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Power Quality Assessment and Enhancement using FLC based SPV Supported Cascaded H-Bridge Multilevel Inverter

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ABSTRACT

Solar photovoltaic (SPV) is one of the most common renewable energy sources used at present. The major issue with renewable energy resources is power quality to meet the growing energy demand. In recent times reliability and flexibility of energy supply are also associated with the quality of power. The issues attached with line faults, voltage sag/swell, harmonics in supply and flicker are the key concerns for poor power quality. The new scenario is designed to challenge electrical resources like generation, transmission and distribution. Considering renewable energy in the existing power system requires additional research and analysis to synchronize new components. From this point of view, many power electronics converters and switching devices are designed to increase the reliability and efficiency of the system. Similarly, solar PV system requires a maximum power point tracker to extract the power upto the maximum extent. It consists of two stages: DC to DC converter and Pulse Width Modulation controlling phase. A multi-level inverter (MLI) is used to enhance the power quality of the overall system. It reduces the harmonics distortion and stabilizes the system near the unity power factor. This paper comprehensively analyses the cascaded H-bridge Multilevel Inverter associated with the fuzzy logic controller (FLC) and SPV system. The simulation results are compared with the 3-level and five levels Multilevel Inverter.

1. Introduction

The quality of power extracted from solar PV is becoming a major issue for the newly designed electrical system. A few decades ago, researchers were only concerned about the quantity of power to meet the increasing demand of energy. Now, the situation is different, there are significant concerns about the reliability and flexibility of the power. Poor power quality is observed due to line faults, harmonics, voltage sag/swell, and flicker. In the novel scenario, it is a great challenge for electrical engineers to increase the reliability and efficiency of the system considering the new electrical generation resources with existing transmission and distribution system.

Fossil fuels are conventional energy sources, resulting in greenhouse emissions and environmental pollution. Researchers move towards renewable energy sources (RES) to reduce these problems. With the recent development, the demand for non-conventional energy resources like solar, wind, and biogas is increasing. Among all the RES, Solar is widely used. It is exhaustible, pollution-free and environmentally friendly. A huge amount of energy production is expected from solar PV systems over the next 20 years [1]. The Solar Photovoltaic energy system produces electricity in DC form. Therefore, the SPV system is coupled with a converter system into the existing system. The multi-aspects research has designed many electronics converters and the researchers tend towards multi-level inverters (MLI), which become more effective for AC topologies. MLI has many advantages over conventional converters. It gives high power quality waveform, high voltage capability, and low switching losses [2–3]. Cascaded H-bridge Multilevel Inverter (CH-BMLI) is mostly used in converters with growing demand.

Tapping the maximum energy from solar radiation is known as Maximum Power Point Tracking (MPPT) Arrangement. Many techniques are available in the literature, like Perturb & Observe, Incremental Conductance method, Fractional short circuit current technique, and Fractional open circuit voltage terminology [4–6]. The MPPT methods are based on various technical schemes and algorithms, as their

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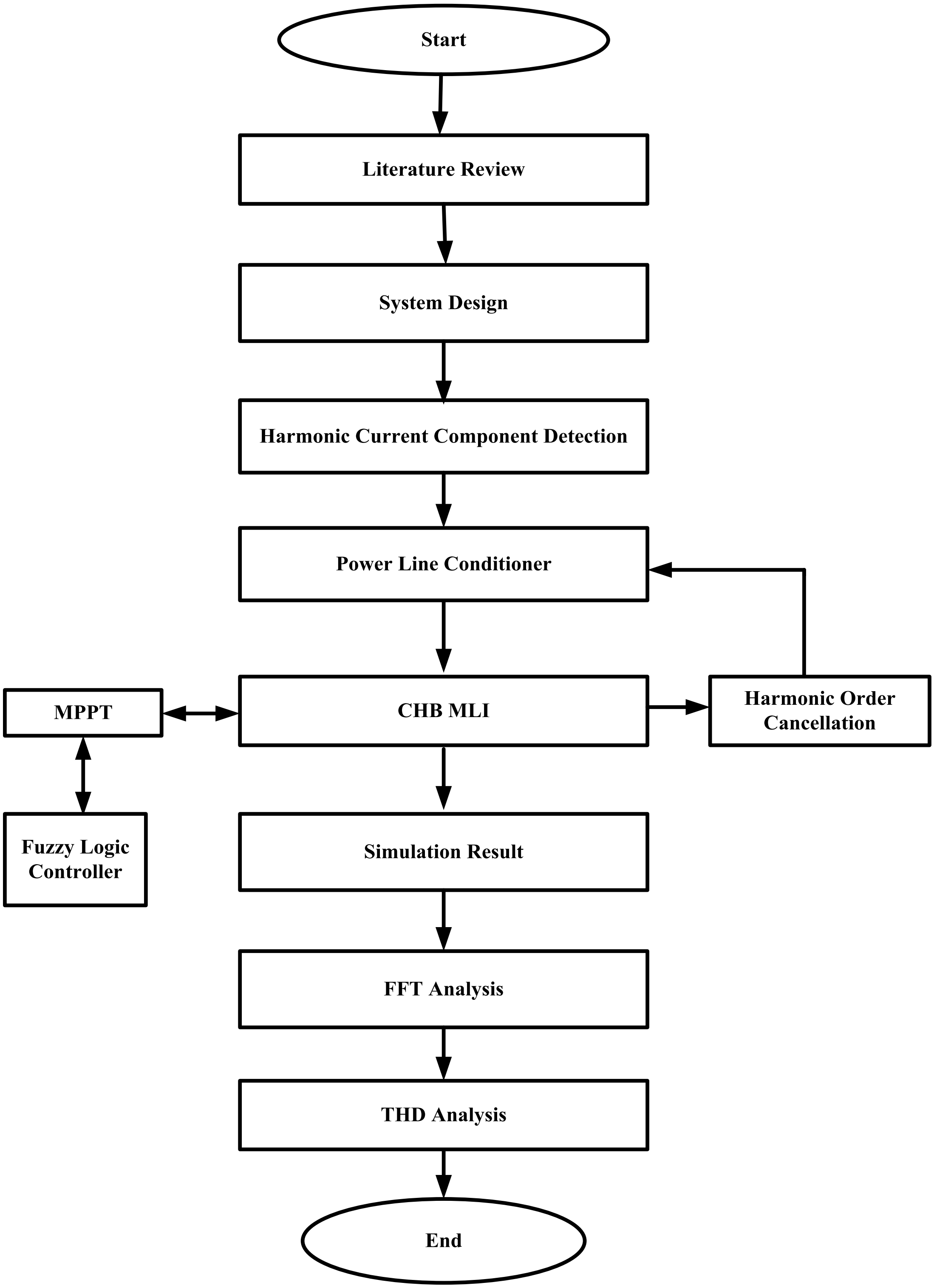

Fig. 1. Methodology Implication

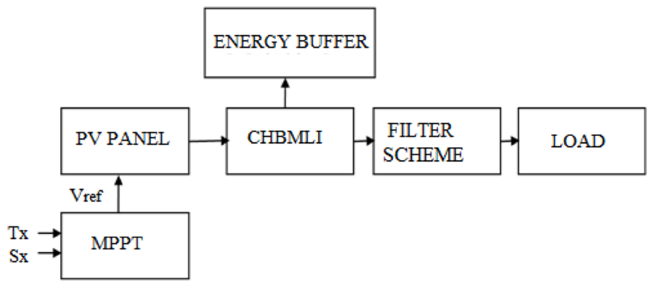

Fig. 2. PV panel and CHBML1 interfacing

name reflects, including recent techniques, Ripple correction techniques, Fuzzy logic control (FLC), Artificial Neural Networks, partial swarm, and genetic algorithms. Among all these MPPT techniques, the FLC method is considered the most suitable for achieving Maximum Power points [7–10].

In this paper, a line conditioner is designed using cascade H-bridge Multi-level inverter in which conventionally input source of excitation is replaced by SPV system associated with Fuzzy logic control for extracting the maximum power. The proposed line conditioner generates a compensating current opposite in direction of line current to minimize the effect of harmonics present in the composite system. The Simulation results are compared with the 3-level and 5-level inverters designed for the same composite system. The total harmonics distortion (THD) and power losses are important parameters for the estimation and augmentation of performance analysis of proposed system.

Key elements and technologies in the field of renewable energy based power conditioning compensators are multilevel inverters, Maximum Power Point Tracking (MPPT), and solar photovoltaic (SPV) systems. Each is essential to improving the performance, dependability, and efficiency of the systems. The relevance of SPV systems lies in their ability to harness solar energy. MPPT ensures the efficient utilization of the available solar power by optimizing the operating point of solar panels. Multilevel inverters act as power conditioner to convert the DC power generated by solar panels into high-quality AC power for distribution in the electrical grid, contributing to overall system efficiency and stability. Together, these technologies enhances the performance and viability of the proposed systems.

