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A Novel Multilevel Inverter for Renewable Energy Applications with Optimized Controller and Reduced Switches

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Abstract: - Multilevel converters have the capability of handling high power as well as deliver output with reduced harmonics. So they can be implemented with renewable energy sources to produce multilayer output with symmetric cascade arrangement with reduced switches. Here the control technique is developed in such a way to reduce the harmonics in the grid integrated PV system. The paper proposes optimized Fractional Order Proportional Integral Derivative (FOPID) controller for a seven level reduced switch multilevel inverter. The War Strategy Optimization Algorithm (WSOA) which utilizes optimizing the strategic movements of armed forces (assault and defend) towards the final optimal value is used to optimize the FOPID controller. This WSOA algorithm is used to adjust the gain parameters of the FOPID controller there by improving the system performance. The characteristics of grid connected PV system are regulated by implementing this suggested technique. The projected approach is incorporated using MATLAB / Simulink and the performances are evaluated and compared with the conventional techniques like GA – PID and WSOA – PID controllers.

Keywords: PV array, THD, RSCMLI, FOPID controller, WSOA and microgrid

I. INTRODUCTION

Power electronics and processors play critical roles in current technology in domains such as light management, motor control, power supply, heat control, HVDC, vehicle systems, renewable applications, and FACTS [1]. Power converters with greater operating voltages are to be built with the aid of semiconductor device technology [2]. Multiple devices must connect in series to satisfy the voltage rating because a single device cannot withstand such high voltages [3]. The demand for the upkeep of a sinusoidal power supply with varying voltage and frequency presents another difficulty for the industrial sector [4]. The introduction of inverters overcomes the drawbacks. A control system in the inverters allows the series connected switches to share the voltage stress related to the high voltage rating, hence minimizing losses [5].Inverters are also employed for moderate-voltage systems because of their low-loss characteristics [6]. The conventional square-wave converter running at greater power generates dominating harmony, which has a significant influence on the operation of the inverter's load side and front end [7]. Although passive methods are used to solve the problem, leakage rates rise and the space required increases [8]. Multilevel inverters (MLI) provide an alternate solution by employing an altering procedure to generate a sine wave signal in a set of power stages [9]. Additional benefits of MLI include lower electromagnetic interference, lower current distortion, higher-quality voltage and current waveforms, and superior quality voltage waveforms [10].

The three fundamental forms of MLI includes a pair of H, traveling condensers, and level-controlled MLIs [11]. To synthesize nearly sinusoidal voltage, a greater number of levels must be manufactured using additional shifts, reports, and gateway devices [12]. As a result, additional switches are used in the conduction path, the efficiency drops. The study domain was guided by the research difficulties to design novel topologies with improved THD, lower switching loss, lower conduction loss, and lower voltage stress on devices, even at the expense of fewer devices and sources [13].One potential solution involve adjusting the current topology or creating new topologies with fewer devices by using the new structure in high, low, or hybrid frequency symmetric, asymmetric, and hybrid modes of operation [14]. Since the input voltage is often a steady DC voltage, the PWM approach is appropriate for DC-AC conversion. For improving the output, MLIs offer a visually pleasing alternative by combining a staircase waveform that resembles a sinusoidal waveform. Such a waveform reduces the dv/dt stress and has minimal distortion. Furthermore, employing PWM, MLIs can function at both fundamental switching and high frequency switching [15].

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In this way, an MLI can provide a superior output waveform using medium voltage control switches for high power/high voltage applications and is therefore preferred over well-known two-level inverters. Current Source Inverters (CSI) have found uses, especially in situations where quick dynamic performance is not required, such as in home fans, pumps, etc., even though Voltage Source Inverter (VSI) topology is commonly employed in industries. The application of PWM methods to MLIs results in acceptable waveforms for both input and output. With Selective Harmonic Elimination (SHE) switching and dynamic performance, the MLI boasts an amazing harmonics elimination performance. In this paper WSOA optimized FOPID controller based seven level RS-MLI is presented for reducing the THD and optimize the efficiency of the proposed networked photovoltaic array. The work is organized as below: Section 2 presents research on RS-MLI with renewable energy applications. Section 3 provides a full discussion about the designed controller and electrically linked photovoltaic system. The fourth section presents the suggested system's performance and comparative analysis using simulated outcomes. At last, the fifth section presents the suggestion's result.

II. RELATED WORK: RECENT RESEARCH WORKS

In the literature, many reduced switches symmetrical multilevel inverter for renewable energy applications are developed by researchers. Few works are reviewed in this section.

Dhananjay Kumar et al. [16] presented an additional level of parallel and unbalanced MLI with fewer devices for solar power sources. A simple organism section of reduced device count (RDC) MLI with six devices for switching was demonstrated. Combining a pair of similar essential units with twelve sensors yields a 49-range outcome exhibiting an assessed THD of 1.63%.

