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Integrated Power Quality Controller Based Multilevel Inverter For Micro Grid With Power Quality Improvement

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ABSTRACT-This paper presents the integrated power quality controller (IPQC) for micro grid. In current control the novel variable reactor based on the magnetic flux control is used. A transformer with air gap is selected, and the primary winding current of the transformer is detected. A voltage-sourced inverter is applied to follow the primary current to produce another current, which is injected to the secondary. While it's operational principle and dynamic performance are analyzed. Based on the developed variable reactor, a novel integrated power quality controller (IPQC) suitable for micro grid is proposed, which can cater for the peculiar requirements of micro grid power quality, such as the harmonic high penetration, frequent voltage fluctuation and over current phenomenon, and bidirectional power flow and small capacity. For the fundamental, the equivalent impedance of the primary winding is a variable reactor or capacitor. For the nth-order harmonic, the equivalent impedance is very high impedance and acts as a "harmonic isolator." The system control strategy is also analyzed in detail. A set of three-phase IPQC has been constructed. The simulation results are presented by using Matlab/Simulink software.

Index Terms—*Micro grid, overcurrent, power flow, power quality, transformer, variable reactor, Multilevel Inverter.*

I. INTRODUCTION

To have sustainable growth and socialprogress, it is necessary to meet the energy need by utilizing the renewable energy resources like wind, biomass,hydro,cogeneration,etc.Theneedto integrate Renewable energy like wind energy into power system is to make it possible to minimize the environmental impact on conventional plant [1]. The issue of power quality is of great importance to the wind turbine [2]. In the fixed speed wind turbine operation, all the fluctuation in the wind speed are transmitted as fluctuations in the mechanical torque, electrical power on the grid and leads to large voltage fluctuations. A STATCOM based control technology has been proposed for improving the power quality which can technically manages the power level associates with the commercial wind turbines. The paper is organized as follows. The Section II introduces the power quality standards, issues and its consequences of wind turbine [3]. The control design as well as the test system waveforms/results and conclusion respectively. Micro grid [4] may be defined as an agglomeration of Distributed generation (DG) units usually linked through power electronic based devices (Voltage Source Inverter) to the utility grid. DG units can be built with Non-conventional energy sources such as fuel cells, wind turbines, hydroelectric power, solar energy, etc. Micro grid can function either tied to the grid or isolated from the grid. The impact of power quality hitches is concerning while linking of micro grid to the main grid and it could become a foremost area to investigate. If unbalance in voltage is alarming, the solid state Circuit Breaker (CB), connected between the microgrid and utility grid will open to isolate the microgrid [5]. When voltage unbalance is not so intense, CB remains closed, resulting in sustained unbalance voltage at the Point of Common Coupling (PCC). Generally power quality problems are not new in power system, but rectification methodology has increased in recent years. Maintaining a near sinusoidal power distribution bus voltage at rated magnitude and frequency is referred as electric power quality [6]-[7].Two three phase four leg inverters is tend to construct grid interfacing system to compensate harmonic current it increases the complication and losses in the system [8]-[9]. Distributed generator not only inject power to the grid it also enhance power quality. By means of droop control technique it autonomously compensates voltage unbalances active and reactive droop control [10].A flexible AC distribution system aims to improve the power quality and reliability in microgrid, the design of control algorithms and extended kalman filters is meant for frequency tracking and to extract harmonic in grid voltage and load current in micro grid. By minimizing the total system planning and operation cost and cost of load shedding co-optimization of power system is taken over to increase the economic and reliability of the grid [11].

The main advantage of multilevelinverters is that the output voltage can be generatedwith a low harmonics. Thus it is admitted that theharmonics decrease proportionately to the inverterlevel. For these reasons, the multilevel inverters arepreferred for high powerapplications[12]. However,there is no shortage of disadvantages. Their control ismuch more complex and the techniques are still notwidely used in industry. In this paper, modeling andsimulation of a multilevel inverter using NeutralPoint-Clamped(NPC) inverters have been performedwith motor load using Simulink/ MATLAB program.In the first section multilevel inverter controlstrategies are presented before to detail a study ofseven-level inverter in the second section. TotalHarmonic Distortion (THD) is discussed in the thirdsection. The aim is to highlight the limit at which themultilevel inverters are no longer effective inreducing output voltage harmonics [13, 14].

II PRINCIPLE OF THE VARIABLE REACTOR

A) System Configuration:Fig. 1 shows the single-phase system configuration of the novel variable reactor based on magnetic flux control. Suppose that the turns of primary and secondary winding of the transformer are N_1andN_2, respectively. The turns ratio is represented by $k = N_1/N_2$. A transformer with air gap is selected, and its primary winding *AX* can be connected inseries or in parallel with power utility. The secondary winding *ax* is not connected with a normal load but a voltage-sourced inverter. The voltages of the primary and secondary windingsare $u_1$andu_2, respectively. The primary winding current $i1$ of the transformer is detected and functions as the reference signali_{ref}. *h*is the gain of the current sensor. $U_d$is the voltageof dc side of the inverter. C_dStands for the capacitance of the dc capacitor. $\alpha$is a controllable parameter, which will be explained later. The voltage-sourced inverter and the currentcontrol are applied to yield a controlled currenti_2, which has the same frequency as i_1.$i_2$is inversely in phase injected to the secondary winding *ax*.

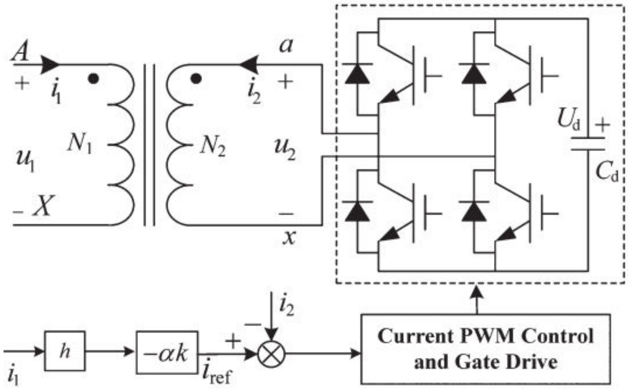

Fig.1.System configuration of the novel variable reactor

B) Equivalent T-Circuit of Thetransformer: The magnetically coupled circuit of the transformer is central to the operation of the novel variable reactor, which is shown in Fig.2. The flow of currents in the two windings produces magneto motive forces (MMFs), which, in turn, set up the fluxes.

