given by

$$A = \begin{bmatrix} \frac{-Rt}{L_t} & \omega_0 & 0 & \frac{-1}{L_t} & \\ \omega_0 & \frac{-R_t}{L} & -2\omega_0 & \frac{RlC\omega_0}{L} & -\frac{\omega_0}{R} \\ 0 & \omega_0 & \frac{-Rl}{L} & \frac{1}{L} - \omega_0^2 C & \\ \frac{1}{C} & 0 & \frac{-1}{C} & -\frac{1}{RC} & \end{bmatrix} \quad (7)$$

$$B^T = \left[\frac{1}{L_t} 000 \right] \quad (8)$$

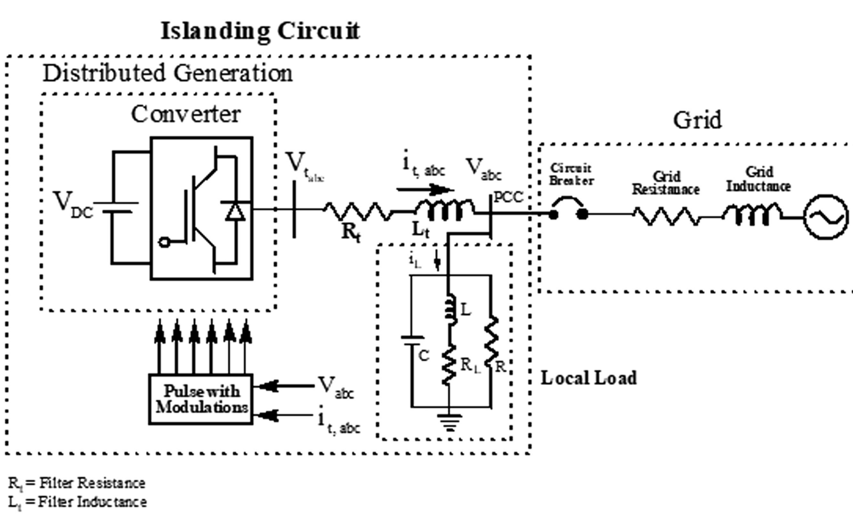

Fig. 1. Network model for testing the islanding detection method, ROCOVPA.

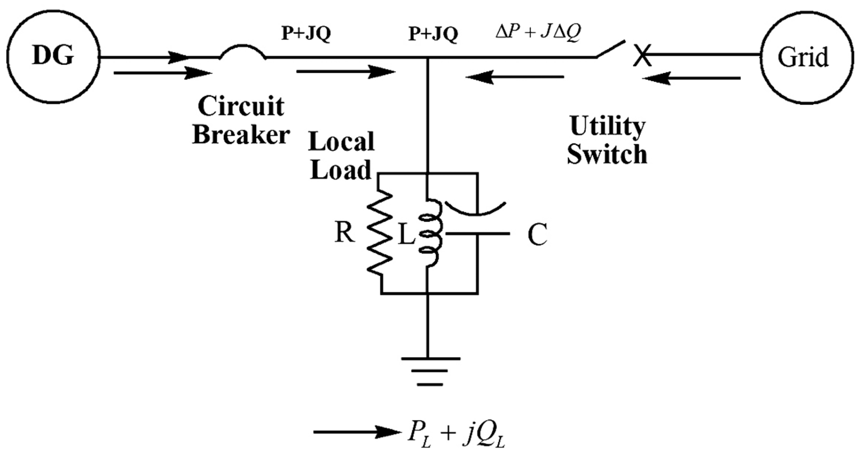

Fig. 2. DG network connected with grid system.

$$C = \begin{bmatrix} 0 & 0 & 0 & 0 \end{bmatrix} \tag{9}$$

$$D = [0] \tag{10}$$

$$X^T = \begin{bmatrix} i_{td} & i_{tq} & i_{Ld} & V_d \end{bmatrix}. \tag{11}$$

These equations give the transfer functions of V_d/V_{td}, where V_d and V_{td} are input and output components of the d axis.

