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Microgrid Islanding Detection with a Hybrid Method

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Abstract: **As the fast integration of Distributed Generators is developing rapidly, it has become mandatory for the Microgrids to be more stable and controllable to feed the loads connected, uninterruptedly. The general condition of any Microgrid is in synchronism with the main grid in a normal way. This is also as per the Department Of Energy of United States of America . The IEEE-1547 standards also say that the Microgrid must have the robust islanding detection method, incorporated in the interfaced inverter, to detect the fault within the time duration specified.**

For this purpose an efficient islanding detection method, which is a hybrid technique utilizing both passive and active islanding types is proposed in this paper. The passive one is, Rate of Change Of Frequency (ROCOF) and the active type is reactive current injection at inverter output terminals. The islanding detection is achieved with the cumulative sum of rate of change of frequency(CSROCOF).

With this method, the low active power mismatch at point of common coupling is also compensated and the islanding detection is achieved in the specified time as prescribed by the standards. With all these controls embedded, the false detection and tripping of the Microgrid, islanding from maingrid is avoided. The non detection zone area is also substantially reduced. The proposed methodology has been tested in Matlab / Simulink environment and the results prove the efficiency of the method.

Keywords - ROCOF-Rate Of Change Of Frequency ; CSROF-Cumalative Sum Of Rate Of Change Of Frequency; NDZ-Non Detection Zone; DG-Distributed Generation;Reactive Current Injection; PCC- Point of Common Coupling; ID- Islanding Detection; RES-Renewable Energy Resources; DER-Distributed Energy Resources; DFIG- Doubly Fed Induction Generator;

I. INTRODUCTION

Modern power systems are becoming active networks with the introduction of RESs. The Microgrids are becoming bi-directional because if excess power is available after supplying to loads, the power can be exported to grid. As the power systems are modernized due to the presence of power electronics based inverters, protection is developed to suit to the non-inertial DGs. But there are some more areas like trasition states. They are grid to islanding and islanding to grid modes[1,2]. The islanding detection is more crucial a safety aspect and stability concern is involved. If there is any fault in the main grid, it is to be sensed and Microgrid has to switched over to islanding mode seamlessly so that there is no interruption of power to microgrid loads which are termed as essential[3,4]. These are also called un-intentional islanding. Intentional islanding is, when maintenance work is to be performed either on grid or Microgrid, the Microgrid is to be isolated from main grid. This iolation of Microgrid is achieved through a hybrid islanding detection technique of both passive ROCOF and active reactive current injection at inverter terminals.The islanding detection becomes easy if there is mismatch between generation and load. But if there is no difference supply and demand during islanding, the passive methods do not detect the islanding phenomena and hence NDZ occurs. At this juncture exactly, the active islanding detection technique to identify the islanding condition and to isolate the Microgrid is a must. This will bring the Microgrid stability and safety is ensured. The active islanding method of injecting a small reactive current into the system parameters like voltage and frequency. When grid is available these disturbances are taken care of. But in the absence, care is to be taken on the stability of the Microgrid[5,6].

The paasive ROCOF technique can not sense, if the deviations are below 15% active power at PCC. Hence an active islanding detection of small reactive current injection at inverter terminals is used, so that the power quality is not disturbed. This a hybrid technique which combines both passive ROCOF and active reactive current injection. If this small % age is not enough, it is slightly increased to detect actual islanding. Hence the zero active power mismatch is also achieved to detect islanding by shedding the local load and bringing the load frequency to 50 Hz[8,9].

A periodic small value of reactive current with frequency less than system frequency is injected to grid side converter. The drift is sensed by ROCOF.The CSROCOF is comutred for 50ms. If the CSROCOF is beyond threshold value , the magnitude of reactive current injection is increased and CSROCOF is again compared, to confirm the islanding state. This method avoids nuisance tripping of Microgrid without actual islanding condition. The ROCOF detects islanding if active power mismatch is above 15%. But with the Hybrid methodology, ROCOF and CSROCOF efficiently detects the islanding condition[10,11].