Novelty of the proposed line compensator has dynamic capability for enhancing the quality of power by tracking the load current harmonics content. Proposed compensator uses Solar PV system instead of DC voltage source in conventional CHBMLI. The fuzzy logic based MPPT controller is implemented to track the maximum power from SPV system. Hysteresis current control scheme is exerted for generating the reference current to inject the active power component through PV supported VSC. Tracked load current containing harmonic component passes through low pass filter for obtaining the smooth sinusoidal current which is used as error signal and render from actual load current for generating a compensating current in such manner that is opposite in phase sequence of harmonic current present in the system with same magnitude to rendering the harmonic effect.

2. Methodology

The work discussed in the paper contains the power quality improvement of 3-phase supply by injection of compensating current in opposite direction of analyzed harmonic current at point of common coupling. The whole process is executed in a sequential manner. The approach followed this methodology of execution shown in Fig. 1. It clearly elaborates the step by step process of considered system. The methodology of current work gathers information of power quality of existing system and analysis the harmonic current component present in the system [11–14]. The power line conditioner designed using CHBMLI produces a compensating current in reverse manner to eliminate the effect of harmonics present in the system. Simulation results, FFT and THD analysis depicted and validated the whole process.

Power line conditioner uses a Solar PV system for excitation, uses fuzzy logic based maximum power point controller. It is performed by three functions as, Fuzzification, Interface and De-fuzzification. Input of the fuzzy logic is solar temperature (Tx) and solar irradiance (Sx) and output is found as voltage. This voltage is used as a reference voltage (V_{ref}) for calculating the power of the panel. Fig. 2 shows the output of fuzzy system[15–17].

The MLI efficiently converts DC power to AC power with reduced harmonic distortion, while the FLC adapts the inverter's operation based on real-time conditions using fuzzy logic reasoning. This collaborative approach enhances the overall efficiency, reliability, and adaptability of the solar power system.

2.1. Composite System design

The interfacing of SPV Panel and CHBMLI is shown in fig.2, where energy buffer involves battery or any other storage device [18–19]. It is used for continuity in supply when the solar energy is not available

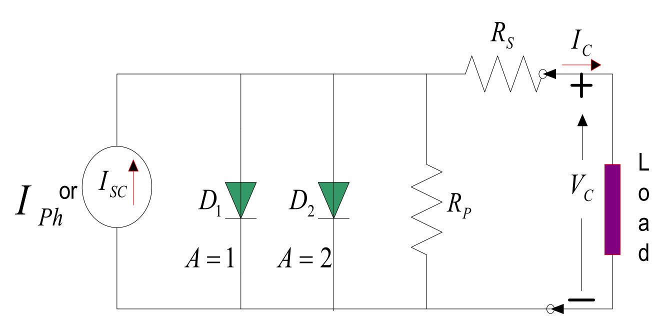

Fig. 3b. Approximate equivalent circuit of PV cell.

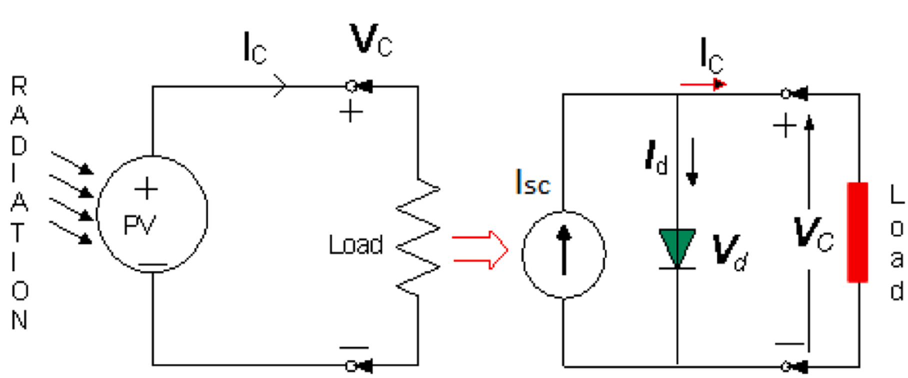

Fig. 3a. PV cell equivalent circuit with resistive load

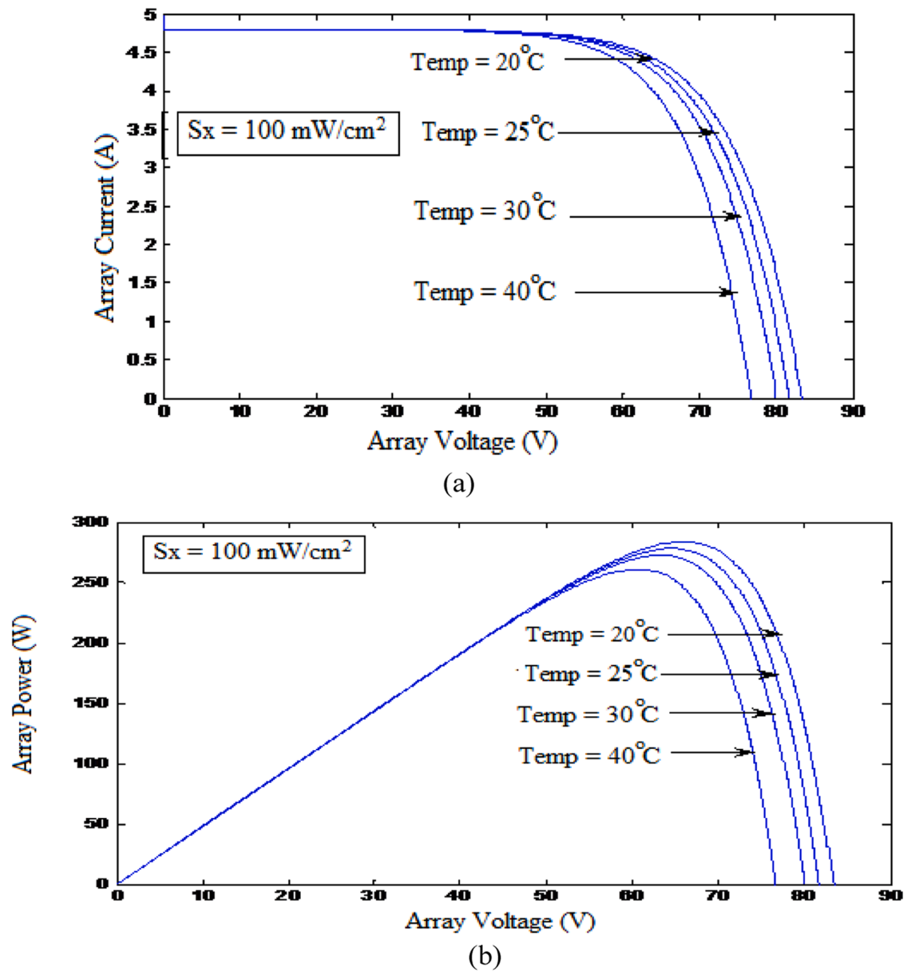

Fig. 4. (a) I-V characteristics (b) P-V characteristics

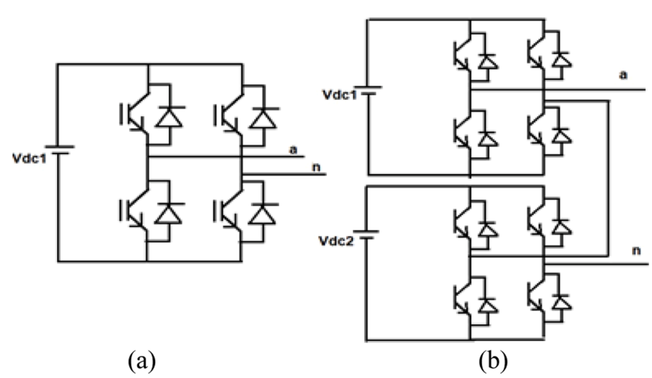

Fig. 5. Cascaded inverter (a) 3-level (b) 5-level

mostly in cloudy or night time. This power is fed on the multilevel inverter (MLI) in which voltage source converter (VSI) is used as compensator which minimize the ripple of current. To reduce the harmonics, shunt active power filter (SAPF) [20–23] is designed to achieve the output voltage near the sinusoidal manner. It also reduces the filter size and cost. The structure of 5 levels MLI is shown in Fig. 9. The output of the system is V_α, V_β and V_0 [24–25].

The cascade H-bridge Multilevel Inverter is selected due to its capacity to boost voltage, lower harmonic distortion, modular design, and efficiency. The selection of the Fuzzy Logic Controller is based on its flexibility in dealing with nonlinear systems, low implementation complexity, resilience to uncertainty, and effective energy conservation. These elements work together to enhance a solar power system's overall dependability and performance.

