Journal of Green Engineering (JGE)

Volume-10, Issue-2, February 2020

Optimal Control Strategy Using PV Based LUO Converter for a Micro Grid to an Unelectrified Zone

[1]P.Sivagami and [2]N.M Jothi Swaroopan

[1]Research Scholar, Department of Electrical and Electronics Engineering, Sathyabama Institute of Science and Technology, Tamilnadu, India.
E-mail: sivagamitec@gmail.com
[2]Professor, Department of Electrical and Electronics, RMK Engineering College, Tamilnadu, India. E-mail: nmjothi@yahoo.com.

Abstract

Today's world, it is callous to envision the lifestyle without the provision and processing activities which use electrical energy, and its supply. In recent years, research concentrates not only on the design to effectuate the procreation of energy from sources which is available in plenteous but also contributes to the technical development in the environment. The sources that does not impoverish are renewable energy sources. It helps in providing pollution free and charge free power without any interruption. It is a challenging issue to design a controller of high performance to ensure system stability under any operating conditions such as disturbances due to environmental factors like irradiance and temperature in case of SOLAR and also load disturbances that is changes in load. The boosting techniques becomes mandatory for the fluctuating output of PV array. A frame work consisting of Photo Voltaic array (PV) array with positive super lift LUO converter for DC-DC conversion, H-bridge inverter for DC-AC conversion, with fuzzy controller on the converter side and sliding mode controller on the inverter side respectively. Fuzzy and Sliding Mode Controller (SMC)has high dynamic performance, robustness under fluttering parameters. In order

Journal of Green Engineering, Vol. 10_2, 463–479. Alpha Publishers

Alpha Publishers

to expound the schemed system efficacy, the simulated output of delineated controller is compared with PID, PI. The proffered module uses MATLAB. In order to envision the imperil a prototype is developed and experimented.

Keywords: Photo Voltaic array, Sliding Mode Controller,Fuzzy logic controller, environmental factors, pollution free.

1 Introduction

Middling to power our homes, industries we basically depend on energy sources which are exhausting. For meeting our power needs, however we have limited source of these resources on earth. In order to overcome this catastrophe non depleting energy sources are being used which not only assist in cutting down the emission of carbon gases but also brace us with charge free energy. The preeminent green energy sources that afford to formation of power are wind, photovoltaic, fuel cell systems, bio gas etc. In order to run over contemporary days energy crisis one green approach is to extract electrical energy from the sun's radiation which is free of charge for everyone on earth. Low operational and maintenance cost, environmentally friendly makes us prefer PV among all other available resources on earth. It is adumbrated that between 2019 and 2024 the power capacity generation contributed will increase to about 50% by SOLAR only. The operating point where the PV taps maximum light to harvest extreme power is named Maximum Power point (MPP). It is quintessential to harvest maximum power at all times for varying load conditions in spite of corporeal parameters such as insolation for energy conversion, temperature etc. Normally, MPPT method involves a dc-dc converter at the front end, with varying pulse width for the converter to overcome the impairment in power. Now a day's super-lift LUO converter has received significance due to geometric increment in the output voltage, high gain, low ripple, robustness etc. Luo converter output fed to ac load by using the usage of single-phase inverter. SMC ameliorate the potency at the output of the inverter.

Reduced order model SMC designed for input voltage and load as exotic parameters. The control law based on sliding mode module and estimator module are designed to have regulated output voltage [1]. Hampered power point tracking control scheme for controlling inductor current and MPPT for maximum power is interspersed with current loop in the inner and voltage loop in the outer for boost converter to effectuate fast transient response [2]. Positive output LUO converter is modified to have bridgeless structure with single voltage sensor for multitudinous variations such as variations in load power and supply voltage [3]. Adaptive twisting

algorithm takes into consideration of phase current of grid and dc line capacitor voltage. Grid phase sniff out current from the inner loop and voltage from outer loop. ASTA control method is effective for unknown variations in parameters [4]. Fuzzy logic controller designed for three phase inverters fed by PV. The estimated value of d and q axis used in injecting pulse for the inverter to obtain quality and stable power to the load [5]. For islanded grid, two level hierarchical control unit is developed for improving the performance of loads which may be static or dynamic [6]. Inner power loop and outer voltage loop based on second order sliding mode is proposed for variations in load and also for better tracking power [7]. A delineation for downsizing sensor numbers and computations forge slider by using output voltage and inductor current as the parameter is proposed [8]. A direct method for regulating output voltage of re lift converter insensitive to variations of load is designed [9]. Adaptive sliding mode control is proposed for nonlinear parameter perturbates. SMC technique employ the voltage across the capacitor in the output, maintaining the power factor close to 1 [10]. In order to attain stability sliding model control method is proposed for three phase inverters [11]. Sliding mode control jaunt out with current equivalent. The attribute magnitude for current is provided by external voltage loop to exhibit constant voltage at the output [12]. For maintaining constant output voltage for a step-up converter with coupled inductor MPPT controller is designed to have maximum power for varying irradiations [13]. PI controller is designed and simulated for various lift LUO converters [14].The constant output voltage positive output elementary fourth order converter is designed and developed involving the factors such as the inductor current at the output and the current available at the input. But for better regulation of output voltage input inductor current is sufficient [15].

