Power quality enhancement in microgrid engineering essay

Engineering

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Abstract – Microgrid becomes one of the key spot in research on distributed energy system. Since the definition of the microgrid is paradigm by the first time, investigation in this area is growing continuously and there are numerous research projects in this moment over the world. The main objective of this paper is to make a comprehensive survey focused on the power quality improvement in microgrid. The increased infiltration of non-linear loads and power electronic interfaced distribution generation systems creates power quality issues in the distributed power system. Whereas major power quality problems are voltage unbalance, frequency regulation and harmonic elimination are discussed.

Keywords — Microgrid, Distributed generation (DG), Power quality, Voltage unbalance, Harmonic.

I. INTRODUCTIONMicrogrid can generally be viewed as a cluster of distributed generation connected to the main utility grid, usually through some Voltages Source Inverter (VSI) based interfaces [1-2]. Due to radial increase of load demand leads to the development of this scenario made infrastructure to main grid. Distributed generation system based on renewable energy sources such as solar energy, wind turbines, hydro electric power, fuel cells etc. are used. They offer many advantages for power system. The impact of power quality problems are concerning while interfacing of microgrid to the main grid and it could becomes a major area to investigate [3]. If unbalance in voltage is serious, the solid state Circuit Breaker (CB), connected between the microgrid and utility grid will open to isolate the microgrid. When voltage unbalance is not so solemn, CB remains closed, resulting in sustained unbalance voltage at the Point of Common Coupling (PCC) [4]. Generally Power Quality problem are not new in power system, but rectification methodology are increased in recent years. The term Electric Power Quality broadly refers to maintaining a near sinusoidal power distribution bus voltage at rated magnitude and frequency. In addition, the energy supplied to a customer must be interrupted from the reliability point of view. The major power quality problems which affect the utility grid are presence of harmonic content, loadunbalance, increased reactive power demand and fluctuation in system voltage. Generally, current harmonic and voltage-frequency imbalance increase losses in ac power lines. The current control loop based on synchronous reference frame and conventional PI regulator is used for voltage-frequency regulation [5]. The power quality parameters are made conditioning with the support of voltage source inverter interfaced distributed energy resources. Since, they need of conventional filter inorder to detect apparently the unbalance in voltage and harmonic in the main system. The art of designing of filter in three phase power system indulged adopting of band pass and band stop filter to eliminate the harmonic in microgrid [6]. Flexible Distributed Generation

(FDG), which relates in the functional of FACTS is proposed to active power flow control and to mitigate harmonic, unbalance load and voltage flickering [7]. The current controller functions to inject sinusoidal current to grid, although in presence of nonlinear load and unbalance voltage distortion [8-9]. So as to attain fixed switching frequency, the controller complexity will be raised, although hysteresis controller is used [10]. Fast and robust voltage control characteristic is essential to facilitate robust microgrid operation and mitigate interaction among converter [11]. A control strategy is proposed to improve power quality and proper load sharing in both islanded and grid connected modes [12]. Voltage dip is often responsible for disrupting the operation of sensitive electronic equipment [13]. The characteristic of VSI relays on the current control strategy which is adopted and to provide power quality requirement, hence inverter in the microgrid would attain very good characteristic of harmonic elimination. The organization of this paper is as follows. Section-II describes the current control strategy using artificial intelligence technique. The implementation of Particle Swarm Optimization (PSO) and the improved performance of power quality in microgrid are discussed. In section-III various conventional current control strategies are discussed and produced the best among them were illustrated. Section-IV presents power quality enhancement obtained by compensating devices. Thus shunt and series compensator are described and provide excellence regulation of unbalancedvoltage. Section- V deals with the harmo nic selective filters for extraction of characteristics harmonic from fundamental harmonic and also describes the mitigation of negative sequence component using complex filter. Section-VI describe a new control technique, Recursive

