High Gain Superlift Luo Convertor Based Grid Connected Hybrid Solar Wind Energy System

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Abstract- *As electric distribution technology steps into the next century, many trends are becoming noticeable that will change the requirements of energy delivery. These modifications are being driven from both the demand side where higher energy availability and efficiency are desired and from the supply side where the integration of distributed generation and peaks having technologies must be accommodated. The increase in power demand and pollution caused by the use of fossil fuels has shifted the attention to renewable energy systems (RES).The RE resources have play a vital role in unpolluted and green energy provident, but it'ssuffer from intermittency and low power levels, necessitating the use of boost converters.In addition, the MPPT strategy is essential for the maximum power extraction in energy generation system.As a result, the SUPERLIFT LUO converter and the NEURO fuzzy MPPT method are used in this work for efficient output and maximum power traction, respectively.A PV panel's output power is fed into the SUPERLIFT LUO converter, and the converter's enhanced output is converted to AC via a 3ΦVSI, which is then injected into the grid after optimal synchronisation. This research gives a model of a PV micro grid system with RL load driving via SUPERLIFTLUO converters. Harmonic distortions and voltage variations are two of the most significant issues associated with RES integration. A PI controller is implemented to address these PQ issues and increase the grid's performance. The PWM generator is employed in this study to generate the proper pulses. MATLAB/Simulink is used to verify the modelled system's effectiveness.*

Keywords- RES, PV system, SUPERLIFTLUO converter, NEURO fuzzy MPPT, PQ issues and MATLAB.

I. INTRODUCTION

As electric distribution technology steps into the next century, many trends are becoming noticeable that will change the requirements of energy delivery. These modifications are being driven from both the demand side where higher energy availability and efficiency are desired and from the supply side where the integration of distributed generation and peaks having technologies must be accommodated. Power systems currently undergo considerable change in operating requirements mainly as a result of deregulation and due to an increasing amount of distributed energy resources.

In many cases DERs include different technologies that allow generation in small scale (micro sources) and some of them take advantage of renewable energy resources (RES) such as solar, wind or hydro energy. Having micro sources close to the load has the advantage of reducing transmission losses as well as preventing network congestions. Moreover, the possibility of having a power supply interruption of end-customers connected to a low voltage (LV) distribution grid is diminished since adjacent micro sources, controllable loads and energy storage systems can operate in the islanded mode in case of severe system disturbances.

II. PROPOSED CONTROL METHODOLOGY

In the proposed control topology shown in Figure 1, the grid synchronization of renewable energy source applications like PV source is performed.

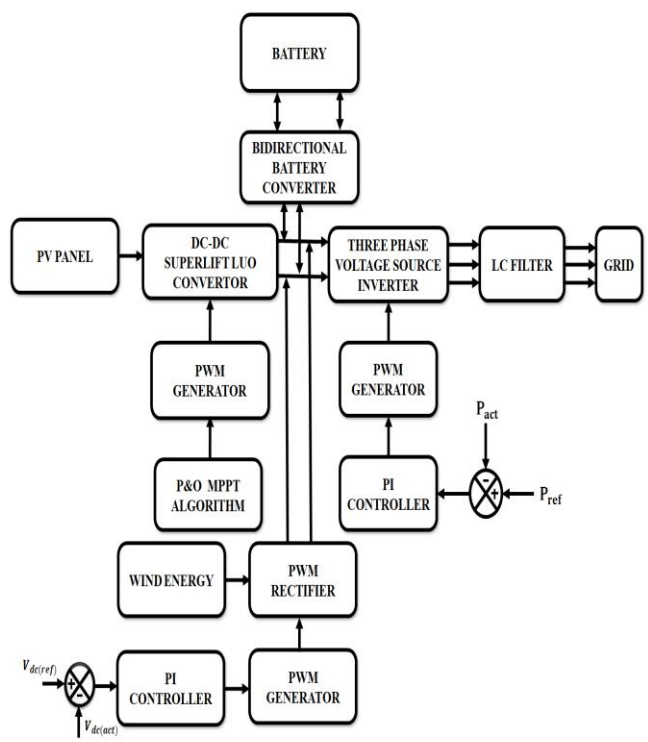


Figure 1 Proposed block diagram

The resultant PV voltage is insignificant and generally gets influenced by the impacts of climate variations including irradiation and temperature. Hence, a NEURO fuzzy MPPT controller is employed which is robust and does not demand information regarding the actual model.

