HIGH FREQUENCY IMPEDANCE ESTIMATION OF ISLANDING DETECTION METHOD FOR MULTI DG SYSTEMS BY USING FUZZY LOGIC CONTROLLER

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Abstract: In this paper presents active islanding recognition techniques are for the most part utilized for grid connected inverter-based Distributed Generation (DG). however, there may be common impacts and power quality issues caused by the disturbance signal when numerous inverters are included. To address those issues, this paper examines the potential failure component of the f-Q (frequency reactive power) drifting dynamic technique in various DG circumstances. In this paper proposed an islanding detection method based on high frequency impedance estimation utilizing external centralized transient injections. a high frequency transient injection based islanding discovery strategy that is reasonable for both single and numerous DGs is proposed. Contrasted and the customary injection strategies, a high frequency impedance display for DG and by using fuzzy logic controller performance was improved under disturbance conditions. By methods for the irregular Time Domain Low Voltage Condition (TDLVC) injection control, this technique can accomplish great precision and diminish unsettling influences to control system.

Key words: islanding detection, active injectin method, high frequency impedance estimation,distributed generation

I. INTRODUCTION

The request of effective vitality use and the advancement of energy electronic innovation are encouraging substantial measure of appropriated generation (distributed generation (DG) for example, photovoltaic (PV) and wind power) to interface with the grid [1]-[2]. whenever grid failures or electrical switch disoperation happens an accidental islanding operation can be framed by the DGs and local loads [3]-[4].The islanding system makes potential dangers to field administrators, the system hardware, line rebuilding and the electrical switch reclosing operations. In this manner, it is vital to distinguish the system islanding working circumstances successfully [5].

Islanding identification strategies can be grouped into two classes: the communication based techniques [6]-[9] and the local measurement based techniques that are additionally partitioned into the dynamic strategies and the passive strategies. The communication based technique includes remote-end estimation [6]-[7] and wide-range phasor estimation [8]-[9] that depends on continuous information transmission. This could build the system venture and may cause transfer mal-work because of correspondence disappointments. The inactive strategies examine the difference in/rate of progress of (ROCO) electrical amounts a t the hand-off area, caused by confounding of the DG output and nearby loads [10]-[11] .

The essential hypothesis of the inactive technique is clear and simple for handy use. Recently, explores on this technique fundamentally concentrate on the savvy flag preparing calculations. The estimation of signal parameters through rotational invariance procedures (ESPRIT), quick Gauss-Newton calculation (FGNWA), Tufts– Kumaresan (TK), autoregressive (AR) are utilized to select the helpful flag from commotions and bends. And after that, the example acknowledgment calculations, for example, Decision Trees (DTs) Naive-Bayes classifiers (NBC bolster vector machine (SVM) and characterization and relapse trees (CART) are utilized for islanding recognition. Applying brilliant information handling to various measured factors, the non-location zone (NDZ) can be lessened. In any case, the hypothetical NDZ may even now exist when the DG output control matches with the neighborhood loads and the confounded information handling could make the uninvolved technique less ideal for industry application.

At present, dynamic techniques are basically received by the inverter-based DGs. These techniques change the inverter control loops (incorporate the phase bolt circle) or the control reference esteems to actuate little power, voltage amplitude phase and frequency errors to the inverter outputs., these errors will be enlarged for exact location While islanding condition happens. In any case, for multi-inverter-based DGs, it is conceivable that disturbance signals delivered by this dynamic strategy could be increased (risking the power quality and the system strength) or could balance each other (causing disappointment of islanding discovery). For multi-inverter circumstance, with a specific end goal to stay away from the mutual impacts, the master slave injector is ordered. The master inverter consistently or discontinuously infuses a high frequency current symphonious (regularly in the range from 300Hz to 700Hz) through the “q” or “d” current control loops. The islanding can be identified by measuring the system impedance varieties (or voltage reaction). Applying this infusion technique for multi-DG system, the normal downsides are: 1) the deliberate impedance (or voltage reaction) can't be hypothetically disclosed because of the way that the harmonics won't just stream to the fundamental system yet in addition to alternate inverters and the inverter models in high frequency area are not given; 2) the master inverter needs to infuse a relative vast mutilation to keep up an exact estimation (particularly in the high frequency range) and this may cause system control quality issues.

Concurring the two downsides of the current infusion strategies,in this paper to avoid the mutual impacts of inverters a centralized high frequency transient infusion technique is proposed for multi-DG systems. The disappointment component of the regular dynamic strategy is examined. The dynamic high frequency impedance demonstrate for inverter-based DG is proposed. This model is immaterial to the control calculation and source qualities and is reasonable for all the inverter-based DGs. By methods for discontinuous Time Domain Low Voltage Condition (TDLVC) infusion, great estimation exactness and the system control quality can be accomplished for revise islanding identification.

The term "fuzzy" refers to the fact that the logic involved can deal with concepts that cannot be expressed as the "true" or "false" but rather as "partially true". Fuzzy logic has the advantage that the solution to the problem can be cast in terms that human operators can understand, so that their experience can be used in the design of the controller. A trend that is growing in visibility relates to the use of fuzzy logic in combination with neuro computing and genetic algorithms. More generally, fuzzy logic, neuro computing, and genetic algorithms may be viewed as the principle constituents of soft computing.Unlike the traditional,hardcomputing, *softcomputing* accommodates the imprecision of the real world. The guiding principle of soft computing is: Exploit the tolerance for imprecision, uncertainty, and partial truth to achieve tractability, robustness, and low solution cost. In the future, soft computing could play an increasingly important role in the conception and design of systems whose MIQ (Machine IQ) is much higher than that of systems designed by conventional methods.