Least Square (RLS) algorithm is implemented in FDG interfaced in utility grid for harmonic extraction and to mitigat e voltage flickering. Finally the conclusions are presented in section-VII. II. CURRENT CONTROL STRATEGY USING SOFT COMPUTING TECHNIQUE (PSO) IN MICROGRIDIn this section, Current control strategy for VSI is more responsible to mitigate the power quality problems is investigated. VSI are made interconnecte d by widely used PWM, have high switching frequency and nonlinear voltage-current characteristic which affect the equality of power supply. Therefore current control strategy is needed in VSI. Current controller are categories into two, one is closed loop nonlinear current control type PWM anoth er one is open loop linear voltage control type PWM is used. In nonlinear controller for three phase grid connected V SI is employed by Hysteresis Current Control (HCC). Linear c ontrol is employed with Space Vector PWM (SVPWM) is used to compensate the current error by conventional regulato r or any control algorithm. Recently power controller b ased on an inner current control loop has been investigating for better microgrid configuration. Real time optimization is carried out in power controller. This controller is made inte rfaced along with current control, based on synchronous reference frameconventional PI regulator is used toa chieveexcellencedynamic response. When sudden loadchangesoccurs inmicrogrid there arise of power quality problems. Inorder to overcome this problem voltage and frequency are carried out by real time self tuning of Particle Swarm O ptimization (PSO) algorithm to regulate grid voltage and frequency. Power controller employs active-reactive power control strategy and voltage – frequency control strategy. Th ese strategies are made tunned with PSO algorithm to impro ve power quality in microgrid. Simulation result shows that PS O algorithm tunes the current control loop to achieve Voltage-frequency regulation. Fig. 1 (a). The microgrid voltage regulated by Vf contro l. In Fig. 1(a). it is noted that PSO controller react and provides, after a short transient, voltage equal to 0. 9544 p. u. At 1s, theVf control is adopted to offer an excellence behaviour and maintains the microgrid voltage equal to 1. 047 p. u. Fig. 1(b). The microgrid frequency regulated by Vf control. In Fig. 1(b). show that frequency equal to 0. 998 p. u. At 1s, Vf control is used and maintained the microgrid frequency equal to 1. 0044 p. u. This results show s that PSO controller provides proper voltage-frequency regulation in the microgrid without creating any other parameter of power quality. Although these strategy posses sufficient reliability in power quality. III. CURRENT CONTROL STRATEGY IN MICROGRIDThis section investig ates different Current control strategy implemented in micro grid. The objective nature of control is to inject a clean si nusoidal current into the grid, even though nonlinear/ unbalance loads are connected. Different strategies like Proportional-Integral (PI), Proportional-Resonant (PR), p redictive Dead Beat (DB) and repetitive control are investigated. The PI control scheme is implemented in synchronous rotating (d, q) reference frame is often used. The control scheme of PR is stationary (α, β) reference frame which is popul ar due to elimination of error, by controlling sinusoidal signals and having the capability to mitigate harmonic. Predictive DB controllers are widely used for current error compensation and to offer high characteristic of current controlled VSIs. Repetitive control theory is simple learning control method, which provide an alter method to eliminate the THD content in voltage or current. It is composed of current control loop along with repetitive controller inorder to inject the current into the utility grid. This mechanized typed con troller allows attaining an excellence tracking characteristic over a wide range of utility grid frequency. The control str ategy is estimated in the grid connected mode under tw o different scenarios: with unbalanced loads and with nonlinear loads. TABL E - ITHD of the current sent to the G rid: With unbalanced loads. ControllerCurrentTHD %Grid voltagerepetitiveTHD %1. 031. 57PR3. 841. 45PI4. 381. 52DB3. 651. 61From TABLE - I it is clearly defined that repetitive controller provides best performance c ompared to other controller with unbalanced loads. TABLE – IITHD of the current sent to the Grid: With nonlinear loads. ControllerCurrentTHD %Grid voltagerepetitiveTHD %5. 271. 6PR16. 711. 47PI16. 021. 41DB16. 541. 