2 Modules of Proposed System

The proposed work consists of an advanced boost converter. The delineation for the proffered scheme is shown in the Figure 1.In this work, the super-lift LUO converter is employed in which voltage increases in geometric progression. The circuit enrooted to overcome the impairment in the value of voltage at the output side of the converter is fuzzy logic controller. The output available from the converter becomes the input to the inverter bridge circuit, for the conversion of DC to AC. The inverter output is distributed to the load after filtering by LC filter.

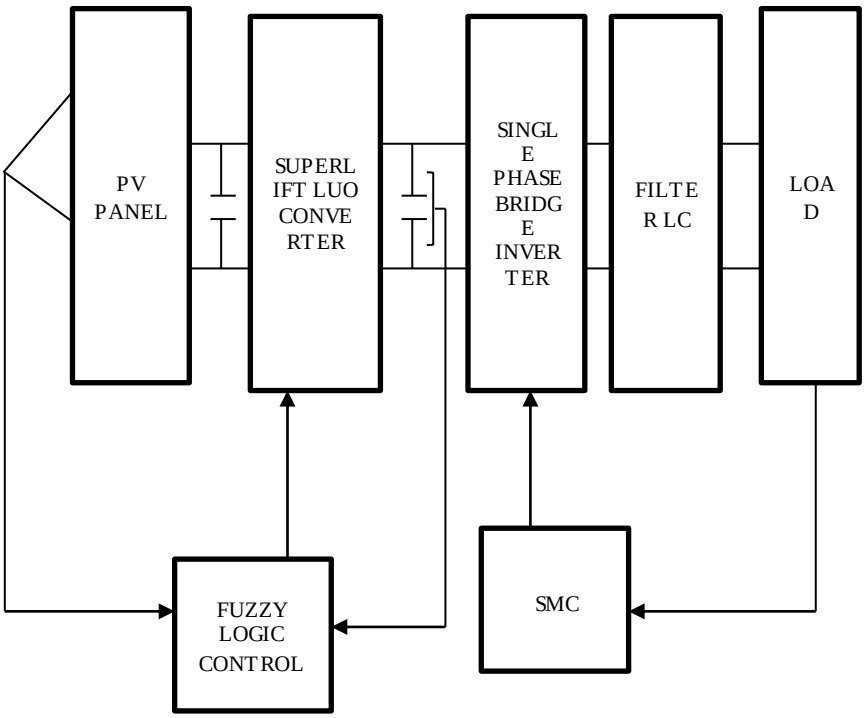

Figure 1 Representation of module proposed

The burgeoning of tapped PV power reckons the transmogrification efficacy of the brand of solar panel used. Among different types monocrystalline panels have approximately 20% efficacy but concentrated PV cell has 41% efficiency rate when it has additional set up of tracker and cooling system. Among other brands monocrystalline is endorsed and table 1 gives its particularization.

Table 1 Specifications of Monocrystalline Solar Panel

Parameter	Description
Dimension	1650 x 987 x 40 mm
Weight	17.5 kg
Cell / Matrix	60; Poly Crystalline;10 x 6
Open circuit voltage	38.25V
Current at Pmax	8.62 A
Short circuit current	9.14
Voltage at Pmax	30.79V
Rated power	265 Watts
Tc of Pm	-0.35 %/°C
Power tolerance	-0 / +4.99 W

The maximum energy harvested from PV is processed by positive voltage elementary super lift LUO converter. The two sensors perceive and arbitrate the magnitude of two quantities namely voltage and current, at the input and output. The output available at PV is calculated using the formula

$$P_{out} = V_{out} * I_{out} \quad (1)$$

V_{out} & I_{out} is the voltage and current available at PV panel output. The data sheet dispenses the values of solar panel for different temperature and irradiation.

Industrial requirement has made us to search DC-DC conversion technique which can harness energy at its maximum. LUO converter integrated with FLC harvest maximum energy with reduced ripple and high transfer gain.

3 Controller Technique for DC System Proffered

The output available from the fuzzy logic controller helps in forging decisions for the desiderate response. Bounteous applications for a wide sway of control requires sleek operation. FLC procreate the pulses required for LUO converter based on the error signal.