II. FAILURE MECHANISM OF CONVENTIONAL ACTIVE METHOD BASED ON INVERTER DISTURBANCE

A. Frequency-reactive power Drift Method

one of the regular inverter-based dynamic islanding identification is The frequency reactive power (f-Q) feedback floating technique. It depends on the connection between frequency of the DG's output voltage and the reactive power. The frequency float is quickened by a f-Q feedback control procedure after the islanding happens. This will amplify the frequency contrasts regardless of the possibility that the neighborhood burdens' devouring force matches with the DGs' output control. An ordinary system connected inverter-based DG system with nearby paralleled loads is improved and appeared in the Fig.1. As per the adequacy and frequency varieties of inverter's output voltage, the islanding circumstance can be identified. The inverter, as appeared in the Fig.1, is controlled for greatest genuine power output while the reactive power is set to be zero for ordinary operation.

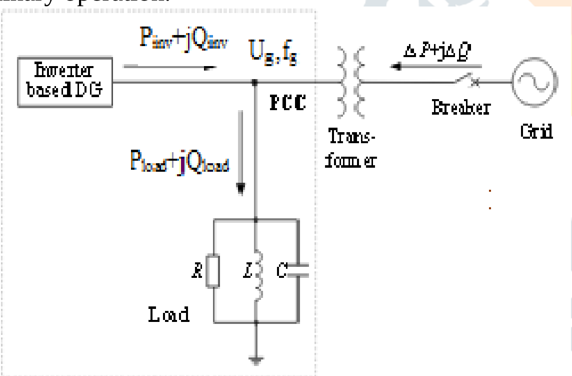

Fig. 1. The equivalent circuit of a grid connected inverter system

For the grid-connected situation, there will be:

$$P_{load} = \frac{3U2g}{R} = P_{inv} + \Delta P \quad (1)$$

$$Q_{load} = 3U_g^2\left(\frac{1}{2\pi f_g L} - 2\pi f_g C\right) = Q_{inv} + \Delta Q \quad (2)$$

Where by, P_{load} and Q_{load} are the dynamic and reactive power devoured by loads in ordinary operation; P_{inv} and Q_{inv} are the inverter's dynamic and reactive power outputs; ΔP and ΔQ are the dynamic and reactive power provided by the grid; Ug and fg are the amplitude and frequency of the inverter's output voltage.

In islanding circumstance, U_{island} and f_{island} signify the magnitude and frequency of the terminal voltage of the nearby loads, P'_{load} and Q'_{load} are the dynamic and reactive power devoured by the neighborhood loads. At the point when the inverter works on steady power control mode, there will be:

$$P_{load} = \frac{3U2island}{R} = P_{inv} \quad (3)$$

$$Q'_{load} = 3U^2_{island}\left(\frac{1}{2\pi f_{island} L} - 2\pi f_{island} C\right) = Q_{inv} \quad (4)$$

The terminal voltage of the neighborhood loads in islanding peration can be calculated by (5):

$$U_{island} = \sqrt{\frac{P_{inv}R}{3}} \quad (5)$$

in unity power factor mode if the inverter works which means Q_{inv} =0, the inverter won't supply reactive power to the loads after islanding. Thus, the frequency of the terminal voltage can be represented by (6):

$$f_{island} = \frac{1}{2\pi\sqrt{LC}} \quad (6)$$

Therefore, the relationship between *ΔQ* (the mismatching reactive power) and f_{island}, can be expressed as:

$$\frac{\Delta Q}{P_{inv}} = \left(\frac{U_g}{U_{island}}\right)^2 Q_f\left(\frac{f_{island}}{f_g} - \frac{f_g}{f_{island}}\right) \quad (7)$$

Where $Q_f = R\sqrt{\frac{C}{L}}$ is the quality factor of load

As appeared in (7), the reactive power contrast between inverter's output and the nearby load will bring about frequency variety during islanding.

In this way, the network connected inverter system's islanding operation can be identified by the amplified frequency floating which is caused by reactive power aggravation. With a specific end goal to acquire adequate reactive power aggravations from a little change in the frequency and enhance the identification speed, a frequency feedback is utilized in the reactive power control loop. The feedback is set as (8) and the control piece chart is appeared in Fig.2.

$$Q_{inv} = k(f_a - f_g) \quad (8)$$

Where k is the frequency feedback coefficient, fa is the frequency of the voltage at the point of common coupling (PCC), f_g is the rated frequency of the main grid (50Hz).

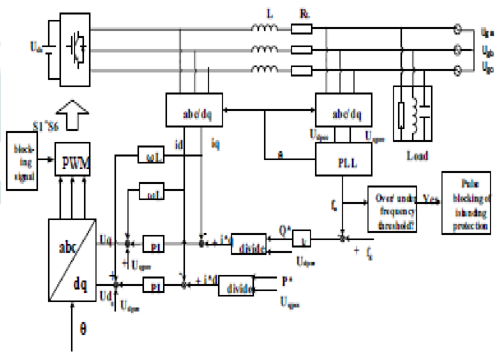

Fig. 2. Control strategy of f-Q feedback method in the inverter.