II. LITERATURE SURVEY

The heart of any Microgrid is the controller. The controller must be capable enough to keep the Microgrid stable in grid mode, to be stable in transition from grid to island mode, stable in island mode and must be ready to synchronize to grid again for exporting and importing for economical benefits [7]. Nowadays , the Microgrids may be owned by consumers and

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they can become prosumers by supplying power to another Microgrid with agreed tariff arrangements. A thorough review is done with references indicated below.

It is suggested a method of intentional islanding. He has very elaborately pointed out different modes of inverters. Under grid connected mode the inverters should be CCM mode to share the loads proportionally. But in islanded mode they will revert to VCM mode to maintain constant voltage and frequency at PCC [21].

It is also pointed out different scenerios of photo voltaic and wind mill sources during grid, islanded and transition states [22].

It is discussed in the reference about MPPT and battery control. He has suggested different maximization techniques like V-f, P-Q methods. [24]

A special controller is proposed, which detects both positive and negative sequence components during unbalanced faults [23].

A remarkable work is done by focussing on stability during grid mode only. The modeling was done in PSCAD/EMTDC platform [25].

Discussed in the reference, about the stability of three phase grid connected and islanded mode with linear load with and without anti-islanding controller [26].

The author discussed about voltage source inverters with DGs about control of constant voltage and frequency [27].

Pointed out different scenerios about stability during islanding when grid fault occurs and after islanding also [28].

Reference paper also discussed about different protection methods against different faults [29].

III. HYBRID ISLANDING DETECTION METHOD

The ROCOF detection of islanding can not work for active power mismatch is between 0-15%. The frequency variation is not much enough for ROCOF to detect islanding condition at PCC ib this condition. This is passive detection method of islanding detection method[12,13].

To counter this gap an active islanding detection method of injecting reactive current at inverter terminals while in grid mode still. There is drift in frequency only under islanding. Otherwise there is no effect in frequency if grid is present. But setting a low value gives false tripping signal and at the same time higher value increases NDZ[14,15].

But in this paper a low value of 1% of reactive current is injected with 30 Hz at q-axis at q-axis control of inverter at PCC. Precaution is taken to keep the reactive current injection value as low as possible to see that the power quality is deteriorated. This low value reactive current injection is not a matter when the active power mismatch if high. But the frequency drift is very small when the active power mismatch is low or zero. So for such small deviations, which are within the zone, Microgrid need not be islanded. Hence the real scenario is identified [16,17].

For small variation of frequency the ROCOF can not identify the islanding. The disturbances may be due to load switching transients. But to get exact islanding condition CSROCOF index is used for a time period of 50 ms with a discrete model of 50 μs.. The number of sample per 50ms is 1000 and is given by,