I MODELING OF PROPOSED CONTROL SYSTEM

A. PV cell model

Modelling of PV module with 36 solar cells have been described in this section. PV panels are made up of many photovoltaic cells that are connected in series or parallel. The total number of solar cells connected in series and parallel is denoted by $N_s$andN_p. $N_p I_{ph}$Denotes the total photo current caused by cell temperature and solar irradiation. Figure 2 depicts a PV module with a single diode circuit.

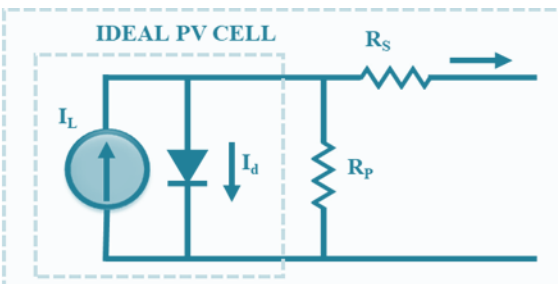


Figure 2 PV cell model

The PV output current and voltage relation can be given as follows,

$$I_{PV} = I_L - I_0 \left[e^{\frac{q(V_{PV}+I_{PV}R_s)}{N_s knT}} - 1 \right] - \frac{V_{PV}+I_{PV}R_s}{R_p} \quad (1)$$

$$I_L = [I_{SC} + K_1(T - T_r)]\frac{G}{1000} \quad (2)$$

$$I_0 = I_{rs}\left(\frac{T}{T_r}\right)^3 \exp\left[\frac{qE_g}{nK}\left(\frac{1}{T_r} - \frac{1}{T}\right)\right] \quad (3)$$

Where,

I_L	-	Light current
I_0	-	Reverse saturation current
R_s	-	Series resistance
R_p	-	Resistance in parallel
I_{SC}	-	Short circuit current
q	-	Charge of electron (1.602×10^{-19} C)
G	-	Irradiation (W/m^2)
n	-	Ideality factor
k	-	Boltzmann's constant ($k = 1.3806 \times 10^{-23}$ J/K)
T	-	Cell temperature
T_r	-	Reference temperature

B. SUPERLIFT LUOconverter Model

Positive and negative output versions are available for the DC-DC SUPERLIFTLUO-converter. Figure 3 depicts the positive output Luo-converter, whereas Figures 4 and 5 depict the analogous circuits of SUPERLIFT LUO converter during switch OFF and ON condition, respectively.

