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Islanding Detection in Microgrid System Using Current Components of α-β Transformation

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***Abstract*— This paper introduces a novel islanding detection technique(IDT), which is based on the current components of α-β transformation. Index defined in the proposed technique is the reciprocal of the product of alpha and beta components of current. The proposed technique is designed with three photovoltaic systems as distributed generations (DG). The proposed method distinguishes the islanding events(IE) from non-islanding events even at zero power mismatch (ZPM) and fifty percent active power mismatch(APM). It identifies the islanding events as soon as possible and also limits the unwanted tripping due to various types of non-islanding events. General cases of IE and non-islanding events have been simulated. The simulation results show the proposed technique's flexibility and efficiency based on the MATLAB(Simulink) platform.**

***Index Terms*— Islanding detection, Distributed generation, Islanding event, PCC.**

I. INTRODUCTION

The Due to rising global energy demand and the insufficient resources of traditional power-generation approaches, DGs (distributed generators) like wind, water and micro-turbines, solar cells and fuel cells are increasingly being used in current distribution networks [1] [2]. Despite the benefits of these DG sources, like lower power losses, improved voltage profiles, and improved power quality (in some situations), several downsides are harming utility grid safety, with islanding being the most problematic. The islanding phenomenon occurs when a circuit breaker is opened which isolates the generating unit and loads from the utility grid. However, the issue is that the PV system remains to supply the power to these disconnected loads.

The islanding event should be detected within the period of 2 seconds according to IEEE 1547 standards. Many detection techniques came into existence after several research works. IDTs are mainly categorised into 4 types they are: (i) Passive detection techniques (ii) Active detection techniques (iii) Communication based detection techniques (iv) Hybrid detection technique [3]. Monitoring of various system characteristics like as voltage, total harmonic distortion, frequency, and impedance at any anticipated locations goes under passive approaches, in which the values are compared to a pre-determined threshold to determine the IE. Passive techniques are favoured since they make use of the data on the DG while not interfering with its usual operation. The main drawback of passive approaches is their dependence on threshold levels. Islanding circumstances may not be identified efficiently at higher threshold values, whereas other scenarios of non-islanding events may be detected as Islanding at lower threshold values [4][5][6].

This paper introduces a new passive IDT using the reciprocal of rms current components of the α-β transformation near the PCC(Point of Common Coupling) and at desired DG locations.

II. SYSTEM DESCRIPTION

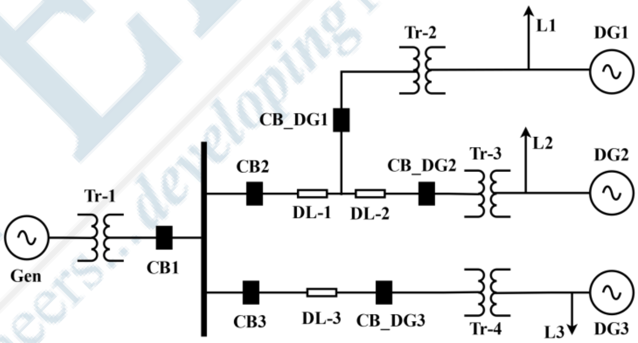

Fig. 1. SLD of proposed system

The proposed system's single line diagram (SLD) is shown in Fig.1. which represents the utility grid, transformers, circuit breakers, distribution lines, loads and distributed generations as shown in the single line diagram.

The following constraints were used to test this system [7]:

Main grid parameters: short-circuit MVA_{rated} = 100, kV_{rated} = 120, f = 50Hz, V_b= 120kV.

DGs: DG1 = 3MW, DG2 = 3MW, DG3 = 200kW.

Transformer Parameters: Tr-1: MVA_{rated} =50, f= 50Hz, kV_{rated}= 120/25, V_b= 25kV, R1= 0.00375p.u, R_m= 500p.u, X_m= 500 p.u.

Tr-2, Tr-3 & Tr-4: MVA_{rated} = 10, f = 50Hz, kV_{rated}= 575/25, V_{base} =25kV, R1= 0.00375p.u, Rm = 500p.u, X_m = 500p.u.