The performance metrics used for evaluating a solar power system, particularly when incorporating a Cascade H-bridge Multilevel Inverter (MLI) and a Fuzzy Logic Controller (FLC), can be diverse and depend on the specific goals and priorities of the system. Here are some key performance metrics commonly used for evaluation:

- Energy Conversion Efficiency: Energy conversion efficiency is a measure of how effectively the solar power system converts sunlight into usable electrical energy. It is typically calculated as the ratio of the electrical energy output to the solar energy input, expressed as a percentage.
- Total Harmonic Distortion (THD): THD quantifies the distortion in the output waveform, indicating how closely the inverter output resembles a pure sinusoidal waveform. It is expressed as a percentage and is calculated based on the amplitudes of harmonics relative to the fundamental frequency.
- Maximum Power Point Tracking (MPPT) Efficiency: MPPT efficiency measures how well the MPPT algorithm tracks and maintains the solar panels at their maximum power point under varying environmental conditions. It is the ratio of the actual power output to the maximum power available from the solar panels.
- Response Time: Response time measures how quickly the solar power system, including the Fuzzy Logic Controller, can adapt to changes in environmental conditions or system parameters. It is

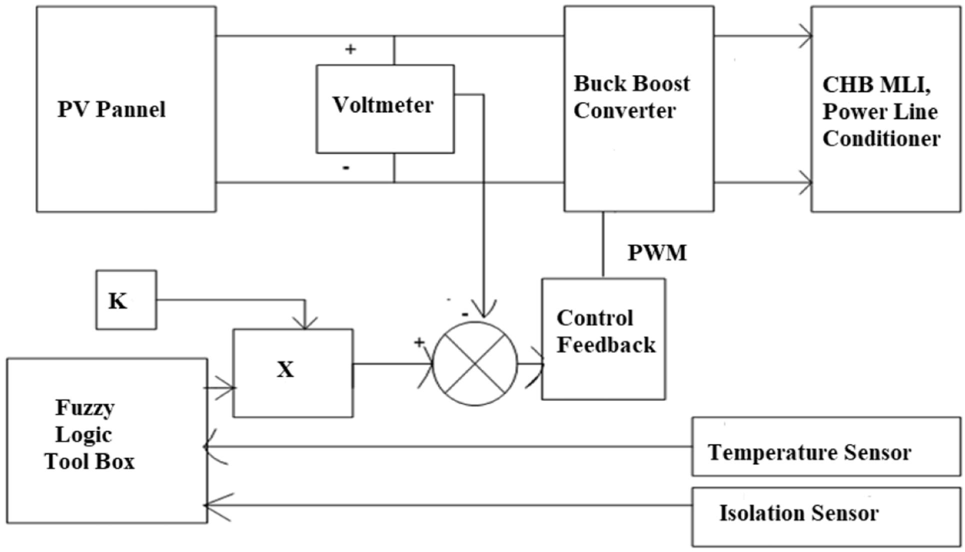

Fig. 6. Fuzzy logic based MPPT controller

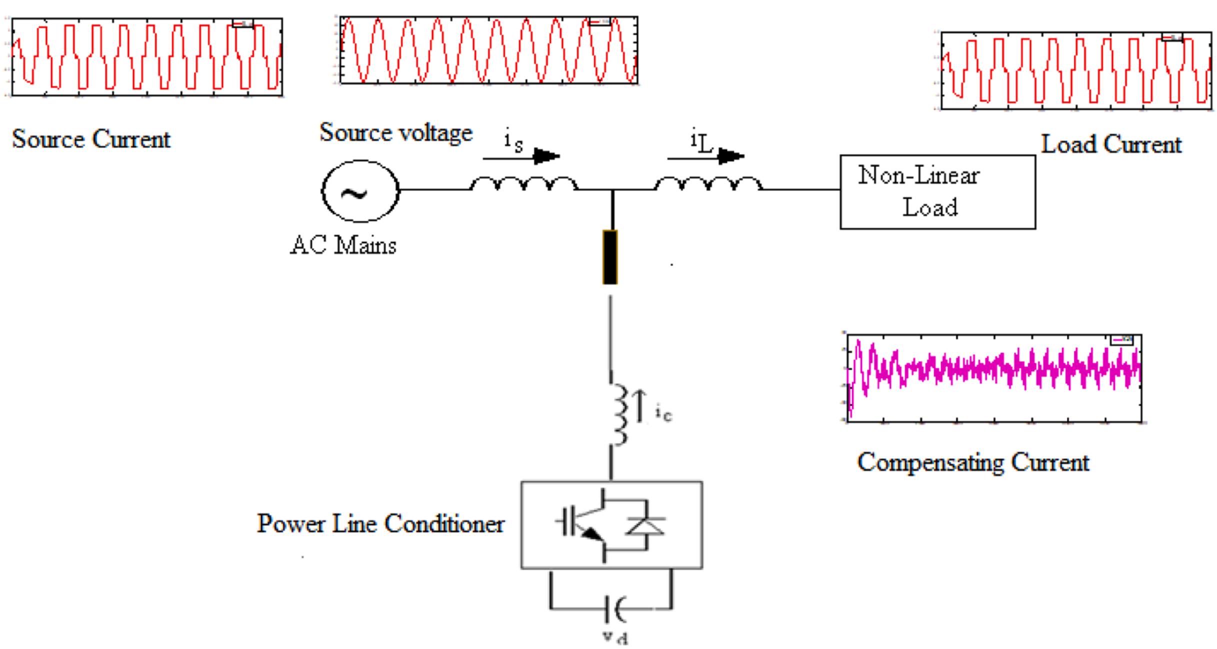

Fig. 7. Current compensation characteristic of the shunt active power filter

Table 1
Power Quality Categories with Characterization methods

Specific Categories	Methods of Characterization
Sag	Magnitude and Duration
Swell	
Under voltage	
Over voltage	
Voltage-Imbalance	Symmetrical-Components
Harmonics	THD and Harmonic spectrum
Notching	
DC- Offset	Volts and Amps
Voltage flicker	Frequency of occurrence and modulating-frequency

often measured in seconds and indicates the system's agility in responding to dynamic conditions.

- Modulation Index Control: The modulation index controls the amplitude of the output waveform in multilevel inverters. Efficient control of the modulation index is crucial for optimizing the inverter's performance. It involves assessing the ability of the Fuzzy Logic Controller to adjust the modulation index dynamically.

2.2. SPV Panel

The solar cells are the primary component of SPV panels. In general, the solar cells are carrying fundamental properties of photoelectric diodes [26–28]. Therefore, the basic properties and equivalent circuit model of solar cells are considered for developing the solar PV Simulink models as depicted in Fig. 3(a).

The output current is quantifying by KCL and computed as

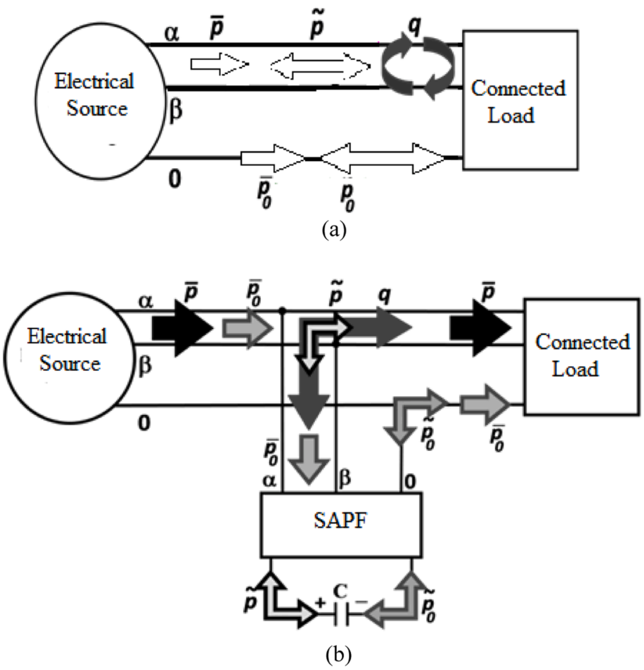

Fig. 8. (a) p-q power components (b) Compensation of power components.

$$I_C = I_{SC} - I_d \quad (1)$$

Where, output current through load is denoted byI_{SC}andcurrent through the intrinsic diode$I_d$is given by the following expression

$$I_d = Isc\left(e^{\frac{qVd}{kTc}} - 1\right) \quad (2)$$

The open circuit voltage in the above circuit can be obtained as;

$$V_{OC} = \frac{kT_C}{q} \ln\left(\frac{I_{Ph}}{I_O}\right) \quad (3)$$

A direct relation is interposing between short circuit current (*Isc*), irradiance (S_x) and illumination intensity (S_c) and procured as

$$I_{SC-S_X} = \left(\frac{S_X}{S_C}\right) I_{SC-S_X} \quad (4)$$

The approximation of equivalent circuit is amended in Fig. 3(b) to clarify the results and characteristics is plotted in Fig. 4(a)-(b).