As appeared in the Fig.2, both the dynamic and reactive power of the inverter's output are consistent because of the steady P-Q control. Voltage at PCC of the DG system, braced by the main grid, is the rated voltage and the comparing esteems U_{dpcc}, U_{qpcc} in d-q organize system. Likewise, reference current i^*_q and i^*_d can be computed from the external power control loops. The present state feedback esteems, ωLid and ωLiq, are acquainted with accomplish decoupling. The internal current loop outputs the reference voltages U_d and U_q which produce PulseWidth Modulation (PWM) flags after the dp/abc transformation.

The frequency at the PCC changes almost no subsequent to islanding if nearby loads matches with the power output of the inverter. Be that as it may, by presenting the feedback loop, the reactive power counterbalance will be amplified and this would influence the frequency to rise/drop out of the reasonable range for precise islanding location.

B. Failure Mechanism of f-Q Feedback Method

To consider on the exhibitions of the f-Q feedback technique in the islanding identification, the simulation model is worked in Matlab/Simulink as indicated by the system structure presented in the Fig.1 and control procedure introduced in the Fig.2. Itemized recreation parameters are: the inverter's output is ventured up by means of transformers to a 220kV arrangement of vast limit. The dynamic power output of the inverter is 300kW and the reactive power output is controlled by the frequency contrast, that is Q_{inv}=k(fa−50) Var, where the feedback factor is k=−380^2. The RLC parallel load is connected with the 10.5kV bus and the heap expended dynamic and reactivepower are P_{load}=300kW,Q_{loadL}=150kVar and Q_{loadC}=−152kVar separately. This power is put to make a match between the DG output and the heap. This paper is attempting to depict the advances of the proposed technique contrasted and the customary dynamic strategy and for the power confusing circumstances even the uninvolved strategies work fine. All the islanding simulations explored in this paper are in the power matching condition. Islanding is set at 0.2s and the reproduction span is 1.2s. Without the f-Q feedback strategy, the frequency will stay around 50Hz in the wake of islanding due to the high-degree coordinating between the inverter output and the power devoured by the load. Connected with the three-phase f-Q feedback technique, the outcomes are demonstrated the in Fig.3 with a similar simulation conditions.

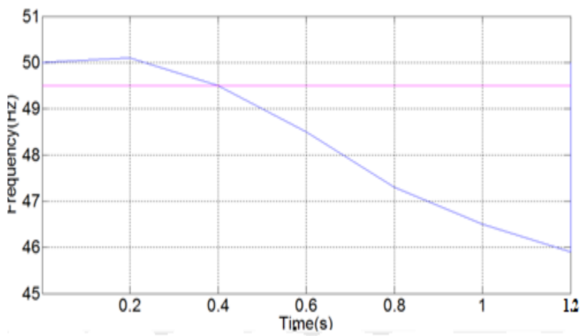

Fig. 3.Frequency measured at the outlet of the inverter with f-Q control

In Fig.3, because of the f-Q feedback calculation, the reactive power increments and the frequency drops in the wake of islanding. Along these lines, the difference in the system working state can be distinguished within 200ms (the edge is set to be 49.5Hz). however, in multi-DG systems, reactive power aggravations created by various inverters may interfere or balance each other. This could make it difficult to shape the constant f-Q feedback to quicken the frequency float and the islanding location may come up short.

In perspective of the investigation over, the recreation of three paralleled inverters connected with a 220kV bus through step up transformers is completed. The dynamic power output of every inverter is 100kW. by using frequency difference, The reactive power output is dictated that is $Q_{inv}=k_i$(fa−50) Var. By and by, considering the hand-off affectability and the system control quality, the feedback factor changes for various makes. To exhibit that variable feedback components can bring dead zone of the traditional dynamic islanding identification technique, elements of the three inverters are set as: for the inverter “1”, “2”and “3”are $k_{1,2}$ =−380^2, and k_3 =2*380^2 individually. The simulation conditions and parameters are the same with each of the single-inverter as appeared in Fig.3 above. The simulation outcome of multi-DGsystem are appeared in the Fig.4.

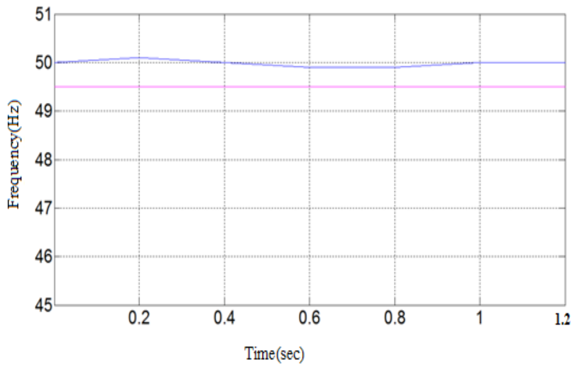

Fig.4.a)The frequency of voltage at the outlet of No.1 inverter

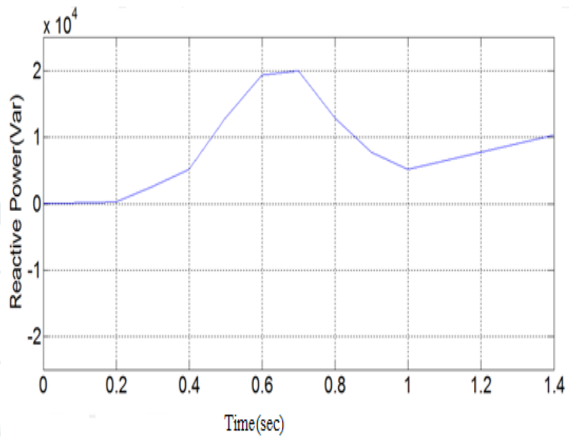

fig.4.b） The output reactive power of No.1 inverter

Fig. 4. The frequency and reactive power curves in multi-inverter system derived using the f-Q feedback method.