UshaSengamalai et al. [17] designed a 15-stage generator and decreased the number of energy connections. It's formed of three separate modeling wires, one of which has ten valves and the second has twelve in total. Changing the pulse timing of the contacts in the stated 10 switch construction serves lower harmony, current anxiety, and common-mode energies. Furthermore, a piece of filtering is fitted at the connector to lower the complete THD quantity for varied AC workloads. Low switching speeds allow the MLI to create excellent results while reducing harmony, damage, and common-mode voltage.

MadhuAndela et al. have designed a RS-MLI for 127-levels [18]. Compared to the laser-restrained complex converter, transmitted-style MLI, and flying battery multi-level inverter, the latter uses the fewest switches to accomplish the most levels in the electricity supply voltage gradient. Reducing the total number of connections in the system lowers the price. To lower conversion damage, a sine wave switch was used in that design rather than a narrow pulse variation. Less harmonics and THD are now present in the pulsating AC output voltage waveform.

Dinanath Prasad et al. developed the 3-phase grid-interfaced solar-wind composite renewable energy system (RES) that serves three-phase applications [19]. The system that is suggested consists of an integrated rooftop photovoltaic system, a three-phase IGBT-based voltage source converter (VSC), a lifetime magnet-based synchronous generator (PMSG), a DC-DC converter, a gradual conductance-based maximum power point tracker (MPPT), and a third-order generalized integrator (TOGI) control technique. The above approach has multiple features, such as energy benefits, balance of load, and harmonic mitigation. The TOGI-based controller recovers a considerable percentage of the load current and sends switching pulses to the VSC, improving power quality. An imprecise logic-based controller was utilized for calculating the VSC loss as well as keeping up the DC link voltage. Fuzzy thinking works better flexibly than traditional.

A capacitor-based boost multilevel inverter (CB-MLI) structure has been presented by KancharapuAditya et al. [20]. With just eleven switches, three capacitors, and one isolated source, it was able to produce an eleven-level waveform. The architecture is unique due to the capacitors' self-balancing characteristic. To switch the IGBTs, a constant carrier PWM-based control method was applied. The suggested capacitor's operating modes and potentiality were based on the CB-MLI architecture. Finally, the benefits offered by the recommended arrangement are defined by the number of parts and the overall priceby illustrating the suggested and current MLI circuits. It was also a more straightforward design that required less room and footprint.

A. *Findings from literature review*

- ✓ To link photovoltaic power to the arrangement, lower-power PV panels are linked in parallel to produce large DC power. This approach requires the addition of high-rated power invert hardware and a step-up converter, leading to the structure's damages, expenses, pounds, and bulk.

- ✓ FL beats conventional PI devices in regards to fluid flexibility owing to the practical calculation of the logarithmic variable (Kp) and essential variable (Ki), making it slower to select PI benefits.
- ✓ Traditional designs like neutral point clamped (NPC), flying capacitor (FC), and cascaded H-Bridge (CHB) convert more switches for every single level, leading to complex structures requiring higher controller and protective loop needs.
- ✓ CHB is famous due to its modular design and ease of adaptation for greater voltage requirements. For increasing output levels, three circuit changes may result in fewer switches and switching losses in MLI topologies: (i) switch connections, (ii) asymmetric sources, and (iii) combining both techniques.
- ✓ CHB MLI works well with PV panels but requires additional panels in series or parallel as the number of levels grows. As the level of the inverter grows, so does the number of switches in CHB MLI. It also specifies the cost, size of the circuit, dependability, and complexity. As a result, the number of switches required in relation to the desired voltage level is critical when building MLI.
- ✓ Reducing the number of switches, diodes, capacitors, and voltage sources increases the reliability of converters. This additionally decreases all expenses and damages, leading to an effective and cheap structure.

B. Objective of the proposed work

- ✓ To get the identical output as a 7-level CHB MLI, an entirely novel architecture was created with less switching and additional H-bridges.
- ✓ Researchers are proposing reduced switch changers to get around the errors of CHB MLI, hoping to lower the number of units.

III. SYSTEM DESCRIPTION FORTHE PROPOSED CONTROL METHODOLOGY

The proposed microgrid contains PV, RS-MLI for managing power requirements. Figure 1 depicts the proposed system's design. It is possible to control both DC and AC loads. The system utilizes PV to generate energy to satisfy the power needs in a microgrid framework. The paper uses RS-MLI to change DC to AC using a large number of outcomes levels at a low cost and with fewer switching components. The suggested RS-MLI circuit improves protection against overvoltage and deviation breakdown consideration while lessening the voltage load on the switches.

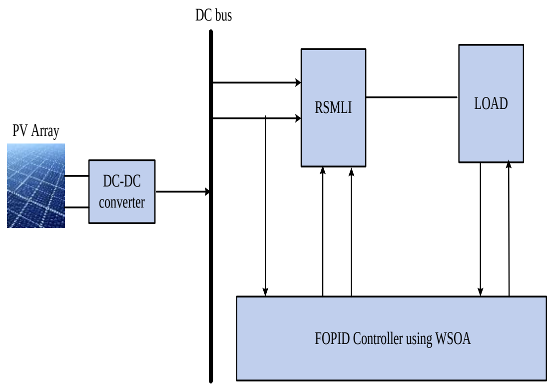


Fig. 1. Architecture of the proposed method

The PV energy is boosted by using DC-DC converters and the MPPT controller can be introduced for enhancing the power from PV sources under varying environmental conditions. The linear and nonlinear loads are utilized for power management in the micro grid structure. The grid parametersare enhanced by the proposed FOPID controller by optimizing the gain parameter with the WSOA.