$$CSROCOF = \sum_{n=1}^{1000} |ROCOF(n)|$$

The islanding detection algorithm is shown in Figure.1

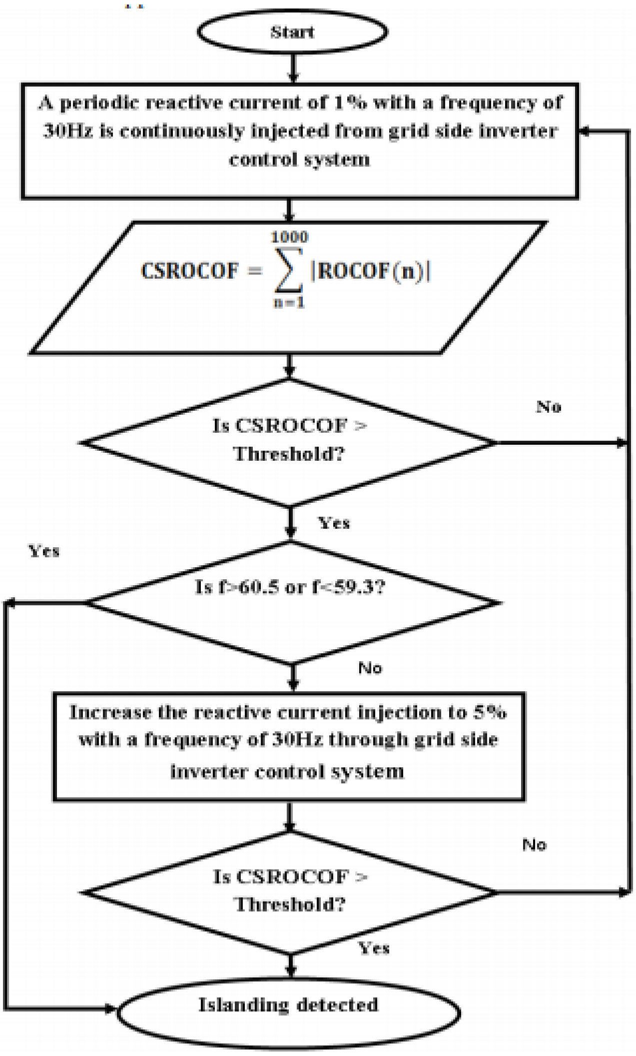

Figure.1 Islanding detection algorithm

If the threshold value of CSROCOF crosses the value and the frequency goes beyond the range, than islanding is detected and it indicates that the cative power mismatch is high. During low active power mismatch, CSROCOF crosses the threshold value within the frequency range. The islanding may be because of some switching transients, hence islanding is not

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activated, Which is the realistic scenario. Reconfirmation is done through injecting reactive current of 5 % at 30 Hz. If the CSROCOF computation value for 50ms exceeds threshold, confirms the islanding. For non-islanding , the value does not cross[18,19].

IV. MATLAB SYSTEM MODEL

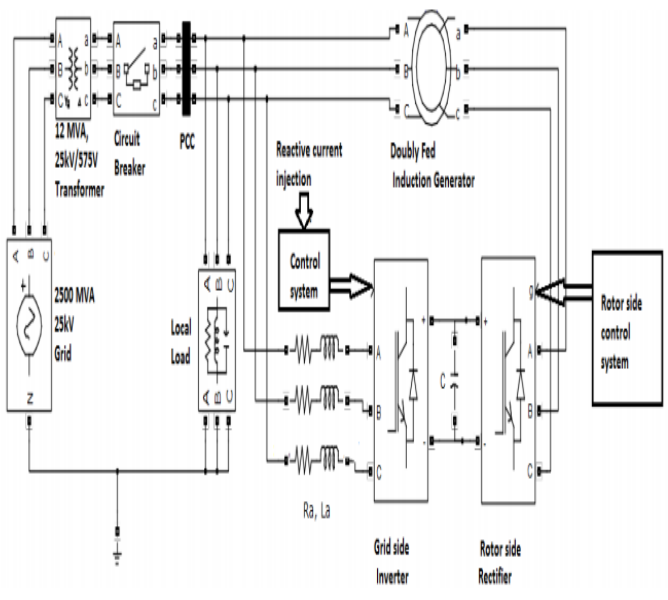

Figure.2 Matlab inverter model with DG

The system parameters are shown in Table.1. A PWM based AC/DC/AC IGBT converter / inverter is the interfacing inverter of DG[20]. DG feeds a load of 5 MW at 50 Hz. The Matlab Simulation model is shown in Figure.2.

TABLE I
SYSTEM RATINGS AND PARAMETERS

Grid	2500MVA, 25kV, 60Hz
Transformer	12MVA, 25kV/575V, 60Hz
DG	9MVA, 575V, 60Hz
DG rated active power (P_{DG})	4.8MW
Ra, La	5.95mΩ, 11.75μH
Local Load Tuned at 60 Hz	68.88mΩ, 26.5H, 265nF
DC Link voltage	1200V
PWM (switching frequency)	f_s =1620Hz

The circuit parameters are shown in Table.1.

