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Unit Kerja	: Universitas Bhayangkara Surabaya

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1. Mereview makalah jurnal internasional bereputasi berjudul “"A Hybrid Control Topology to Cascaded H- Bridge Multilevel Inverter for Improve the Power Quality of Smart Grid Connected System: NBO-RERNN Approach” dari Jurnal Cybernetics and Systems, Publisher: Taylor & Francis United Kingdom Tahun 2023, Terindeks Scopus Q2.
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Kepala LPPM

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Lampiran 1

Bukti Korespondensi Email dengan Editor/Pengelola Jurnal

Ubhara Surabaya

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Reviewer Invitation for A Hybrid Control Topology to Cascaded H- Bridge Multilevel Inverter for Improve the Power Quality of Smart Grid Connected System: NBO-RERNN Approach

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Jan 03, 2023

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I would be grateful if you would review a paper entitled "A Hybrid Control Topology to Cascaded H- Bridge Multilevel Inverter for Improve the Power Quality of Smart Grid Connected System: NBO-RERNN Approach" for this journal.

This is the abstract:
This manuscript proposes a hybrid control approach for the grid connected photovoltaic (PV) generation system with cascaded multilevel inverter (CMLI). The proposed hybrid method is the integration of both the Namib beetle optimization (NBO) and recalling-enhanced recurrent neural network (RERNN) method, hence called as NBO-RERNN technique. By using the proposed controller, the CMLI is intended to increase the optimum control signal. By utilizing the minimum number of switches, the CMLI is designed. The major purpose of the proposed approach is to improve power regulation or maximal solar energy conversion system(SECS) and to achieve good power quality(PQ) of the system. The optimal control signal dataset is generated by the proposed NBO approach in offline way. Based on the satisfied dataset, the RERNN executes and calculates the most optimal control signals of cascaded multilevel inverter in online manner. For controlling the insulated gate bi-polar switches (IGBT) of cascaded MLI, the resulting control signals are used. The parameter variations of system and external disturbances are mitigated and the load demands are fulfilled optimally by using this control technique. The proposed NBO-RERNN control topology is implemented in MATLAB or Simulink site and its performance is evaluated by comparing with existing methods.

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On-Behalf of

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Editorial Assistant

Ubhara Surabaya

Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id>

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Karin Pils-Vorsteher
Editorial Assistant
Cybernetics and Systems

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Ubhara Surabaya

Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id>

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Cybernetics and Systems

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Bukti Pendukung

Cybernetics and Systems

A Hybrid Control Topology to Cascaded H- Bridge Multilevel Inverter for Improve the Power Quality of Smart Grid Connected System: NBO-RERNN Approach

--Manuscript Draft--

Full Title:	A Hybrid Control Topology to Cascaded H- Bridge Multilevel Inverter for Improve the Power Quality of Smart Grid Connected System: NBO-RERNN Approach
Manuscript Number:	UCBS-2022-0864
Article Type:	Research Article
Keywords:	Photovoltaic system; Multilevel inverter; Total Harmonics distortion; Switches; Power regulation and Maximum energy conversion
Abstract:	This manuscript proposes a hybrid control approach for the grid connected photovoltaic (PV) generation system with cascaded multilevel inverter (CMLI). The proposed hybrid method is the integration of both the Namib beetle optimization (NBO) and recalling-enhanced recurrent neural network (RERNN) method, hence called as NBO-RERNN technique. By using the proposed controller, the CMLI is intended to increase the optimum control signal. By utilizing the minimum number of switches, the CMLI is designed. The major purpose of the proposed approach is to improve power regulation or maximal solar energy conversion system(SECS) and to achieve good power quality(PQ) of the system. The optimal control signal dataset is generated by the proposed NBO approach in offline way. Based on the satisfied dataset, the RERNN executes and calculates the most optimal control signals of cascaded multilevel inverter in online manner. For controlling the insulated gate bi-polar switches (IGBT) of cascaded MLI, the resulting control signals are used. The parameter variations of system and external disturbances are mitigated and the load demands are fulfilled optimally by using this control technique. The proposed NBO-RERNN control topology is implemented in MATLAB or Simulink site and its performance is evaluated by comparing with existing methods.
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A Hybrid Control Topology to Cascaded H- Bridge Multilevel Inverter for Improve the Power Quality of Smart Grid Connected System: NBO-RERNN Approach

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Abstract

This manuscript proposes a hybrid control approach for the grid connected photovoltaic (PV) generation system with cascaded multilevel inverter (CMLI). The proposed hybrid method is the integration of both the Namib beetle optimization (NBO) and recalling-enhanced recurrent neural network (RERNN) method, hence called as NBO-RERNN technique. By using the proposed controller, the CMLI is intended to increase the optimum control signal. By utilizing the minimum number of switches, the CMLI is designed. The major purpose of the proposed approach is to improve power regulation or maximal solar energy conversion system(SECS) and to achieve good power quality(PQ) of the system. The optimal control signal dataset is generated by the proposed NBO approach in offline way. Based on the satisfied dataset, the RERNN executes and calculates the most optimal control signals of cascaded multilevel inverter in online manner. For controlling the insulated gate bi-polar switches (IGBT) of cascaded MLI, the resulting control signals are used. The parameter variations of system and external disturbances are mitigated and the load demands are fulfilled optimally by using this control technique. The proposed NBO-RERNN control topology is implemented in MATLAB or Simulink site and its performance is evaluated by comparing with existing methods.

Keywords: *Photovoltaic system, Multilevel inverter, Total Harmonics distortion, Switches, Power regulation and Maximum energy conversion*

1. Introduction

Recently, the most gained broad attention in power system is renewable energy sources (RES) utilized to satisfy the increasing energy demand without polluting the nature (Sun et al,2011). The RES are combined to form the hybrid systems to improve the trustworthiness of power supply (Letha et al,2016). In this type of renewable energy sources, the energy sources of wind and solar are often used together and efficiently (Blaabjerg et al,2011). Through high-efficient wind turbines, one of the very important RES is wind power because it is easily available and gather (Thitichaiworakorn et al,2013). Additionally, an auspicious green energy source is solar energy that is used more and is easily harnessed through the use of PV modules (Xiao et al,2014). At the night time, the solar power is not present but the wind power is obtained, so the solar and wind power is complement to each other (Samadaei et al,2016). The solar and wind system utilization is increased because of high electronics devices of power and control technique (Latran and Teke,2015).

In RES system, the strategy and power electronic converters control are important (Song et al,2009). The power electronic devices such as rectifiers, boost converters and inverters are utilized to transfer the power efficiently (Ozdemir et al,2008). The converters of direct current (DC) to dc and direct current to ac are utilized for sources and load side and its control mechanism is important (Perez et al,2014). In recent times, the multilevel inverters (MLI) topologies are very popular due the advantages, such as increasing capability of voltage handling, approximately sinusoidal output voltage waveform with best harmonic spectra, lesser voltage stress for the switches and best electromagnetic compatibility (Bakhshizadeh et al,2015). When working with RES system power quality issues, such as harmonic generation, voltage variations, capacitor voltages of unbalanced direct current-link and flickers are occurred to produce the utilization of power converters (Cecati et al,2010). Because of the variation of solar irradiation, the power output is issued with flicker or voltage variation (Busquets-Monge et al,2008). Therefore, the dc capacitor current peak values are varying, which produces the unbalanced dc-link capacitor voltages (Panda and Suresh,2012).

Fig 1: Here

Due to unbalanced dc-link voltage, voltage stress occurs in switching devices, which makes the use of DC/AC converters ineffective (Panda and Suresh,2012). Hence, direct current-link of capacitor voltages and current are regulated individually (Suresh and Panda,2012). There are various MLI topologies are introduced with grid connected system to compensate these PQ issues (Ali and Krishnaswamy,2018) Among these topologies, the "cascaded H-bridge inverter (CHBI) " is mostly used due to high resolution, modular design, characteristics of less voltage rated semi-conductor switches for obtaining high or medium levels of power (Kouro et al,2010). The MLI is utilized to achieve improved synchronization with the power flow of controlled and calibrated (Kaliamoorthy et al,2014). The main thing is to consider cascaded H-bridge(CHB) topology as a needed inverter or rectifier to have equal direct current- link voltages to examine the same allowable voltage stress across every switching devices in multilevel topologies in the application of high voltage (Colak et al,2011).

In this manuscript, a hybrid control method for grid connected photovoltaic generation system with cascaded MLI (CMLI) is proposed. The proposed hybrid method is integrated with Namib beetle optimization algorithm and recalling-enhanced recurrent neural network, hence called as NBO-RERNN method. By using proposed controller, the cascaded multilevel inverter is designed to improve the optimum control signal. Also, by utilizing the minimum count of switches, the CMLI is intended. The important aim of proposed method is to improve the regulation of power or maximal SECS and to achieve good PQ of the system. Organization of proposed work is displayed in fig 1.