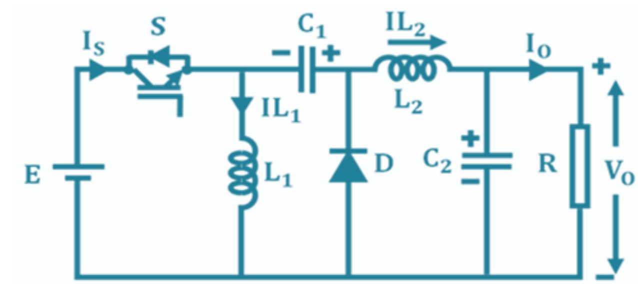


Figure 3 Equivalent circuit model ofSUPERLIFT LUO converter

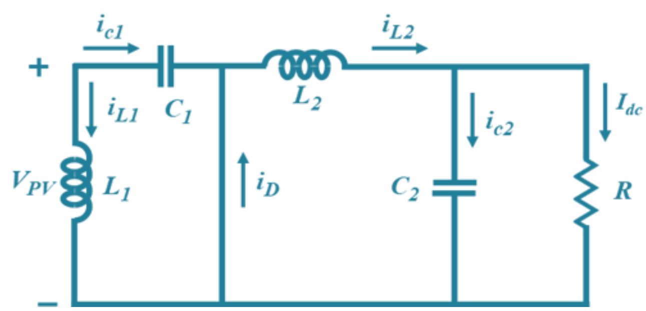


Figure 4 Switch OFF state

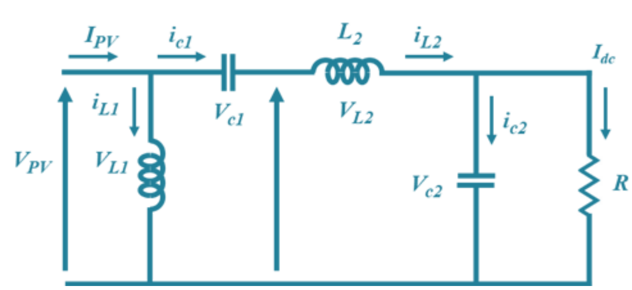


Figure 5 Switch ON state

Switch OFF Mode

The stored energy is transferred from the inductance L_1 to the capacitor C_1 during the switch OFF state, and subsequently this energy is conveyed to the load R_s during switch ON condition. The capacitor $C_1$and the inductance $L_1$are responsible for storing and transferring power from the source to the Load. The output voltage and current equations for the superliftLuo-converter are as follows:

$$V_{dc} = \left(\frac{k}{1-k}\right) V_{PV} \quad (4)$$

$$I_{dc} = \left(\frac{k}{1-k}\right) I_{PV} \quad (5)$$

Thus, the voltage transfer gain is given as,

$$G = \frac{V_{dc}}{V_{PV}} = \frac{I_{PV}}{I_{dc}} = \frac{k}{1-k} \quad (6)$$

The output voltage variation ratio can be expressed as,

$$\xi = \frac{\frac{\Delta v_{dc}}{2}}{V_{dc}} = \frac{k}{16Gf^2C_2L_2} \quad (7)$$

Thus the output voltage is expressed as,

$$V_{dc} = k(1-k)\frac{R}{2fL_1}V_{PV} \quad (8)$$

Switch ON Mode

The current i_{L1} grows with the source voltage during switching-on (V_{PV}). i_{L1}Decreases during switch-off and is reversed by ($-V_{C1}$). Thus, the inductor current variation is given as,

$$\Delta i_{L1} = \frac{kV_{PV}}{fL_1} \quad (9)$$

The variation ratio of current i_{L1} is described by the equation given below,

$$\xi_1 = \frac{\frac{\Delta i_{L1}}{2}}{I_{L1}} \quad (10)$$

The current i_{L2} increases with $(V_{PV} + V_{C1} + V_{dc})$ at switch-on state. i_{L2} Drops during switching-off and is reversed by ($-V_{dC}$). Thus, the current variation is given as,

$$\Delta i_{L2} = \frac{kV_{PV}}{fL_2} \quad (11)$$

The i_{L2}current variation ratio is given as,

$$\xi_2 = \frac{\frac{\Delta i_{L2}}{2}}{I_{L2}} = \frac{kV_{in}}{2fL_2I_{dc}} = \frac{k}{2G}\frac{R_s}{fL_2} \quad (12)$$

The diode current can be expressed as,

$$i_D = i_{L1} + i_{L2} \quad (13)$$

$$\Delta i_D = \Delta i_{L1} + \Delta i_{L2} \quad (14)$$

$$\Delta i_D = \frac{kTV_{PV}}{L_1} + \frac{kTV_{PV}}{L_2} = \frac{kTV_{PV}}{L} = \frac{(1-k)TV_{dc}}{L} \quad (15)$$

$$I_D = I_{L1} + I_{L2} = \frac{I_{dc}}{(1-k)} \quad (16)$$

The diode current's variation ratio is notes as,

$$\xi_3 = \frac{\frac{\Delta i_D}{2}}{I_D} = \frac{(1-k)^2TV_{dc}}{2L I_{dc}} = \frac{k(1-k)R}{2GfL} = \frac{k^2R}{G^2 2fL} \quad (17)$$

The peak to peak voltage variation is,

$$\Delta v_C = \frac{(1-k)}{C} TI_{PV} \quad (18)$$

$$\xi_4 = \frac{\frac{\Delta v_C}{2}}{V_C} = \frac{T(1-k)I_{PV}}{2CV_{dc}} = \frac{k}{2}\frac{1}{fCR} \quad (19)$$