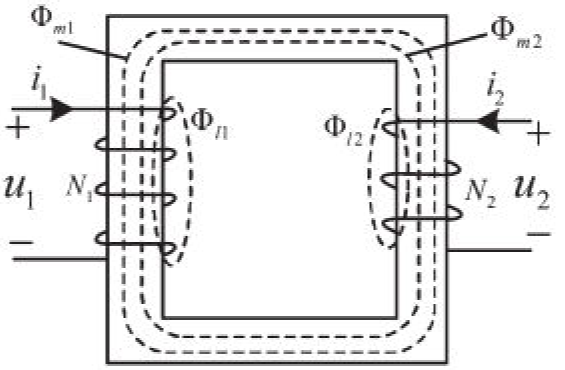

Fig.2. magnetically coupled circuit of the transformer

The total flux linking each winding may be expressed as

$$\Phi 1 = \Phi l1 + \Phi m1 + \Phi m2 = \Phi l1 + \Phi m \quad (1)$$

$$\Phi 2 = \Phi l2 + \Phi m2 + \Phi m1 = \Phi l2 + \Phi m \quad (2)$$

Herein, $\Phi l1$ and $\Phi l2$ are the leakage fluxes of the primary and secondary windings. $\Phi m1$ is the magnetizing flux produced by the primary winding, and it links all turns of the primary andsecondary windings. $\Phi m2$ is the magnetizing flux produced by the secondary winding, and it links all turns of the primary and secondary windings. Φmdenotes the resultant mutual flux.The voltage equations of the transformer can be expressed as

$$u1 = r1i1 + d\lambda 1/dt \quad (3)$$

$$u2 = r2i2 + d\lambda 2/dt \quad (4)$$

Where$r1$ and $r2$ are the resistances of the primary and secondary windings, respectively. $\lambda 1$ and $\lambda 2$ are the flux linkages related to the primary and secondary windings, respectively. Ifsaturation is neglected and the system is linear, the following equations can be achieved.

$$\lambda_1 = L_{l1}i_1 + L_{m1}(i_1 + \frac{N_2}{N_1}i_2) \quad (5)$$

$$\lambda_2 = L_{l2}i_2 + L_{m2}(\frac{N_1}{N_2}i_1 + i_2) \quad (6)$$

Here in, L_{l1} andL_{l2} are the leakage inductances of the primary and secondary windings, respectively. L_{m1}And$L_{m2}$are the magnetizing inductances of the primary and secondarywindings, respectively.$^{L_{m1}}/_{N_1^2} = {}^{L_{m2}}/_{N_2^2}$According to, when the quantities of the secondary winding are referred to the primary winding, (3) and (4) become

$$u_1 = r_1 i_1 + L_{l1}\frac{di_1}{dt} + L_{m1}\frac{d}{dt}\,(i_1 + i'_2) \quad (7)$$

$$u_1 = r'_2 i'_2 + L'_{l2}\frac{di'_2}{dt} + L_{m1}\frac{d}{dt}\,(i_1 + i'_2) \quad (8)$$

Here, the prime denotes referred quantities of secondary winding to primary winding. Equations (7) and (8) can be expressed as the following equations in phasor form:

$$U_1 = r_1 I_1 + j\omega L_{l1} I_1 + j\omega L_{m1}(I_1 + I'_2) \quad (9)$$

$$U'_2 = r'_2 I'_2 + j\omega L'_{l2} I'_2 + j\omega L_{m1}(I_1 + I'_2) \quad (10)$$

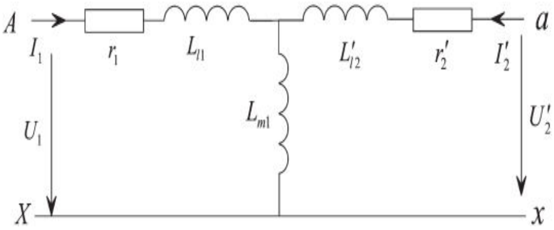

Fig.3 Equivalent T-circuit of the transformer.

The voltage equations in (9) and (10) with the common L_{m1} suggest the equivalent T-circuit shown in Fig.3 for the two winding transformer. Note that, in some equivalent T-circuit of the transformer, a core loss resistance r_m, which accounts for the core loss due tothe resultant mutual flux, is connected in parallel or in series with the magnetizing inductance L_{m1} (in the later analysis, a series core loss resistance $r_m$is taken into account in theequivalent T-circuit of the transformer).

Let$Z_1 = r_1 + j\omega L_{l1}$which is the leakage impedance of the winding.$Z'_2 = r'_2 + j\omega L'_{l2}$, which is the leakage impedance of the secondary winding *ax* referred to the primary winding.$Z_m = r_m + j\omega L_{m1}$, which is the magnetizing impedance of the transformer. Here, ω is the fundamental angular frequency. Then, (9) and (10) become

$$U_1 = Z_1 I_1 + Z_m(I_1 + I'_2) \quad (11)$$

$$U'_2 = Z'_2 I'_2 + Z_m(I_1 + I'_2) \quad (12)$$

C) Principle of the Variable Reactor: In Fig.1, the primary winding current is detected and functions as the reference signal, and the voltage-sourced inverter is applied to track the reference signal to yield a controlled currenti_2. When controlled current i_2 and the primary current i_1 satisfy

$$I'_2 = -\alpha I_1 (i.e., I_2 = -\alpha k I_1) \quad (13)$$

Herein, α is a controllable parameter. The transformer is double side energized, and then, the following equations can be obtained:

$$U_1 = Z_1 I_1 + (1-\alpha) Z_m I_1 \quad (14)$$

$$U'_2 = Z'_2 I'_2 + (1 - {}^{1}\!/_{\alpha}) Z_m I'_2 \quad (15)$$

In terms of (14), from the terminals AX, the equivalent impedance of the transformer can be obtained, i.e.,

$$Z_{AX} = \frac{U_1}{I_1} = Z_1 + (1-\alpha) Z_m \quad (16)$$

In terms of (16), the equivalent impedance of the primary winding of the transformer is a function of the controllable parameter α. When α is adjusted, the primary winding exhibits consecutively adjustable impedance. Equation (16) can be also achieved in terms of the resultant. MMFs of the two windings acting around the same path of the core. When a controlled current $i2$ produced by a voltage sourced inverter is injected into the secondary winding of the Transformer and$i_2 = -\alpha k I_1$, the resultant MMF is $N_1 I_1$+ =$N_2 I_2$ (1 − α)$N_1 I_1$. Then, the resultant flux set up by the MMF of the two windings is $(1 - \alpha)\phi_m$. Then, the inducedvoltage produced by the resultant flux can be expressed in phasor form as

$$E_1 = (1-\alpha) j\omega L_m I \quad (17)$$

Table.I
Equivalent Impedance of the Primary Winding of the Transformer

α	The equivalent impedance of terminal AX	Impedance charateristic
$\alpha < 0$	$Z_{AX} > Z_1 + Z_m$	resistive and inductive
$\alpha = 0$	$Z_{AX} = Z_1 + Z_m$	
$0 < \alpha < 1$	$Z_1 < Z_{AX} < Z_1 + Z_m$	
$\alpha = 1$	$Z_{AX} = Z_1$	
$1 < \alpha < 1 + Z_1 / Z_m$	$Z_1 < Z_{AX} < 0$	
$\alpha = 1 + Z_1 / Z_m$	$Z_{AX} = 0$	0
$\alpha > 1 + Z_1 / Z_m$	$Z_{AX} < 0$	resistive and capacitive

The primary voltage equation can be achieved as (14). In terms of (16), the relation between the equivalent impedance of the primary winding and the parameter α is shown in Table I. The variable reactor features hardly producing harmonics, simple control scenario, and with consecutive adjustable impedance. Many flexible ac transmission systems (FACTS) devices can be implemented in terms of the novel principle. The variable reactor can be used in unified power flow controller to change the line impedance between the sending and receiving ends to control the power flow; it can also substitute the thyristor-controlled reactor of the thyristor-controlled series capacitor; however, the proposed variable reactor does not produce any harmonics; fault current limiter can be also implemented in terms of the novel principle of the variable reactor. Reactive power compensation can be all realized by the novel variable reactor. In addition, it has been successfully applied the hybrid series active power filter based on fundamental magnetic flux compensation.

D) Dynamic Analysis of the Variable Reactor: One of the key techniques of the novel variable reactor based on the magnetic flux control is current control. Nowadays, the widely used current control technique includes the hysteresis current control, the ramp comparison current control, and the predictive and deadbeat control. In the digital control system based on DSP, the most widely used current control is the ramp comparison current control with the proportional–integral (PI) controller. In this case, the system block diagram of the variable reactor system is shown in Fig.4. Herein, h is thegain of current sensor; the combined transfer function of the sample and delay is represented as $G_{di}(s) = 1/(1 + sT_{di})$; the transfer function of the voltage-sourced inverter is denotedby $G_{PWM}(s) = k_{PWM}/(1 + sT_{PWM})$.The transfer function of the PI controller is denoted by $G_{PI}(s) = k_i (1 + sT_i)/sT_i$.

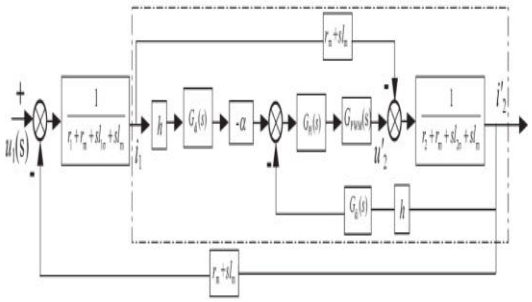

Fig.4. System block diagram of the variable reactor

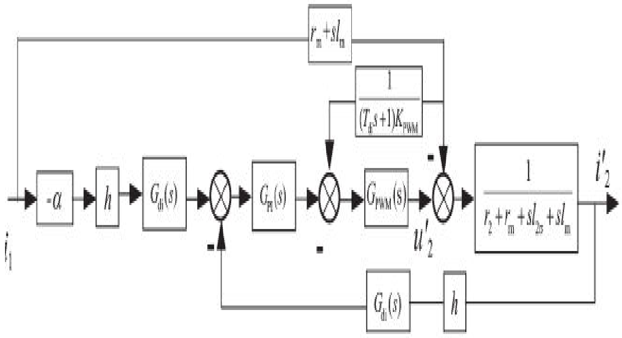

Fig.5. Block diagram of current control with feed forward

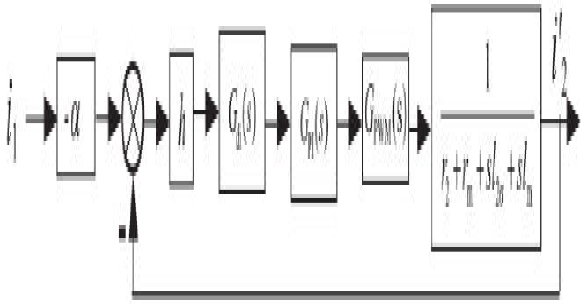

Fig.6. Block diagram of current control

The system admittance transfer function can be derived as (18), shown at the bottom of the page, which means that the overall system is a five-order system. The current control component is in dash-dotted frame shown in Fig.4. In order to improve the system anti-interference performance in low-frequency band, a feed forward element is designed in the block diagram of the current control component, which is shown in Fig.5. In this case, the block diagram of the current control component becomes Fig.6. The open-loop transfer function of the current control block in Fig.6 is