The value that lapse is transition between the reference and real output voltage. The permeation between product of voltage and current at the instant and the maximum power is also taken into scrutiny. Fuzzy factor is the ratio change in value of power to change in value of voltage. The permeation is the ratio of shift between the power at wink and previous state to the difference in voltage at instant and previous value. The error transition is the variation between error at instant and error before. The five variables of fuzzy logic are negative big, positive big, negative small, positive small and zero. Figures 2 and 3 delineate the membership functions and error transition. Figure 4, 5, 6 exhibit output variable plot, rule set and surface view.

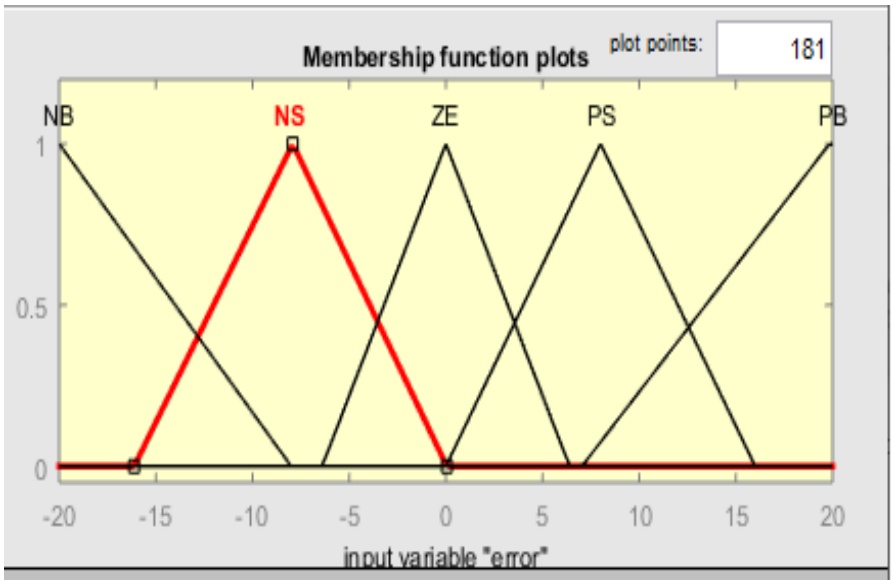

Figure 2 Membership functional plot for error

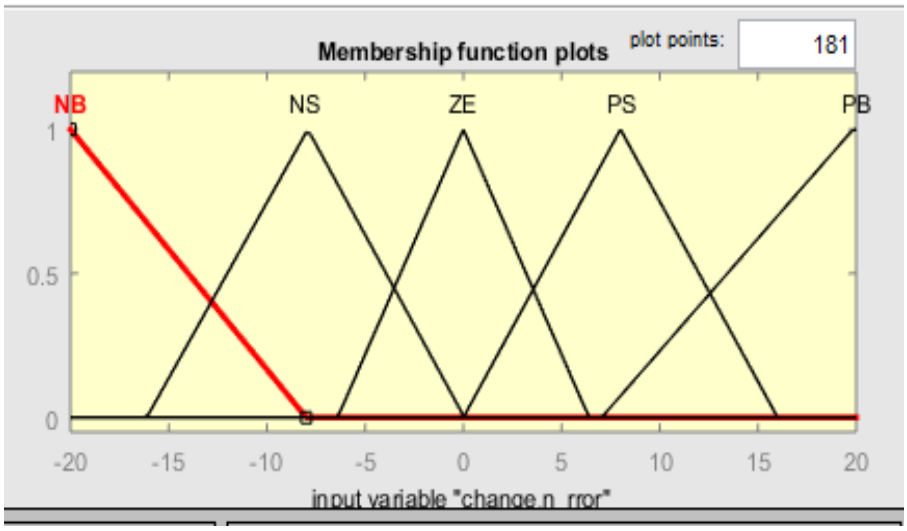

Figure 3 Membership functional plot for change in error

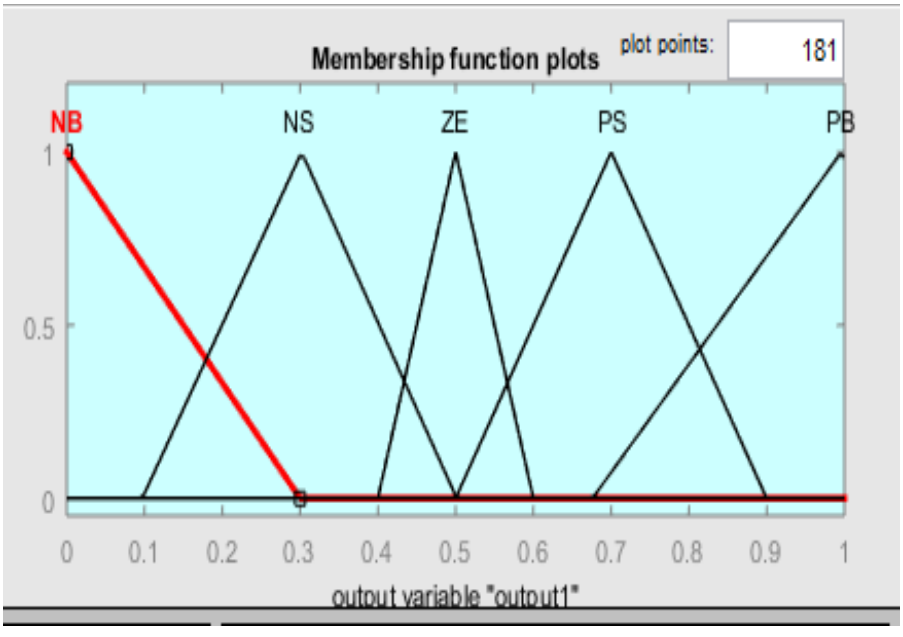

Figure 4 Membership functional plot for output

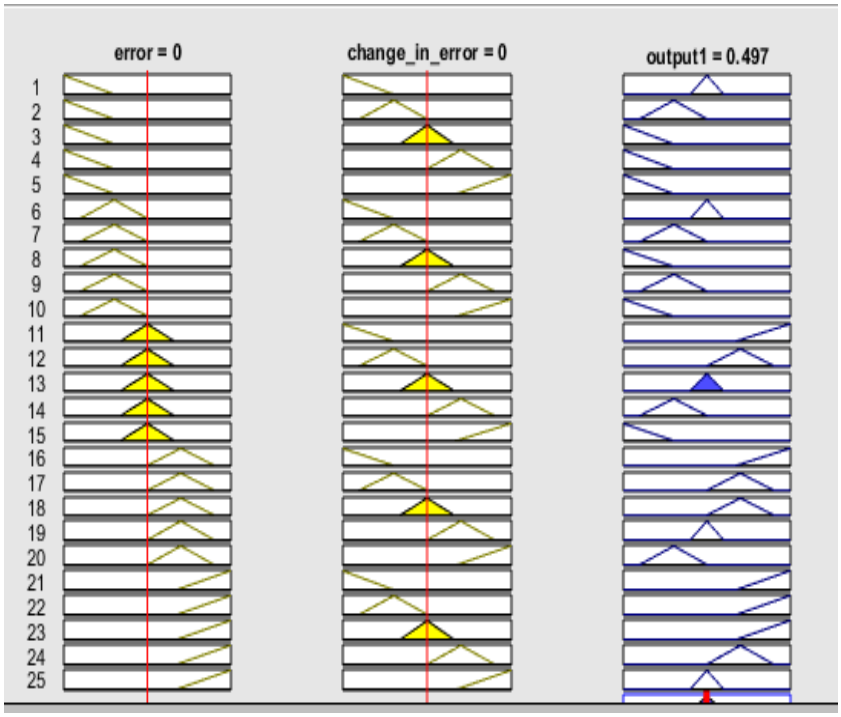

Figure 5 Rule view appearance of Fuzzy Logic controller

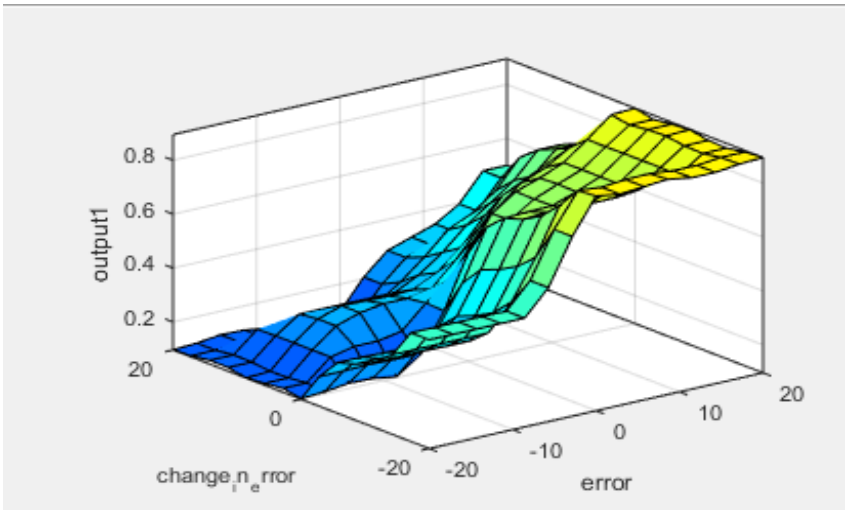

Figure 6 Surface view appearance of Fuzzy Logic Controller

4 SMC Controller Technique for Single Phase H Bridge Inverter