C. Grid synchronized 3ϕ VSI with LC filter

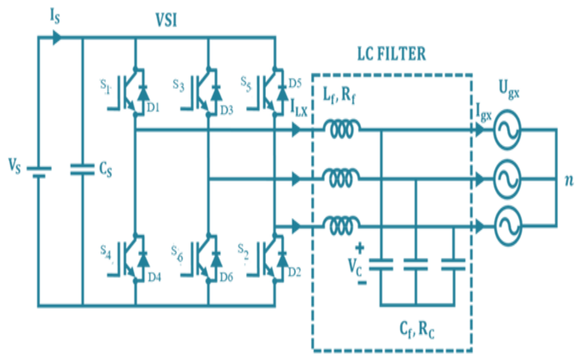


Figure 6 3ϕ VSI with LC filter

Figure 10 shows the connection diagram of 3ϕ VSI along with an LC filter comprising of switches $S_1, S_2, S_3, S_4, S_5, S_6$ which are fast controllable in nature. Diodes $D_1, D_2, D_3, D_4, D_5, D_6$ are connected in parallel across the switches and the terminals for output of the inverter are connected to the ac load through the LC filter. The inverter circuit consists of three terminals for load phase and the current across the inverter switches is regarded as dc link current. The magnitude of dc link current varies in step manner during the ON and OFF condition of switches. The basic functioning of the three phase inverter is the conversion of DC voltage to AC voltage ensuring its operation as a complete source of energy.

An LC filter connected to 3ϕ VSI includes inductor as well as capacitor values which are minimum and the efficiency, cost, size, losses, and weight are varying, depending on the nature of filter. Initially the maximum ac current ripple is to be defined for the design of LC filter and an inductance of inverter side is selected at rated power with a phase current of 5%. To select the filter capacitance, the maximal power factor variation of the grid is considered as 5%.

The general equipment of the inductance voltage is zero in this stage and hence the voltage at the inductance is given as:

$$V_L = V_{INL} - V_G \quad (20)$$

The complete power factor variance of the grid is made to 5% during the selection of the filter capacitor. From the variation of the capacitor, the base value of the impedance in overall system, Z_B is given by:

$$Z_B = \frac{V_G^2}{P_{Av./3}} \quad (21)$$

$$C_B = \frac{1}{\omega_N . Z_B} = \frac{1}{2\pi f_N . Z_B} \quad (22)$$

$$C_{max} = 0.05\, C_B \quad (23)$$

Here, v_G indicates the line-to-line rms voltage, P_{AV} indicates the rated active power, and ω_N indicates the grid frequency.

II RESULTS AND DISCUSSION

The optimal DC voltage extracted from the PV panel using NEURO fuzzy based MPPT is injected into a SUPERLIFTLUO converter, which helps to improvise the dc voltage. The performance of SUPERLIFTLUO converter with NEURO fuzzy MPPT is verified. The simulation for the proposed approach is done in MATLAB and the obtained results are given as follows.

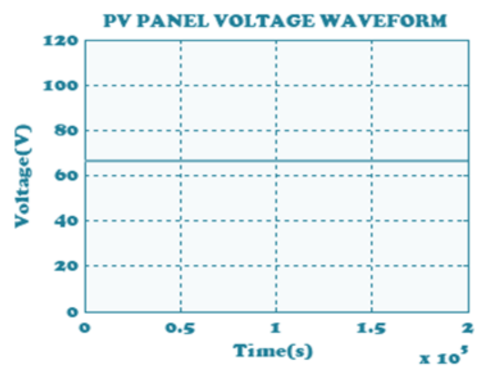
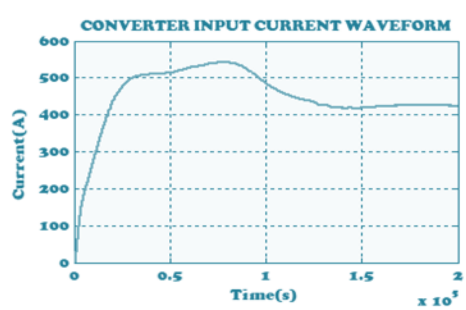
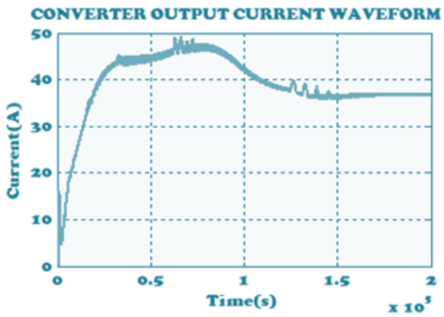