$$G_Y(s)=\frac{i_1(s)}{u_1(s)}$$

$$=\frac{hk_i(1+T_is)K_{PWM}+(r_2+r_m+sl_{2\sigma}+sl_m)(1+T_{di}s)sT_i(1+T_{PWM}s)}{hk_i(1+T_is)K_{PWM}[r_1+r_m+sl_{1\sigma}+sl_m-\alpha(r_m+sl_m)]+[(r_1+sl_{1\sigma})(r_2+sl_{2\sigma})+(r_m+sl_m)(r_1+r_2+sl_{1\sigma}+sl_{2\sigma})](1+T_{di}s)sT_i(1+T_{PWM}s)} \quad (18)$$

$$G_{\text{open}}(s)=\frac{hk_i(1+sT_i)K_{\text{PWM}}}{(1+T_{\text{di}}s)sT_i(1+T_{\text{PWM}}s)(r_2+r_m+sl_{2\sigma}+sl_m)} \quad (19)$$

Let $Ti = (l_{2\sigma} + l_m)/(r_2 + r_m)$ and $T\text{PWM} \approx 0.5T\text{di}$, when combining the two elements with little time delay, (16) becomes

$$G_{\text{open}}(s) = \frac{\frac{hK_{\text{PWM}}k_i}{(r_2+r_m)}}{(1+1.5T_{\text{di}}s)sT_i} \quad (20)$$

$$k_i=T_i(r_2+r_m)/(3T_{\text{di}}K_{\text{PWM}}h)$$

Here, when the current control system performance will be approximately optimum.

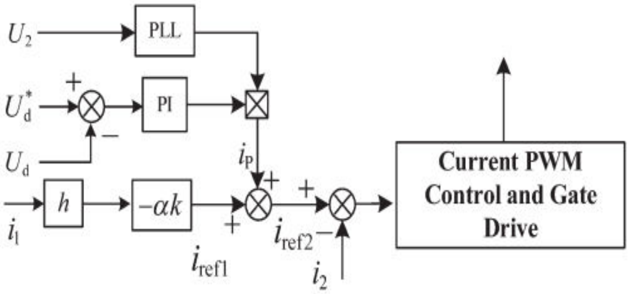

Fig.7. DC-link voltage control schematic

E) Dc-Link Voltage Control of The Variable Reactor: There must be some losses when the novel variable reactor system with inverter operates normally, and the inverter will absorb active power to maintain the dc voltage constant. Fig.7shows the dc-link voltage control schematic of the variable reactor system. Herein, U_d^* and $U_d$represent the inverter dc reference and pi_{ref} to achieve a new reference signal $i$ref2. A dc-link voltage PI controller is applied to make the inverter dc practical voltage $U_d$follow thedc reference voltageU_d^*. The output of the voltage PI controller is multiplied by the phase-locked loop (PLL) output of u_2 to yield the active currentreferencei_p.

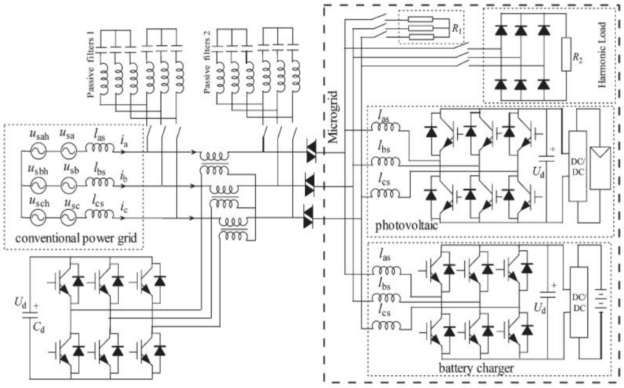

Fig.8. Circuit of the Proposed IPQC

III. PRINCIPLE OF THE IPQC

a) System Configuration: The novel IPQC can be installed in series and parallel in microgrid or point of common coupling (PCC). For simplicity, the IPQC is installed in PCC. Fig. 8 shows the three-phasedetailed system configuration of the IPQC with transformer and inverter. $U_s$and$L_s$represent the source voltage and impedance of conventional power supply, respectively. The passive filters, which have the function of absorbing the harmonics, are shunted in both sides. The primary winding of a transformer is inserted in series between the conventional power utility and the microgrid, whereas the secondary winding is connected with a voltage-source PWM converter. $U_d$is the voltage of the dc side of the inverter. The microgrid contains a harmonic load, a photovoltaic cell system, a battery storage system, and a normal load. The proposed IPQC has the following functions.

b) Power flow Control: When the power flow control and the fault current limiter are of concern, only the fundamental is taken into account. In terms of the preceding analysis, the primary winding exhibits adjustable impedance $Z_1 + (1-\alpha)Z_m$. With the change in coefficient α, the equivalent impedance of the primary winding can be achieved, which is shown in Table I. Therefore, when the primary winding is connected in series in circuit, it can be applied to control the power flow between the conventional power utility and the microgrid or the internal power flow of the microgrid. The schematic of power flow control is shown in Fig. 9 when the novel variable reactor is connected in series between the sending and receiving ends. Suppose that the equivalent impedance $Z_1 + (1-\alpha)Z_m$of the variable reactor is $R + jX$. In terms of the vector diagram in Fig.9, the following equations can be obtained:

$$U_m \cos\varphi = U_s \cos(\varphi - \delta) + RI \tag{21}$$

$$U_m \sin\varphi = U_s \sin(\varphi - \delta) + XI \tag{22}$$

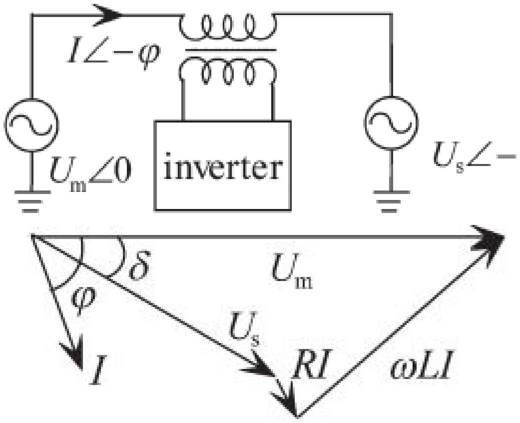

Fig.9. Power flow control principle and its vector diagram.