A. Solar PV System Modeling

Numerous scholars have written on PV modeling and MPPT algorithm design in the literature to increase PV panels' power output. The I-V characteristics of the PV panel shall be expressed numerically as follows:

$$I_L = I_S - I_{sat}\left[\exp\left(\frac{V_t + R_{series} I_L}{cV_T} - 1\right) - \frac{V_t + R_{series} I_L}{R_{parallel}}\right] \quad (1)$$

Here, $I_L$is the PV panel's current output, I_{diode} isthe diode's electricity passing through it, $I_S$isthe PV panel's current, the thermal voltage is representedby V_T. The series and parallel branch resistances as well as the diode constant are represented by R_{series}, $R_{parallel}$ and C respectively, and Isatis the reverse saturation current [21]. The boost converter and MPPT algorithm are coupled to the PV panel. The P&O MPPT algorithm overcomes the shortcomings of the traditional MPPT algorithm, such the local maximum point of power selection under partial irradiation and super performance under irregular irradiation [22].

B. Reduced switch multilevel inverter (RS-MLI)

In RS-MLI arrangement of seven switches $SW_1 – SW_4$ and $T_1 – T_3$ with two diodes D_1 and D_2 are used. Fig. 2 depicts the PV RS-MLI scheme configuration.

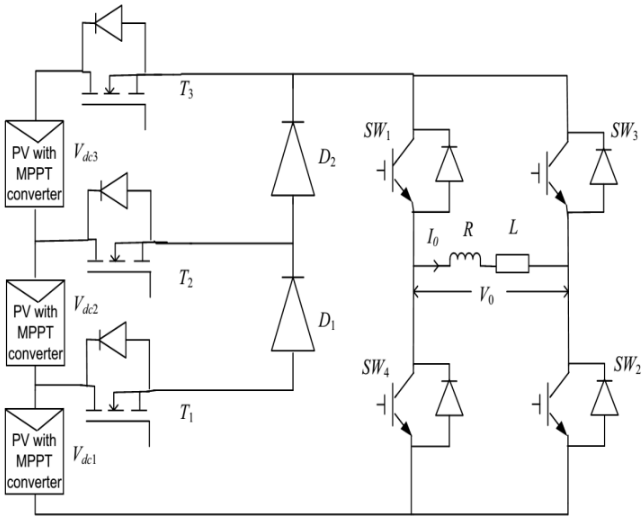


Fig. 2. A description of a seven-level RS-MLI with PV system

While level generation switches function at a high switching frequency, H-bridge switches, also known as switches for polarity generation $T_1 – T_3$ function at low switching frequency. Therefore, using components with minimal changing energy to operate the H-bridge and substantial changing energy to phase productionis a financially sensible option. The following examples provide a summary of the RS-MLI's operation.

Case a

$T_1$is ON, current passes through the diode D_1 and D_2 and switches $SW_1$and SW_2. The voltage across the load at the output is $+V_{dc1}$. Accordingly, when SW_3 and $SW_4$are turned on, the transformer power between the load is $– V_{dc1}$.

Case b

In this case, the switch $T_2$is switched on, and the electricity goes via the transistor D_2 and switches SW_1 and SW_2. The voltage across the load at the output is $V_{dc1}+V_{dc2}$. Accordingly, when $SW_3$and SW_4turns on, the output voltage across the load is $– (V_{dc1}+V_{dc2})$.

Case c

$T_3$is ON in this mode, passage of current through SW_1 and SW_2. The voltage across the load at the output is $V_{dc1}+V_{dc2}+V_{dc3}$, D_1 and D_2 reverse biased. Correspondingly when SW_3 and $SW_4$are turned on, the output voltage is $– (V_{dc1}+V_{dc2}+V_{dc3})$.

Case d

In this mode,each SW_1 and SW_3 or SW_2 and $SW_4$are ON making T_1, T_2andT_3 OFF, across the load, produces zero outputvoltage.

The functioning of the suggested RSCMLI for producing multiple power levels, as well as the RSCMLI's changing strategyare illustrated. The generated energy produced by a solar energy system without a boost converter oscillates owing to variations in incidence and climate, which has to be mitigated for constant power.