As appeared in the Fig.4, because of the counterbalance and obstruction of reactive power aggravations from various inverters, the frequency curve vacillates inside a tight range around 50 Hz and does not surpass the islanding location limit. The output reactive energy of every inverter changes in a little scale and the summation of the output feedback reactive power from all inverters is near zero. On this event, this dynamic islanding recognition strategy based on inverter unsettling influence won't work.

III. ISLANDING DETECTION FOR MULTI-DG SYSTEM

A. Rationale of Impedance Estimation Method

The external injection based method can be used for all the DGs (directly grid connected and the inverter grid interfaced). Equivalent schematic of impedance evaluation method using external

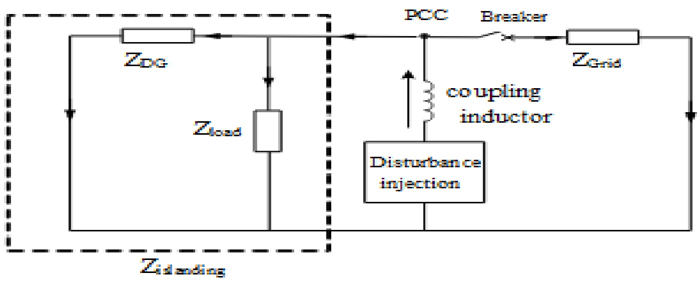

Fig. 5. Schematic of equivalent system impedance under external centralized disturbances

centralized disturbances is appeared in the Fig.5. It applies independent centralized injection at the PCC, other than conventional inverter-based injections.Schematic eqvivalent diagram of system impedance undert disturbances shown in figure 5.the measred impedance attributes at the infusion point and the fundamental rule of islanding discovery are outlined as takes after:

For the most part, the proportionate impedance of system is significantly lesser than that of DG and load in a grid connected disseminated era system as a result of their ability contrasts

$$. Z_{Grid} << Z_{DG} ,Z_{Grid} << Z_{load} \quad (9)$$

$$Z_{islanding}= \frac{Z_{DG}Z_{load}}{Z_{DG}+Z_{load}} >>Z_{Grid} \quad (10)$$

where Z_{Grid}, Z_{DG} and Z_{load} are the identical system impedance, DG impedance and the heap impedance in the high frequency. $Z_{islanding}$ is the deliberate islanding impedance in the high frequency. Before islanding, the measure impedance $Z_{measure}$ at PCC is:

$$Z_{measure} = \frac{Z_{Grid}\, Z_{islanding}}{Z_{Grid}+Z_{islanding}} < Z_{Grid} \quad (11)$$

After islanding, the measured impedance $Z'_{measure}$ at PCC is:

$$Z'_{measure}= Z_{islanding} >> Z_{Grid} >Z_{measure} \quad (12)$$

Conditions (11)- (12) demonstrate that during normal operation the measure impedance indicates DG impedance, load impedance and the grid impedance are in parallel and this incentive in the wake of islanding (stack impedance and the DG impedance in parallel) will be higher than ordinary operation. This can be used for islanding recognition. Because of the way that just a single disturbance is utilized, the mutual impedances of various inverters can be maintained a strategic distance far away.

B. Impedance Model of Grid-connected Inverter under External Disturbance Signals

The inverter-based DGs typically have a DC support circuit and a three-phase Insulated Gate Bipolar Transistor (IGBT) bridge. The Permanent Magnetic Synchronous Generator (PMSG) is one of the regular inverter-based DGs. Utilizing PMSG as a portrayal, this paper researches the high frequency impedance model of inverter-based DGs under outside aggravations.

Fig.6 demonstrates the setup of a GE PMSG connected with system through an inverter. The three-phase AC voltage created by the synchronous generator is initially changed over into DC voltage (at C_{dc}) through an uncontrolled rectifier and a boost circuit, and afterward into three-phase AC voltage in the PWM frame through a 3-phase completely controlled inverter.

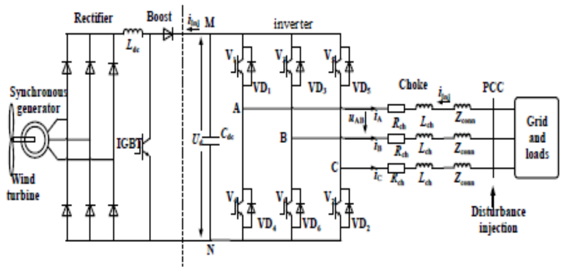

Fig. 6. Model of PMSG connected to grid through an inverter.