The maximum extracted energy available from PV acts as source of input to proffered inverter. The switches number cut down to four for energy conversion. The maximum energy tapped from the light is unidirectional source which is inseminated with the unit H bridge inverter. It transforms unidirectional source to a bidirectional source for the applications of load. This controller is built up and implemented for single phase supply. The SMC controller circuit is implemented along with filter circuit to provide harmonic less component to the load. The figure 7 put into effect the H bridge inverter. The table 2 shows the output + Vdc when switches S1, S2 are kept closed. S3, S4 switches are closed to yield -Vdc. The magnitude of voltage available at the inverter side is reconciliated into effect by SMC.

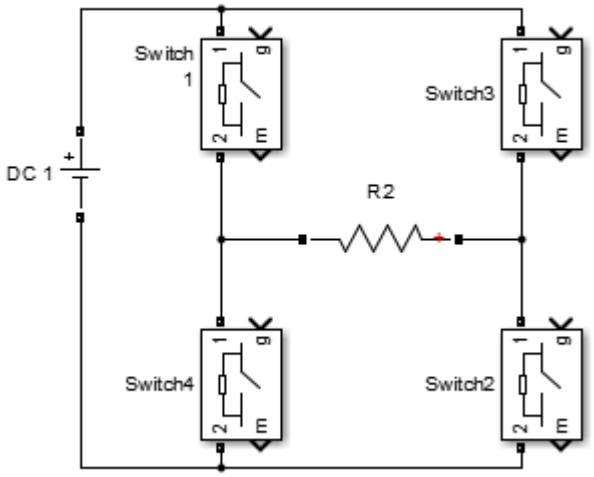

Figure 7 Representation of H bridge inverter

Table 2 States of H bridge inverter

State	Switches Closed	Vo
1	S1 & S2	+ Vdc
2	S3 & S4	-Vdc
3	S1 & S3	0
4	S2 & S4	0

5 Simulation and Results Discussion

Success of the venture is determined by the output we get from the assembled hardware. The output of the hardware provoked in various forms. One among them is the fusing of the components by the use of MATLAB Simulink software. The delineated system is simulated using it. The duty cycle of the power converter and inverter whip up using PI, PID, FLC and SMC controller respectively and it is simulated based on the chosen data. The schematic figure 8 and 9 shows the Simulink of FLC controller and PID.