C. Harmonic elimination theory

The expression for the multilayer voltage is found by analyzing the multilayer inverter's output voltage using Fourier theory. In the event where the multilayer inverter's DC input voltage is equal, the fundamental switching frequency control technique may be stated asbelow:

$$V(t) = \sum_{n=1,3,5}^{\infty} \left(\frac{4V_{dc}}{n\pi} \right) \{ \cos n\theta_1 + \cos n\theta_2 +,..., \cos n\theta_s \} \sin n\omega t \quad (2)$$

Where,θ is the switching angle, V_{dc} is the DC supply voltage provided by the inverter's solar PV module and S is the total amount of switching angles..Because the inverter's output voltage is odd quarter-wave symmetric, the equation demonstrates that it lacks even order harmonics [23]. The device switching angle is used to express the peak value of the odd order harmonics θ_1, θ_2 etc. Transcendental equation refers to the inverter voltage's harmonics equation. The n^{th} harmonic elimination theory, which can be stated as follows, is used to eliminate harmony.

$$\cos n\theta_1 + \cos n\theta_2 +,..., \cos n\theta_s = 0 \quad (3)$$

D. Switching angle analysis

The modulation method used on the suggested converter determines the characteristics ofthe output voltage of the inverter waveform. The seven levels of output voltage are obtained using the SHE approach. Choosing proper switching angle prevent or remove the odd order harmonics. In addition to generating the required switching angle to provide output voltage, the SHE approaches reduces overall harmonic distortion [24]. Additionally, it minimizes loss and electromagnetic interference brought on by higher frequency switching.

Regarding the specified ideal reference voltage V, the essential switching angles θ_1, $\theta_2 \ldots \theta_s$ are determined in a manner that minimizes the output voltage's THD. When normalized, the magnitude of the Fourier coefficients with respect to the reference voltage is expressed as,

$$V = \left(\frac{4V_{dc}}{\pi} \right) \{ \cos\theta_1, \cos\theta_2,..., \cos n\theta_s, \} \quad (4)$$

The modulation index (M) regulates the amplitude of the basic component, which is expressed as,

$$M = \frac{V}{V_{dc}} \quad (5)$$

Where Vis the maximum value of the inverter's output voltage.The inverter, which uses the SHE approaches, has a Degree of Freedom (DoF) of S. Of this, one is chosen to determine the output voltage value, and the remaining DoF is used to remove the harmonic component. By employing SHE, higher order odd harmonics (S – 1) willbe eliminated.

$$\cos\theta_1 + \cos\theta_2 +,..., \cos n\theta_{16} = \frac{M\pi}{4} \quad (6)$$

The approximate value of the switching angle is found by solving the non-linear transcendental equation, which also must be able to remove harmonics at a certain modulation index(M). Due to the harmonic equation's non-linearity, a highly accurate solution cannot be found using standard mathematical techniques. The half equal phase approach, which considers several factors, is used to generate switching angles in the most efficient manner and will result in a superior output waveform that falls between 0 to π/2. Given is the switching angle:

$$\theta_i = i \frac{90^0}{m + 1/2} = i \frac{180^0}{m+1} \quad (7)$$

Where, $i = 1,2,..., \frac{m+1}{2}$ and 'm' is the inverter result power phase. The changing pitch between 0 to 2π is extended by adjusting the equation. To get the optimal switching angle combinations for the suggested controller for improving the power parameters of the grid, WSOA algorithm is implemented.

E. FOPID controller

A fractional order PIDcontroller's differential equation is expressed as,

$$u(t) = k_p * e(t) + k_i * D_t^{-\lambda} * e(t) + k_d * D_t^{\mu} * e(t) \quad (8)$$

By using the Laplace transform, after obtaining the FOPID, the continuous transfer function is given as,

$$G_c(s) = k_p + k_i * s^{-\lambda} + k_d * s^{\mu} \quad (9)$$

The design ofFOPID controller requires finding the three parameters K_P, K_i, K_d and two more parameters as λ, μare not always expressed as integers. The fractional order controller is a generalization of the conventional integer order PID controller from point to plane. More freedom in accomplishing control goals may result from this growth. The WSOAis used to optimize the gain settings; a full description of the algorithm is provided in the section below.

F. War Strategy Optimization Algorithm

The WSOA is a contemporary technique to optimize the world that focuses on troops' strategic maneuvers (assault and defensive) through conflict. Depending on their combat ability (well-being value), each participant in every cycle has an equal chance of becoming a power or a king. On the battlefield, the commander and the rulers advance together as the vanguard. In the arena of battle, a Lord and Commander develops to guide other participants. It is likely that the adjacent optima, or rival warrior, will put up a fierce fight against the lord or officer if they are cohesive enough to fool the vanguard. Combatants follow the commander's or alternate commander's position in addition to their own integrated development tactics to avoid this [25]. Figure 3 displays the flowchart of the suggested methodology.

1) *Initial population*

In the initial population, the weighting gain parameters are initialized. First, the population is forced according to the lower bound and upper bound of the problem using the condition,

$$X_{I,J} = I_J + RAND.\left(U_J - L_J\right), I = 1,2,\dots,N, J = 1,2,\dots,M \quad (10)$$

Here, U_J can be defined as the upper bound of problem variables, L_J can be defined as the lower bound, $RAND$ can be defined as random number, M can be defined as the number of problem variables, N van be defined as the count of population members, $X_{I,J}$ can be defined as the parameter of the jth parameter defined by the candidate solution.

2) *Fitness Evaluation*

In the proposedcontroller, the WSOAis used for improving the controlling pulses for optimized the gain parameters of FOPID controller. The objective function is selecting the optimal gain parameters of the controller for improving the power parameters.