49From the TABLE – II shows that repetiti ve control gives the excellence suppression over other controller under nonlinear loads. Inference from TABLE – I & II implies that repetitive control scheme give the finest performance among the different current control strategies. IV. MICROGRID POWER QUALITY EN HANCEMENTThe proposed compensator with each and every individual distributed generation system in microgrid is comprised of shunt and a series compensator, which provide optimal control to attain an improvement of both power quality in the microgrid and to enhance the quality of power flow within the utility system and the microgrid. Increased losses in motor loads and subnormal operation of sensitive equipment is occurs when unbalance in voltage . Low line impedance is achieved when huge unbalance current flow between microgrid and unbalanced functional grid. When voltage unbalance arise, the compensator u sed to compensate all the unwanted positive, negative an d zero sequence component originated with in the utilit y grid. The shunt compensator is used to ensure balance voltage condition within microgrid and also to regulate dispatching of power among DG systems. The series compensato r is accustomed to inject zero sequence and negative sequence voltage in series inorder to balance the line currents and by creating zero reactive and real power. The proposed current limiting algorithm made integrated along with c ontrol scheme of inverter inorder to prevent the microgrid from huge fault current during sag in utility grid voltage. Simply we can say that shunt inverter is used for power c ontrol and voltage regulation, likewise series compensator is adopted for balancing line current and to limit the fault currentFig. 2. Simulated waveform of (a) main grid voltages, (b) load voltage in microgrid. Fig. 2(a) shows that voltage profile of grid are initially balanced. From t = 1. 2s onwa rds, negative sequence voltage of 0. 1 p. u. are added to original balanced voltage. When grid interface compensator is added and Fig. 2 (b) implies that, voltage in sensitive load of microgrid is kept well balanced and makes the system healthy under unbalance voltage conditions. From this it is verified clearly that shunt compensator offer excellence compensation in microgrid to attain good power quality. Fig. 3 (a) Line current without series inv erterFig. 3 (b) Line current with series inverterFrom Fig. 3 (a) and (b) it is clearly shows the extremely unbalance line current under grid voltage made mitigated with series inverter. This verifies t hat series inverter gives good performance in mitigation on line current in unbalanced condition. V. SEQUENCE / FREQUENC Y ELIMINATION BY FILTERSThe filtering techniqu es in three phase utility grid system involve employing of band pass filter which allow the frequencies within its limit without attenuation. This method however gives raise of exce llence dynamic performance between desired and undesired frequencies. Mostly electrical distribution system include voltage imbalance and harmonic generating loads, hence the ga p between the two frequencies is very low, although those methods won't provide good performance. Advance metho d of filtering in three phase, three wire power system is attained by the designing of complex band pass and band stop section using three phase space vector quantities. Since these selective filters are implemented in VSI, that are e mployed as interfacing device of DG. Conventionally filters are having limitation in Negative Sequence Filtering (NSF). The negative sequence filter is composed to preserve unity gain factor for negative sequence of 50 Hz by provi ding zero transmission to the positive sequence of 50 Hz component in space vector component in three phase syste m. Likewise Positive Sequence Filter (PSF) is obtained by making change of NSF. Here the design of complex co-efficient of filter involves attaining a high quality output. As a result of that negative sequence filter is designed. The improved develo pment of active filter leads to the harmonic extraction than the existing filter inorder toenhance power quality. Although active filter are accurate and fast elimination of harmonic content/ negative sequence are dangerous in the function of grid connected power electronic component in addition with fault diagn osis of electrical machine. The accurate prediction of performance degradation and the induction machine characterisation are made used to improve frequency/ sequence filterin g technique is significantly essential. An unbalance voltag e is created in three phase load by abrupt switching of three phase asymmetrical impedance attained in parallel later a little cycle leads to voltage unbalance in microgrid. The advance range of frequency/ sequence selective filter is employed for enhancement pf power quality in a microgrid. Additional key functionality of the filter is its response ti me and it is related to bandwidth. Line voltage drop is meas ured accurately by adopting the NSF and PSF transfer functions in the Distributed Energy Resources (DER) current and it is multiplied with this line reactance correspo ndingly. both band stop and band pass sectors incorporated inorder to attain high quality output. The harmonic selective filter allows 5th and 7th harmonic at unity gain factor with zero phase delay and reject other frequency component. Hence the response time of designed filter can be minimized without influencing the filter performance inorder to mitigate harmonic content. Fig. 6. 