Solar photovoltaic (PV) systems have a wide range of real-world applications across various sectors, contributing to sustainable energy production and environmental conservation.

- Solar PV systems can be connected to the grid, allowing excess electricity to be fed back into the grid. This not only provides a source of income through feed-in tariffs but also contributes to overall grid stability.
- Remote or off-grid areas can benefit from solar PV systems as a reliable and sustainable source of electricity, powering homes, schools, healthcare facilities, and other essential services.
- Solar PV system can install rooftop solar panels to generate electricity for their own use, reducing reliance on the grid and lowering utility bills.
- Solar panels integrated into electric vehicles (EVs) or used as standalone charging stations can extend the range of EVs and reduce the environmental impact of transportation.

2.3. CHBMLI

The multi-level inverter consisting of a series of single complete H-bridge converters, each with a separate dc bus. Conventionally it used to convert DC to AC source as shown in Fig. 5 [29–32]. In the proposed work it is used to replicate the compensating current.

Comparing cascade H-bridge multilevel inverters with 3-level and 5-level multilevel inverters involves evaluating various criteria to determine their performance, efficiency, and suitability for specific applications. Here are several criteria consider:

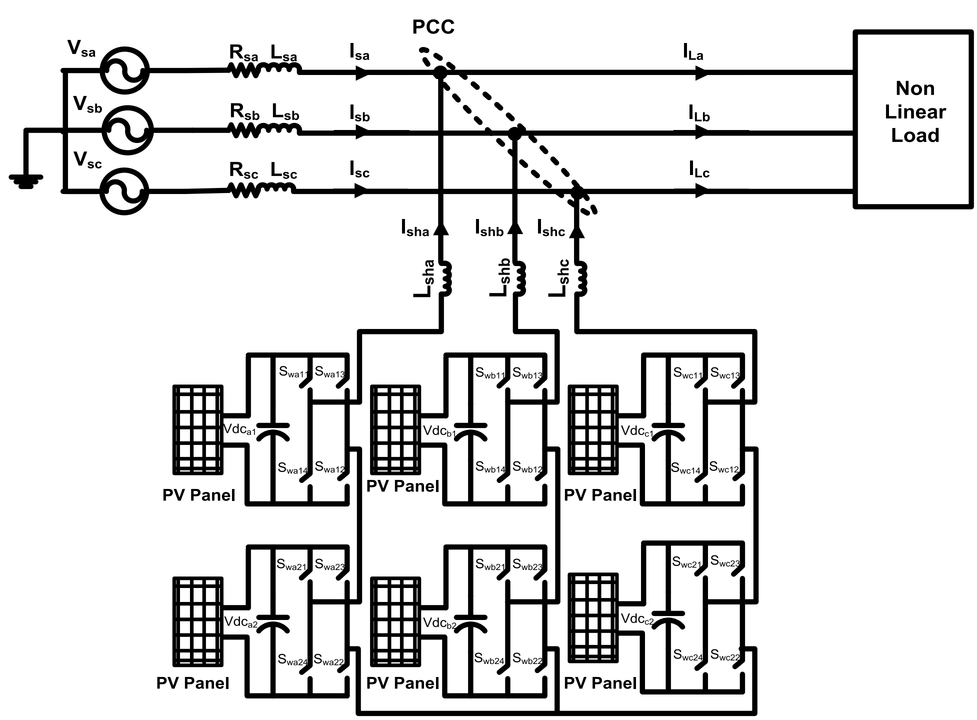

Fig. 9. Schematic diagram of 5-level cascaded Inverter.

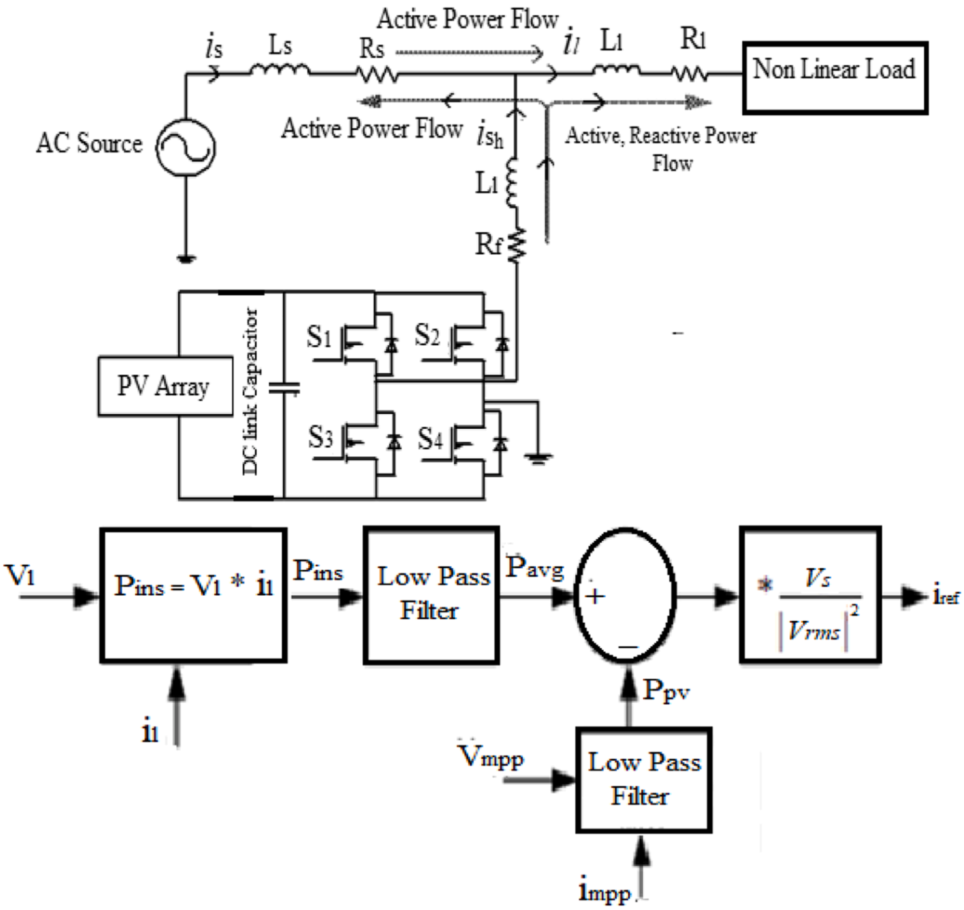

Fig. 10. (a) Schematic diagram of integration of PV power. (b). Schematic diagram of reference current generation through PV supported VSC.

Table 2
Switching sequences for the IGBTs

If (Error $>h_{max}$)		
1.	S1=1,	S4=1
2.	S2=0	S3=0
Else if (Error $>h_{min}$)		
1.	S2=1,	S3=1;
2.	S1=0,	S3=0;

- Capable of achieving a high number of voltage levels by cascading multiple H-bridge inverters.
- THD depends on the number of cascade stages and modulation technique. 3-level inverter: Typically lower THD compared to 2-level inverters. 5-level inverter: Generally lower THD compared to 3-level inverters.
- Cascade H-bridge: May have higher switching losses due to multiple stages. 3-level inverter: Lower switching losses compared to cascade H-bridge for similar power ratings. 5-level inverter have higher switching losses than 3-level inverters but still lower than cascade H-bridge.
- 5 level inverter has more efficiency as compared to 3 level inverter.

2.4. MPPT

The fuzzy logic based MPPT controller is implemented to fulfill the voltage demand of line compensator as shown in Fig. 6. Mamdani's-based constant voltage (CV) method is used for extracting the maximum power which automatically adjusts the reference voltage at various environmental conditions [33–36]. The fuzzy logic controller toolbox is simulated in the MATLAB/Simulink environment to determine the open circuit voltage (Voc).

2.5. Shunt Active Power Filter

Shunt active power filters inject an equal-but-opposite harmonic compensation current to balance out current harmonics. In this instance, the shunt active power filters functions as a current source, injecting the phase-shifted harmonic components produced by the load. Any kind of load regarded as a harmonic source can be used according to this approach [37–38]. The compensation approach is shown in Fig. 7.

3. Power Quality Problems in Composite Power System

The broad categories of power quality problems of composite power system are categorized in Table 1 [27].

3.1. Mathematical modeling of Power Quality Compensation with Instantaneous p-q Theory

By specifying zero sequence power, the p-q theory emphasizes a three-phase, four-wire system. The goal of this simulation is to examine the performance of the compensation procedure in generalized power quality enhancements such as reactive power compensation, harmonic elimination, and imbalance compensation [39–40]. This is done by using the instantaneous p-q theory to verify the compensation technique. The next section contains the required transformation formulae.