The outside unsettling influence producing gadget infuses transient aggravation motion into the system from the PCC. The flag courses through all branches of the system as: the primary network, burdens and PMSGs. For the PMSG, the aggravation flag experiences the Choke channel and the inverter into the inward piece of the PMSG (left half of the dashed line). The u_{AB} is the voltage between phase A and phase B of the inverter output. i_A and i_B are indicates current of phase A, B correspondingly, whose positive directions are set to be leaving the inverter. The i_{Inj} is the disturbance flag getting from the PCC. Its positive course is set to be entering the inverter as the dashed bolt appeared in Fig.6.

Inside the intrigued frequency extend (a few kHz), it is expected that the infused current flag is lesser (contrasted and the vast intrinsic system current) and superimposes upon the characteristic current without impacting the genuine course of the innate current. The power electronic gadgets are viewed as perfect gadget whose on-state is seen as short circuit and off-state as open circuit in the kHz extend. As per the PWM adjustment, the inverter output voltage (u_{AB}) is a tri-level PWM wave identical to the sine-balancing wave. The inverter's output streams (i_A, i_B) are roughly sine waves (incorporate a specific measure of sounds) with a 120° phase contrast. totally with the genuine on-off condition of extension arm. At the point when the u_A is certain, connect arm 1 is on; and when u_A is negative, the scaffold arm 4 is on. At that point in light of i_A, the on-off condition of nitty gritty components in bridge arm can be additionally finished up. At the point when i_A is certain, V_1 (the IGBT) or VD_4 (the diode) will be on; and when i_A is sure, V_4 or VD_1 will be on.

As indicated by the single phase examination above, mix of on/off conditions of all extension components of phase A and B can be finished up: the high voltage level of u_{AB} ($+U_{d}$) compares to the on-condition of scaffold arm 1,6 and the V_1,V_6 are controlled at its on-state as of now. Moreover, using the mix of i_A and i_B's directions, it can be worked out whether the current experience the IGBT or its freewheeling diode. Thus, the low voltage level of u_{AB} ($- U_d$) relates to the on-condition of extension arm 3,4 and the zero voltage level of u_{AB} (0) implies the on-condition of scaffold arm 1,3 or 4,6.

In view of the considerable number of examinations over, the on-off conditions of all extension arms and their components in the entire inverter can be finished up from the PWM voltage and current output waveforms. There are absolutely 16 sorts of ways through which the aggravation signals go into the inverter regarding the infusion mode alluded above (not each of the 16 ways exist inside a cycle, contingent upon the relative phase connection of i_A, i_B and u_{AB}). In the light of the blend of i_A, i_B's sure/negative bearings inside a cycle, the ways of the infusion transient can be arranged into four gatherings ： i_A positive and i_B negative, i_A positive and i_B positive， i_A negative and i_B positive， i_A negative and i_B negative. Each gathering contains four flag ways.

The Fig.7 demonstrates the four flag ways of gathering 1 (when i_A is sure and i_B negative). The other twelve flag ways can be broke down in the comparative way. Whatever is left of the 12 ways are given in the Appendix.

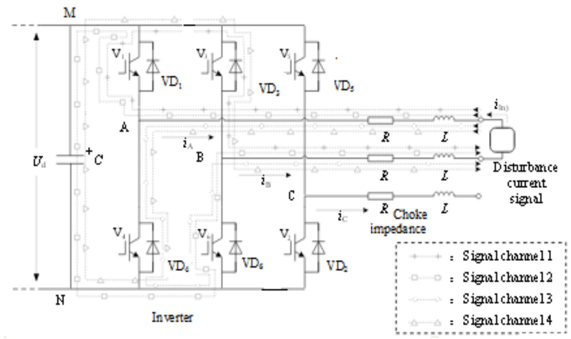

Fig. 7. Channel analysis of external disturbance (when i_A is positive and i_B negative).

The four infusion flag ways are appeared in Fig.7 utilizing dashed lines. The infused flag, superimposed upon the extensive innate system current, may stream as per the bearing of system current or inverse to it, conveying no alter to course of characteristic system current.

At the point when the IGBT of the boost circuit is off and the diode will be on, a little segment of the infused flag will experience the diode rectifier to the synchronous generator as appeared in Fig.8.

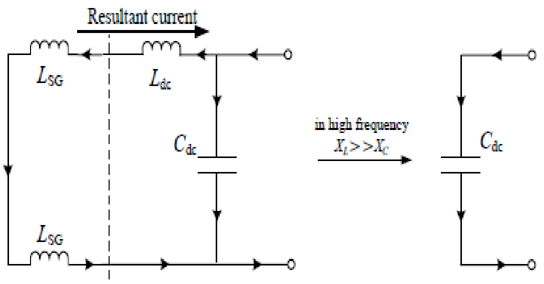

Fig 8. Equivalent impedance when the IGBT of Boost circuit is off.

The arrows in Fig.8 demonstrate the direction of the infusing signal and course of the resultant current made out of disturbance current and the intrinsic DC charging current. L_{SG} is the single-phase identical inductor of the synchronous generator; C_{dc} is the DC connect capacitor; L_{dc} is the lift circuit inductor. In the intrigued high-frequency go (kHz), for an ordinary setting of the PSMG, the reactance of the capacitor can be 10^3~10^4 times lesser than the reactance of the inductors and can be disregarded for handy use. For this situation, the high frequency proportional impedance circuit is appeared in the right part of the Fig.8.