5thHarmonic selective filterFrom the Fig. 6. it is observedthat the input contains bothfundamental frequency and also5th harmonic component. Theoutput wave form shows that band pass of 5th harmoniccontent. Thethirdwavefor mcontaining thedifferencebetween the input and output isdisplayed to demonstrate thatFig. 4. NSF input and output waveform. extraction of 5th harmonic are carried out by bandstop filter. Likewise 7th harmonic is elimin ated. Hence the complex filterFig. 4. illustrate the input and outputo f NSF. Inferenceprovidesexcellencefilteringofsequence/frequencyinmicrogrid. obtained is output of filter NSFout be comes zero untilimbalance is occurred, when filter picks up negative sequenceVI. POWER QUALITY IMP ROVEMENT BY FLEXIBLEcomponents it made filtered out of negative sequence. DISTRIBUTED GE NERATION (FDG)In this section how the power quality made improvedby using Flexible Distributed Generation (FDG) are discussed. A novel utilization of existing DG interfaced not only tocontrol the active power flow but also to mitigate harmonicand voltage flicker, and to m anage reactive power of thesystem. An innovative processing unit based Recursive LeastSquare (RLS) algorithm is proposed to contact with unbalancein voltage, harmonic eliminati on and to compensate reactivepower. Inorder to regulate voltage at substation buses, tapchanging transformers are employed to overcome the slowFig. 5. PSF input and output waveform. response. FDG willeliminat elinecompensatorusedforreactive power compensation as well as it perform theFig. 5. gives the input and output of P SF. From this wefunction of managing reactive p ower flow and also to mitigateobserved that PSF swapping out ofnegativesequencepower quality problems. The o bjective of RLS algorithm is topresented in the input waveform and maint ain balanced output. inject and to uphold both the ac tive and reactive power by theIn previous discussion selective sequence filter were adoptedDG interconnected to the ma in grid and also to provideto distinguish the fundamental frequency, Positive sequentialsufficient compensation for load harmonic, voltage flickeringcomponent and negative sequential component. Theseand unbalanced load condition. One advantage in FDG is itsselective sequence filter called as complex filter, are involvedinsensitivitytoparamete rvariation. Furthermore, to split fundamental frequency from its characteristicinterconnected control feature is to deal with reactive powerharmonics like 5th and 7th order. The design of complex co-flow andtocompensatesev eral powerqualityproblems. efficient filter involves frequency response whichcontainsHence multifunctionDGinte rconnectedwithmain gridisrender to DG flexible. The existing DG clearly defines the flexible function helps to improve the usage of electronic power component technically and economic ally. Harmonic can certainly extracted by using low pass or high pass filters, but on account of accuracy it is restricted due to bandwidth and selectivity. Inorder t o get accurate and fast harmonic estimation, RLS algorithm is proposed. TABLE – IIITotal Harmonic Distortion (THD) of Suppl y Current. Supply CurrentBeforeAfterCompensationcompensationPhase – A13. 2% THD4. 3% THDPhase – B17. 5% THD3. 7% THDPhase – C20. 3% THD3. 5% THDFrom the TABLE - III it is observed that Compensation is carried out by RLS algorithm to mitigate the harmonic content in supply current. One of the important power q uality problems is voltage flickering. It causes unbalance in supply voltage and creates perception to human eyes. It is caused by resistance welder, the most common flicker generators in distribution systems. However it can be easily damped by employing FDG with RLS tracking algorithm. The weld er is made by a thyristor switched inductor. Fig. 7. p. u. voltage at PCCFig. 7. portrays the p. u. voltage at the PCC. Before switching on the FDG at t= 0. 22s, the p. u. voltage v aries from 0. 75 to 0. 87. Since it shows the FDG succeeds in regulating the voltage at the desired value of 1. 0 p. u. an d compensating for the voltage flicker is achieved. VII. CONCLUSIONIn this paper an attempt has been made to review various methodologies used to improve the power quality in microgrid. Different techniques in current control strategy for VSI are implemented using artificial intelligent and conventional regulators to improve the q uality of power in microgrid. Three phase four wire or three phase three wire compensator are used to regulate volta ge unbalance and current by shunt and series compensator. Moreover voltage unbalance create sequence component, since they are suppressed by NSF and PSF. Major powe r quality issues is harmonic elimination, which is done by c onventional filters, current control strategy for VSI and Flexible Distributed Generation (FDG). Whereas FDG incorporated with RLS algorithm is carried out for regulation of voltage flickering. Each and every method has its own advantage and disadvantage relates to various power quality problems. This paper gives an idea to enhance power quality in microgrid. REFER ENCESR. H. 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