Multiply cosϕin both sides of (21) and multiply sin ϕ in both sides of (22), then the following equation can be obtained by adding them:

$$U_m(U_m - U_s\cos\delta) = PR + QX \tag{23}$$

Multiply sin ϕ in both sides of (21) and multiply cosϕin both sides of (22), then the following equation can be obtained by subtracting them:

$$U_s \sin\delta = PX - QR. \tag{24}$$

In terms of (23) and (24), the active and reactive power from $U_m$to $U_s$are

$$P = \frac{U_m}{R^2 + X^2}\left[R(U_m - U_s\cos\delta) + XU_s\sin\delta\right] \tag{25}$$

$$Q = \frac{U_m}{R^2 + X^2}\left[-RU_s\sin\delta + X(U_m - U_s\cos\delta)\right] \tag{26}$$

In the power system with high voltage level, the inductive reactance component of the transmission line is much more than the resistance component of the transmission line, (25) and (26) become

$$P = \frac{U_s U_m}{X}\sin\delta \quad Q = \frac{U_m}{X}(U_m - U_s\cos\delta) \tag{27}$$

In microgrid with low voltage level, when the resistance component of the transmission line is much more than the inductive reactance component of the transmission line, (25) and (26) can be expressed as

$$P = \frac{U_m}{R}(U_m - U_s\cos\delta) \quad Q = -\frac{U_m U_s}{R}\sin\delta \tag{28}$$

In terms of (28), there is a striking difference in power flow control and voltage regulation between microgrid and conventional power grid.

c) Fault Current Limiter: When the terminal *AX* is connected in series in circuit, in the normal operation state, the coefficient α can be controlled as α = 1 + Z_1/Z_m, and the equivalent impedance of the primarywinding *AX* is zero. Hence, the series transformer does not have any influence on the power system normal operation. The maximum system current$i_{smax}$of the three phases is obtainedby a current-detecting circuit and compared with a reference current. In case of a short-circuit fault, maximum system current i_{smax}reaches the reference current, the coefficient α canbe controlled between −1 and 1 in terms of the requirement of fault current, and the equivalent impedance of the primary winding *AX* is controlled between $Z_1 + Z_m$and Z_1 to limitthe system current to a desired value.

d) Voltage Compensation: In order to compensate the voltage fluctuation, the primary winding of the transformer is connected in series between the power electric utility and the load. When the load voltages higher than the desired voltage, the coefficient α can be controlled between 0 and 1 + Z_1/Z_m, and the primary winding exhibits inductive impedance. When the load voltage is lowerthan the desired voltage, the coefficient α is controlled more than 1 + Z_1/Z_m, and the primary winding exhibits capacitive impedance. Therefore, the load voltage can be controlled as a stable voltage.

e) Harmonic Isolation: The preceding function of power flow control, fault current limiter, and voltage compensation is concerned with the fundamental. If there exits harmonic in the power utility, theprimary current contains the fundamental current and *n*th order harmonic currents, that is to say, $i_i = i_1^1 + \Sigma i_1^n$ The fundamental componenti_1^1rather than harmonic is detectedfrom the primary winding current $i1$ and functions as a reference signal. A voltage source inverter is applied to track the fundamental reference signal i_1^1 to produce a fundamentalcompensation currenti_1^2, which has the same frequency as i_1^1. $i_2^1$is inversely in phase injected to the secondary winding *ax*. When α = 1 +Z_1/Z_m, the fundamental equivalent impedance of primary winding *AX* is zero, which is shown in Fig. 10. Meanwhile, for the *n*th- order harmonic, since only a fundamental current is injected to the secondary winding of

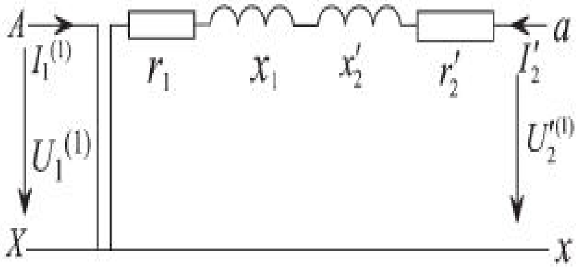

Fig.10. Fundamental equivalent circuit

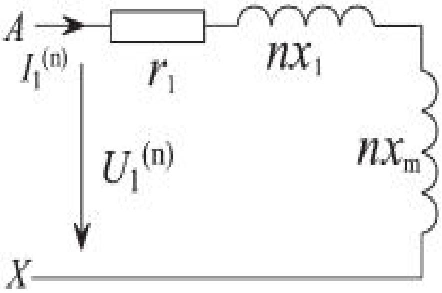

Fig.11.Harmonic equivalent circuit

Thetransformeri_2 does not include any order harmonic current other than the fundamental current, which means that the transformer is open circuit to harmonic current. Therefore, theequivalent circuit of the transformer to the *n*th-order harmonic is shown in Fig.11. Then, the harmonic equivalent impedance of the transformer is $Z_{AX}{}^{(n)} = (r_1 + \mathrm{j}nx_1) + jnx_m \approx nZ_m{}^{(1)}$.From the primary winding, the series transformer exhibits very low impedance at the fundamental and simultaneously exhibits high impedance to harmonics to act as a “harmonic isolator.” Then, the harmonic currents are forced to flow into the passive *LC* filter branches in both sides.

e) ***IPQC:*** When integrating the preceding functions of variable reactor, power flow control, fault current limiter, voltage compensation, and harmonic isolation, a novel IPQC can be achieved. For fundamental and harmonic, the primary winding of the series transformer exhibits the impedance of $Z_1{}^{(1)} + (1-\alpha)Z_m{}^{(1)}$ and $nZ_m{}^{(1)}$ respectively. That is to say, the primary winding of the series transformer exhibits adjustable impedance, which plays the role of power flow control, fault current limiter, and voltage compensation to fundamental. Meanwhile, the primary winding of the series transformer exhibits high impedance $nZ_m{}^{(1)}$ to harmonic, which can greatly improve the source impedance to harmonics, and really acts as a harmonic isolator. Therefore, it can mitigate the harmonic high penetration.