2. Recent Research Work: A detail Review

Numerous works previously presented in literatures based on cascaded MLI(CMLI) in grid connected RES system using various techniques. Some of the research works were reviewed here,

For specifying the problem of wind speeds deviation within windmills as partial shading condition of photovoltaic system, B. Sharma et al. (Sharma et al,2019) have illustrated a comprehensive control method for the cascaded H-bridge MLI (CHBMLI) based grid connected bulk wind energy conversion system (WECS). For high and medium power wind energy conversion system with increasing trustworthiness, the illustrated control method uses independent direct current-link with fewer voltages, like topology as a good model. The inconsistency of wind speeds causes different voltage conditions in every turbine between isolated direct current-link of cascaded H-bridge(HB) inverter MLI, HB cells (HBC) may leads to uneven power generation. For a mitigated switch of CMLI (RSCMLI) was applied to wind energy conversion system to combine solid state transformer (SST), B. Sahoo et al. (Sahoo et al,2019) have postulated the artificial neural network(ANN)- proportional integral(PI) based controller. Here, a 7-level RSC machine level inverter was established. The parameters of utility side and direct current-link voltage of inverter were mitigated by ANN, proportional integral and fuzzy logic controller(FLC). The solid-state transformer was given to distribution system in the place of grid side converter for better operational benefits. The 2 aims, like reactive power support and real power control were delivered by the grid interface converter and machine components of solid-state transformer under inadequate wind energy generation condition. B. Sharma et al. (Sharma et al,2019) have described an improved CHB multilevel inverter based grid-tied hybrid wind and solar energy conversion system (HWSECS) along with PQ command. Thus, the WECS and solar energy conversion system (SECS) were joined separately to an isolated direct current-link of cascaded HBMLI through their own direct current to direct current converter depends on maximum power point tracking (MPPT) system .

For a MLI based single stage, photovoltaic stand-alone and three phase system , N. Kumar et al. (Kumar et al,2019) have presented a vector control method. The power circuit was engaged with photovoltaic module operated by multilevel inverter were connected with load or grid by a 3-phase transformer, which contains open-winding in multi-level inverter side. The control method was improved to distribute real power even in the levels of solar irradiance and variable load. The presented control ensures the stable real power across ddirect current -link capacitors of inverters and it fulfills the transient performance directories of photovoltaic stand-alone system. The direct current-link voltage level of multilevel inverter was improved all through the operation to attain the preferred power for delivery point through the designed method. For improving the performance of static synchronous compensator (STATCOM) using cascaded HB MLI, R. Palanisamy and K. Vijayakumar(Palanisamy and Vijayakumar,2018) have proclaimed a controller of hysteresis current. A 5 level single phase cascaded MLI with 2 individual sources of direct current, which was improved by hybrid energy source of PV-wind. By the hysteresis current controller, the voltages across every direct current source was balanced and standardized. To mitigate the Total Harmonic Distortion (THD) and to enhance the closed loop hysteresis current control and output voltage was attained by utilizing the controller of phase locked loop(PLL) and proportional integral. S. Lee and J. Kim (Lee and Kim,2018) have presented the design method of modeling and control-loop with an inverted decoupling method of single-phase PV grid-tied 5-level CHB MLI. For the unity power factor, the current controller of proportional and integral with the duty ratio of feed forward compensation was utilized. Also, to attain MPPT of every PV array, the stacked units were in the condition of partial shading and every direct current voltage was steadily regulated to its maximum power points (MPP) through the controller of committed voltage to every HB method. The control method reduces the consequence of loop interaction in separate direct current-link voltage control loop in a 2 input and 2 output system. For a grid connected doubly fed induction generator (DFIG) depending on WECS, B. Sahoo et al. (Sahoo et al,2019) have presented a repetitive control (RC) approach and 31-level reduced switch cascaded inverter (RSCI) topology with an united hybrid active filter capability. The repetitive control method was considered for the operation of inverter because of improved accuracy and controllability under the condition of periodic disturbance. In addition to that extract the system performance by distributing the preferred reactive power to doubly fed induction and harmonic reduction, a thirty one level reduced switch cascaded inverter topology with a mitigated count of uni-directional switch operations was executed in rotor-side converter (RSC). The reference frame control of indirect current and flux oriented were executed for the converter of grid and rotor side

2.1. Background of Research Work

Recently, the research work depicts that renewable energy sources with multilevel inverter in power distribution system are an important contribution factor. The issues of micro grid PQ are the major challenge in mutual installation of control designs, like active power filters, voltage regulators, automatic current regulator, the combination of renewable generation gets distributed. The alternating current of power grid may cause protection issues and voltage fluctuations. This increases the challenge of utility grid trustworthiness and PQ. To overcome the problem, multi-level inverters are used to provide an extra-ordinary method in digital interfacing of power. It can increase the effectiveness of output strength generated to grid. Also, the real-time execution of carrier based control method on multi-level inverter with PV interface and its comparison over the other topologies, such as diode clamped MLI (DCMLI), cascaded MLI (CMLI) and so on. The advantages of the method are self-balancing property with no feedback control, isolated direct current connection, voltage and capacitors in main direct current-link is same. The system has some problems, like complex control method to balance voltage of direct current-link capacitor, fast development in the count of clamping diodes through increasing the count of levels. In literatures very few works are given to resolve this problem and the presented works are not effective. Furthermore, the control topology of hybrid is required. Thus, these disadvantages and problems are inspired to do this research.

3. Proposed NBO-RENN method Based Power Quality Improvement of SG

The hybrid NBO-RERNN method is proposed to expand the PQ of smart grid system. Here, considered PV as source and utilized the cascaded multilevel inverter for reducing the harmonics. The variation of system parameter and the disturbance on external is reduced by proposed method and it fulfills the load demand of the system. The detailed description of proposed method is described as follows,

3.1. Control Signal Generation Using Namib Beetle Optimization (NBO) Algorithm

One of the insects is Namib beetles are utilized as an exciting tactic for surviving and collecting water in the desert. Based on these characteristics, this algorithm is introduced. This method is utilized to select the features and reduce the dimension (Chahardoli et al,2022). These beetles gather water and it moves to highest hills. In these mountains, they look for the areas of high humidity and elevation, so they access extra water. The peak and height of hills are reached because they are visible to the currents of moist air, increasing bodies to absorb the moist air, and convey it with its mouths. In this manuscript, NBO is utilized to attain the optimum control parameter of HDLNN. The stepwise procedure is explained by,

Step 1: Initialization

Initializing the input parameter of the system. Here, consider the parameters, likeload current, dc link voltage, PV voltage, PI controller gain parameters, constraints, iteration of the system

Fig 2: Here

Step 2: Random Generation

After initialization, the input parameters are created randomly.

$$Y = \begin{bmatrix} \varsigma^{11}(t) & \varsigma^{12}(t) \ldots & \varsigma^{1m}(t) \\ \varsigma^{21}(t) & \varsigma^{22}(t) \ldots & \varsigma^{2m}(t) \\ \vdots & & \vdots \\ \varsigma^{n1}(t) & \varsigma^{n2}(t) \ldots & \varsigma^{nm}(t) \end{bmatrix} \quad (1)$$

Here, gain parameters of PI controller is denoted as ς

Step 3: Fitness Function

It is evaluated depending on the objective function. Thus, it is described by,

$$F = MIN(THD) \quad (2)$$

Step 4: Analysis the location of Beetle for Water Collection

Every beetle has the capability to gather moisture and water, which counts for a great deal in terms of objective function. From this, the beetle in question is placed in the optimum area, and for other beetles, this area is considered as attraction that leads to the collection of water in these areas. Every area where a beetle is present has the potential to host many beetles, which is determined by,

$$c_I = c_{MAX}.\sin\left(\frac{F(NB_i) - F_{Min}}{(F_{Max} - F_{Min})}\frac{\pi}{2}\right) \quad (3)$$

Here, count of beetles capacity in the area is denoted as c_I, maximal capability of the count of beetles in 1 area is denoted as c_{MAX} ,ability of beetle is denoted as $F(NB_i)$, minimal and maximal capabilities of the population beetles is denoted as F_{Min}, F_{Max}.

Step 5: Moving Towards Wet Areas

To find water, every problem solver or beetle must choose the areas with enough moisture. The distance among two beetles are determined by,

$$D_{IJ} = \sqrt{\sum_{K=1}^{D}\left(nb_{I,K} - nb_{J,K}\right)^2} \quad \textbf{(4)}$$

Step 6: Update the Solution by Using the Movement of Wet Mass

By using the smell sense, it detect the areas to determine the optimal solution and it utilized the gravity,

$$nb_I^{NEW} = nb_I^{OLD} + Rand.(nb^* - \bar{nb}) + L \quad (5)$$

Here,position where most of the moisture is denoted as nb^*, position of water gravity is denoted as $\bar{nb}$.

Step 7: Removal of population

Here, some are hunted by lizards. These solutions are eliminated in this step.

Step 8: Termination Criteria

When checking the termination criteria, if suppose the optimal outcome is obtained then process is end otherwise go to step 3. Flowchart of proposed NBO-HDLNN method is displayed in fig 2.