3) *Attack Strategy*

In the primary scenario, every fighter modifies its position determined by the locations of the administrator and ruler. To launch a devastating attack on the opponents, the master is waiting for a valuable opportunity. As such, the most potent offensive officer or the healthiest officer is regarded as the ruler.

$$X_I(t+1) = X_i(t) + 2 \times \rho \times (c - k) + RAND \times (w_i \times k - X_i(t)) \quad (11)$$

Here, $k$is characterized as the kingly stance, $c$can be characterized as the commander's prior position, $X_I(t+1)$may be a new role, $w_i$is characterized as the weight.

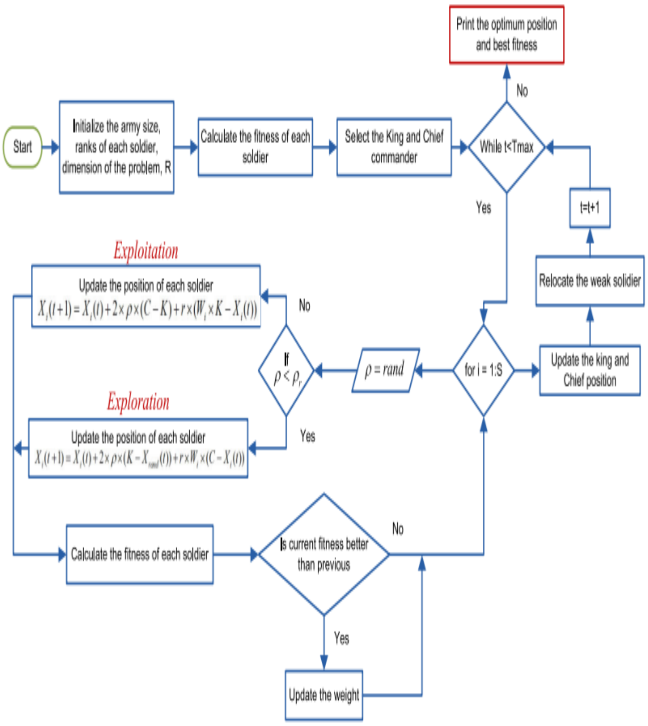


Fig. 3. Flow diagram for the suggested approach [25, 26]

4) *Updating Rank and Weight*

The position of each troop and the message from the commandant and commander determine the status update for each search specialist. The rank of every soldier was determined by how successful they had been in managing the battlefield. The rank of every soldier was determined by their track record of accomplishment in the battlefield, and this will have an impact on the weighting factor. Each soldier's rank determines their relative proximity to the top.

$$X_I(t+1) = X_I(t+1) \times (f_n \geq f_p) + X_I(t) \times (f_n < f_p) \quad (12)$$

The warrior considers the last place, f_p, to be the prior location, and compares the fitness of the current position, f_n, with less. The soldier's rank $R_i$is promoted if they upgrade the location effectively [26-28].

$$R_I(t+1) = (R_I + 1) \times (f_n \geq f_p) + R_I \times (f_n < f_p) \quad (13)$$

This formula can be used to determine the new weight in respect to the rank.

$$w_i = w_i \times \left(1 - \frac{R_I}{Maximumiteration}\right)^a \quad (14)$$

5) *Defence method*

Future technological advancements are contingent upon the standings of the Lord, Warlord, and Irregular Troops. Here, weighting, updating and ranking is achieved by below equation.

$$X_I(t+1) = X_i(t) + 2 \times \rho \times (c - Xrand(t)) + RAND \times (w_i \times c - X_i(t)) \quad (15)$$

Since this fight style incorporates the location of an arbitrary combatant, it traverses a larger hunting zone than the previous mode. For notable advancements, the soldiers advance greatly and enhance their surroundings. Every time they refresh situation, of Wisconsin Fighters creates small advancements.

6) *Spare/transfer of weak sold*

For each priority, order the fighters' fitness by absolute weakness.

$$X_w(t+1) = LB + RAND \times (UB - LB) \qquad (16)$$

On a battlefield, the weaker warrior moves forward in steps towards the center of a fully equipped force. The assembly performance of the computation is also recovered by this method.

7) *Exploration and Exploitation*

Every metaheuristic progress calculation involves two essential actions: Double commitments (for assembly) plus inquiry (as a World Optimizer). If both of them attributes could be fairly balanced, the computation would be more reliable. Attack technique is characterized as the use of force whereas defense technique is characterized as investigation. The WSOA's shared benefits are listed in the following order:

- ❖ An excellent trade-off is made between exploration and exploitation by the suggested method.
- ❖ Considering their status, each officer has an attractive weight assigned to them.
- ❖ Assuming the fighter is making progress toward improving his health, each fighter's weight is updated at the update step. Weight regeneration is thus only determined by a molecular position regarding lords and lordship.
- ❖ Non-linear changes occur in loads. Larger variations in loads occur during the first stress cycle, while lesser variations occur during the subsequent cycles. Faster convergence to the global optimal parameter is enabled by this.
- ❖ The stage regeneration cycle consists of two phases. It makes it more capable of researching global ideal layout.
- ❖ The suggested method is simple to use and necessitates little processing power.