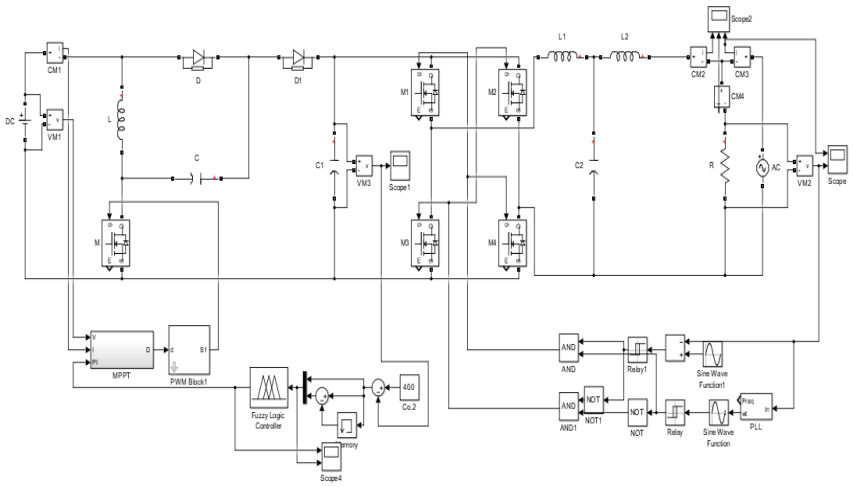

Figure 8 Simulink of FLC

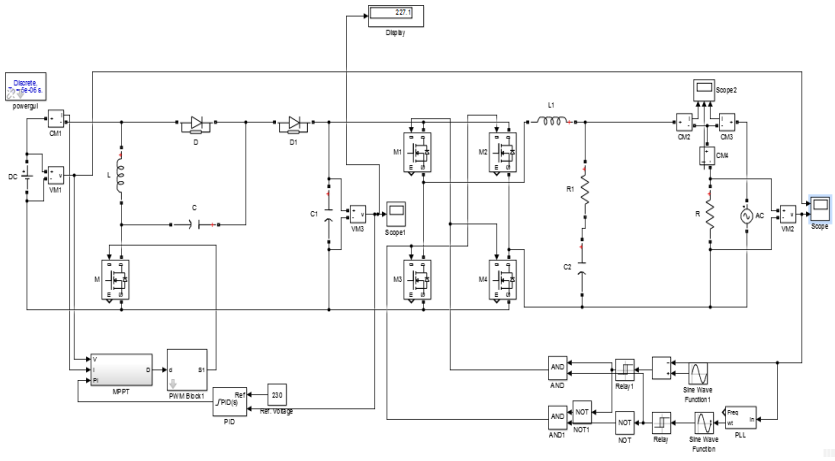

Figure 9 Simulink of PID

The output obtained from the simulation of FLC and PID is represented by figures 10 and 11. The table 3 and 4 is the outcome of simulation for various inputs of dc input voltage of FLC and PID. The output voltage and current of inverter after simulating using SMC controller is delineated in figure 12 and 13. The hardware setup invoked for the designed scheme is exhibited in figure14.