3.2. Optimal Prediction Using RERNN Approach

The Recalling-enhanced recurrent neural network(RNN) is the radial basis function based training process. It is operated based on the artificial Neural Network. The difference amid the RERNN and Elman recurrent neural network are the number of layers. RERNN has six layers but the Elman RNN contains 3 layers. The layers of Recalling-enhanced RNN are sum layer, memory layer, delay layer, state layer, input layer, hidden layer and output layer. The input layer accepts input and also utilized the outcome of hidden layer (Gao et al,2020). The memory layer is processed by the result of sum and state layer. The memory layer is utilized to determine the size of preceding information of sum layer. The function of summation is executed by the sum layer. The final recurrent hidden result, present input, results of memory layer are added by sum layer. The hidden layer provides the last probabilistic value of output layer. The delay layer performs the back propagation of the outcome of hidden layer. The outcome of RERNN is depends on Conjugategradient descent method and generalized Armijo search method. Recalling-enhanced RNN structure is displayed in fig 3. In the proposed system, the Recalling-enhanced RNN is utilized for choosing the perfect cost of the system and optimal sizing and energy management is achieved. The stepwise procedure of Recalling-enhanced RNN is described below ,

Input layer: Input layer consist of $m+n$ linear nodes from which m nodes are called blank nodes and it is utilized to receive input sample vector. The n nodes are called black nodes and it is developed to guide the output of hidden into delay layer vector, $H_{q-1} = (H_{(q-1)1}, H_{(q-1)2},..., H_{(q-1)N})$ straightly. From which $H_{q-1} = (H_{(q-1)1}, H_{(q-1)2},..., H_{(q-1)N}) = H_{q1}, H_{q2},..., H_{qN})$ is supplied by the delay layer of the system. It is written by,

$$x_q^* = (x_q, H_{q-1})t \tag{6}$$

Fig 3: Here

State layer: The goal is to deliver 0/1 state for memory layer that is illustrated as.

$$g(.) = \begin{Bmatrix} 0, ifC_{(Q-1)j} isunimpor\tan t, \\ 1, ifC_{(Q-1)} isimpor\tan t. \end{Bmatrix} \tag{7}$$

Memory layer: The output of sum layer and current state layer output is received through memory layer n nodes. Thus, J^{th} node of output is calculated as,

$$C^*_{(Q-1)j} = C_{(Q-1)JGJ,} \tag{8}$$

When q = 1 , 2 , …, Q and j = 1 , 2 , …., n. For introducing the layer of memory, $(C_q = C_{q1}, C_{q2},..., C_{qN})$ is essential. Also, it defines the magnitude of the pervious sum of output layer of the information is transferred to other layer. Further, it is highly based on the value of gate, $G_{qJ} \in (0,1)$ that is in state layer.

Sum layer: In this, the node accepts current input, output of memory layer and last recurrent hidden layer. Thus, the j th node is represented as,

$$\begin{aligned} C_{QJ} &= C_{QJ} + C_{(Q-1)JGQJ} = U_J X_Q^* + C_{(Q-1)JGQJ} \\ &= U_J^X x_Q^T + U_J^H H_{Q-1}^T + C_{(Q-1)JGQJ}, \end{aligned} \tag{9}$$

Hidden layer: There are n nodes are occurred. The hidden layer output For the conventional Elman network in recalling-enhanced recurrent neural network method is computed as,

$$H_{qj} = Tan(C_{qj}) = TanH(C_{qj} + C_{(q-1)} G_{qj}) \tag{10}$$

Delay layer: The RERNN is the delay layer that is used to realizes the function that is used to feed back the present hidden layer of the output vector $H_q = (H_{q1}, H_{q2},..., H_{qN})$ is the black input nodes treat into input variables of the system, that is

$$(H_{(q-1)1}, H_{(q-1)2},..., H_{(q-1)N}) = H_{q1}, H_{q2},..., H_{qN}) \tag{11}$$

This is used to create the new input, like $x_q^* = (x_q, H_{q-1})$ T that is used to introduce the layer of input. Further, the of output vector for the layer of sum as $(C_q = C_{q1}, C_{q2},..., C_{qN})$, which is used to fed again to the layer of memory.

Output layer:Every node represents the exact components of the output In the S nodes of the layer. Let $(V_{1t}, V_{2t},..., V_{Nt})^t \in r^N$ are weight vector, which is connected to the layer of hidden and to T^{th} output node. Next, it suddenly becomes the total weight of matrix within the layers of output and hidden that is, $v = [v_1, v_2,...., v_S]_{N \times S}$.While assuming the activation function, the layer of output is to identify the function of linear by using the actual output of RERNN is computed.

4. System Description

Structure of proposed PV system is displayed in fig 4. Here, considered the level of inverter is 13 levels and utilized the six level direct current to direct current boost converter (Sahoo et al,2019). To extract the maximal power, the six- level dc-dc converter is connected with solar PV system. The harmonics of the system is decreased by the control of voltage and current of the system. By utilizing the proposed method , the control switching signal of 13- level inverter is operating and provides high power quality (Vasu et al,2021). The control signal is generated by using NBO and the prediction of optimal control signal is performed by using RERNN.

Fig 4: Here

4.1. Modelling of the characteristic of PV

Generally, solar system is incorporated into PV module, dc to dc converter and load (Kumar and Sasi Kumar,2021). In order to get a certain value of current and voltage from the photovoltaic panel, the photovoltaic cells are arranged in parallel or in series. The solar cell forms p-n junction, which uses the sunlight, creates the photocurrent and works as a diode on dark or shadows. Single diode model of PV is illustrated in fig 5. A diode and a resistor are incorporated into the current source. The mathematic expression of the PV characteristics is given below,

Fig 5: Here

Open Circuit Voltage

When it is crossways by the light current, the output voltage of a photovoltaic cell is depends on the voltage drop across the diode. Hence, the voltage is expressed as,

$$v_{op} = \left(\frac{nKt}{q}\right)\ln\frac{i_{lig} - i_o}{i_o} + 1 \qquad (12)$$

Here, open circuit voltage is denoted as v_{op}, diode ideality constant is denoted as n, Boltzmann constant is denoted as K, temperature in Kelvin is denoted as t, electron charge is denoted as q, light generated current is specified as i_{lig}, saturation diode current is specified as i_o.

Light Generated Current (Radiation)

The light generating current is described by,

$$i_{lig} = \left(\frac{g_{rad}}{g_{rad}^{\mathrm{Re}f}}\right)\times\left(i_{lig}^{\mathrm{Re}f} + \beta i_{sc}\left(t_c - t_c^{\mathrm{Re}f}\right)\right) \qquad (13)$$

Here, G is the radiation is denoted as g_{rad}, radiation under standard condition is denoted as $g_{rad}^{\mathrm{Re}f}$, photoelectric current under standard condition is denoted as $i_{lig}^{\mathrm{Re}f}$ 0A, temperature at present condition is denoted as t_c, module temperature under standard condition is denoted as $t_c^{\mathrm{Re}f}$, temperature coefficient of short circuit current is denoted as β.

Reverse Saturation Current

Reverse Saturation Current is described by,

$$i_o = i_{oR}\left(\frac{t_c}{t_c^{\mathrm{Re}f}}\right)^3 e^{\frac{q\times e_G}{(K\times n)\times\left(\frac{1}{t_{ref}}\right)-\left(\frac{1}{t_c}\right)}} \qquad (14)$$

$$i_{oR} = \frac{i_{scn}}{e^{\left(\frac{v_{ocn}}{n \times v_{tn}}\right)}} \tag{15}$$

Here, reverse saturated current is represented as i_o, saturation current is represented as i_{oR}, ideality factor is represented as n, and band gap for silicon is denoted as e_G .

Short Circuit Current

Through the cell, the generated greatest value current is short circuit current and it is obtained under the short circuit condition.

$$i_{SH} = (i_{lig} - i_o) \times \left(e^{\frac{ev}{Kt}} - 1 \right) \tag{16}$$

4.2. Modelling of Six Level DC to DC Boost Converter

To obtain the maximal power of photovoltaic boost converter is utilized. The maximal power point (MPP) is calculated depending on the switching transistor duty cycle of converter. Fig 6 displays Circuit diagram of multi-level cascaded direct current-direct current boost converter (Yu et al,2022, Meenalochini and Sakthivel,2021, Gulbudak and Gokdag,2021). The major contribution of the boost converter is, it converts and boosts the solar energy. The maximized power obtained from boost converter is given to the CMLI.

Fig 6: Here

$$v_{o/p} = \frac{1}{1 - D_S} v_{i/p} \tag{17}$$

If $v_{o/p} > v_{i/p}$, then,

$$D_S = \frac{T_{on}}{T_{swit}} \tag{18}$$

Here, $v_{o/p}$, $v_{i/p}$ are the DC input and output voltage, on time period of semi-conductor switch is denoted as T_{on} , switching period of semi-conductor switch is denoted as T_{swit}. Thus, the boost inductor value is determined by,

$$l_{bo} = \frac{v_{i/p} D_S T_{swit}}{\Delta i_l} \tag{19}$$

Here, Δi_l is expressed as inductor ripple.

4.3. Multilevel Inverter Model

The multilevel inverter executes power conversion on multiple voltage steps with ultimate goal of achieving better power quality, and greater voltage capacity. 13- Level CMLI is depicted in fig 7.