Based on this proposed algorithm, FOPID controller gain parameters are optimizedfor managing the RS-MLI's switching pulse. The inverter enhances the power parameters ofthe PV system connecting to the grid. Based on the controller parameters,the proposed system performances are evaluated and compared with some existing controllers as GA-PID and WSOA-PID. The simulated results and the performance evaluation is presented in followed section.

IV. SIMULATION RESULTS AND DISCUSSIONS

This section implements and validates the suggested methodology's performance.The suggested approach is carried out using MATLAB and SIM technology. The projected technique is validated with the reduction of THD andimproved performance of proposed controller, which is utilized to empower the grid integrated PV applications. The proposed system contains the WSOA optimized FOPID controller for reducing the THD using the RS-MLI. The implementation parameters of PV are given in table 1.

TABLE I: IMPLEMENTATION PARAMETERS OF PV

Parameters	***Values***
Ncell	96
Voc (V)	64.2
Isc (A)	5.96
Vmp (V)	54.7
Imp (A)	5.58
IL (A)	6.0092
I0 (A)	6.30e-12
Diode ideality factor	0.94504
Rsh (ohms)	269.5934
Rs (ohms)	0.37152
fn (Hz)	60

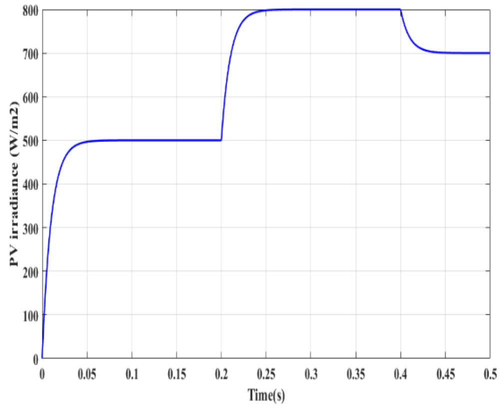


Fig. 4. Examination of the level of fluctuation in PV irradiance

In figure 4 illustrated the input of PV as irradiance, which is helps to generate maximum power and it is boosted by utilizing the DC-DC converter. The corresponding generated voltage and current are seen in Figure 5. Figure 6 shows a performance study of DC-link strength. Figure 7 depicts an examination of the optimum control signal for the suggested controller.