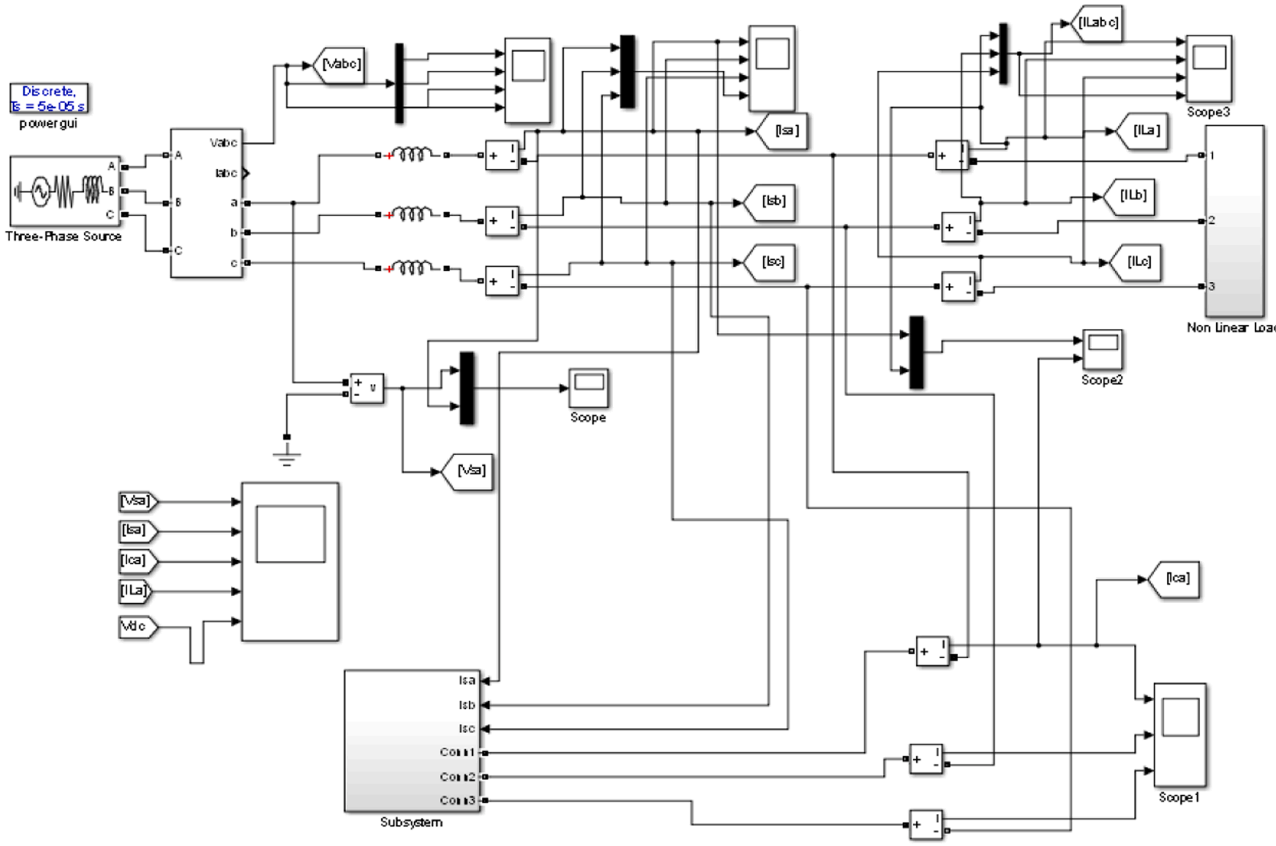

Fig. 11. Simulink model of composite system with proposed power line conditioner

Table 3
Simulation Parameter

Parameters	Numerical Value
Source Voltage V_S per phase	60 V
No. of solar cell connected in series and parallel	108 & 2
Number of modules connected in series and parallel	2 & 1
System Frequency	50 Hz
Source Resistor (R_S) and Inductor (L_S)	1 Ω & 0.5 mH
Non-Linear Load: Diode Rectifier	6-diode
Load Resistor (R_L)	10 Ω
Load Inductor (L_L)	100 mH
Filter: Inductor (L_F)	2 mH
Resistor (R_F)	1 Ω
DC-side Capacitance (C_{DC})	1000 μF
Reference Voltage (V_{DCref})	200 V

3.2. Compensation with p-q Theory

The algebraic conversion of the currents and voltages in three-phase to two-phase sequences based on p-q theory instantaneous power components is rendered as follows.

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

i_0, i_α, i_β are zero sequence current along α axis and β axis current respectively.

$$\begin{bmatrix} v_o \\ v_\alpha \\ v_\beta \end{bmatrix} = \sqrt{\frac{2}{3}} \begin{bmatrix} \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \\ 1 & \frac{-1}{2} & \frac{-1}{2} \\ 0 & \frac{\sqrt{3}}{2} & \frac{-\sqrt{3}}{2} \end{bmatrix} \begin{bmatrix} v_a \\ v_b \\ v_c \end{bmatrix}$$

v_0, v_α, v_β are zero sequence voltage, α axis, β axis voltage respectively.

$$\begin{bmatrix} p \\ q \end{bmatrix} = \begin{bmatrix} v_\alpha & v_\beta \\ -v_\beta & v_\alpha \end{bmatrix} \begin{bmatrix} i_\alpha \\ i_\beta \end{bmatrix}$$

$$P_0 = v_0 i_0$$

p, q, p_0 are instantaneous real, reactive and zero sequence power and depicted in Fig. 8(a) and 8 (b) evinced that the active filter capacitor is sufficient to recompense the alternating unusual active and zero sequence power [20–26].

Instantaneous zero-sequence power is recompensed using active filter capacitor, so $i_{c0}{}^* = i_0$. The reference compensating currents in two and three phase sequence respectively is deduces as,

$$\begin{bmatrix} i^*_{c\alpha} \\ i^*_{c\beta} \end{bmatrix} = \frac{1}{v_\alpha^2 + v_\beta^2} \begin{bmatrix} v_\alpha & v_\beta \\ -v_\beta & v_\alpha \end{bmatrix} \begin{bmatrix} p_x \\ p_y \end{bmatrix}$$

$$\begin{bmatrix} i^*_{ca} \\ i^*_{cb} \\ i^*_{cc} \end{bmatrix} = \sqrt{\frac{2}{3}} \begin{bmatrix} \frac{1}{\sqrt{2}} & 1 & 0 \\ \frac{1}{\sqrt{2}} & \frac{-1}{2} & \frac{\sqrt{3}}{2} \\ \frac{1}{\sqrt{2}} & \frac{-1}{2} & \frac{-\sqrt{3}}{2} \end{bmatrix} \begin{bmatrix} i^*_{c0} \\ i^*_{c\alpha} \\ i^*_{c\beta} \end{bmatrix}$$