Distribution line(DL) Parameters: DL-1, DL-2, DL-3: length= 20km, V_{rated} = 25kV, MVA_{rated} = 20, V_{base}= 25kV, R_0= 0.413Ω/km, R_1= 0.1153Ω/km, L_0= 3.33mH/km, L_1= 1.05mH/km, C_0= 11.33nF/km, C_1 = 5.01nF/km.

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III. PROPOSED METHOD OF ISLANDING DETECTION

The reciprocal of the products to the rms values of current components of α-β transformation at the target location is used in this proposed technique of islanding detection [8].

The following steps are used in this method for detection of islanding after we get the appropriate currents at the point of common coupling [9]:

α-β transformation of currents measured at PCC can be written as

$$\begin{bmatrix} i_\alpha \\ i_\beta \\ i_\gamma \end{bmatrix} = \begin{bmatrix} 1 & \frac{-1}{2} & \frac{-1}{2} \\ 0 & \frac{\sqrt{3}}{2} & \frac{-\sqrt{3}}{2} \\ \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \end{bmatrix} \begin{bmatrix} i_a \\ i_b \\ i_c \end{bmatrix}$$

σ is multiplication factor which is defined as

$$\sigma = i_{\alpha rms} * i_{\beta rms}$$

Where σ is the scaling factor

Where $i_{\alpha rms}$ represents the α-component of the rms current. $i_{\beta rms}$ represents the β-component of the rms current

Index, which is the reciprocal of products of rms current of α-β components is obtained as

$$\lambda = \frac{1}{\sigma}$$

When the following condition is satisfied, islanding is detected.

$$\lambda \geq 0.00056$$

Where, 0.00056 is the threshold value of the test system. The performance of technique is determined by the value of index which crosses 0.00056. The value is empirically determined in this case.

Fig. 2 depicts the proposed technique's flow chart.

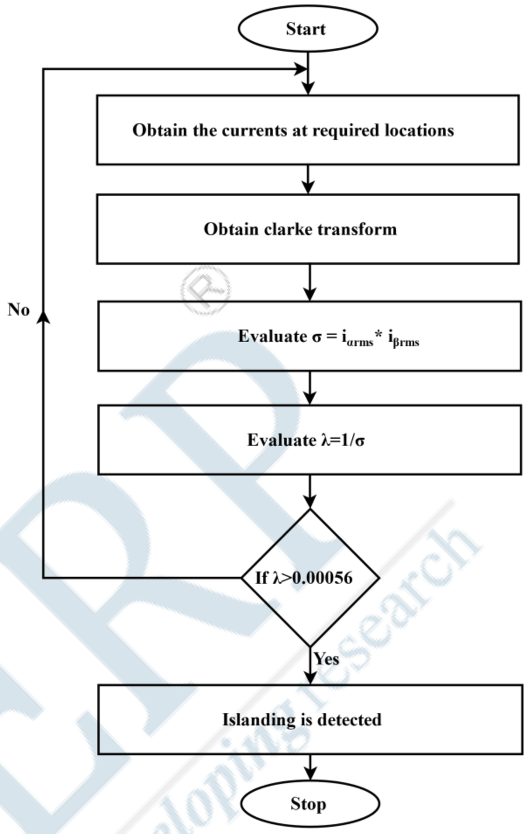

Fig. 2. Flowchart for proposed technique

IV. SIMULATION RESULTS

The performance of proposed method for islanding detection is supported using the MATLAB(Simulink) software.

System is simulated for islanding cases at ZPM (zero power mismatch) and 50% of APM (active power mismatch) for 1 second. The IE is established by opening the circuit breaker CB1 at 0.5 seconds. Fig.3, Fig.4, Fig.5 shows the index of different active power mismatching conditions of the system.