IV. MULTILEVEL INVERTERS

Multilevel power conversion was first introduced more than two decades ago. The general concept involves utilizing a higher number of active semiconductorswitches to perform the power conversion in small voltagesteps. There are several advantages to this approach whencompared with the conventional power conversion approach.The smaller voltage steps lead to the production of higher powerquality waveforms and also reduce voltage (dv/dt) stress onthe load and the electromagnetic compatibility concerns.Another important feature of multilevel converters is that thesemiconductors are wired in a series-type connection, whichallows operation at higher voltages. However, the series connection is typically made with clamping diodes, which eliminatesovervoltage concerns. Furthermore, since the switches are nottruly series connected, their switching can be staggered, whichreduces the switching frequency and thus the switching losses.However, the most recently usedinverter topologies, which are mainly addressed as applicable multilevel inverters, are cascade converter, neutral-pointclamped (NPC) inverter, and flying capacitor inverter.Some applications for these new converters include industrial drives, flexible ac transmission systems (FACTS),and vehicle propulsion. One area where multilevelconverters are particularly suitable is that of renewable photovoltaic energy that efficiency and power quality are of great concerns for the researchers.

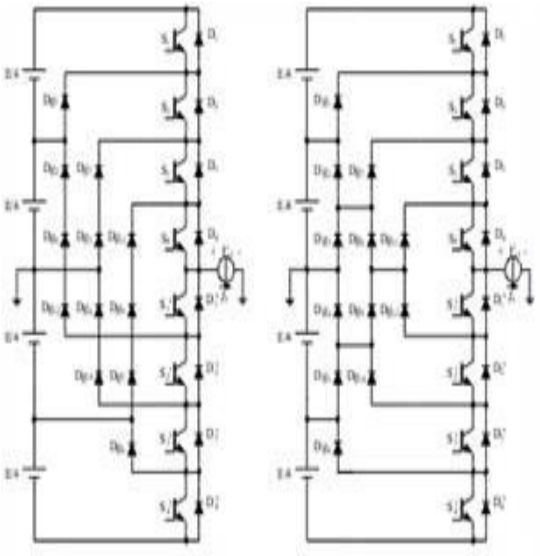

Fig.12.single leg of five level NPC inverter

V.MATLAB/SIMULINK RESULTS

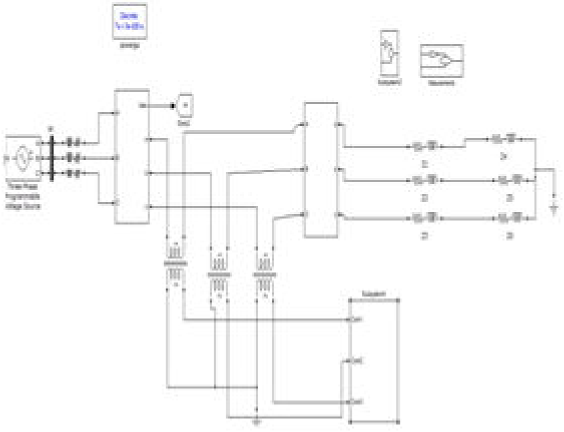

Fig 13Conventional diagram for IPQC

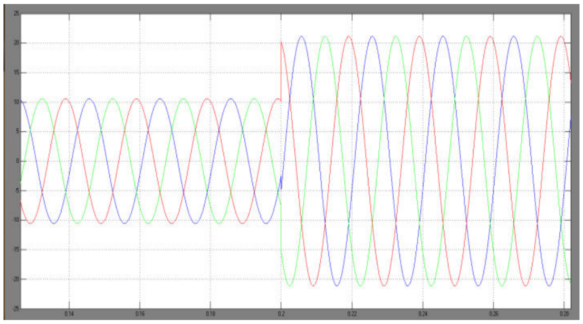

Fig14Current waveforms of the primary winding when α suddenly changes from 0.1 to 0.6

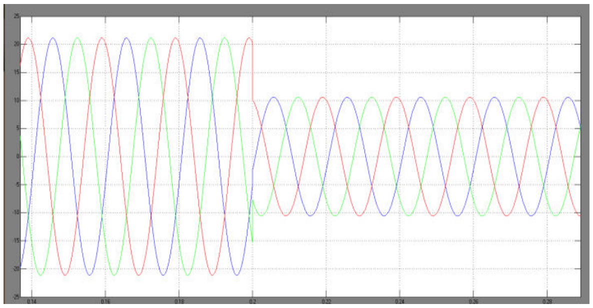

Fig 15Current waveforms of the primary winding when α suddenly changes from 0.6 to 0.1