Fig 7: Here

MLI (Liu et al,2016, Zare and Abapour,2017, Sun et al,2022, Kartick et al,2016, Sandeep and Yaragatti,2017) is composed of a multi-level bridge topology serial connection. The general output voltage of MLI is,

$$v_{o/p} = v_{o/p}^1 + v_{o/p}^2 + \cdots v_{o/p}^n \tag{20}$$

The count of voltage level of inverter is described below,

$$N_s = 2n + 1 \tag{21}$$

Maximal output voltage of n level inverteris expressed below,

$$v_{out}^{\max} = n * v_{dc} \quad (22)$$

For n level inverter, the quantity of voltage steps is provided by,

$$\text{For } j = 1, 2, \ldots .n, \; N_s = \begin{cases} 2^{n+1} - 1 \; if \; v_j = 2^{j-1} v_{dc} \\ 3^n \quad if \; v_j = 3^{j-1} v_{dc} \end{cases} \quad (23)$$

The maximal output voltage of these n level inverters are expressed as,

$$\text{For } j = 1, 2, \ldots .n, \; V_{out}^{\max} = \begin{cases} (2^n - 1) v_{dc} \quad if \; v_j = 2^{j-1} v_{dc} \\ \left(\frac{3^n - 1}{2} \right) v_{dc} \quad if \; v_j = 3^{j-1} v_{dc} \end{cases} \quad (24)$$

4.4. Modelling of CMLI with Grid Connection

Proposed CMLI with grid connection is displayed in fig 8. The state space method (Sharma et al,2019) of proposed system is stated by,

$$\frac{d}{dt} \begin{bmatrix} i_a \\ i_b \\ i_c \end{bmatrix} = \frac{r_{lum}}{l_{lum}} \begin{bmatrix} i_a \\ i_b \\ i_c \end{bmatrix} + \frac{1}{l_{lum}} \left(\begin{bmatrix} v_{sa} \\ v_{sb} \\ v_{sc} \end{bmatrix} - \begin{bmatrix} v_a \\ v_b \\ v_c \end{bmatrix} \right) \quad (25)$$

Eqn (16) is modified by the Park's transformation, and then it is described by,

$$\frac{d}{dt} \begin{bmatrix} i_D \\ i_Q \end{bmatrix} = \begin{bmatrix} -\frac{r_{lum}}{l_{lum}} & f_{ang} \\ -f_{ang} & -\frac{r_{lum}}{l_{lum}} \end{bmatrix} \begin{bmatrix} i_D \\ i_Q \end{bmatrix} + \frac{1}{l_l} \left(\begin{bmatrix} v_{sD} \\ v_{sQ} \end{bmatrix} - \begin{bmatrix} v_D \\ v_Q \end{bmatrix} \right) \quad (26)$$

Here, r_{lum} as lumped resistance, l_{lum} as lumped inductance, grid voltage is denoted as v_s, direct and quadrature axis current is denoted as i_D, i_Q. The two quadrant signals are obtained from the three phase original signal, which is described in eqn (15) and (16).

Fig 8: Here

4.5. Modeling of Active and Reactive Control for Grid-Connected PVSystem

For generating the essential reference voltage and current, the three phase grid current is passed to the proposed method. The reference current, grid voltage and current are converted from the reference frame of abc to dq, then the dq(Kala and Arora,2019) components are passed through the proportional integral controller, which is tuned by the proposed method and it delivers the control signals. By using PWM, the switching signal of CMLI is generated. The active and reactive control action with dq control architecture is displayed in fig 9.

Fig 9: Here

4.6. Voltage and current harmonic distortion

Due to passive as well as active nonlinear devices, the power system produces harmonics. The total current harmonic distortion(TIHD) and Total voltage harmonic distortion (TVHD) is used to determine the harmonic performance of the bus system. The ratio of the sum of power of entire harmonic voltage components to the power of essential voltage frequency is called as TVHD.

$$TVHD = \frac{100 \times \sqrt{v_{rms}^2 - v_{frms}^2}}{v_{frms}} \quad (27)$$

$$TIHD = \frac{100 \times \sqrt{i_{rms}^2 - i_{frms}^2}}{i_{frms}} \quad (28)$$

Here, TVHD denotes net voltage harmonic distortion, $TIHD$ denotes net current harmonic distortion, v_{frms} denotes fundamental voltage frequency, i_{frms} denotes fundamental current frequency, v_{rms} denotes harmonic voltage component, i_{rms} denotes harmonic current component.

5. Results and Discussion

The performance of the proposed method depends on simulation results. NBO-RERNN method is proposed for enhancing the PQ of the system. The cascaded MLI (CMLI) is utilized to mitigate the harmonics of the system. CMLI is incorporated into less count of sources, diodes and switches are modeled to attain the optimal control signal with the proposed controller. The proposed method is simulated in MATLAB or Simulink tool and its performance is compared to existing methods. The proposed method is evaluated on 3 conditions, such as change of irradiance, various weather conditions, various load conditions. Here, the parameters, like voltage, current, active and reactive power; irradiation and temperature are investigated to determine the performance of system. The existing methods, like sliding mode controller (SMC), fuzzy logic controller, Nomadic people optimizer (NPO) are utilized to compare the performance of proposed method.

Analysis of irradiance change of PV is displayed in fig 10. The irradiance is changed form 250 W/m^2 to 1000 W/m^2 at 0 to 0.35 sec. At 0 to 0.35 sec, the irradiance is varied in various step conditions. Under this condition, the PV power and voltage are analyzed. Analysis of PV power is displayed in fig 11. At 0 to 0.039 sec, the PV power is improved from 0 to 3×10^4 W, and then at 0.039 to 0.09 sec, the photovoltaic power is constant in 3 $\times10^4$ W. After, at 0.1 sec, the photovoltaic power is decreased to 2.4×10^4 W. Investigation of PV voltage is displayed in fig 12. At 0 to 0.2 sec, the PV voltage is increased from 0 to 250 V, and then at 0.38 sec, the voltage is again increased to 520 V. Next, at 0.38 to 0.8 sec, it is constant to 520 V and at 1 sec, the voltage is 480 V. Investigation of PV current is depicted in fig 13. The output current is increased from 5 to 15 A at 0 to 0.08 sec. Then, it is increased to 35 A at 0.09 to 0.2 sec. Again the current is increased from 30 to 60 A at 0.2 to 0.38 sec. Then, the current is constant to 60 A at 0.38 to 0.9 sec and it reduced to 55 A at 1 sec. Investigation of six level cascade multilevel DC to DC converter output voltage is depicted in fig 14. At 0 to 0.1sec, the voltage is varied from -450 to +450V. It is the first stage output of dc to dc converter. Analysis of 13 level dc to ac inverter output voltage is displayed in fig 15. The voltage is varied among -500 V to 500 V at 0 to 0.1 sec. Investigation of grid voltage is illustrated in fig 16. The voltage of grid is varied from -350 to 350 V at 0 to 0.2 sec. Investigation of grid current is displayed in fig 17. The grid current is varied from -280 to 280 A at 0 to 0.2 sec.

Fig 10: Here
Fig 11: Here
Fig 12: Here
Fig 13: Here
Fig 14:here
Fig 15: Here
Fig 16: Here
Fig 17: Here
Fig 18: Here
Fig 19: Here
Fig 20: Here
Fig 21: Here
Fig 22: Here

Fig 23: Here

Analysis of load real power is displayed in fig 18. The load real power is initially zero and it is increased to 14.5×10^4 W at 0.018 sec and it is constant to 14.5×10^4 W at 0.018 to 0.2 sec. Analysis of load reactive power is displayed in fig 19. The load reactive power is initially zero and it increased to 12.5×10^4 W at 0.018 sec and it is constant to 12.5×10^4 W at 0.018 to 0.2 sec. Analysis of PV power under different weather conditions is displayed in fig 20. The maximum obtained photovoltaic power is 200 kW and it is obtained at 0.4 sec that power is given to the grid. Analysis of PV power under various load conditions is displayed in fig 21. The shortage of power is occurring at 0.0 to 0.4 sec and after 0.4 sec, the load is utilized power from the utility grid and the extra power is given to grid. The THD is a measure of how much distortion of a voltage or current is attained because of harmonics in the signal. One of the main analyses of power system is power quality improvement. Analysis of voltage THD percentage is displayed in fig 22. The three phase's voltage THD for proposed and existing methods are analyzed. From the analysis, the proposed method r, y and b phase THD becomes 1%, 1.8 % and 1.03 % respectively. The existing NPO method r, y and b phase THD becomes 1.08%, 2.65%, 1.35 % respectively. The existing SMC method r, y and b phase THD becomes 1.09 %, 2.71%, 1.5 % respectively. The existing FLC method r, y and b phase THD becomes 1.13 %, 2.8%, 1.67 % respectively. From the analysis, it is conclude that, the proposed approach based voltage THD is less compared to existing methods is proved. Analysis of current THD percentage is displayed in fig 23. The three phase's current THD for proposed method and existing methods is analyzed. From the analysis, the proposed method r, y and b phase THD becomes 0.1%, 1.02% and 1.1% respectively. The existing NPO method r, y and b phase THD becomes 0.15%, 1.19%, 1.28 % respectively. The existing SMC method r, y and b phase THD becomes 0.12 %, 2.71%, 1.5 % respectively. The existing FLC method r, y and b phase THD becomes 0.18%, 1.34%, 1.52 % respectively. From the analysis, it is conclude that, the proposed method based current THD is less compared to existing methods is proved.

