As per UGC guidelines an electronic bar code is provided to seure your paper

International Journal for Modern Trends in Science and Technology, 8(06): 545-555, 2022

ISSN: 2455-3778 online
DOI: https://doi.org/10.46501/IJMTST0806093
Available online at: http://www.ijmtst.com/vol8issue06.html

Check for updates

Modified MPPT Converter with PI Control Technique for DC-to-DC Converter Application

Persey J[1] | Dr.S. Titus[2]

[1]Dept. of Electrical & Electronics Engineering, K. Ramakrishnan College of Engineering (Autonomous)
[2]Dept. of Electrical and Electronics Engineering, K. Ramakrishnan College of Engineering (Autonomous)
*Corresponding Author : percyantrya26@gmail.com

To Cite this Article
Persey J and Dr.S. Titus. Modified MPPT Converter with PI Control Technique for DC-to-DC Converter Application. International Journal for Modern Trends in Science and Technology 2022, 8(06), pp. 545-555. https://doi.org/10.46501/IJMTST0806093

Article Info
Received: 22 May 2022; Accepted: 18 June 2022; Published: 24 June 2022.

ABSTRACT

An dc- dc converter is used in MPPT (Maximum Power Point Trackers) to improve match between solar panel and loads. Solar (PV) modules are controlled by an electronic control system that permits each module to produce the maximum amount of electrical energy possible. Using MPPT technology, the modules can operate at varying electrical operating points, allowing them to deliver maximum power. Additional power collected from the modules is used to expanded battery charging current. MPPT takes a gander at the results of the boards and analyses the battery voltage to determines absolute maximum power that panel can produce by using an algorithm. By converting it to the best voltage, it gets the most AMPS into the battery. Most MPPTs are 92-97% capable of converting data. When compared to a normal PWM controller, we gain 20 to 45 percent power in the winter and 10-20 percent in the summer. Solar panels provide the majority of their electricity all at once known as Maximum Power Point (MPP).MPP is impacted by the progressions in ecological factors like sun irradiation and temperature. In order to produce maximum power, solar cells must always reach their MPP despite changes in climate. For this reason, the applied controllers on solar panels employ the MPPT algorithm. Our objective is to design an MPPT method based on the PI logic controller (PI) that will reach MPP in a short period of time and will adapt to change environmental conditions when necessary. It focuses primarily on writing and re-enactments. The MPPT based on PI seems to be able to detect and reach MPP regardless of whether the irradiance changes slowly or quickly.

KEYWORDS:SolarPhotovoltaic (PV), Flyback Converter, LUO converter and PI Controller

1. INTRODUCTION

The DC/DC converter widely used to manage switch mode DC power supply. The contribution of these converters is an unregulated DC voltage, which is obtained by PV exhibits and subsequently, it will vary because of changes in radiation and temperature. In those converters, the regular DC yield voltage need tomanaged to be likened to the correctreally well worth albeit the information voltage is evolving. According to power perspective, yield voltage tenetwithinside the DC/DC converter carried outvia way of means ofusuallyconverting how an awful lotpower is retained from the supply and that infused into the heap, that isconsequentlyrestrainedvia way of means ofthe overall lengths of the retention and infusion stretches.

These two fundamental cycles of energy assimilation and infusion establish an exchanging cycle. Naturally talking, assuming that the energy storage capacity of the converter is too small or the switching period is relatively too long, then the converter would have transmitted the stored energy to the load before the following cycle starts. This presents a idling period quickly following the infusion span, during which the converter isn't performing any specific task. The converter can along these lines work in two distinct modes relying on its energy stockpiling limit and the general length of the exchanging time frame. These two modes are known as the irregular conduction and continuous modes.

The DC/DC help converter just necessitates four parts: inductor, the electronic switch, diode and capacitor. This converter works in 2 unique modes depending upon its energy stockpiling restrict and the general duration of the changing time frame these two working modes are known as irregular conduction mode DCM and CCM there are benefits of PVs like lowering environmental pollution offering easy strength and generating energy everywhere there's sunlight. Voltage and Power of PV panels depend on several factors like irradiation and temperature.

To examine the photovoltaic module's reaction under the exceptional conditions the system turned into operated under variable irradiations and temperatures. PV structures include PV modules and DC-DC converters. Flyback converter is one of the converters used to control the voltage of PV panel.

The topology of flyback converters is totally based on buck-boost converters but there can be a difference in some of the insulated transformers rather than storage inductors. The transformer presents insulation and due to the variable turns ratio, the output voltage can be adjusted easily.

The development of industry new control methods developed, PI control is one of the control methods, which is easy to implement the system, also it has effective results. In this study, PI manage carried out a switch of the converter to adjust the duty cycle PWM to fee the battery with a steady voltage method, the system changed into built and analysed in MATLAB / Simulink.