Figure 7 PV panel voltage waveform

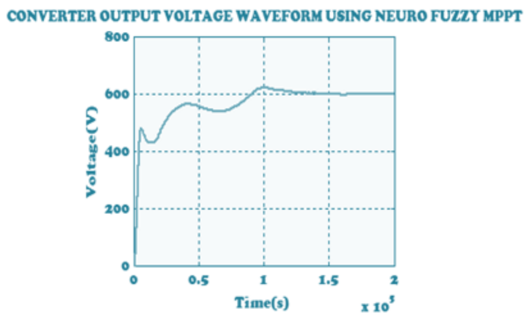
Figure 7 indicates the waveform for PV panel voltage and it represents a constant DC voltage. Generally it remains constant during the presence of sufficient irradiance from sunlight.



(a)



(b)



(c)

Figure 8 Converter waveforms (a) Input current (b) Output current (c) Output voltage

The output waveforms of the SUPERLIFTLUO converter is represented in Figure 8. The desired output waveform of theSUPERLIFT LUO converter with NEURO fuzzy based MPPT is represented in Figure 8 (c). The input voltage is of low range and is boosted to higher range bySuperlift Luo converter.

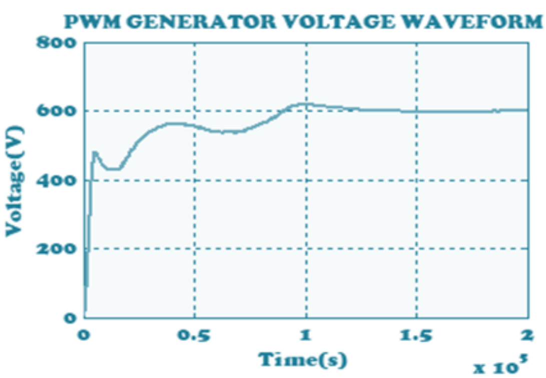
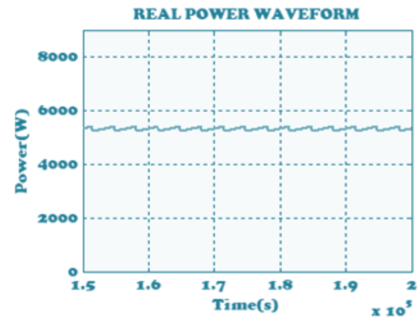
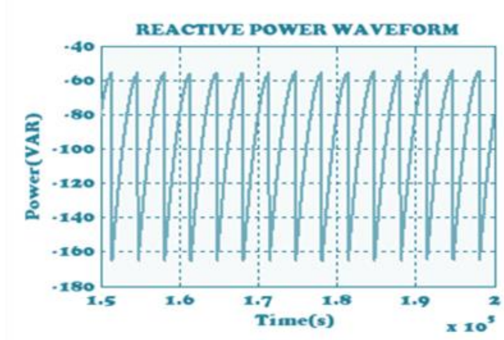


Figure 9 Voltage waveform for PWM rectifier

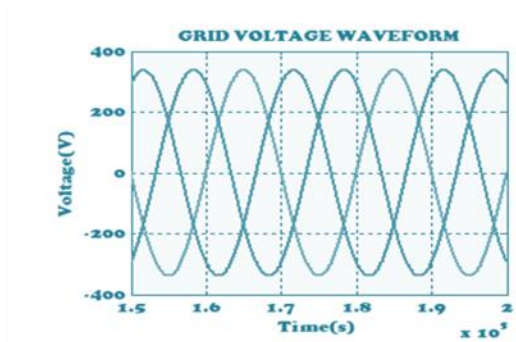


(a)