The grid side inverter is synchronized to grid via PLL. The loads and DG are adjusted for zero mismatch active power. The reactive epower is adjusted to 0 VAr.The circuit breaker is operated to create islanding. The worst scenario islanding is simulated and the islanding technique is evaluated.

V. RESULTS DISCUSSION

Islanding is created as a stiff grid, cative power mismatch is 0 and reactive power is set to 0 VAr.

The sample time is 1.5 secs and the number of samples per 50ms is1000.. The islanding is done at 0.8 secs.

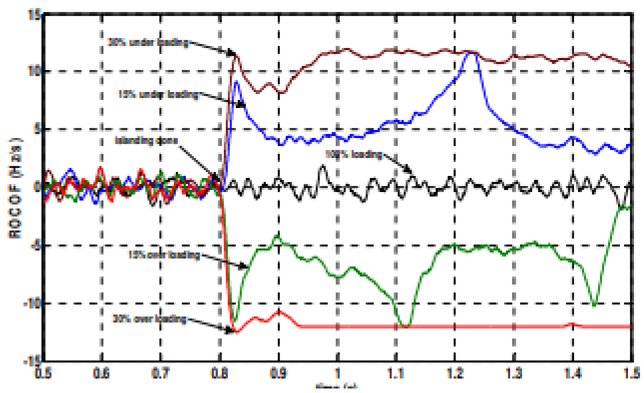

Figure3. In islanding of DG , ROCOF response for loads

It is clear from Figure3., that ROCOF gives correct sensing for More than 15% active power mismatch. But for 0% mismatch, ROCOF technique failed.

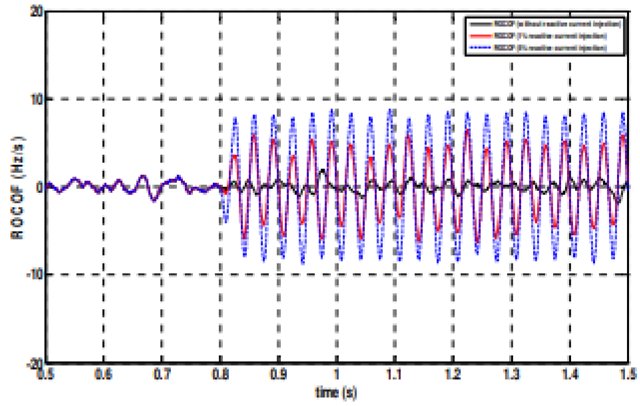

Figure4. Response of ROCOF with reactive current injection

It is clear from Figure4. The ROCOF is drifted as the injection of reactive current is increased from 1% to 5%.But the injection of current magnitude can not be increased to keep the power quality.

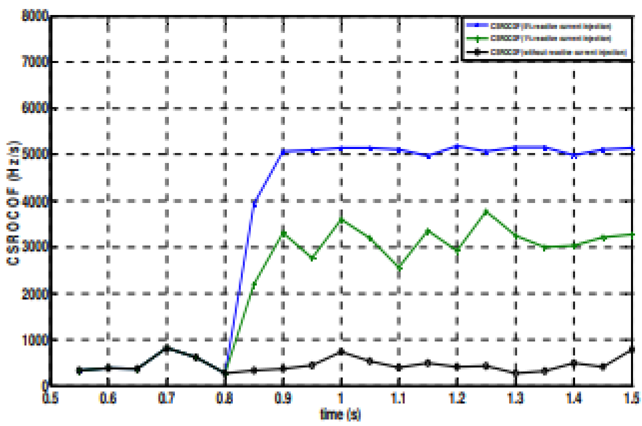

Figure5. For 0%, 1% and 5% reactive injection of CSROCOF

Even during worst condition of islanding, the CSROCOF has not responded without reactive current injection of 0%, 1% and 5%.