6. Conclusion

Here, a hybrid NBO-RERNN method for increasing the power quality of grid-tied photovoltaic system is proposed. The proposed photovoltaic system is connected to six level dc to dc converters and 13- level inverter. The 13- level inverter is incorporated into less number of switches. The proposed NBO method generate the set of control signal, from this the signal optimal is predicted by using the RERNN method. The proposed method is simulated in MATLAB or Simulink tool and its performance is compared to existing NPO, SMC and FLC methods. The proposed method is analyzed in three conditions, such as irradiance change, various weather and load change conditions. Here, the parameters, like voltage, current, active and reactive power, irradiation are investigated. From the simulation, obtained the THD of the proposed method r, y and b phase THD becomes 1%, 1.8 % and 1.03 % respectively. The proposed method provides less THD than the existing one is proved.

References

Ali, JagabarSathikMohd, and VijayakumarKrishnaswamy. "An assessment of recent multilevel inverter topologies with reduced power electronics components for renewable applications." *Renewable and Sustainable Energy Reviews* 82 (2018): 3379-3399.

Bakhshizadeh, Mohammad Kazem, HosseinIman-Eini, and FredeBlaabjerg."Selective harmonic elimination in asymmetric cascaded multilevel inverters using a new low-frequency strategy for photovoltaic applications." *Electric Power Components and Systems* 43, no. 8-10 (2015): 964-969.

Busquets-Monge, Sergio, Joan Rocabert, Pedro Rodríguez, Salvador Alepuz, and JosepBordonau."Multilevel diode-clamped converter for photovoltaic generators with independent voltage control of each solar array." *IEEE Transactions on Industrial electronics* 55, no. 7 (2008): 2713-2723.

Cecati, Carlo, FabrizioCiancetta, and PierluigiSiano."A multilevel inverter for photovoltaic systems with fuzzy logic control." *IEEE transactions on industrial electronics* 57, no. 12 (2010): 4115-4125.

Chahardoli, Meysam, NafisehOsatiEraghi, and Sara Nazari. "Namib beetle optimization algorithm: a new meta-heuristic method for feature selection and dimension reduction." *Concurrency and Computation: Practice and Experience* 34, no. 1 (2022): e6524.

Colak, Ilhami, ErsanKabalci, and RamazanBayindir. "Review of multilevel voltage source inverter topologies and control schemes." *Energy conversion and management* 52, no. 2 (2011): 1114-1128.

Gao, Tao, Xiaoling Gong, Kai Zhang, Feng Lin, Jian Wang, Tingwen Huang, and Jacek M. Zurada. "A recalling-enhanced recurrent neural network: conjugate gradient learning algorithm and its convergence analysis." *Information Sciences* 519 (2020): 273-288.

Gulbudak, Ozan, and Mustafa Gokdag. "Finite control set model predictive control approach of nine switch inverter-based drive systems: Design, analysis, and validation." *ISA transactions* 110 (2021): 283-304.

Kala, Peeyush, and SudhaArora."Implementation of hybrid GSA SHE technique in hybrid nine-level inverter topology." *IEEE Journal of Emerging and Selected Topics in Power Electronics* 9, no. 1 (2019): 1064-1074.

Kaliamoorthy, Mylsamy, VairamaniRajasekaran, Irudayaraj Gerald Christopher Raj, and Lawrence Hubert Tony Raj."Generalised hybrid switching topology for a single-phase modular multilevel inverter." *IET Power Electronics* 7, no. 10 (2014): 2472-2485.

Kartick, Jana Chandra, Biswas K. Sujit, and KarChowdhurySuparna. "Dual reference phase shifted pulse width modulation technique for a N-level inverter based grid connected solar photovoltaic system." *IET Renewable Power Generation* 10, no. 7 (2016): 928-935.

Kouro, Samir, Mariusz Malinowski, K. Gopakumar, JosepPou, Leopoldo G. Franquelo, Bin Wu, Jose Rodriguez, Marcelo A. Pérez, and Jose I. Leon. "Recent advances and industrial applications of multilevel converters." *IEEE Transactions on industrial electronics* 57, no. 8 (2010): 2553-2580.

Kumar, Nayan, Tapas Kumar Saha, and JayatiDey. "Multilevel inverter (MLI)-based stand-alone photovoltaic system: modeling, analysis, and control." *IEEE Systems Journal* 14, no. 1 (2019): 909-915.

Kumar, S. Satish, and M. Sasi Kumar. "Intelligent hybrid technique for cascaded multilevel inverter based three phase grid-tie hybrid power system: a WPSNN technique." *Journal of Ambient Intelligence and Humanized Computing* 12, no. 10 (2021): 9637-9666.

Latran, Mohammad Barghi, and AhmetTeke. "Investigation of multilevel multifunctional grid connected inverter topologies and control strategies used in photovoltaic systems." *Renewable and Sustainable Energy Reviews* 42 (2015): 361-376.

Lee, Seongjun, and Jonghoon Kim."Optimized modeling and control strategy of the single-phase photovoltaic grid-connected cascaded H-bridge multilevel inverter." *Electronics* 7, no. 9 (2018): 207.

Letha, ShimiSudha, Tilak Thakur, and Jagdish Kumar. "Harmonic elimination of a photo-voltaic based cascaded H-bridge multilevel inverter using PSO (particle swarm optimization) for induction motor drive." *Energy* 107 (2016): 335-346.

Liu, Junfeng, Jialei Wu, Jun Zeng, and HuafangGuo. "A novel nine-level inverter employing one voltage source and reduced components as high-frequency AC power source." *IEEE Transactions on Power Electronics* 32, no. 4 (2016): 2939-2947.

Meenalochini, P., and E. Sakthivel. "An efficient GBDTRSO control strategy for PV connected H-Bridge Nine Level MLI System with quasi-Z-source inverter." *Applied Soft Computing* 113 (2021): 108026.

Ozdemir, Engin, SuleOzdemir, and Leon M. Tolbert."Fundamental-frequency-modulated six-level diode-clamped multilevel inverter for three-phase stand-alone photovoltaic system." *IEEE Transactions on Industrial Electronics* 56, no. 11 (2008): 4407-4415.

Palanisamy, R., and K. Vijayakumar. "A hysteresis current controller for PV-wind hybrid source fed STATCOM system using cascaded multilevel inverters." *Journal of Electrical Engineering and Technology* 13, no. 1 (2018): 270-279.

Panda, A. K., and Y. Suresh."Performance of cascaded multilevel inverter by employing single and three-phase transformers." *IET Power Electronics* 5, no. 9 (2012): 1694-1705.

Panda, Anup Kumar, and Yellasiri Suresh."Research on cascade multilevel inverter with single DC source by using three-phase transformers." *International Journal of Electrical Power & Energy Systems* 40, no. 1 (2012): 9-20.

Perez, Marcelo A., Steffen Bernet, Jose Rodriguez, Samir Kouro, and Ricardo Lizana. "Circuit topologies, modeling, control schemes, and applications of modular multilevel converters." *IEEE transactions on power electronics* 30, no. 1 (2014): 4-17.

Sahoo, Buddhadeva, SangramKeshariRoutray, and Pravat Kumar Rout. "Artificial neural network-based PI-controlled reduced switch cascaded multilevel inverter operation in wind energy conversion system with solid-state transformer." *Iranian Journal of Science and Technology, Transactions of Electrical Engineering* 43, no. 4 (2019): 1053-1073.

Sahoo, Buddhadeva, SangramKeshariRoutray, and Pravat Kumar Rout. "Repetitive control and cascaded multilevel inverter with integrated hybrid active filter capability for wind energy conversion system." *Engineering Science and Technology, an International Journal* 22, no. 3 (2019): 811-826.

Sahoo, Buddhadeva, SangramKeshariRoutray, and Pravat Kumar Rout. "Repetitive control and cascaded multilevel inverter with integrated hybrid active filter capability for wind energy conversion system." *Engineering Science and Technology, an International Journal* 22, no. 3 (2019): 811-826.

Samadaei, Emad, SayyedAsgharGholamian, AbdolrezaSheikholeslami, and JafarAdabi. "An envelope type (E-Type) module: asymmetric multilevel inverters with reduced components." *IEEE Transactions on Industrial Electronics* 63, no. 11 (2016): 7148-7156.

Sandeep, N., and Udaykumar R. Yaragatti."Operation and control of an improved hybrid nine-level inverter." *IEEE Transactions on industry applications* 53, no. 6 (2017): 5676-5686.

Sharma, Bhupender, RatnaDahiya, and JayaramNakka. "Capacitor voltage balancing in cascaded H-bridge multilevel inverter and its modelling analysis for grid integrated wind energy conversion system application." *International Journal of Circuit Theory and Applications* 47, no. 8 (2019): 1323-1339.