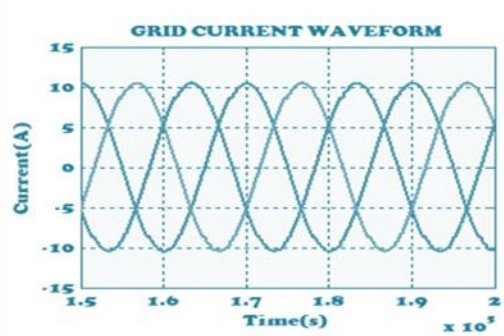


(b)

Figure 10 Power waveforms (a) Real power (b) Reactive power



(a)



(b)

Figure 11 Grid waveforms (a) Current (b) Voltage

An inverter feeds the complete energy produced by the PV system into the 3 grid. As a result, the PI controller is assigned for controlling the inverter’s functioning by analogizing actual and reactive power and securely injecting electricity into the grid. The PI control signal is sent to the PWM generator, which generates sufficient PWM pulses for the inverter, rather than directly to the inverter.From Figure 11 (b), it is noted that the grid current varies from $-10V$ to $+10V$.

III. CONCLUSION

This study presents a grid-connected PV system with an efficientSUPERLIFT LUO converter. The PV system’s output voltage is inefficient, therefore it is fed into theSuperlift Luo converter, which removes ripples from the output and efficiently boosts the voltage level. The converter has a superior voltage gain and fewer switching losses since it works regardless of irradiance variations.The maximum power extraction for the panel is done using the NEURO fuzzy MPPT algorithm.Furthermore, the PI controller has been used for efficient controlling characteristics as well as 3 VSI's conversion of fixed DC voltage to variable frequency AC voltage. The harmonics of the switching frequency are attenuated using an LC filter, resulting in minimal harmonics. As a result, the proposed approach increases power quality while simultaneously reducing grid synchronisation distortion.

REFERENCES

[1] C. Xing, X. Xi, X. He, C. Xiang, S. Li and Z. Xu, 2021"Research on Maximum Power Point Tracking Control of Wind-Solar Hybrid Generation System," 2021 China International Conference on Electricity Distribution (CICED), pp. 826-829.

[2] B. Venkatasamy, L. Kalaivani, P. R. Prakash, S. Prabhu and B. Mathana Gopal, "Performance Analysis of Grid-Tie Inverter for Reactive Power Injection Mode in Hybrid Wind Solar Energy System," 2018 2nd International Conference on Trends in Electronics and Informatics (ICOEI), pp. 652-656.

[3] P. S. Kumar, R. P. S. Chandrasena and K. V. Sam Moses Babu, 2020 "Design and Development of Hybrid Wind—Solar—Battery Power Generation System using SVPWM Based Multilevel Inverter for Grid Connected Application," 2020 IEEE PES/IAS PowerAfrica, pp. 1-5.

[4] A. Kerem, A. Aksoz, A. Saygin and E. N. Yilmaz, 2017 "Smart grid integration of micro hybrid power system using 6-switched 3-level inverter," 2017 5th International Istanbul Smart Grid and Cities Congress and Fair (ICSG),pp. 161-165.

[5] A. Sen, A. Banerjee and H. Nannam, 2020 "A comparative analysis between two DPFC models in a grid connected Hybrid Solar- Wind Generation system," 2020 IEEE International Conference on Power Electronics, Smart Grid and Renewable Energy (PESGRE2020), pp. 1-6.

[6] V. Chaudhary, A. Bhargava and S. Bhasin, "Modeling and Simulation of gird connected hybrid power system integrated with solar PV/Wind and controlled by Voltage Regulator," *2*019 International Conference on Communication and Electronics Systems (ICCES), 2019, pp. 1316-1320.

[7] K. R. Ritu, A. K. Wadhwani and A. Rajoria, 2018 "Techno-Economic Comparison of On Grid and Off Grid Hybrid WT / Solar Photo Voltaic Connected Power Generating Unit Using HOMER," 2018 International Conference on Advanced Computation and Telecommunication (ICACAT), pp. 1-9.

[8] S. Kumar, C. Sethuraman and G. Chandru, "Design of Control Unit for Off-grid and Grid Connected Solar-Wind Hybrid System Suitable for Supplying Power to both AC and DC Loads," 2021 International Conference on Recent Trends on Electronics, Information, Communication & Technology (RTEICT), 2021, pp. 331-338.