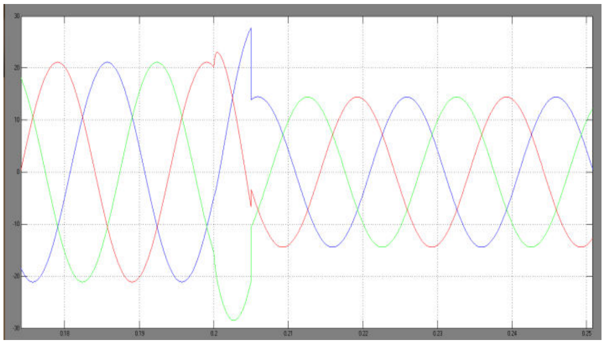

Fig 16Current waveforms of the fault current limiter

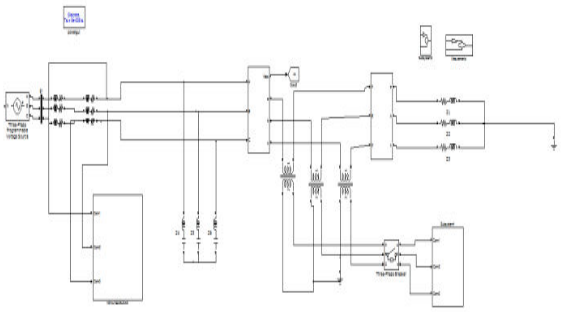

Fig 17 Simulation circuit for harmonic isolation in the first condition

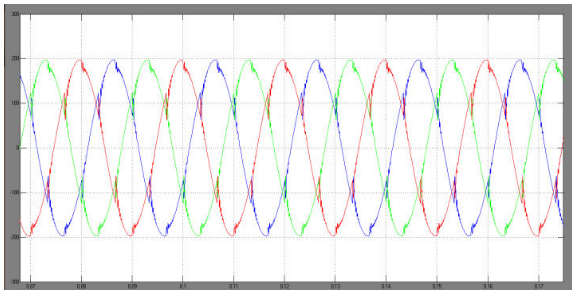

Fig 18System voltage waveforms when the IPQC is not applied

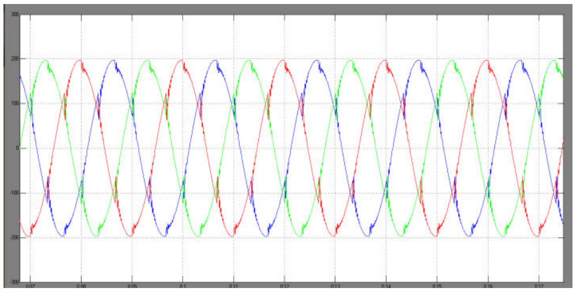

Fig 19System current waveforms when the IPQC is not applied

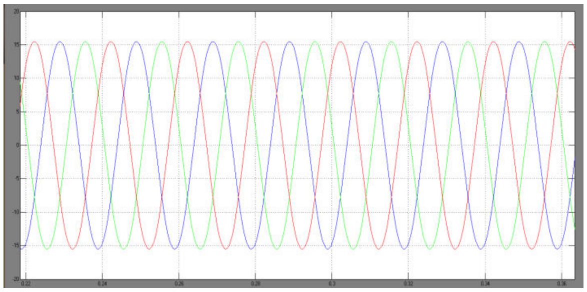

Fig 20Current waveforms at microgrid side when the IPQC is applied

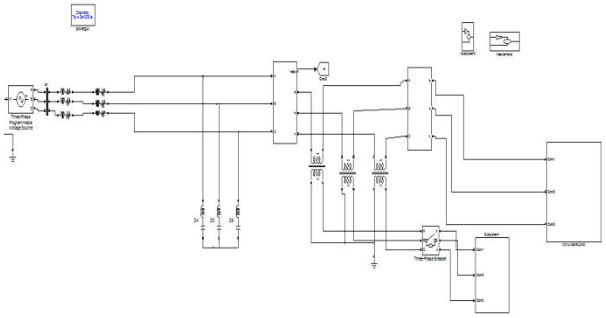

Fig 21 Proposed circuit for harmonic isolation in the second condition

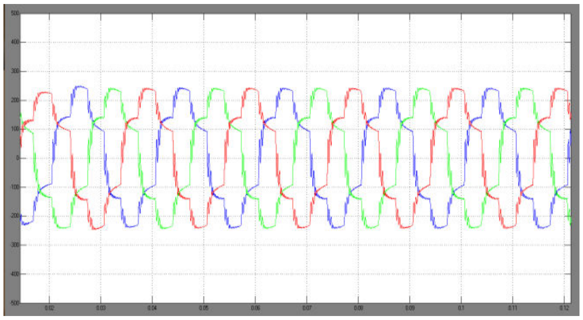

Fig 22 System voltage waveforms when the IPQC is not employed

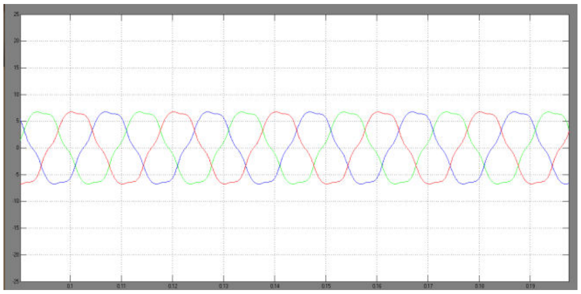

Fig 23 System current waveforms when the IPQC is not employed

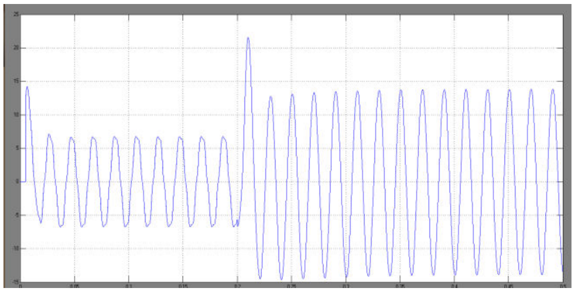

Fig 24 System current waveforms when the IPQC is employed

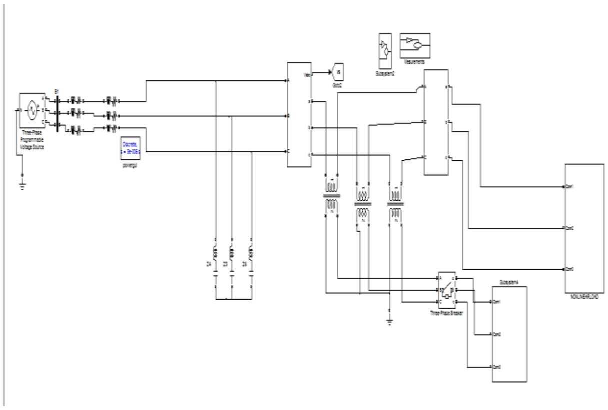

Fig.25 shows the proposed IPQC with MLI

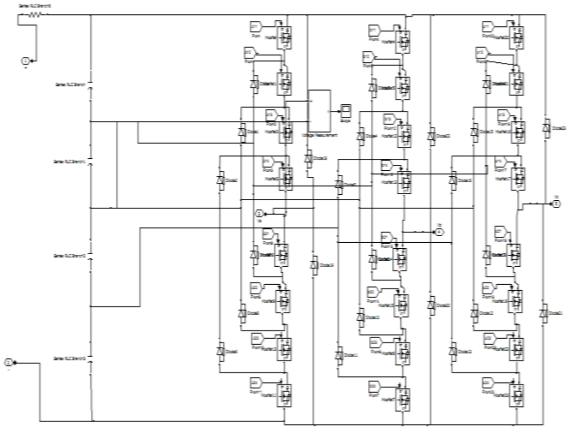

Fig.26 shows the proposed MLI system

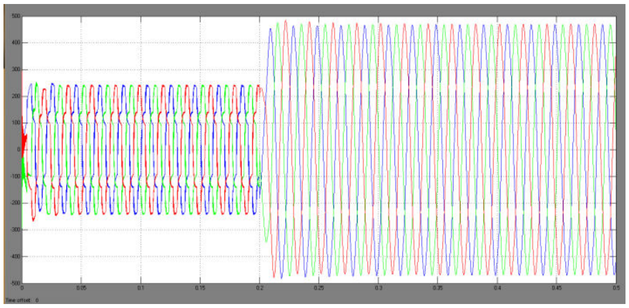

Fig.27 shows the load voltage response before and after MLI based IPQC operation

VI. CONCLUSION

The cascaded inverter switching signals are generated using triangular-sampling current controller; it provides a dynamic performance under transient and steady state conditions, THD analysis also within the IEEE standards. Instantaneous real-power theory based cascaded multilevel inverter based IPQC is connected in the distribution network at the PCC through filter inductances and operates in a closed loop. A cascaded multilevel voltage source inverter based IPQC using instantaneous real power controller is found to be an effective solution for power line conditioning to compensate harmonics, reactive power and power factor with the IRP controller reduces harmonics and provides reactive power compensation due to non-linear load currents; as a result source current(s) become sinusoidal and unity power factor is also achieved under both transient and steady state conditions. This paper has presented a novel variable reactor based on the magnetic flux control. A transformer with air gap is selected, and the primary winding current of the transformer is detected. A voltage-sourced inverter is applied to follow the primary current to produce another