Sharma, Bhupender, RatnaDahiya, and JayaramNakka. "Effective grid connected power injection scheme using multilevel inverter based hybrid wind solar energy conversion system." *Electric Power Systems Research* 171 (2019): 1-14.

Sharma, Bhupender, RatnaDahiya, and JayaramNakka. "Effective grid connected power injection scheme using multilevel inverter based hybrid wind solar energy conversion system." *Electric Power Systems Research* 171 (2019): 1-14.

Song, Sung Geun, Feel Soon Kang, and Sung-Jun Park. "Cascaded multilevel inverter employing three-phase transformers and single DC input." *IEEE Transactions on Industrial Electronics* 56, no. 6 (2009): 2005-2014.

Sun, Pengwei, Chuang Liu, Jih-Sheng Lai, and Chien-Liang Chen. "Grid-tie control of cascade dual-buck inverter with wide-range power flow capability for renewable energy applications." *IEEE transactions on power electronics* 27, no. 4 (2011): 1839-1849.

Sun, Shizhen, Hongjuan Zhang, Xiaoji Wang, Yan Gao, and Baoquan Jin. "Power flow predictive model control to improve the efficiency of regenerative energy storage and utilization." *Journal of Power Electronics* 22, no. 10 (2022): 1758-1768.

Suresh, Y., and A. K. Panda."Research on a cascaded multilevel inverter by employing three-phase transformers." *IET Power Electronics* 5, no. 5 (2012): 561-570.

Thitichaiworakorn, Nuntawat, Makoto Hagiwara, and Hirofumi Akagi. "Experimental verification of a modular multilevel cascade inverter based on double-star bridge cells." *IEEE Transactions on Industry Applications* 50, no. 1 (2013): 509-519.

Vasu, Rajesh, Sumit Kumar Chattopadhyay, and ChandanChakraborty. "Three-Phase Trinary Asymmetric Multilevel Inverter With Single DC Source and Open-Loop Control." *IEEE Open Journal of Industry Applications* 2 (2021): 259-277.

Xiao, Hua F., KeLan, and Li Zhang. "A quasi-unipolar SPWM full-bridge transformerless PV grid-connected inverter with constant common-mode voltage." *IEEE Transactions on Power Electronics* 30, no. 6 (2014): 3122-3132.

Yu, Jingrong, Ruoxue Yu, He Wen, Xianfu Lin, and Kai Hu. "Simplified SVPWM-based SoC balancing strategy for three-phase cascaded H-bridge multilevel converter in off-grid energy storage systems." *International Journal of Electrical Power & Energy Systems* 137 (2022): 107474..

Zare, Kazem, and Mehdi Abapour."Verification of a low component nine-level cascaded-transformer multilevel inverter in grid-tied mode." *IEEE Journal of Emerging and Selected Topics in Power Electronics* 6, no. 1 (2017): 429-440.