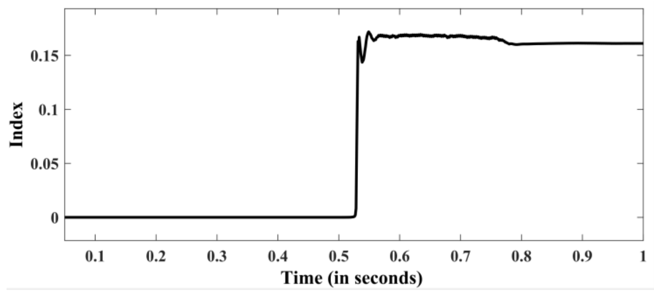

Fig. 3. Proposed method at PCC during islanding for ZPM

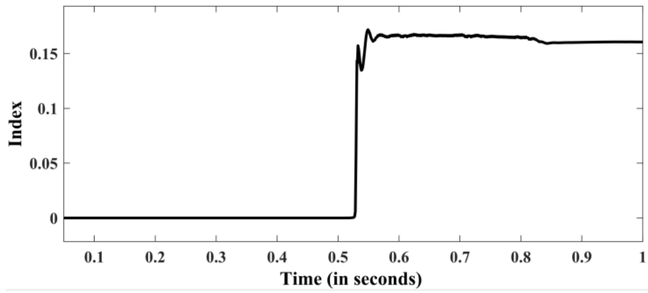

Fig. 4. Proposed method at PCC during islanding for +50% active power mismatch

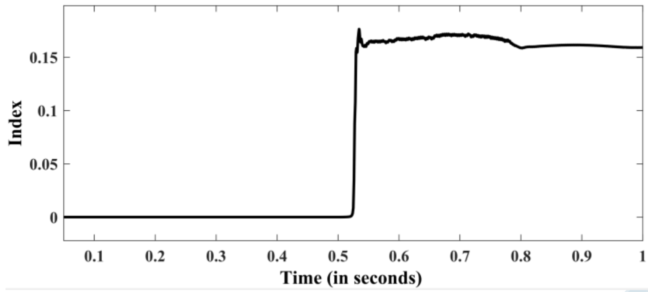

Fig. 5. Proposed method at PCC during islanding for -50% active power mismatch

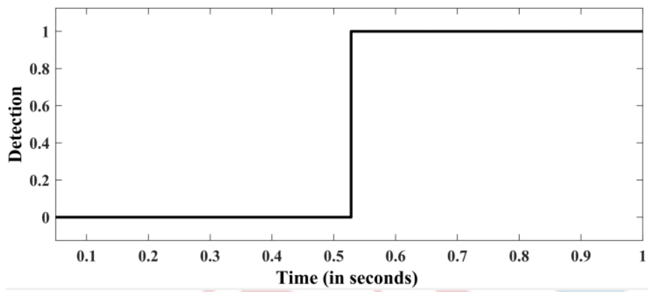

Fig. 6. Detection signal for above simulated active power mismatch cases

Fig.6 shows the islanding detection signal for the islanding conditions of different active power mismatches of the system. which is exactly sensing the IE in the system.

Different non-islanding conditions like faults, single pole tripping, disconnection of distributed generation, load switching and capacitor switching are also teste, for the system [10].

For non-islanding events, the system is simulated for 1 second and different faults are created with the switching time of 0.3 seconds. The results can be seen in Fig.7, Fig.8, and Fig.9 which displays the behaviour of the proposed technique under various fault conditions [11]. No change in index shows the higher accuracy of the proposed technique in non-islanding events.