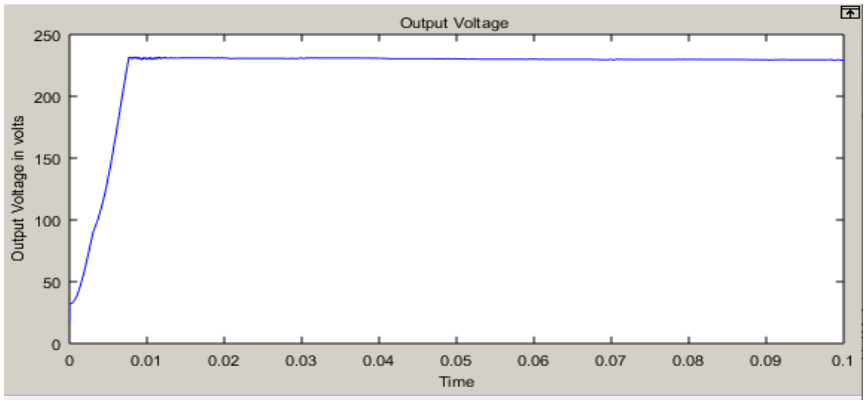

Figure 10 Simulated output voltage for fuzzy logic controller

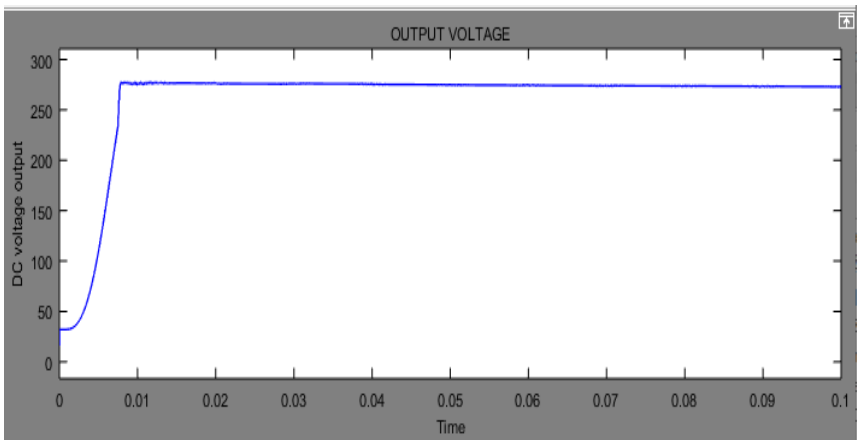

Figure 11 Simulated output voltage for fuzzy logic controller

Table 3 Simulated output results for FLC

S.NO	INPUT VOLTAGE(V)	OUTPUT VOLTAGE(V)	SETTLING TIME
1	22	253	0.07
2	24	255	0.065
3	26	256	0.06

Table 4 Simulated output results for PID

S.NO	INPUT VOLTAGE(V)	OUTPUT VOLTAGE(V)	SETTLING TIME
1	22	259	0.52
2	24	260	0.69
3	26	262	0.8

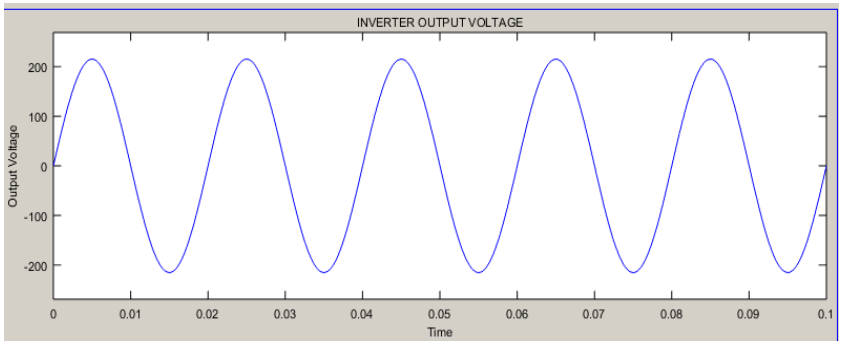

Figure 12 Simulated output voltage of inverter

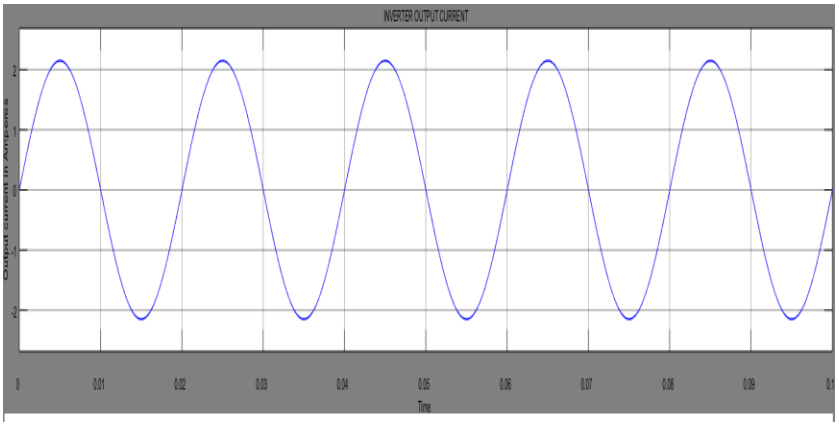

Figure 13 Simulated output current of inverter

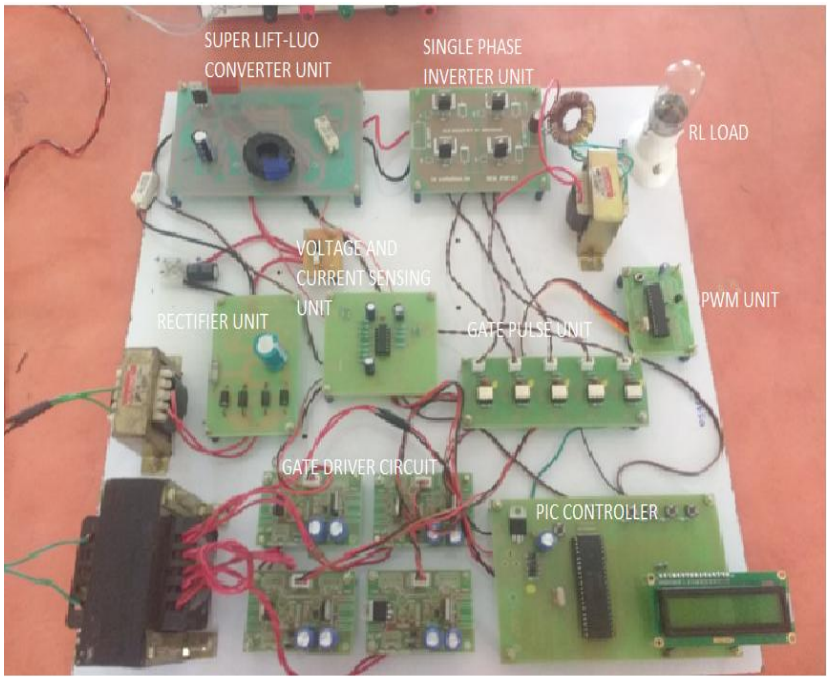

Figure 14 Hardware setup of scheme proffered

6 Conclusions

The hardware pursuance is one in all methods by which one can legitimize the performance improvement of the venture proposed. Controller scheme invoked for tracking maximum output energy extraction form the PV panel and regulating ac voltage of the inverter shows efficacy compared to other controller under transient conditions. Thus, intelligent techniques can harness maximum energy level at the output in spite of various parameter disturbances.

References

[1] M. Mahdavi, M. Shahriari-kahkeshi , N. R. Abjadi, "An Adaptive Estimator-Based Sliding Mode Control Scheme for Uncertain POESLL

Converter", IEEE Transactions on Aerospace and Electronic Systems, vol. 55, no. 6, pp. 3551-3560, 2019.

[2] L. V. Bellinaso, H. H. Figueira, M. F. Basquera, R. P. Vieira, H. A. Gründling , L. Michels, "Cascade Control With Adaptive Voltage Controller Applied to Photovoltaic Boost Converters", IEEE Transactions on Industry Applications, vol. 55, no. 2, pp. 1903-1912, 2019.