IV. NON DETECTION ZONE

The efficiency of islanding detection depends on minimizing the NDZ [4, 5]. The method depends on the percentage of active power mismatch, which, as per IEEE-1547, has to be < 15%. and the detection time has to be < 2 seconds. The network for the NDZ study is shown in Fig. 2. The DG is connected to the grid through an interfacing inverter, PCC, and utility switch [6]. The three-phase parallel RLC load is connected at PCC [7]:

$$P + \Delta P = \frac{v^2}{R} \tag{12}$$

$$Q + \Delta Q = \frac{V^2}{2\pi f L} \tag{13}$$

Equations (12) and (13) give the voltage, and frequency at PCC and is given by,

$$V = \sqrt{R(P+\Delta P)} \tag{14}$$

$$f = \frac{V^2}{2\pi L(Q+\Delta Q)}. \tag{15}$$

However, in islanding conditions, ΔP and ΔQ become zero, as there is no main grid. The voltage V′ and frequency f′ under islanding mode are given by

$$V' = \sqrt{R(P)} \tag{16}$$

$$f' = \frac{v'^2}{2\pi L(Q)} = \frac{RP}{2\pi L(Q)}. \tag{17}$$

With these, the voltage and frequency deviations due to power mismatch are given by

$$\Delta V = V' - V = \sqrt{R(P)} - \sqrt{R(P+\Delta P)} \tag{18}$$

$$\Delta f = f' - f = \frac{v'^2}{L(Q)} - \frac{v'^2}{L(Q+\Delta Q)} = \frac{R \times P}{L \times Q} - \frac{R \times (P+\Delta P)}{L \times (Q+\Delta Q)} \tag{19}$$

Equations (18) and (19) show the variations in voltage and frequency due to power mismatch [2]. If the power mismatch is substantial, the variations in voltage and frequency can be identifiable. However, if the mismatch is too small leading to less than 15%, the islanding cannot be detected and hence the formation of NDZ. Fig. 3 shows the NDZ for different percentages of power mismatches [8, 11].

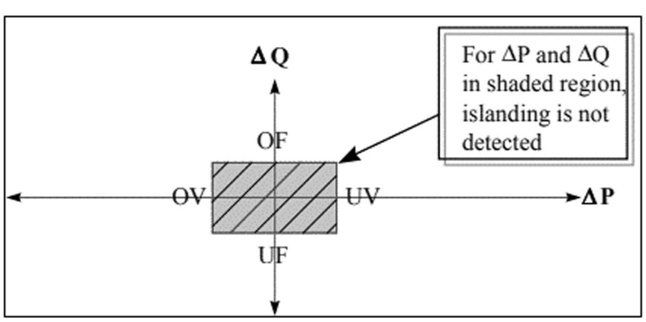

Fig. 3. Mapping of the NDZ in ΔP versus ΔQ for over/under voltage and over/under frequency relays.

NDZ is the operating region in which islanding detection methods cannot detect islanding as specified by IEEE-1547 standards. It is expressed in terms of percentage of power mismatch or in terms of the parameters like R, L, and C of the load. In Fig. 4, the NDZ representation for OVP/UVP was derived as an approximate representation of the NDZ [12, 13].

The NDZ of OVP/UVP (over / under voltage protection) and OFP/UVP (over / under frequency protection) islanding schemes are shown in Fig. 3. These techniques fail to detect islanding in mismatch power less than 15%. In the distribution network, voltage values, as per the standards of IEEE-1547-2018, are between 0.88 p.u. and 1.1 p.u. for voltage relays. These voltage levels are equivalent to 456 V to 365 V (ΔV=91 V), for a 415V nominal voltage level. Similarly, the frequency levels are between 49 Hz and 51 Hz (Δf=2 Hz), for a 50 Hz nominal frequency level. The calculated 15% active power mismatch for our test network (the inverter rated output power is 2.5 kw), is between 2.125 kw and 2.875 kw (Δkw=0.75). Similarly, the 15% reactive power mismatch is between 1.3 kvar and 1.7 kvar (Δkvar=0.4).