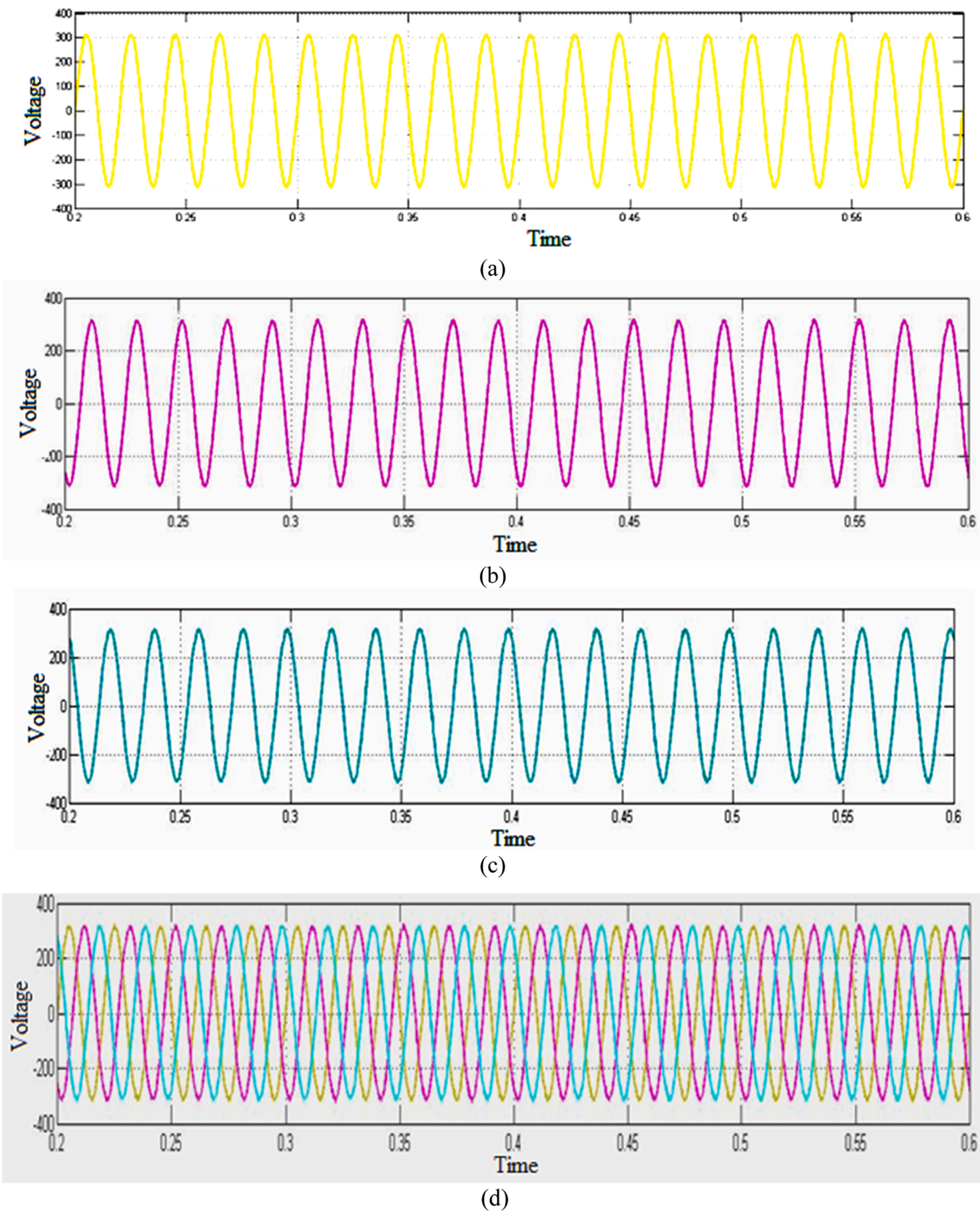

Fig. 12. Source voltage (a) Phase-a (b) Phase-b (c) Phase-c (d) Phase-a-b-c-d

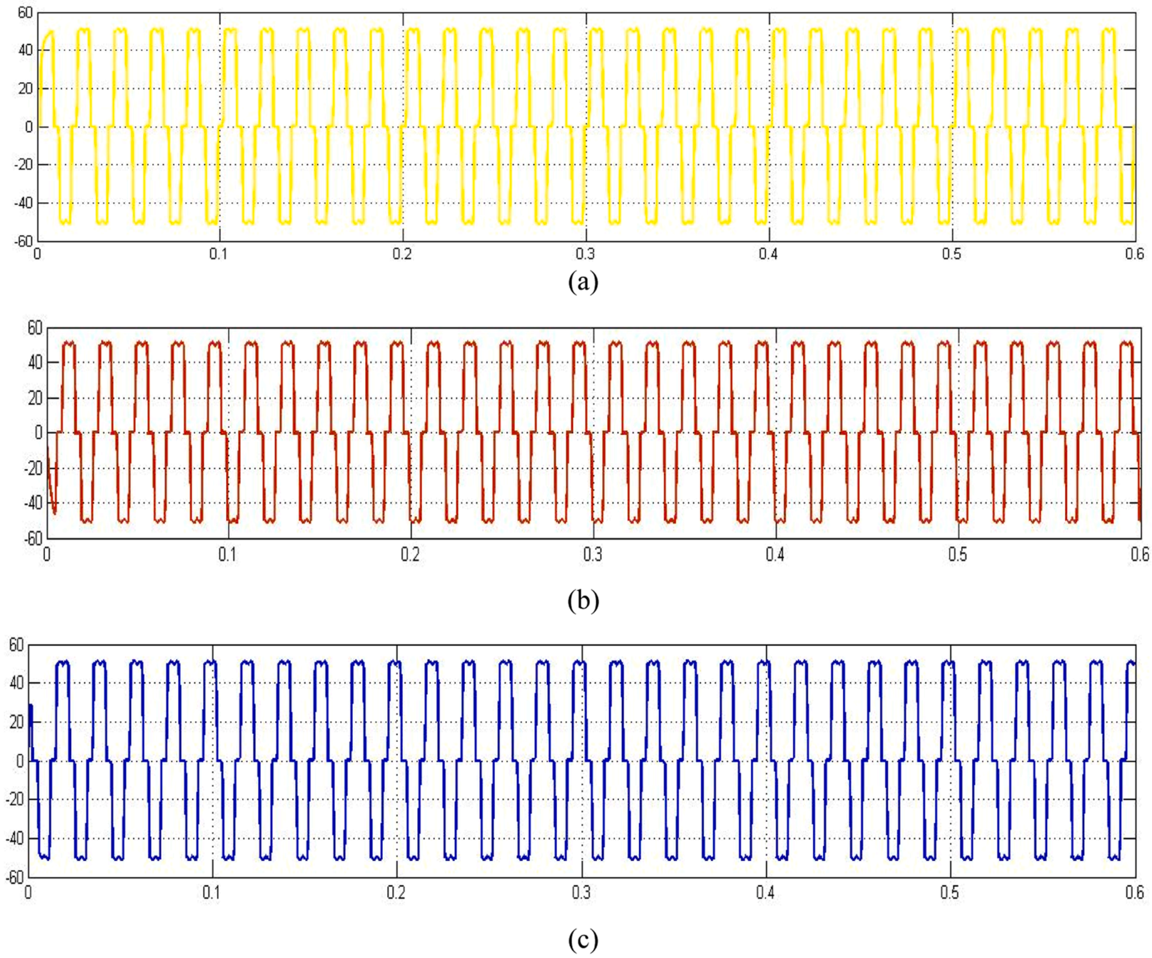

Fig. 13. Source current before compensation (a) Phase-a (b) Phase-b (c) Phase-c

$$i^*_{cx} = -\left(i^*_{ca} + i^*_{cb} + i^*_{cc}\right)$$

Where.

$P0$ = mean value of the instantaneous zero-sequence power
$P_0\sim$ = alternated value of the instantaneous zero-sequence power
p = mean value of the instantaneous real power
$p\sim$ = alternated value of the instantaneous real power
q = instantaneous imaginary power

4. Propose Composite CHBMLI Topology

The proposed topology of power conditioning is depicted in Fig. 9 relates how the PV power is integrating through voltage source converter (VSC) and Fig. 10 (a) reflects active power injection technique through PV supported VSC and exchange between source and load. The objective is to generate a compensating current in such a way which is opposite in phase sequence of harmonic current present in the system with same magnitude to rendering the harmonic effect.

The Block diagram of reference Current Generation for Active Power Injection through PV Supported VSC is demonstrated in Fig. 10 (b) and passes through low pass filter to allow only fundamental component of voltage and current which is responsible for active power production and there per unit sequence generated the reference current.

The error was extracted from the formula given below

$$i_c(t) = i_L(t) - i_{ref}(t)$$

Switching sequences are engendering through Hysteresis current control scheme for the IGBTs is given in the Table 2.

Based on the above condition the switching of the IGBT is done of the shunt converter.

5. Simulink model and results

Simulations were carried out during the implementation of the power line conditioner to study its behavior under various operating situations and to tune some controller parameters in conjunction with the optimization of the active filter component values. The Power System Block set and MATLAB/ Simulink has been accomplished in this instance as simulation tools, which is shown in Fig. 11 along with the simulation's parameters mentioned in Table 3.

A power line conditioner is simulated in MATLAB/Simulink environment and results are discussed in this section. Simulation results showed that distortion comes into picture when a non-linear load is connected to the system. Source side compensation is done at point of common coupling. The source voltage waveforms of all three phases are shown in Fig. 12(a), 12(b), 12(c) and 12(d) respectively. The waveform is pure sinusoidal, the concern of power quality issue comes into picture when non-linear load is integrated with system configuration as it distorted the voltage waveform.

Current waveform of all three phases before compensation is shown in Fig. 13(a)-(c) after integrating the non-linear load in the system. Result analysis depicted that waveform contain 29.84% THD. A fuzzy logic based and solar power supported multi-level inverter is designed as shunt compensator to intending the PQ-issue.