current, which is injected to the secondary. When the injected current is adjusted, the equivalent impedance of the primary winding of the transformer will change continuously. In terms of the novel variable reactor, a novel IPQC suitable for microgrid is proposed. The primary winding exhibits adjustable impedance, which plays the role of power flow control, fault current limiter, and voltage compensation to fundamental.

REFERENCES

[1] B. Lasseter, "Microgrids [distributed power generation]," in Proc. IEEE Power Eng. Soc. Winter Meet., 2001, vol. 1, pp. 146–149.

[2] C. Marnay, F. J. Robio, and A. S. Siddiqui, "Shape of the microgrid," in Proc. IEEE Power Eng. Soc. Winter Meet., 2001, vol. 1, pp. 150–153.

[3] R. H. Lasseter et al., Integration of Distributed Energy Resources: The CERTS Microgrid Concept. Berkeley, CA, USA: Consortium for Electric Reliability Technology Solutions, 2002.

[4] C. Marnay and O. Bailey, "The CERTS micro grid and the future of the macrogrid," Lawrence Berkeley National Laboratory, Berkeley, CA, USA, Rep. LBNL-55281, Aug. 2004.

[5] N. Hatziargyriou, H. Asano, R. Iravani, and C. Marnay, "Micro grids," IEEE Power Energy Mag., vol. 5, no. 4, pp. 78–94, Jul./Aug. 2007.

[6] R. H. Lasseter, "Smart distribution: Coupled micro grids," Proc. IEEE, vol. 99, no. 6, pp. 1074–1082, Jun. 2011.

[7] H. Akagi, E. H. Watanabe, and M. Aredes, Instantaneous Power Theory and Applications to Power Conditioning. Piscataway, NJ, USA: IEEE Press, 2007, pp. 1–17.

[8] C. Sankaran, Power Quality. Boca Raton, FL, USA: CRC Press, 2002, pp. 133–146.

[9] R. C. Dugan, Electrical Power Systems Quality. New York, NY, USA: McGraw-Hill, 2003, pp. 167–223.

[10] A. Baggini, Handbook of Power Quality. Hoboken, NJ, USA: Wiley, 2008, pp. 187–257.

[11] B. Singh, K. Al-Haddad, and A. Chandra, "A review of active filters for power quality improvement," IEEE Trans. Ind. Electron., vol. 46, no. 5, pp. 960–971, Oct. 1999.

[12] F. Z. Peng, "Application issues of active power filters," IEEE Ind. Appl. Mag., vol. 4, no. 5, pp. 21–30, Sep./Oct. 1998.

[13] K. M. Smedley, L. Zhou, and C. Qiao, "Unified constant-frequency integration control of active power filters—Steady-state and dynamics," IEEE Trans. Power Electron., vol. 16, no. 3, pp. 428–436, May 2001.

[14] H. Rudnick, J. Dixon, and L. Moran, "Delivering clean and pure power," IEEE Power Energy Mag., vol. 1, no. 5, pp. 32–40, Sep./Oct. 2003.