Integrating every one of the investigations above, it can be presumed that the entire PMSG's reaction to high frequency aggravation signals is the inverter's impedance qualities. The PMSG (or inverter) can be displayed by two identical impedances under outside unsettling influences: the short ciruit impedance and capacitance impedance. These two sorts of impedance show up then again in a high frequency (a similar frequency level with switching frequency). In any case, under the intrigued high-frequency run, in the perspective of the extensive capacitance (C_{dc}), the capacitor reactance ($X_C=1/\omega C_{dc}$) will be similar to the short circuit. The high frequency impedance model of the PMSG really demonstrates the short circuit impedance attributes of an inverter in addition to the Choke channel impedance in any case the generator output varieties and the control circle outlines. This model can be appropriate for PV and some other inverter-based DGs.

C. Injection Control and Wide-band High-frequency Reactance Calculation

The proposed transient current infusion device is acknowledged by using the standard and structure of single-phase full-bridge inverter circuit as appeared in the Fig.10.

In the Fig.9 a capacitor (charged by a rectifier) gives steady DC voltage to the single-phase full-bridge inverter. The inverter is connected with phase A and B of the system at PCC, through an extensive coupling inductor (L) whose inductance esteem is set by the extent of infusion current and a grid association IGBT switch. By controlling of IGBTs, a square pulse voltage can be created, framing a triangular current 'spike' through the coupling inductor L. Width and plentifulness of the infusion current spike is controlled to acknowledge discontinuous infusions which can diminish the contortions to the healthy system.

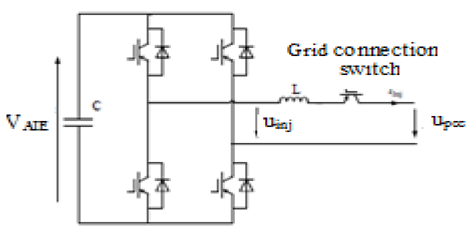

Fig. 9. Schematic of independent disturbance generating device.

Regarding infusion technique, this paper proposes a Time Domain Low Voltage Condition (TDLVC) infusion. It identifies TDLVC of the voltage at PCC and infuses a current spike (i_{Inj}) into the system at TDLVC and measures the PCC voltage u_{PCC} meanwhile for impedance count. The u_{PCC} comprises of the inherent system voltage which is seen as a noise part and the voltage response to the infused current. In light of a short infusion length (0.1ms) and a little information catching window, the proposed strategy can give good signal to noise proportion (SNR) because of the way that little system noise and distortion waveforms are included for impedance estimation. For practical applications, the infusion happens when the voltage is inside a limit that is near zero. Inside this limit, the voltage is low and just little infusion flag is required for rectify estimation. The TDLVC discovery calculation is abrogated during the infusion. The adequacy of infusion current can be altered by legitimizing U_{AIE} and Δt as appeared in the condition (13). The current heartbeat is infused into the system through a coupling inductor or a current transformer.

$$I_L = \frac{1}{L}\int UAIE\,dt \qquad (13)$$

In addition, the grid association IGBT is just exchanged on at the TDLVC where the infusion is done. For this situation, the V_{AIE} simply should be higher than the greatest estimation of voltage restricted inside the short infusion term. This lessens the measure of the DC capacitor and brings more advantage for down to practical usage.

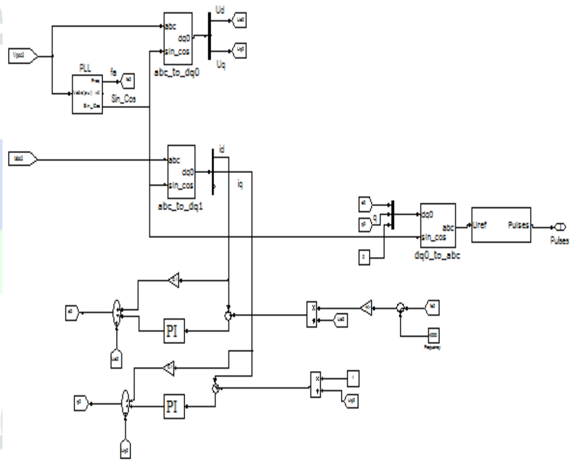

Fig.10 controlling block diagram

Fuzzy Logic Controller

One of the reasons for the popularity of Fuzzy Logic Controllers is its logical resemblance to a human operator. It operates on the foundations of a knowledge base which in turn rely upon the various if then rules, similar to a human operator. Unlike other control strategies, this is simpler as there is no complex mathematical knowledge required. The FLC requires only a qualitative knowledge of the system thereby making the controller not only easy to use, but also easy to design.

Fuzzy Logic Toolbox extends the MATLAB technical computing environment with tools for designing systems based on fuzzy logic. The toolbox contains model complex system behaviors using simple logic rules and then implements these rules in a fuzzy inference system. The toolbox can be used as a standalone fuzzy inference engine. Alternatively, use fuzzy inference blocks in Simulink and simulate the fuzzy systems within a comprehensive model of the entire dynamic system.