Figure

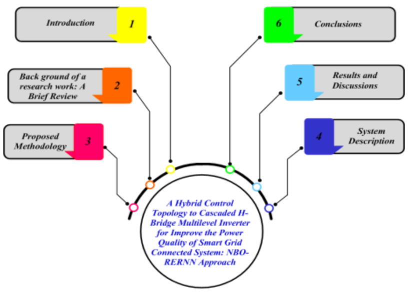

Fig 1: Organization of proposed work

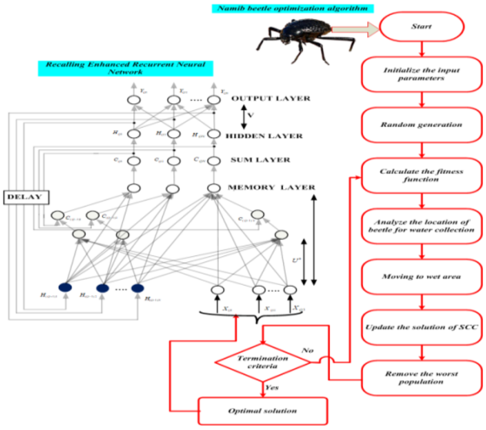

Fig 2: Flowchart of proposed NBO-RERNN approach

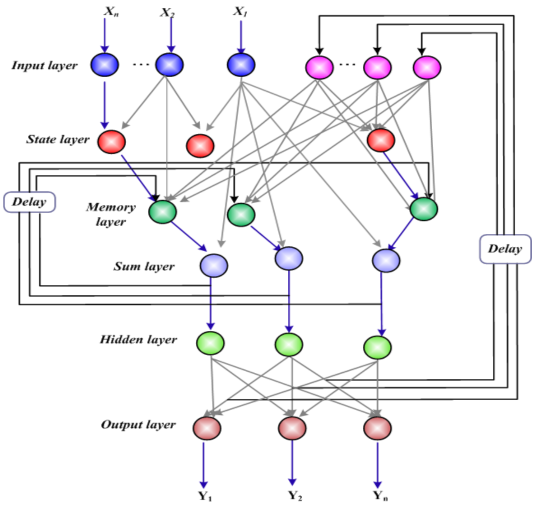

Fig 3: Recalling-Enhanced RNN structure

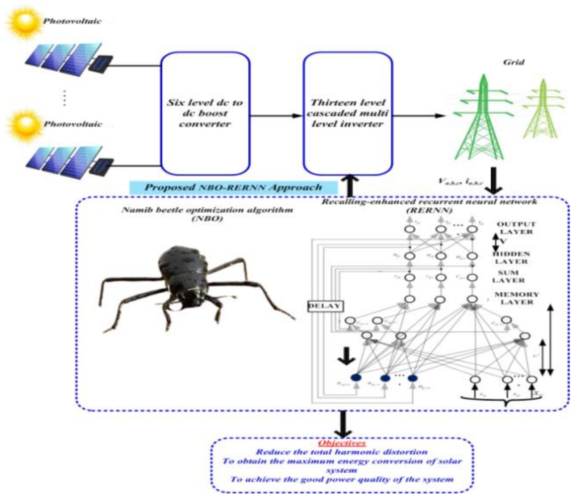

Fig 4: Structure of proposed PV system

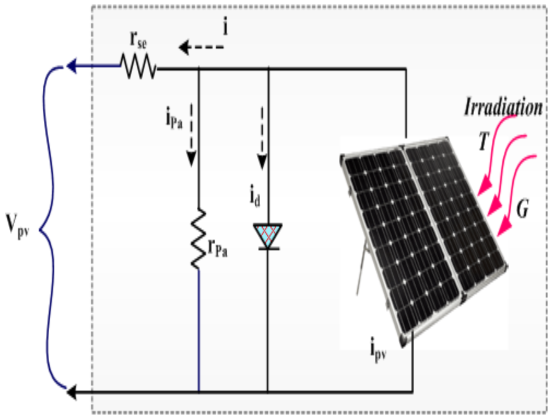

Fig 5: Single diode model of PV

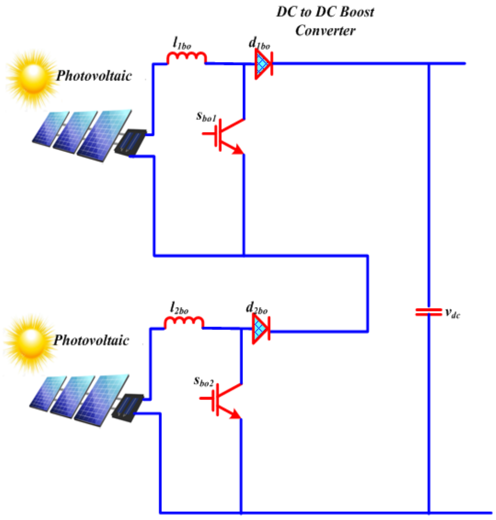

Fig 6: Circuit diagram of multi-level cascaded DC to DC boost-converter

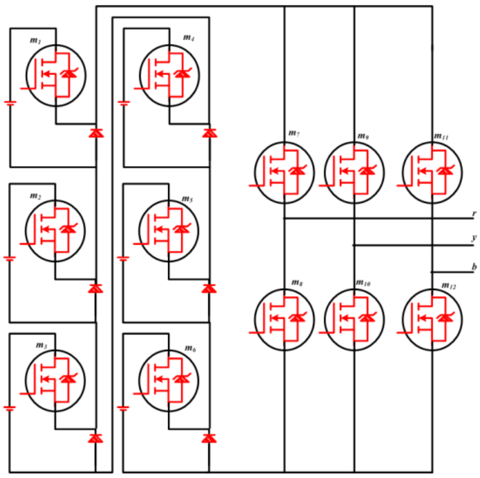

Fig 7: 13- level CMLI

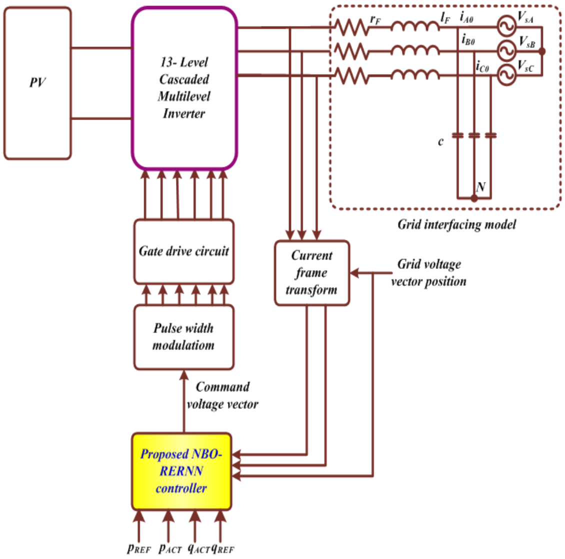

Fig 8: Proposed CMLI with grid connection

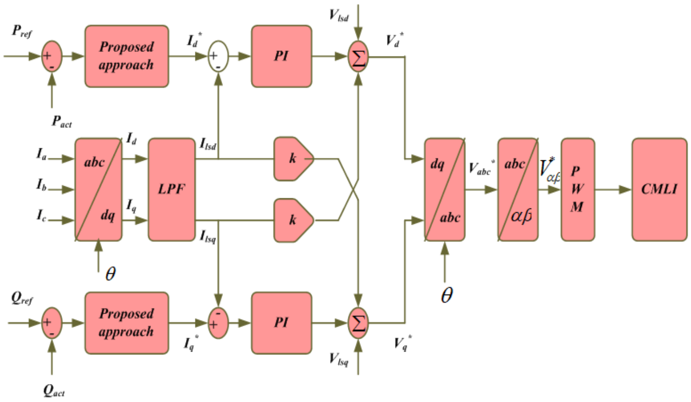

Fig 9: Active and reactive control action with dq control architecture

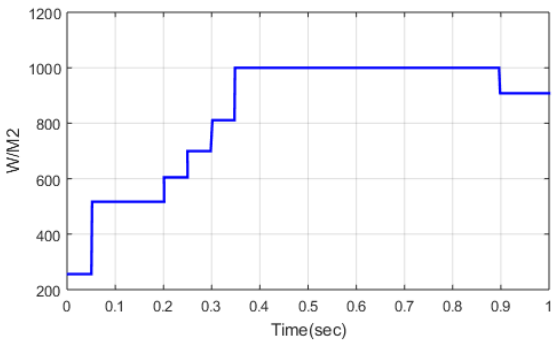

Fig 10: Analysis of irradiance change of PV

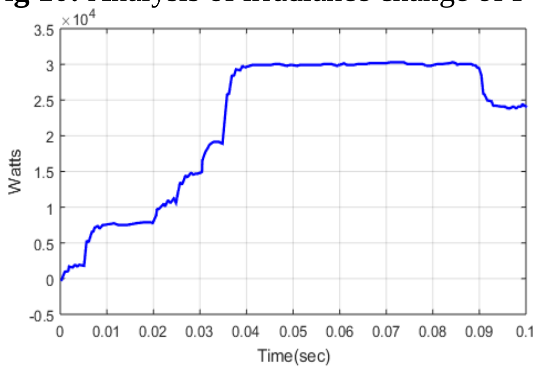

Fig 11: Analysis of PV power

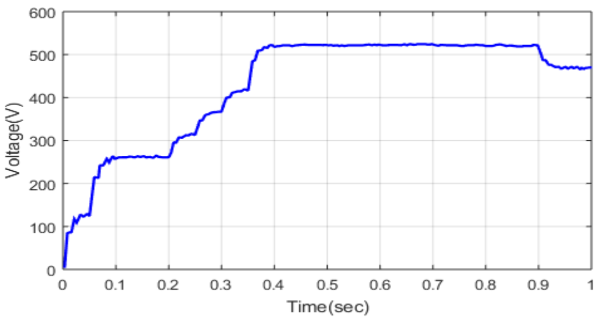

Fig 12: Investigation of PV voltage

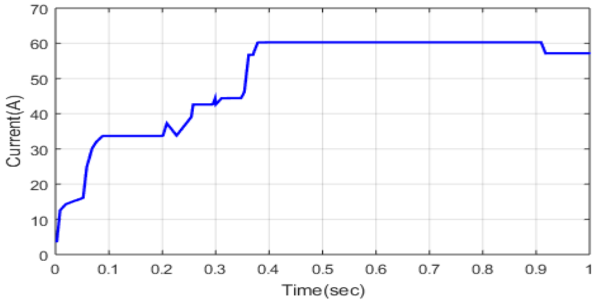

Fig 13: Investigation of PV current

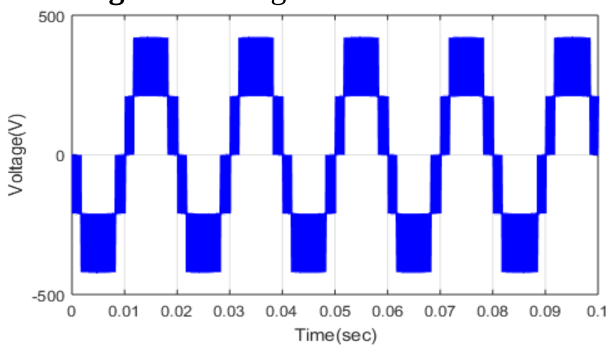

Fig 14: Investigation of six level cascade multilevel DC to DC converter output voltage