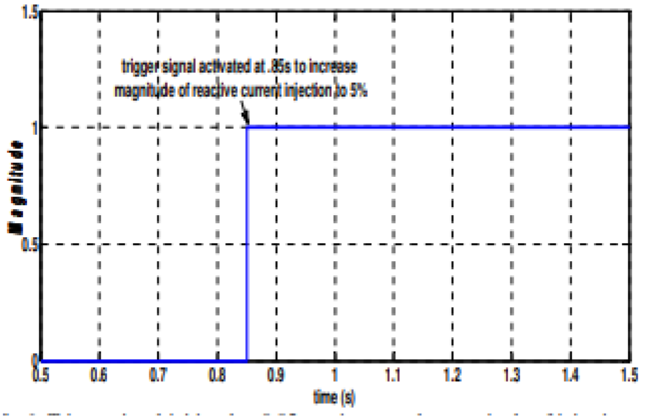

Figure.6 Reactive power is increased to 5% at 0.85 secs at Inverter terminals

Figure.6 shows the increase trigger signal from 0% with a frequency of 30Hz to 5% detects the islanding.

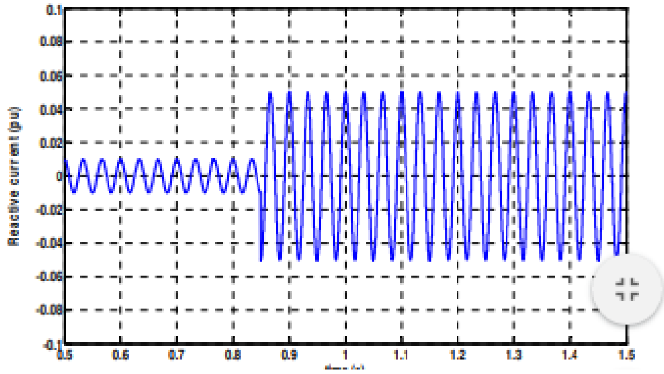

Figure.7 Injection of 5% reactive current injection at inverter terminals , detects the islanding

At 0.85 secs CSROCOF after 5% reactive current injection detects islanding

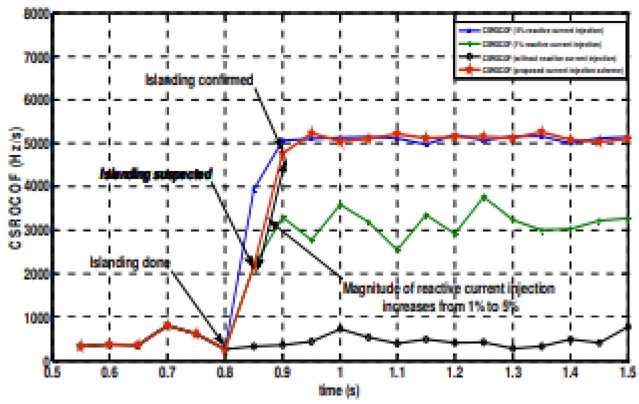

Figure.8 Islanding detection with CSROCOF

As shown in Figure.8, islanding is detected with CSROCOF at 0.85 secs. CSROCOF suspects islanding at 0.9secs due to increase to 5% injection of reactive current. Hence the CSROCOF actually detected real islanding even at zero active power mismatch. The technique is implemented with 50msecs window and with a time duration of 100msecs.

The proposed methodology is robust, which segregates nuisance tripping with reactive current injection.

VI. CONCLUSIONS

The proposed hybrid method of ROCOF with reactive current injection and CSROCOF, successfully islanded the Microgrid within the stipulated time of 2 secs as per the IEEE-1547 standards. This also avoided the nuisance tripping which is mandatory as per standards.

Future work can be on the lines different combinations of hybrid detection methods with hybrid RESs.

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