As shown in Fig. 14(a)-(d) wave form shows that quality is improved

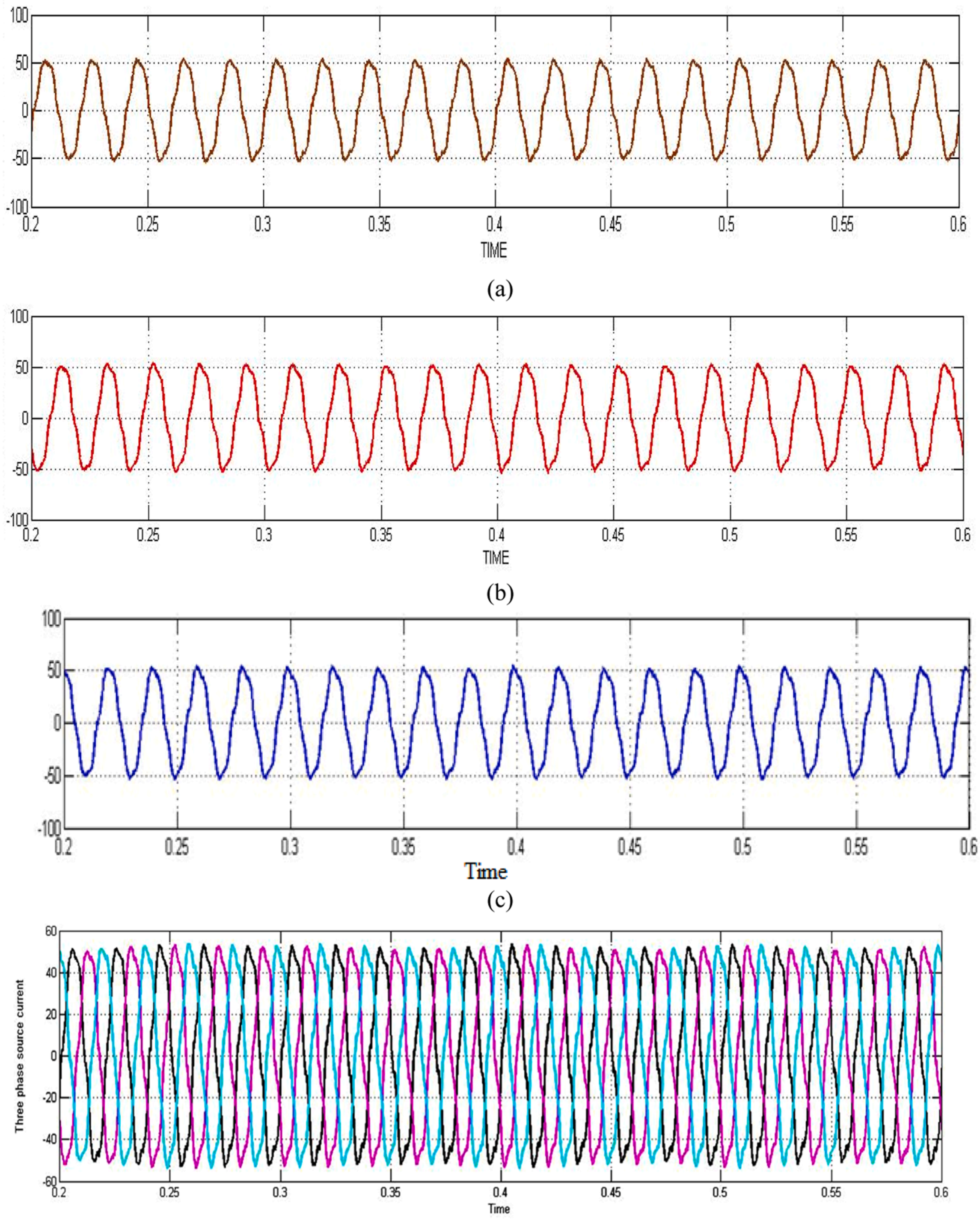

Fig. 14. Source current after compensation (a) Phase-a (b) Phase-b (c) Phase-c (d) Phase a-b-c