In grid mode, the load consumes the reactive power [14]. However, in islanding, DGs cannot inject reactive power to load, as DGs operate at unity power factor, because load behaves like resistance [15], and the load resonance frequency is equal to system frequency at PCC. Hence, to find more deviations in frequency, the load selected is parallel RLC with a high quality factor of 1.8 in islanding mode [9, 10]. The quality factor is given by

$$Q_f = \omega_0 RC = \frac{R}{\omega_0 L} = R\sqrt{\frac{C}{L}} \tag{20}$$

In which, $\omega_0 = 2\pi f_0 = \frac{1}{\sqrt{LC}}$.

Equation (20) gives the energy stored in the RLC circuit. High quality factor loads have high capacitance and small inductance with or without high parallel resistance [16, 17]. The islanding detection is complex, with resonant frequency loads of higher quality factor [18, 19]. The percentage mismatch is not the criterion for load parameters [20, 21]. The load reactive power is given by

$$Q_{\text{Load}} = Vrms^2\left[\frac{1}{\omega L} - \omega c\right] = \Delta Q \tag{21}$$

Equation (21) depicts the variation in reactive power for different values of L and C. The percentages of mismatch power for OVP/UVP and OFP / UFP relays are shown in Fig. 3 and are given by equations for active power imbalance, as

$$\Delta P = 3V \times I - 3(V + \Delta V) \times I = -3 \times \Delta V \times I \tag{22}$$

$$\Delta Q = 3\frac{v^2}{\omega_n L}\left(1 - \omega^2 LC\right) = 3\frac{v^2}{\omega_n L}\left(1 - \frac{\omega_n^2}{\omega_r^2}\right) \tag{23}$$

where ω_n and ω_r are system and resonance frequencies [22, 23]. The system frequency varies till it reaches the resonant frequency of the load in islanding mode and is given by

$$\omega_r = \frac{1}{\sqrt{LC}} \tag{24}$$

and the reactive power imbalance is given by

$$\Delta Q = 3\frac{v^2}{\omega_n L}\left(1 - \frac{fn^2}{\left(f_n \pm \Delta f\right)^2}\right). \tag{25}$$

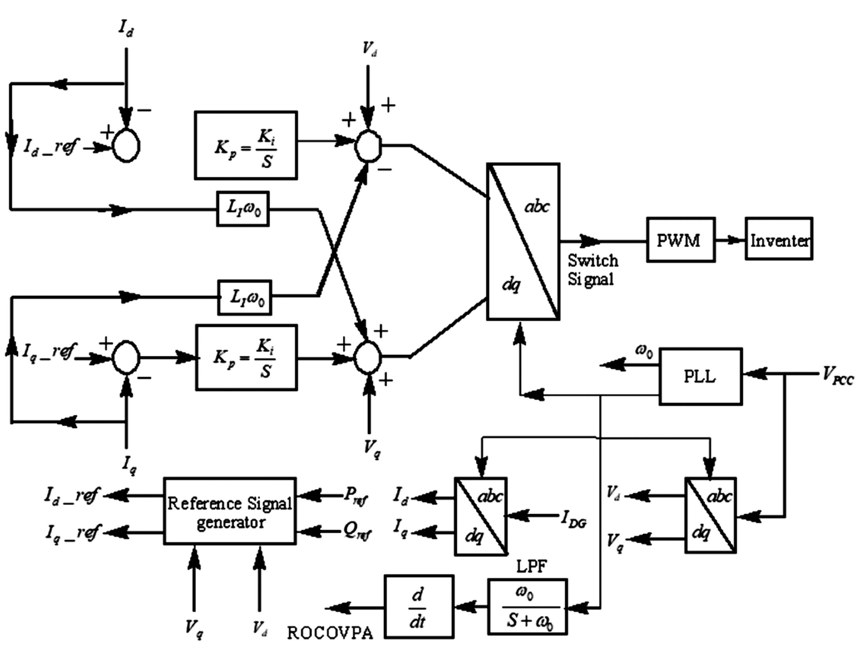

Fig. 4. Current controller block diagram.