.Advantages of Fuzzy Controller over PI Controller

Usage of conventional control "PI", its reaction is not all that great for non-linear systems. The change is striking when controls with Fuzzy logic are utilized, acquiring a superior dynamic reaction from the system

The PI controller requires exact direct numerical models, which are hard to get and may not give sophisticated execution under parameter varieties, load unsettling influences, and so forth. As of late, Fuzzy Logic Controllers (FLCs) have been presented in different applications and have been utilized as a part of the power devices field. The benefits of fuzzy logic controllers over ordinary PI controllers are that they needn't bother with a precise scientific model, Can work with uncertain information sources and can deal with non-linearities and are more powerful than traditional PI controllers.

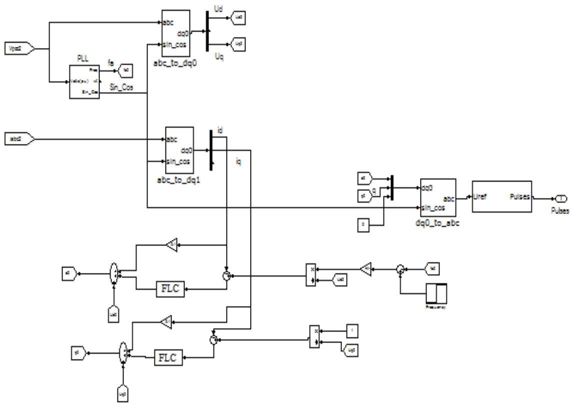

Fig.11. controlling block diagram

SIMULATION RESULTS:

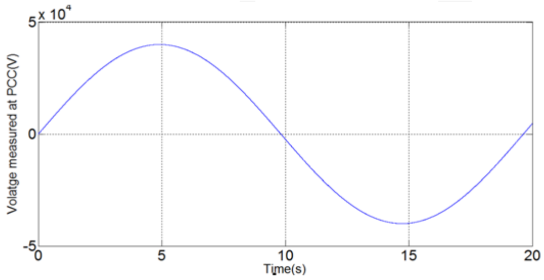

Fig. 12(a).Waveform of voltage measured at PCC

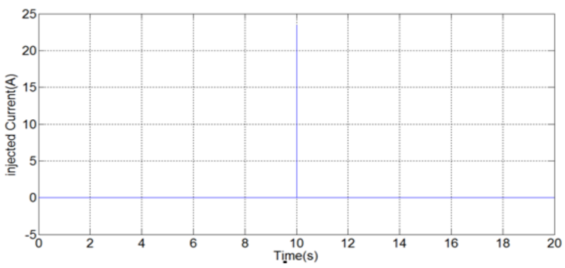

Fig. 12(b). Waveform of current disturbance injected

Fig. 12. Waveform of current disturbance injected and voltage measured at PCC (the cycle in which disturbances injected) using PI controller

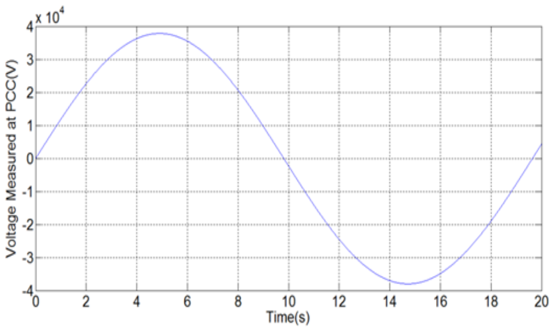

Fig. 13(a).Waveform of voltage measured at PCC

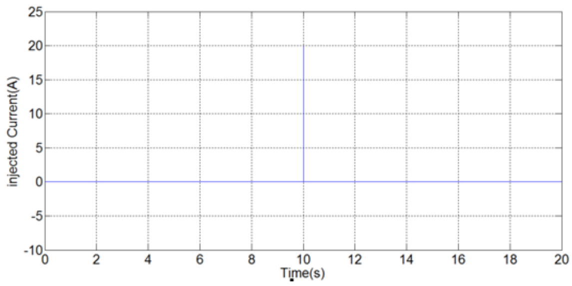

Fig. 13(b). Waveform of current disturbance injected

Fig. 13. Waveform of current disturbance injected and voltage measured (the cycle in which disturbance is injected) using fuzzy controller

The Fig.13 shows the waveforms of the injected current and voltage measured at PCC using the intermittent TDLVC injection control and fuzzy logic controller Peak value of the injected current is set to be 20A that is far lesser than inherent system current It produces only a small and short disturbance to systemvoltage.