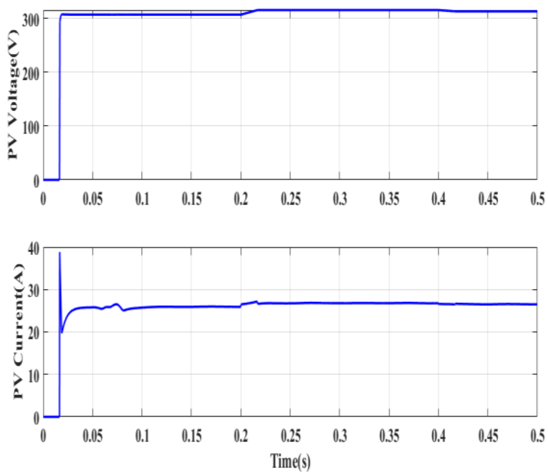


Fig. 5. Analysis of PV voltage and current performance

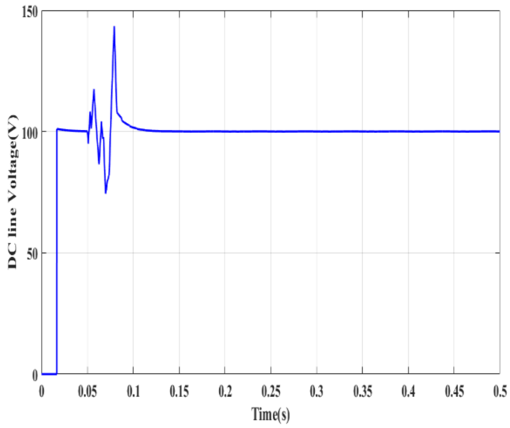


Fig. 6. DC-link voltage performance analysis

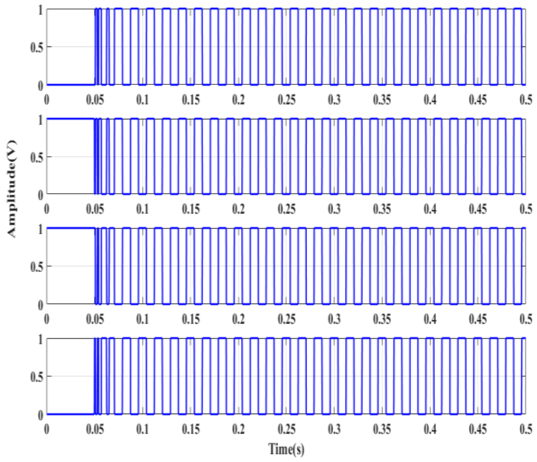


Fig. 7. optimized control signal of the proposed controller

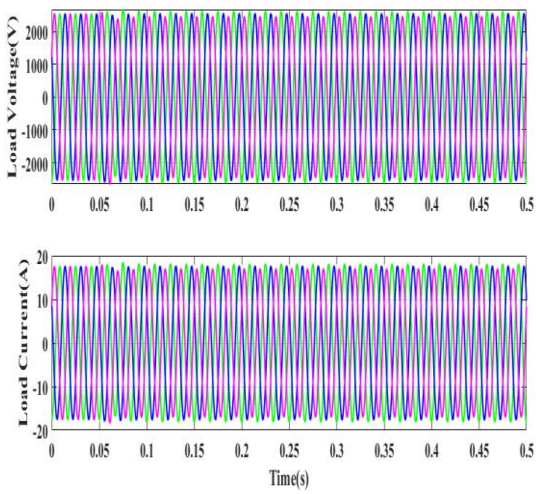


Fig. 8. Evaluation of load potential and power.

Figure 8 shows an examination of load potential and power. Figure 9 shows an examination of grid-side potential and power.

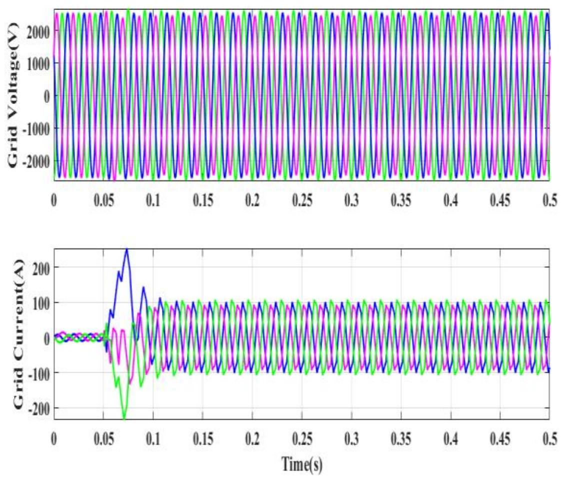
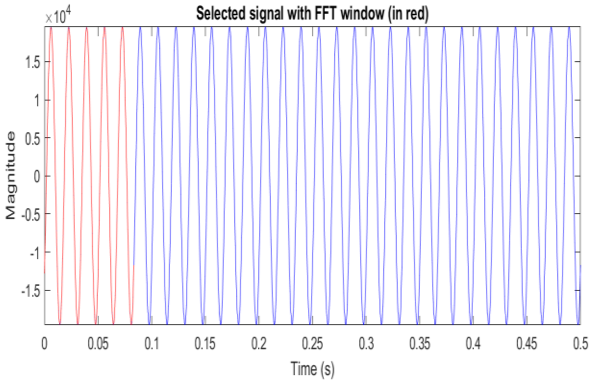


Fig. 9. Analysis of StructurePower and Potential

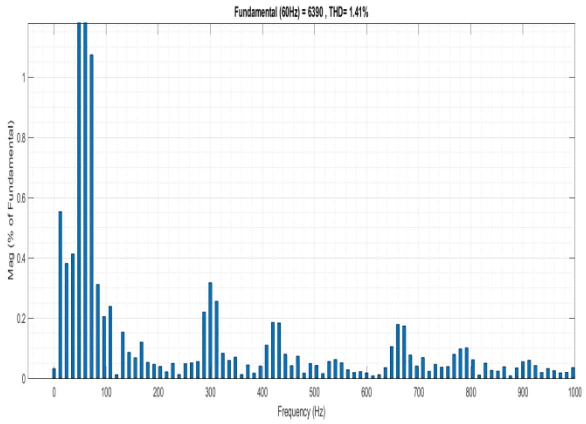
The existing and proposed controller's parameters are given in table 2

TABLE II: THE PROPOSED AND EXISTING CONTROLLER PARAMETERS

Parameters	GA-PID	WSOA-PID	Proposed
Kp	1.4872	14.1159	11.2385
Ki	0.0021	9.7856	10.8576
Kd	0.4842	6.3104	11.4103
Lamda	-	-	10.3632
Mu	-	-	4.253



(a)



(b)

Fig. 10. THD Performance of (a) Output voltage waveform, (b) FFT analysis in GA-PID controller

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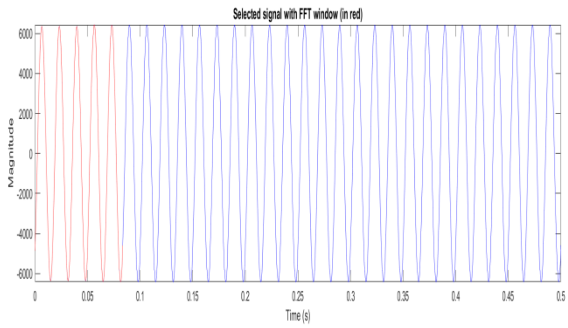
The proposed controller gain parameter is higher than the traditional PID controller gain parameters while the THD is reduced.The GA-PID controller FFT analysis of the voltage on the grid side is represented in figure 10. The WSOA-PID controller FFT analysis of the voltage on the grid side is represented in figure 11.