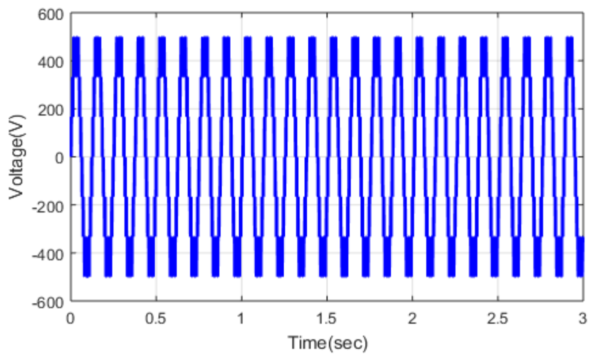

Fig 15: Analysis of 13 level dc to ac inverter output voltage

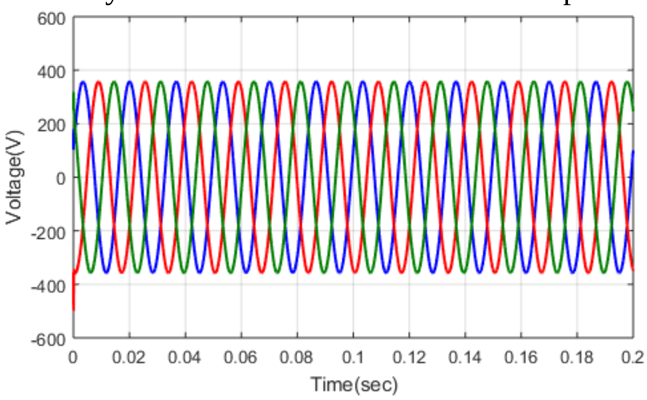

Fig 16: Investigation of grid voltage

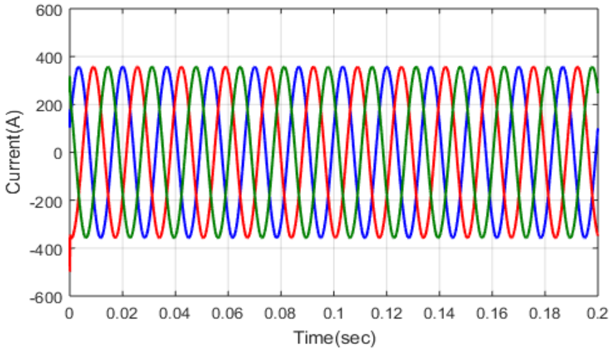

Fig 17: Investigation of grid current

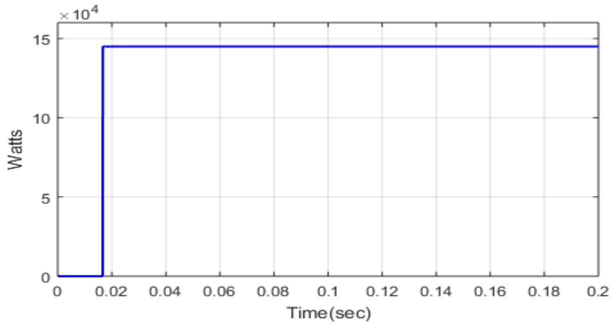

Fig 18: Analysis of load real power

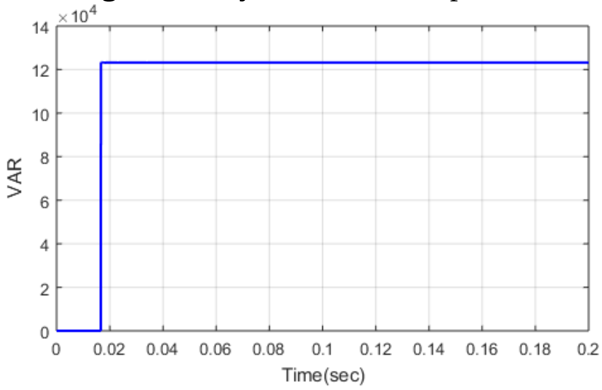

Fig 19: Analysis of load reactive power

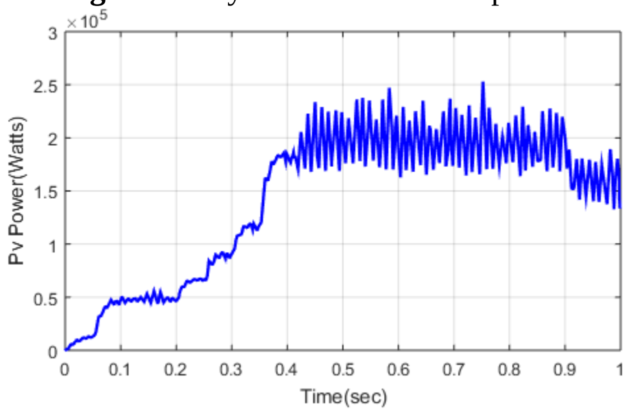

Fig 20: Analysis of PV power under various weather conditions

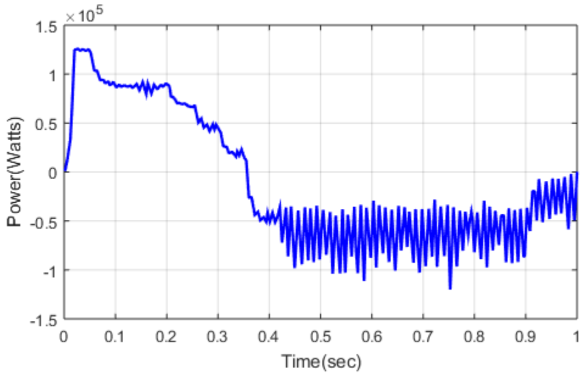

Fig 21: Analysis of load power various weather conditions

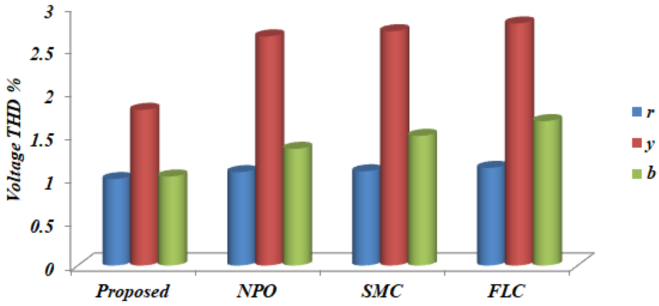

Fig 22: Analysis of voltage THD percentage

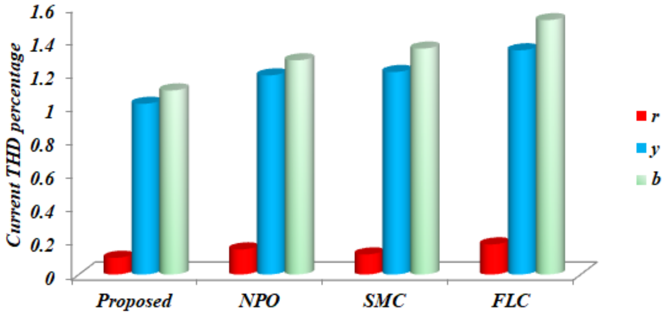

Fig 23: Analysis of current THD percentage

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Original Submission
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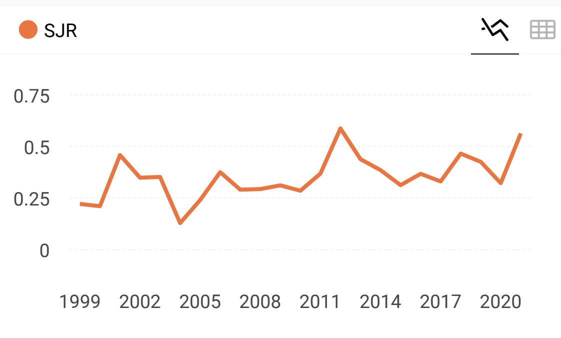

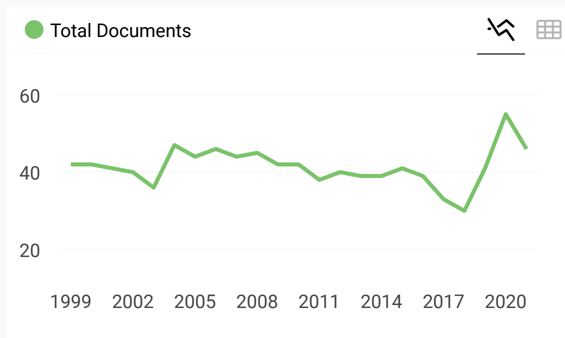

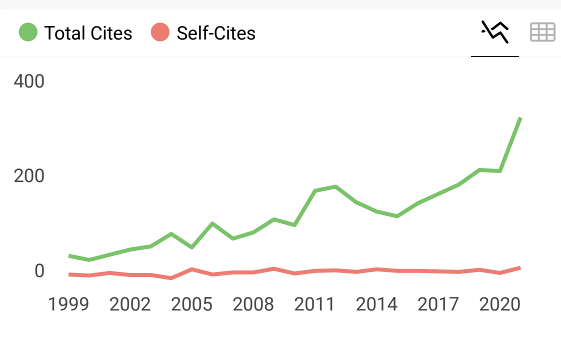

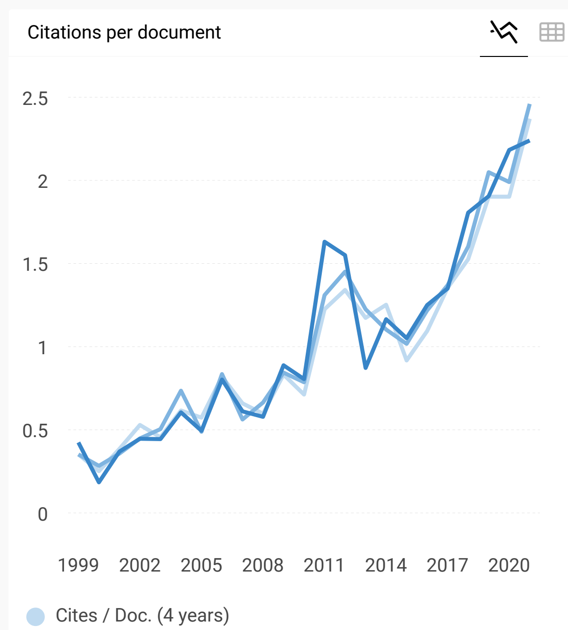

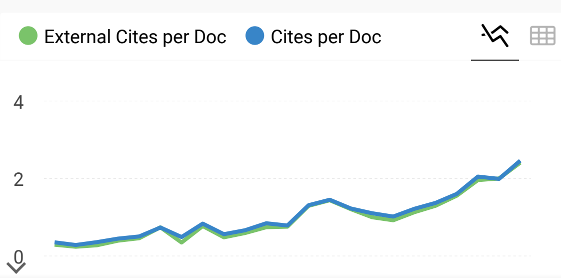

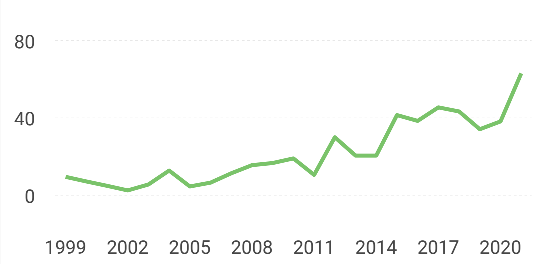

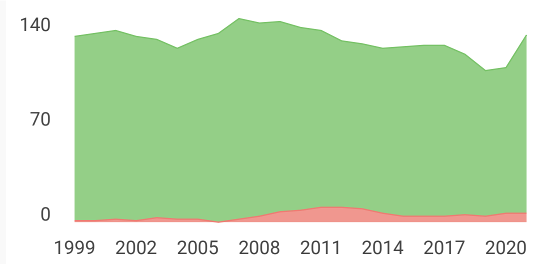

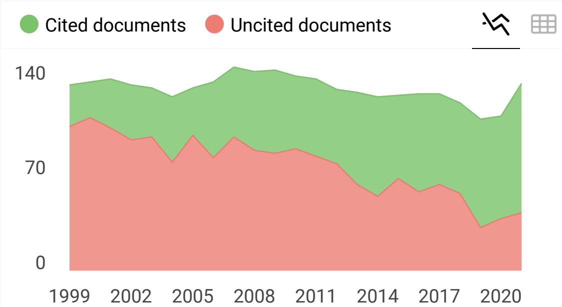

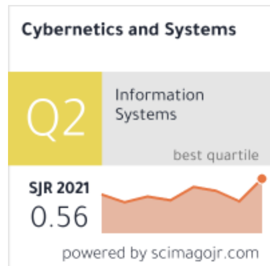

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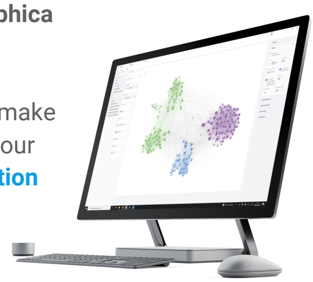

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