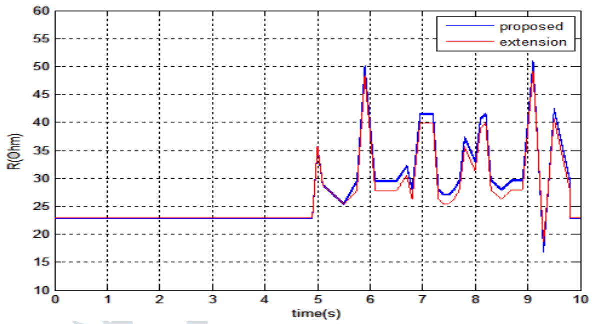

Fig.14(a) Change of resistance before and after islanding

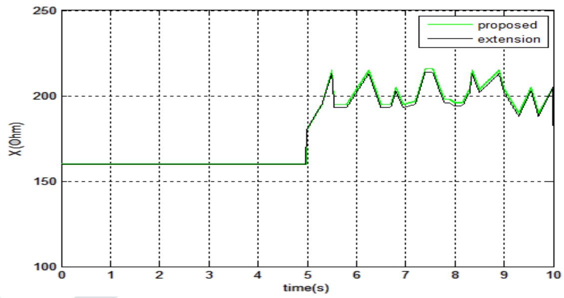

Fig.14(b) Change of reactance with random injection

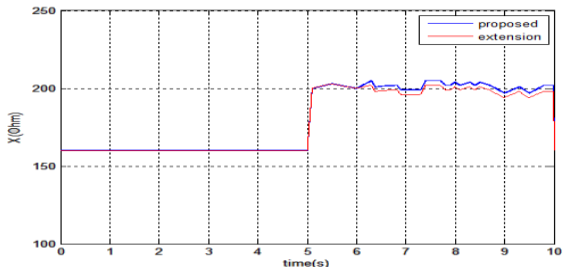

Fig.14c) Change of reactance with TDLVC injection

Fig. 14. On-line impedance characteristic quantity curve in time domain (the islanding occurs at 5s).

As appeared in Fig.14(a) islanding is occurs at 5s. As probably the measured resistance changes after islanding . The Fig. 14 b) and c) shows that the reactance obtained by random injection and the proposed TDLVC injection respectively.

Comparing the reactance estimation using TDLVC injecting with the ractance obtained using random injection, reactance derived using TDLVC gives more accuracy due to less system noise involved. This will result to enhancement in the sensitivity of islanding detection.

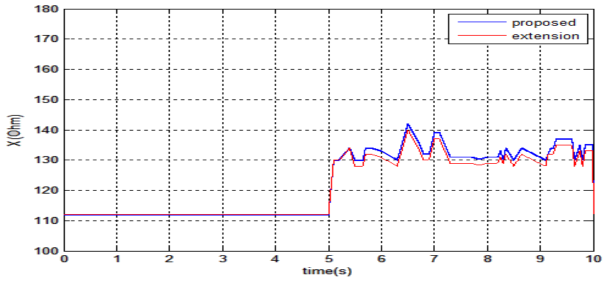

Fig.15(a)Reactance of 3 PMSGs reduced to 4kHz

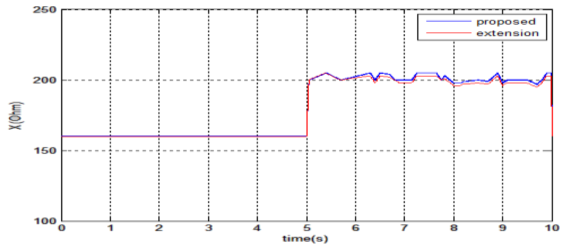

Fig.15(b) Reactance of 1 PMSG with 1% white noise reduced to 4kHz

Fig. 15. On-line impedance characteristic in time domain in the case of 3 PMSGs and 1 PMSG with 1% white noise.

In fig.15(b) 1% white noise is added to the result.comparing results in the fig 15 b) with the fig 14(c) the estimated reactance under 1% white noise maintains small error.

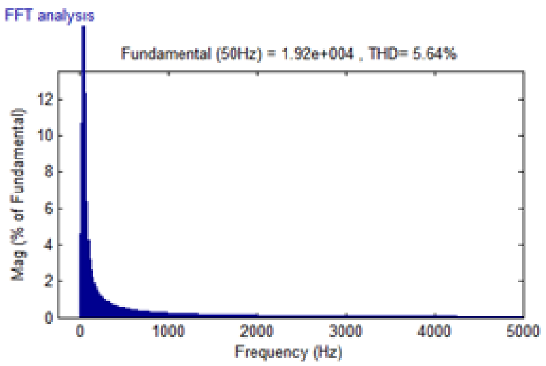

Fig 16(a):harmonic analysis of system volltage using PI controller

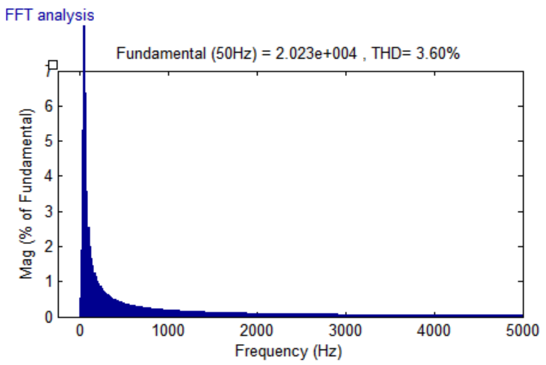

Fig 16(b):harmonic analysis of system volltage using Fuzzy logic controller

CONCLUSIONS

As distributed generation system with numerous DGs creates, regular islanding recognition techniques which chiefly go for single-DG system are confronting challenges. This paper proposed an islanding detection strategy in view of high frequency impedance estimation utilizing external centralized transient infusions..

Utilizing TDLVC injection and wide-band high-frequency reactance count, a good islanding identification exactness is accomplished for multi-DG systems. Additionally, the intermittent TDLVC injection control of short tiny current spikes can make little distortion to the solid power system.

The fuzzy logic control scheme has been designed and implemented in an easier and quicker way than a classical potential integral control method. THDs(Total harmonic distortion)of system voltage using PI controller is 5.64% and 3.6% by using fuzzy controller The Simulation results revealed that the fuzzy logic controller performance was better for islanding detection under disturbance conditions and also reduce the system noise comparatively in a short period than the proportional integral controller.

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