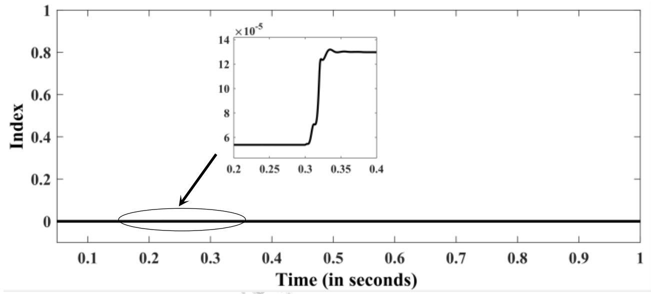

Fig. 7. Index for line to ground fault

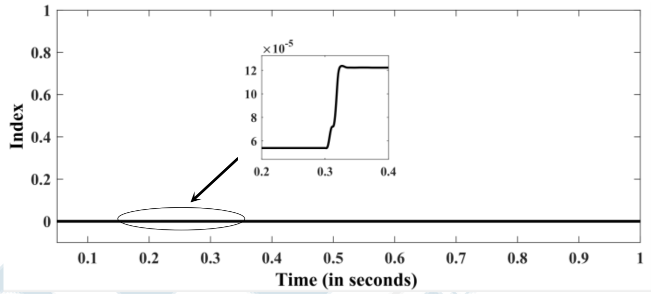

Fig. 8. Index for lline to line fault

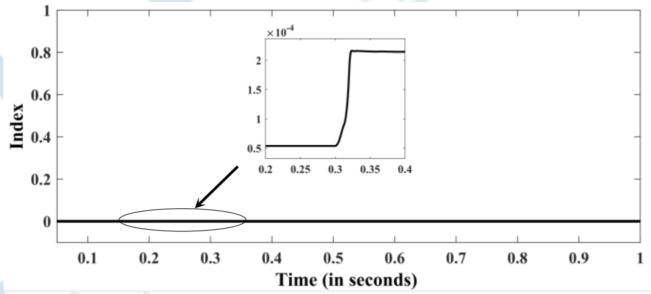

Fig. 9. Index for double line ground fault

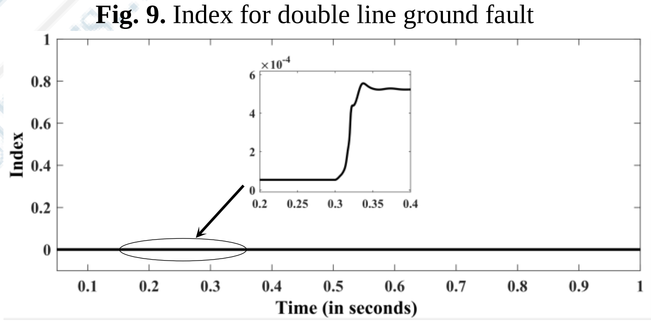

Fig. 10. 3-phase to ground fault with fault resistance of 2.26Ω

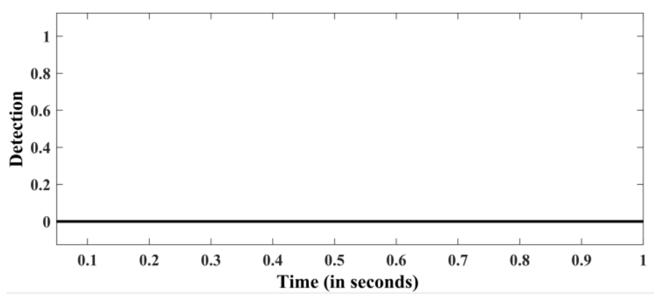

Fig. 11. Decision signal for fault cases

On the other hand, the detection signal (incorrect decision) is generated by the proposed technique for bolted three-phase to ground faults. According to the fault detection zone (FDZ),

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proposed technique is sensitive and does not work below the fault resistance 2.26Ω. The detection signal for the fault cases is shown in Fig.11.which is the indication of satisfactory working of proposed scheme.

Similarly for the capacitor, load switchings and single pole tripping, the system is simulated for one second and given the switching time of 0.5 seconds for the single pole tripping at DG-1 outputs can be seen.