TABLE I.
ISLANDING STANDARDS

Standard	Detection Time (Seconds)	Quality Factor	Trip Frequency Range, Nominal Frequency f_0(Hz)	Trip Voltage Range (V)
IEC 62116	t < 2	1	f_0 - 1.5 $Hz \leq f \leq f_0$ + 1.5 Hz	$0.88 \leq V \leq 1.15$
Korean	t < 0.5	1	59.3 $Hz \leq f_0 \leq$ 60.5 Hz	$0.88 \leq V \leq 1.10$
IEEE-1547-2018	t < 2	1	58.8 $Hz \leq f_0 \leq$ 61.2 Hz	$0.88 \leq V \leq 1.10$
IEEE-929-2000	t < 2	2.5	59.3 $Hz \leq f_0 \leq$ 60.5 Hz	$0.88 \leq V \leq 1.10$

As per IEEE-1547-2018, the frequency range is between 49 and 51 Hz and the voltage range is 0.88 to 1.1 V p.u. [24]. The different islanding standards for voltage, frequency, and detection time are shown in Table I.

V. PROPOSED METHODOLOGY FOR ISLANDING DETECTION

The proposed method can detect at zero percent power mismatch, and the detection time is also less than that of ROCOF. In this method, the voltage phase angle is first measured at the targeted DG and then the rate of change of voltage phase angle is calculated, to detect the islanding phenomenon. In non-islanding, the rate of change of phase angle is negligible after certain time; but in islanding, this becomes substantial so that the islanding is detected. ROCOVPA also avoids nuisance tripping, thus protecting the stability of the microgrid.

The ROCOVPA method is tested with the 2.5 KW DG with current control mode inverter connected to an RLC load with a quality factor of 1.8. Fig. 4 shows the current control mode to control active and reactive power of load. The proposed method, ROCOVPA islanding detection, is tested on the DG with the control methodology used in Fig. 4.

In the proposed method, the variation of voltage phase angle is monitored at the specified DG. If there is change in the voltage phase angle, the rate with respect to time is calculated. During the islanding, the deviations of the rate of change of phase angle are high enough to detect the islanding condition. If the relay threshold is fixed, then the trip command for tripping the breaker can be initiated.

A. Algorithm for ROCOVPA

The flow diagram of ROCOVPA is explained in the Fig. 5. The voltage phase angle at DG is measured first. After measurement of the phase angle of voltage, the rate of change of voltage phase angle is calculated. In a normal situation, this value is < 1 deg/s (fixed threshold value); but during islanding, the value suddenly crosses the threshold, depending on the fault severity, by means of which the islanding is detected. During non-islanding mode, this value is within limits, hence nuisance tripping is avoided.

VI. DESIGN PARAMETERS OF INVERTER

The proposed method of ROCOVPA is tested on the network shown in Fig. 1 and the parameters are given in in Table II.

The DG capacity with interfaced inverter is 2.5 KW. The interfaced inverter is connected to the main grid through a breaker via the PCC. A three-phase parallel RLC load is connected at the PCC. The input DC voltage to the inverter is 500 V. The output line to line voltage of the inverter is 415 V. The inverter filter resistance and inductance are 0.05 mΩ and 3 mH respectively. The nominal grid frequency is 50 Hz. The inverter switching frequency is 10 KHz. The load parameters with a quality factor of 1.8 are, R = 5.5 Ω, L = 7.8 mH, and C = 900 μF. The load resonant frequency is 50 Hz. Current controller gains are $K_P = 0.4$ and $K_i = 500$.

VII. ANALYSIS AND DISCUSSION OF RESULTS

The designed network is tested in MATLAB / Simulink for islanding cases of unintentional unsymmetrical L-L-G fault and non-islanding cases of connection and disconnection of capacitor load at PCC. The MATLAB simulation results of ROCOVPA and ROCOF are compared. It is proved that ROCOVPA is better than ROCOF.