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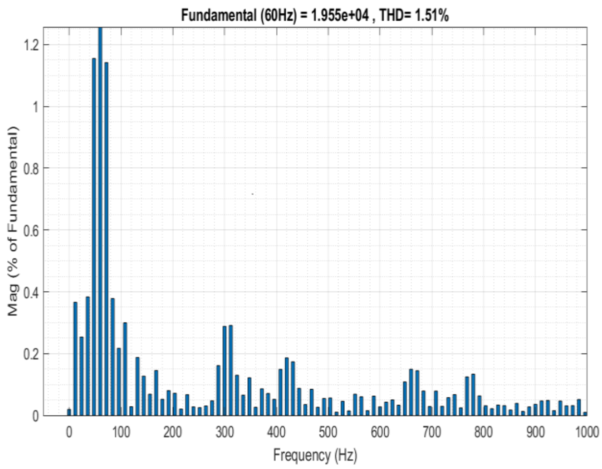
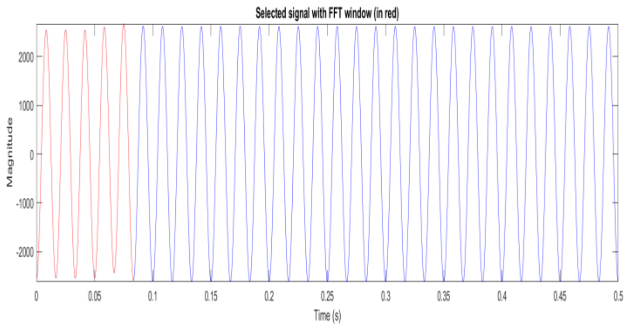
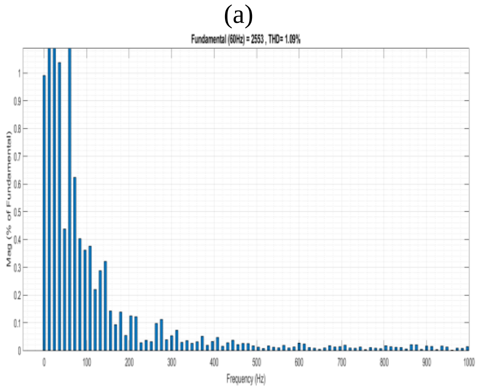


(b)

Fig. 11. THD Performance of (a) Output voltage waveform, (b) FFT analysis in WSOA-PID controller



(a)



(b)

Fig. 12. THD Performance of (a) Output voltage waveform, (b) FFT analysis in proposed controller

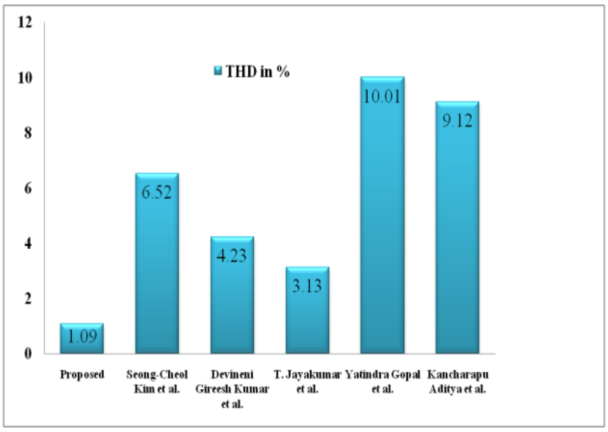


Fig. 13. Grid voltage THD comparative investigation in various controllers

Figure 12 depicts the FFT evaluation of the energy near power using the suggested controller. THD study for the concept system is compared with several techniques, including WSOA-PID and GA-PID. This research shows that there is a significant reduction in the harmonics. It is noteworthy that in certain situations, decreasing voltage THD is preferable. Figure 13 compares the harmonic evaluation of panel edge voltage utilizing suggested and existing research efforts. The comparative study demonstrates the proposed controller's efficacy in regard to the assessment measures. According to the results of the THD comparison study, the proposed technique successfully decreased the THD more than other traditional ways.

V. CONCLUSION

Hence this paper proposes an optimized FOPID controller in seven level reduced switch multilevel inverter for three-phase grid connected PV structure. The FOPID controller's intensity parameter was tweaked with of the WSOA which enhances the performance of the system. With the consideration of the proposed technique, the power parameters were managed in the grid connected PV system. The projected approach was implemented in MATLAB/Simulink and performances were evaluated and compared with some existing controllers like GA-PID and WSOA-PID controllers. In this implemented technique, at different time instants the THD analysis are conducted and their performance is evaluated. In the suggested framework, a pair of significant processors are used. The MPPT controller for the DC-to-DC enhancer monitors the full voltage produced by photovoltaic cells. The WSOA optimized FOPID controller was utilized for optimizing the control signal parameters for grid integrated RS-ML inverter. By regulating the inverter control signals, the output performance was improved and THD was reduced. Based on the simulated results and FFT analysis, the performance of grid connected PV array was improved by reducing the THD.

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