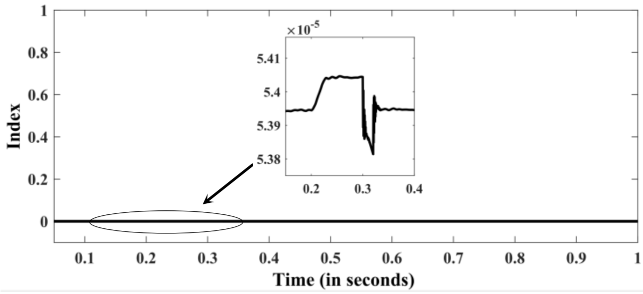

Fig. 12. Capacitor switching at PCC

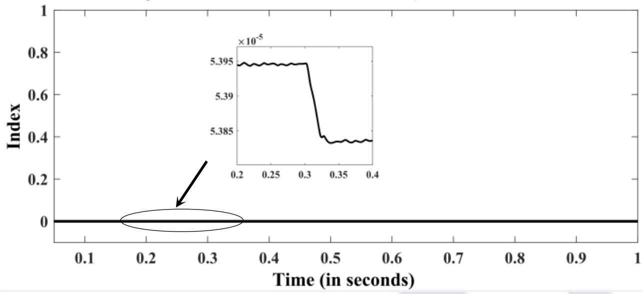

Fig. 13. Load disturbances

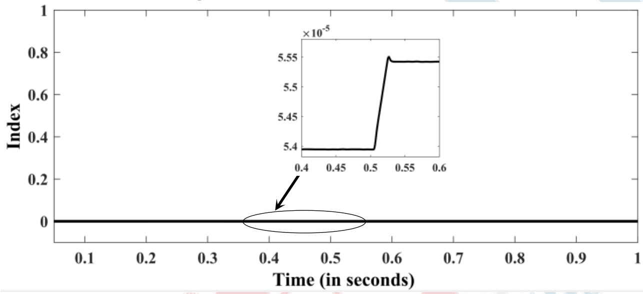

Fig. 14. Single pole tripping at DG1

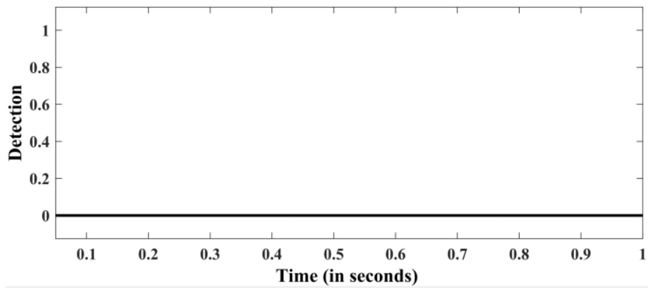

Fig. 15. Decision signal

Fig.12 shows the capacitor switching condition where the capacitor is disconnected at 0.2seconds and reconnected at 0.3s. Fig.13 shows the load switching/disturbances with the switching of 0.3s. Fig.14 shows single pole tripping at DG1 and Fig.15 shows the decision signal for the above cases.

Disconnection of the DG [12] is also one of the non-islanding conditions and it has also been tested for 1 second. The DG3 is removed at 0.3 seconds. No change in index as revealed in Fig.16 is indication of non-islanding events.

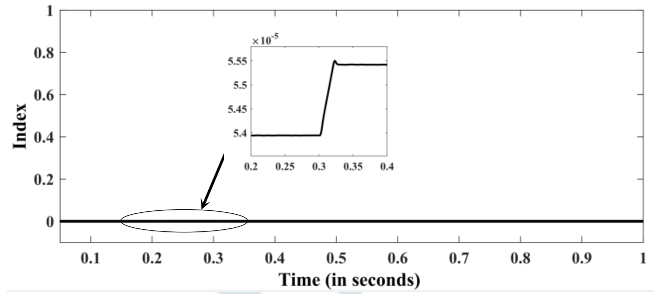

Fig. 16. DG disconnection

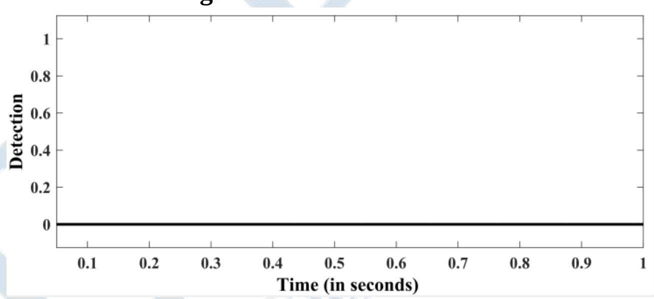

Fig. 17. Decision signal for DG disconnection

The decision signal for the disconnection of DG from the system is shown in Fig.17.

By this verification, it is clear that the proposed method only detects the IE and does not detect the remaining cases (non-islanding events).

V. Conclusion

This paper uses MATLAB/SIMULINK software to detect islanding and validate grid-connected modes of operation. For power mismatches ZPM & 50% APM, as well as non-islanding events including faults, load separation, single pole tripping, DG disconnection, and capacitor switching, the proposed method is tested. The final results are found satisfactory. In the instance of a 3-phase ground fault at the PCC, the approach produced a wrong detection signal, which is minimized by adding the fault resistance of 2.26Ω, but the technique's performance in the other conditions is good. The simulated output clearly depicts the islanding scenario and how it is detected.

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