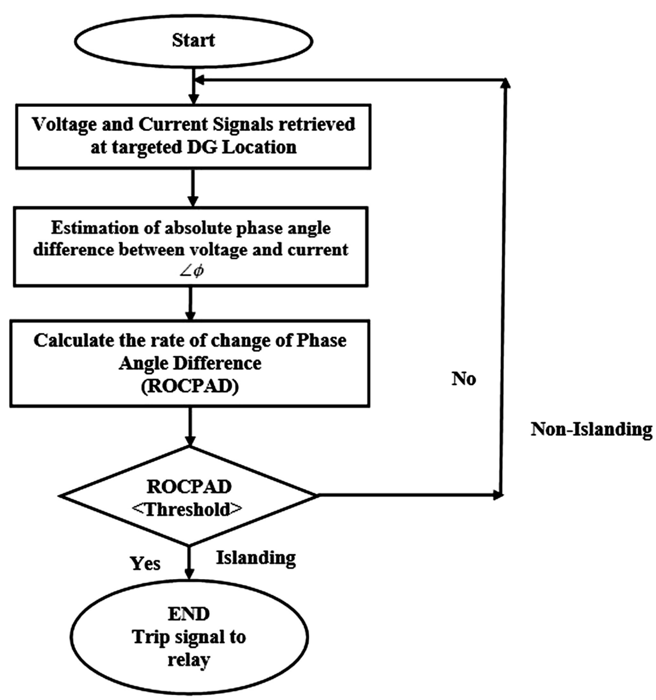

Fig. 5. Flow chart of proposed islanding for the detection of ROCOVPA.

TABLE II.
INVERTER PARAMETERS FOR SIMULATION

Component	Value and Units
DG Power	2.5 KW
Switching frequency	10 KHz
DC input voltage	500
Line voltage	415 V
Inverter Filter inductance Lt	3 m H
Inverter Filter resistance Rt	0.05 Ω
Nominal frequency	50 Hz
Load resistance R	5.5 Ω
Load inductance L	7.8 m H
Load capacitance C	900 µ F
Load quality factor $\left(Q = R\sqrt{C/L}\right)$	1.8
Load resonant frequency $\left(fr = \frac{1}{2\pi\sqrt{LC}}\right)$	50 Hz
Current controller proportional gain, k_p	0.4
Current controller integral gain, k_i	500

A. Islanding case for unsymmetrical fault on the system

The proposed method is tested and compared with ROCOF for islanding case of unintentional unsymmetrical fault L-L-G at 0% power mismatch. In this section, the simulations are discussed for both ROCOVPA and ROCOF, for comparison.

Islanding Testing for L-L-G Unsymmetrical Fault

An L-L-G unsymmetrical fault is initiated on the system at PCC at 0.4 seconds in MATLAB Simulink at 0% power mismatch. PL = PG is the condition for 0% power mismatch, and at that load, a double line-to-ground fault is initiated on the grid side at 0.4 secs on a simulation time of 1 sec. The simulation graph is shown below in Fig. 6. The proposed ROCOVPA detected islanding in 10 ms within a fixed threshold of 1 deg/sec and the relay can exactly detect and send command to trip the circuit breaker to bring the Microgrid to islanding mode from grid mode. The total time is the sum of relay time and breaker time. Any type of the fault is to be cleared within 4 cycles (2 cycles, i.e., 0.04 seconds of relay operation + 2 cycles, 0.04 seconds of breaker operation). Hence, the ROCOVPA can detect the fault condition in less than 1 second and island the microgrid by tripping the circuit breaker, which is less than 2 seconds, as per the standards of IEEE-1547-2018.

The same fault conditions were applied and tested with ROCOF in MATLAB, as shown in Fig. 7, and the islanding was detected in 40 ms. The threshold value was fixed based on the number of simulations, and the threshold value did not cross 0.02 Hz/s in any of the simulations. If the threshold value is fixed at 0.02 Hz/s, the tripping of the circuit breaker can be actuated in around 1 second, which is much below the standards of 2 seconds. The detection time of ROCOF is more than that of ROCOVPA. As the ROCOF is dependent on frequency, at lower percentages of power mismatch, the threshold value cannot be fixed exactly. Hence, detection time varies inversely with the percentage of power mismatch.