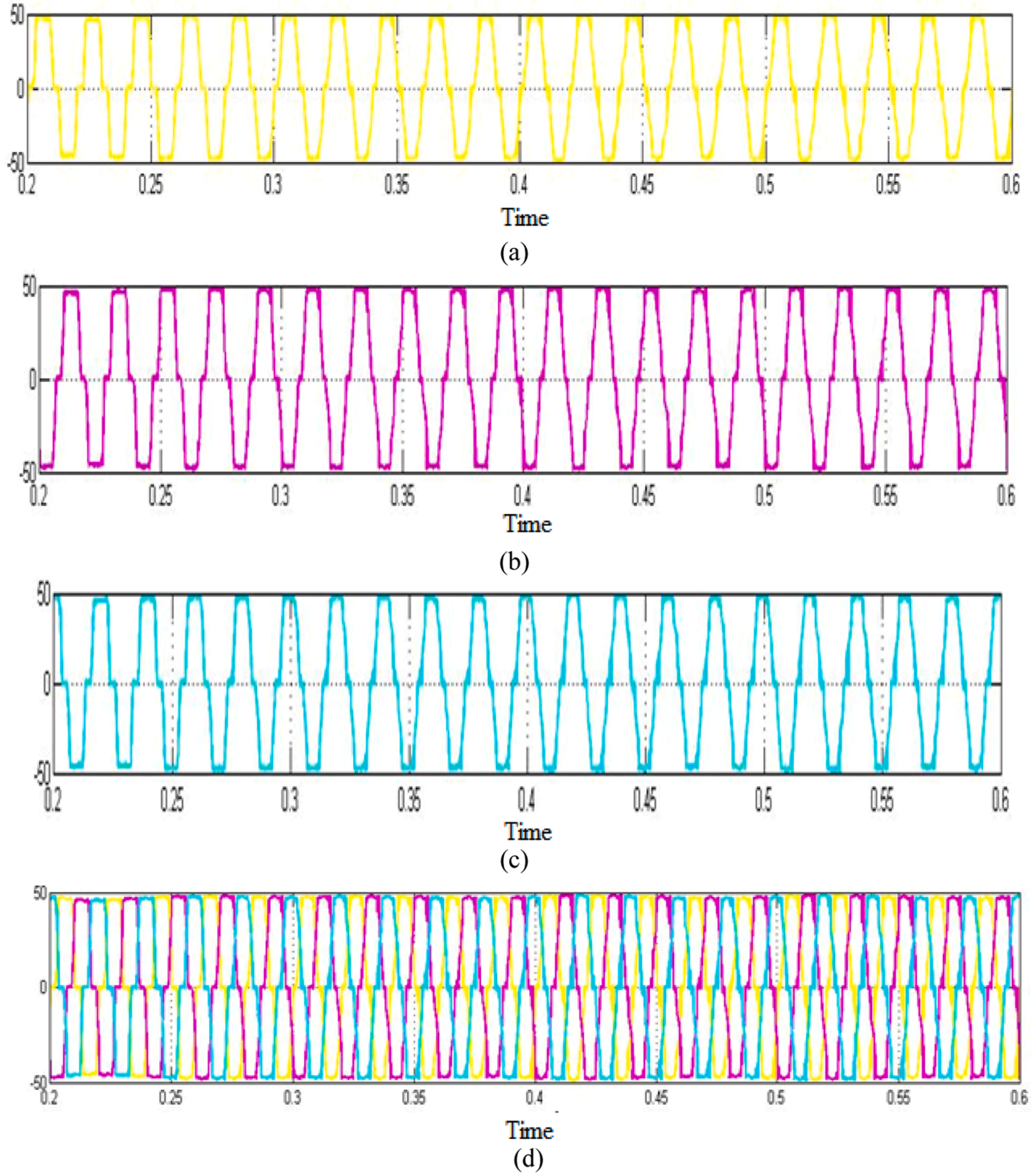

Fig. 15. Load current wave form of respective phases that contain harmonics

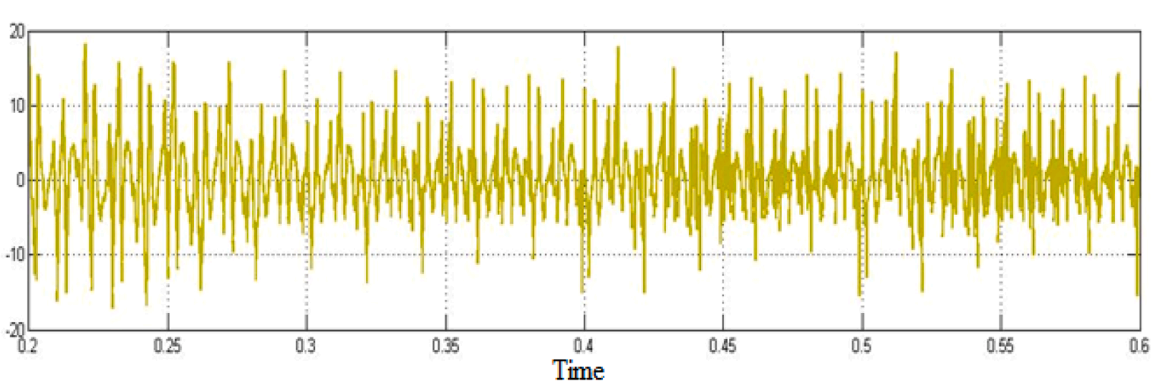

Fig. 16. Compensating current

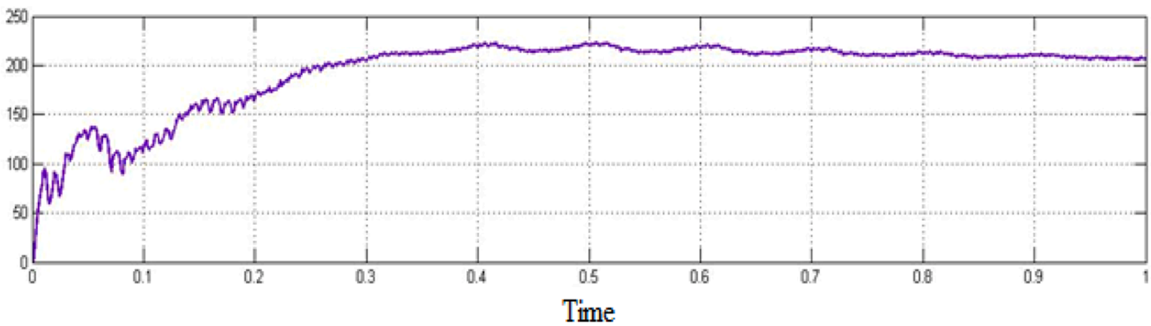

Fig. 17. PV module DC output voltage

Table 4
Comparison to Total Harmonic Distortion of Source Current

Topology	Harmonic distortion in %	1	5	7	11	13
PV based 3-Level Cascaded MLI	Before compensation	100	18.68	12.47	6.52	4.72
	After compensation	100	4.51	3.72	3.01	2.09
PV based 5-Level Cascaded MLI	Before compensation	100	18.68	12.47	6.52	4.72
	After compensation	100	1.91	0.87	0.39	0.23

and THD content in source side currents are 2.96% which is in permissible limit as per IEEE standard and PV based 5 level MLI is acted as power line conditioner. Fig. 15 shows load current wave form of respective phases that contain harmonics. Compensating current generated to ameliorate the source side response as delineating in Fig. 16.

Fig. 17 shows the ripple less voltage extracted from solar panel and act as a constant voltage source through fuzzy logic based MPPT algorithm. The conventional capacitors used in a voltage source inverter are replaced through optimized self-generating solar supported constant voltage source.

5.1. FFT analysis

The detailed FFT analysis is cultivated in Table 4 which is reflection of Fig. 18(a)-(c) to cope the overall objective of work done.

Comparative analysis of 3-level and 5-level MLI based power line conditioner is done on Table 4and results show that the compensating capacity of line conditioner is directly proportional to the switching levels in inverter and 5-level MLI based shunt power compensator is optimized and self-sufficient on considering the system complexity.

6. Conclusion

An FLC based PV supported CHBMLI is depicted as smart power line conditioners. Under various circumstances, the performance of the shunt power filter is studied and efficacious even when the supply voltages are imbalanced and distorted; minimizes THD in source current to levels considerably below the stated limits set as standards. The source current becomes completely sinusoidal, devoid of harmonics, and in phase with the main supply voltage, retaining unity power factor in each of the cases investigated. Multiple non-linear loads have been utilized in each simulation to examine the active filter's temporal response. It has been noticed in each case that the filtering plan of action follows the pattern after one power cycle when the loads vary. The basic positive sequence voltage detector is in high demand when voltage imbalance and distortions both present. The hypothesis worked quite well after the fundamental positive sequence voltage was retrieved. The key point of

Future Research

It can concentrate on enhancing the performance of multilevel inverters in line compensation by optimizing their topology. To improve voltage regulation and harmonic mitigation, this may entail investigating novel configurations, switching schemes, and modulation techniques. It can be develop the advanced control strategies for enhancing the performance of multilevel in line compensation. Also this technology can be integrated with hybrid system like combination of solar with wind.

CRediT authorship contribution statement

Prabhat Ranjan Sarkar: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Software, Validation, Writing – original draft, Writing – review & editing. **Ahmad Faiz Minai:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Supervision. **Isarar Ahmad:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Software, Validation, Writing – original draft, Writing – review & editing. **Farhad Ilahi Bakhsh:** Conceptualization, Data curation, Formal analysis, Software, Supervision, Validation. **Akhlaque Ahmad Khan:** Conceptualization, Formal analysis, Investigation, Methodology, Software. **Rupendra Kumar Pachauri:** Conceptualization, Data curation, Methodology, Software, Supervision, Validation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

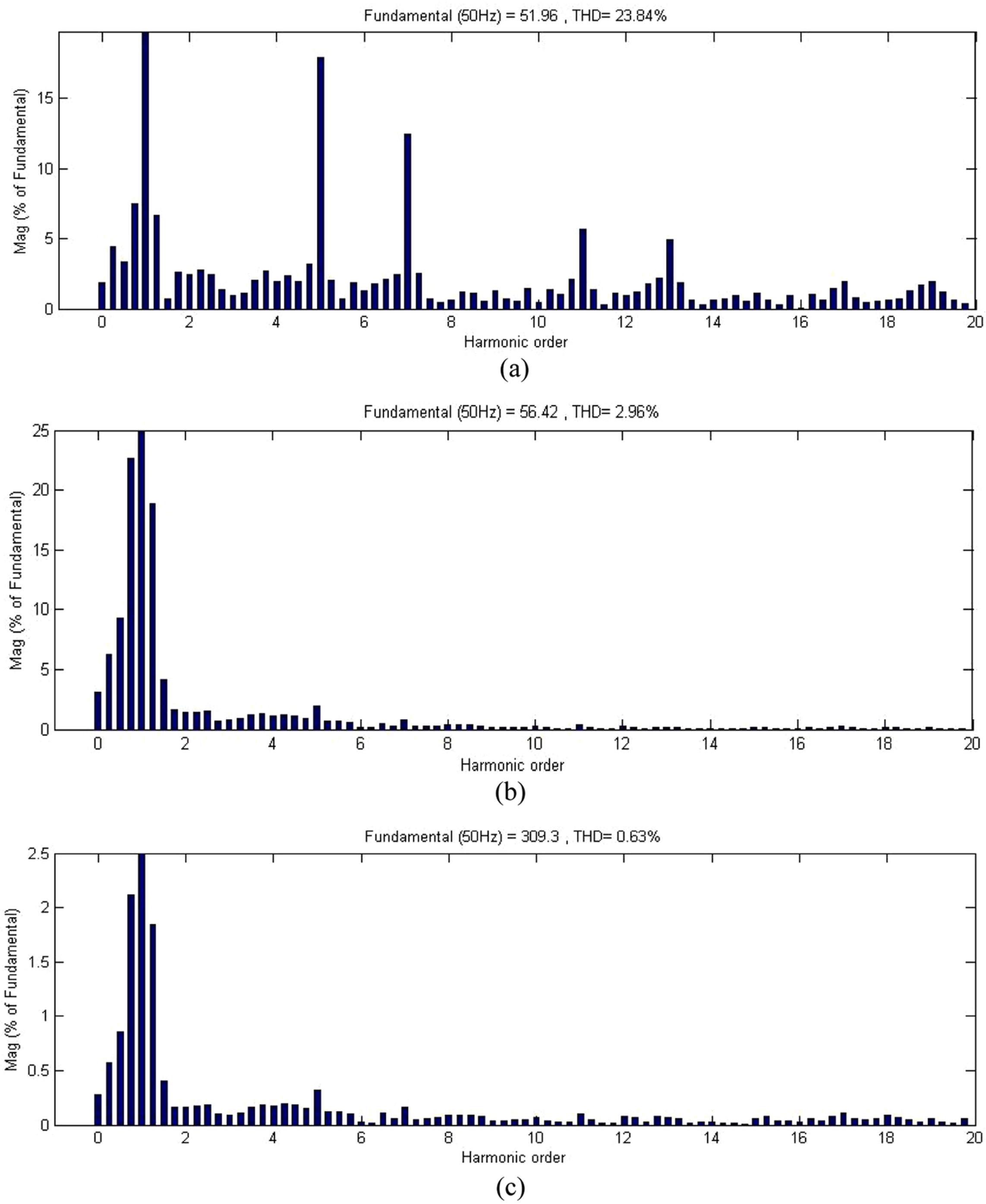

Fig. 18. FFT analysis (a) before compensation (b) 3 level cascaded inverter (c) 5 level cascaded Inverter.

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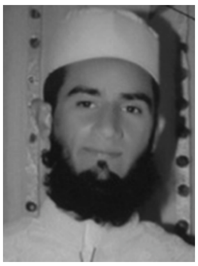

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