[3] J. Gnanavadivel, P. Yogalakshmi, N. Senthil Kumar , K. S. Krishna Veni, "Design and development of single phase AC–DC discontinuous conduction mode modified bridgeless positive output Luo converter for power quality improvement", IET Power Electronics, vol. 12, no. 11, pp. 2722-2730, 2019.

[4] W. Luo, T. Zhao, X. Li, Z. Wang , L. Wu, "Adaptive super-twisting sliding mode control of three-phase power rectifiers in active front end applications", IET Control Theory & Applications, vol. 13, no. 10, pp. 1483-1490, 2019.

[5] M. A. Hannan, Z. A. Ghani, M. M. Hoque, P. J. Ker, A. Hussain A. Mohamed, "Fuzzy Logic Inverter Controller in Photovoltaic Applications: Issues and Recommendations" , IEEE Access, vol. 7, pp. 24934-24955, 2019.

[6] E. S. N. Raju P. , T. Jain, "A Two-Level Hierarchical Controller to Enhance Stability and Dynamic Performance of Islanded Inverter-Based Microgrids With Static and Dynamic Loads", IEEE Transactions on Industrial Informatics, vol. 15, no. 5, pp. 2786-2797, 2019.

[7] J. Liu, Y. Yin, W. Luo, S. Vazquez, L. G. Franquelo , L. Wu, "Sliding Mode Control of a Three-Phase AC/DC Voltage Source Converter Under Unknown Load Conditions: Industry Applications", IEEE Transactions on Systems, Man, and Cybernetics: Systems, vol. 48, no. 10, pp. 1771-1780, 2018.

[8] H. N. Jazi, A. Goudarzian, R. Pourbagher , S. Y. Derakhshandeh, "PI and PWM Sliding Mode Control of POESLL Converter", IEEE Transactions on Aerospace and Electronic Systems, vol. 53, no. 5, pp. 2167-2177, 2017.

[9] W. Jiang, S. H. Chincholkar and C.Y. Chan, "Improved output feedback controller design for the super-lift re-lift Luo converter" , IET Power Electronics, vol. 10, no. 10, pp. 1147-1155, 2017.

[10] J. Liu, Y. Gao, W. Luo , L. Wu, "Takagi–Sugeno fuzzy-model-based control of three-phase AC/DC voltage source converters using adaptive sliding mode technique" , IET Control Theory & Applications, vol. 11, no. 8, pp. 1255-1263, 2017.

[11] M. Zhang, Y. Li, F. Liu, L. Luo, Y. Cao , M. Shahidehpour, "Voltage Stability Analysis and Sliding-Mode Control Method for Rectifier in DC

Systems With Constant Power Loads" , IEEE Journal of Emerging and Selected Topics in Power Electronics, vol. 5, no. 4, pp. 1621-1630, 2017.
[12]Yunfei Yin, W. Luo, J. Liu, S. Vazquez, L. Wu , L. G. Franquelo, "Sliding mode control of three-phase power converters with disturbance attenuation performance", 11th IEEE International Conference on Compatibility, Power Electronics and Power Engineering (CPE-POWERENG), 2017.
[13]G. J. G. Jothi , N. Geetha, "An enhanced MPPT technique for high gain DC-DC converter for photovoltaic applications", International Conference on Circuit, Power and Computing Technologies (ICCPCT), 2016.
[14]R. R. Kumar, M. Ramachandra, S. Saranya ,H. Divya, "Design and performance evaluation of PI controller for multiple lift main series 2 and 4 lift push pull switched capacitor Luo converter", International Conference on Circuit, Power and Computing Technologies (ICCPCT), 2016.
[15]S. H. Chincholkar , C. Chan, "Comparative study of current-mode controllers for the positive output elementary Luo converter via state-space and frequency response approaches", IET Power Electronics, vol. 8, no. 7, pp. 1137-1145, 2015.

Biographies

P. Sivagami She received her B.E degree in Electrical and Electronics Engineering in 2002 from Madras University, Tamil Nadu ,India and M.E degree in power electronics and Industrial drives in 2012 from Sathyabama University, Chennai, India. Currently she is pursuing Ph.D degree in Sathyabama Institute Of Science And Technology. Her research interests Power Electronics, IOT based performance improvement of Renewable Energy sources.

Dr. N.M. Jothi Swaroopan He is working as Professor in the Department of EEE in RMK Engineering College, Tamil Nadu, India. He has received his B.E degree in Electrical and Electronics Engineering in 1997, M.E. and Ph.D in the year 2005 and 2011 from College Of Engineering, Guindy, Tamil Nadu, India. His areas of interest include Renewable energy technologies, Power System and Power Electronics.