To obviate all these issues, ROCOVPA is proposed and proved to be a better islanding detection method for unsymmetrical faults. The MATLAB simulation results of both ROCOVPA and ROCOF are shown in this section.

B. Non-islanding Case for Capacitor Load Connection and Disconnection at PCC on the System

System stability has been studied for different transient conditions during load connection and disconnection at PCC with capacitor load, for ROCOVPA and ROCOF in MATLAB /Simulink. Both methods, ROCOVPA and ROCOF, proved their stability by keeping within the threshold values to avoid nuisance tripping. The ROCOVPA threshold value was fixed at 1 deg/s and that of ROCOF at 0.02 Hz/s based on the number of simulations. The simulation results for non-islanding cases are shown in the following sections.

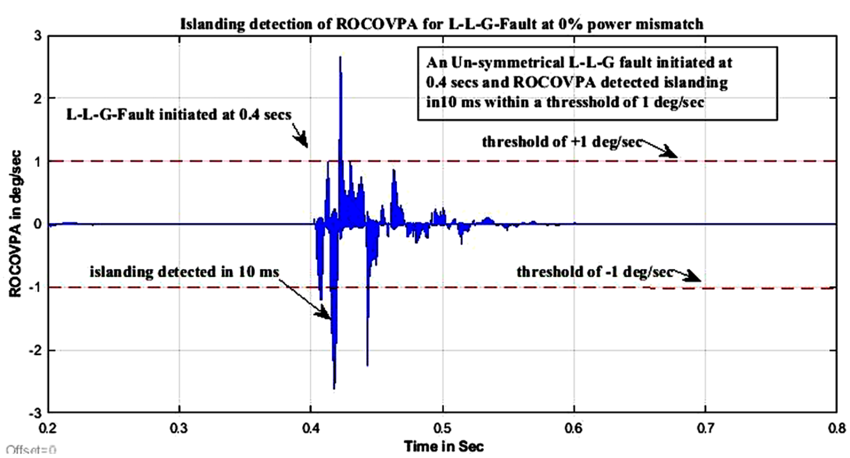

Fig. 6. Islanding detection of ROCOVPA for an L-L-G Fault on the system.

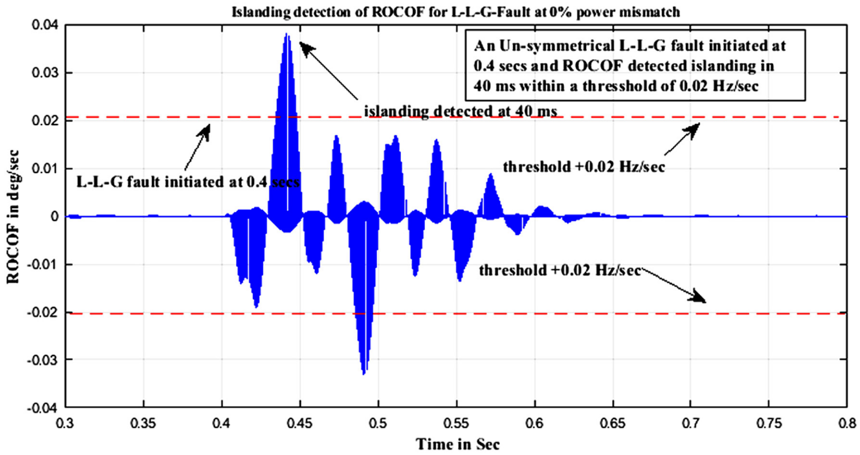

Fig. 7. Islanding detection of ROCOF for an L-L-G Fault on the system.

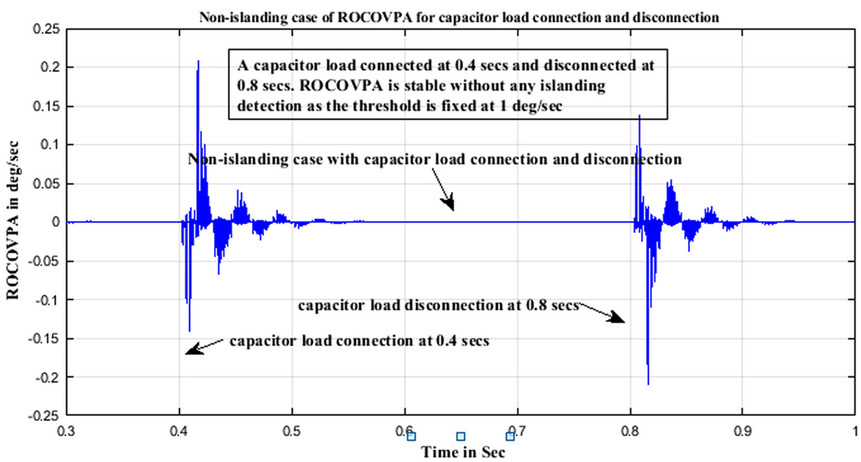

Fig. 8. Non-islanding case of ROCOVPA for capacitor load connection and disconnection.

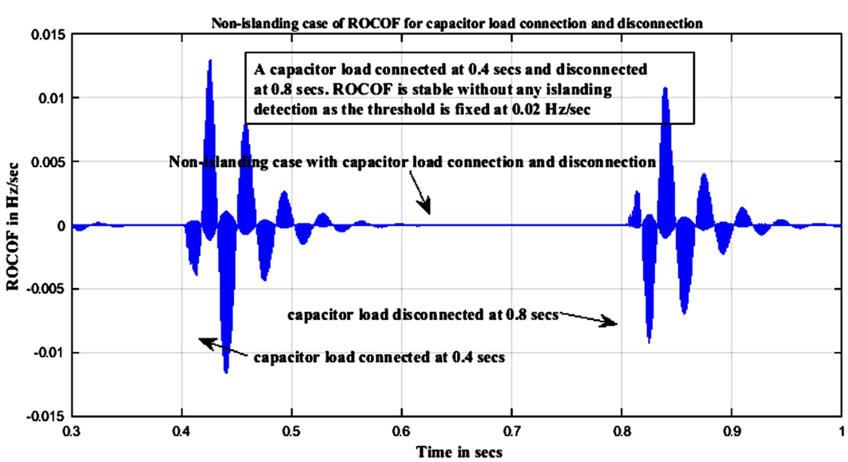

Fig. 9. Non-islanding case of ROCOF for non-linear load connection and disconnection.

Non-islanding Case with Capacitor Load

The stability of the microgrid during non-islanding operation of ROCOVPA and ROCOF during connection and disconnection of capacitor load are tested in MATLAB/Simulink. A capacitor load is connected at PCC at 0.4 seconds and disconnected at 0.8 seconds. The stability of microgrid without nuisance tripping is analyzed through MATLAB simulations. The simulations show that the variations of both ROCOVPA and ROCOF are within threshold values and hence avoid nuisance tripping. The non-islanding conditions with capacitor loads are shown in Fig. 8 and 9. The readings of ROCOVPA and ROCOF show that the thresholds are at higher values, 1 deg/s and 0.02 Hz/s, respectively. Hence, the system is stable without any nuisance tripping of the circuit breaker.

VIII. CONCLUSION

Islanding detection is the main challenge for microgrids. The most common unintentional faults on the system are supposed to be unsymmetrical L-L-G fault, in which two lines are short-circuited and are earthed to the ground. The passive islanding detection method proposed in this paper is ROCOVPA, which is tested for detecting islanding at 0% power mismatch (0% NDZ), with a faster detection time than the widely used ROCOF, and proved to be a better alternative, according to the MATLAB simulation results. This ROCOVPA method was also tested for its stability to avoid nuisance tripping during capacitor load connection and disconnection, and was found to be effective. It is simple to implement in view of methodology, faster in islanding detection (time), safe, and secure. The method discriminates between islanding and non-islanding perfectly, for microgrid operations. The detection is more accurate as the phase angle does not depend on voltage or frequency, and the islanding detection is perfect at almost zero percent mismatch power. Future work is being extended for the detection of symmetrical faults with the same proposed ROCOVPA method and with hybrid DGs.

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