2. EXISTING CONVERTER

MPPT are so critical in PV systems to build their efficiency. Various approach has been proposed to achieve maximum power. PV modules are good for establishing under different environmental conditions.

The structure contains a PV solar module associated with a DC-DC Buck-Boost converter.

The framework has been capable of aggravation in the PV temperature and irradiance level. The simulation result shows the proposed MPT could follow the maximum power unequivocally and viably in all conditions attempted.

Correlation of different performance limits, e.g., following productiveness and response season of the system indicating that proposed approach provides better proficiency and better final performance when compared with perturbation and observation methods.

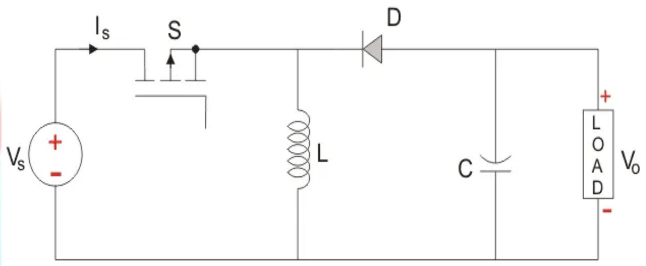

FIG1. EQUIVALENT CIRCUIT OF BUCK-BOOST CONVERTER

It clarifies functioning method for modern-day framework. A buck converter is sort of DC-to-DC converter in any other case referred to chopper that has a result voltage quantity this is both greater outstanding then or now no longer precisely the statistics voltage size.

It is applied to "step up" the DC voltage, like a transformer for AC circuits. It corresponds to a flyback converter using a single inductance instead of a transformer. Two distinct geographies are known as buck-boost converters. DC-DC converters is defined as choppers.

Here we can study the Buck-Boost converter which can act as DC-DC Step-Down converter or a DC-DC Step-Up converter by relying on the duty cycle, D.

Diode is tied, back to step of switch from the power supply, to a capacitor and the heap, and the 2 are related similarly as displayed withinside above FIG.1. The switch is controlled wide to be here and thereby using Pulse Width Modulation (PWM). PWM can be time- based or recurrence-based totally.

3. PROPOSED CONVERTER

The Flyback Converter obtained PV board is constrained by PI technologies. A PV system can be considered as a direct (direct current) source with the goal that one of the DC-to-DC converters, flyback converters, is utilized to manage voltage and current of the PV Panel. The PI Controller applied a switch (MOSFET) to direct the duty cycle (PWM) with consistent voltage technique.

a) DESIGN AND ANALYSIS OF FLYBACK CONVERTER

To regulate the voltage of the PV panel, a flyback converter is used in the proposed system. The flyback converter operation is shown in FIG.2 and FIG. 3. When the switch (MOSFET) is turned on, the primary side of the transformer is connected to the PV panel, and energy is stored in the primary winding.

Since the polarities of primary and secondary windings are different, the series diode of the secondary side gets reverse biased and is not conducting Shown in FIG. 2,3. When the switch becomes off, stored energy withinside the magnetic core and air gap transfer to the secondary winding, the magnetic inductance current flows via the secondary side shown in FIG.3.

There are three modes to operate a Flyback converter; Continuous connection mode (CCM), Discontinuous conduction mode (DCM), and critical operation mode. Because of the fast response to the load current and variations of input voltage, in this system, CCM is preferred.

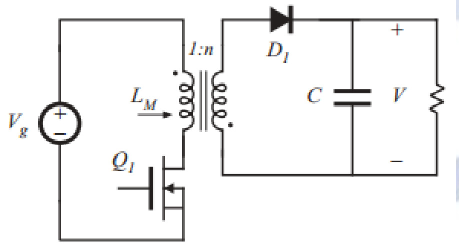

FIG 2. FLYBACK CONVERTER SWITCH ON MODE

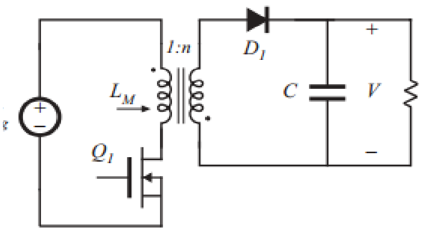

FIG 3. FLYBACK CONVERTER SWITCH OFF MODE

The equation for energy stored at the air gap,

E =1/2x Lp x Ip2.

Where,

Lp is the primary winding inductor

Ip primary winding current.

It is known that mean voltage on the inductors of transformer is zero at steady-state condition,

(Vp -Vsch) x ton = (Vo + Vd) x toff xn,

Where,

Vpv is input voltage (PV),

Vsch is switch voltage,

Vo is output voltage,

Vd is diode anode-cathode voltage,

N is turn ratio of transformer,

ton is switch on time,

toff is switch off time.

The equations of a flyback converter in DCM (discontinuous conduction mode) are following

For CCM the period of the switch is

T = ton + toff

(a) OPERATION SCENARIO OF FLYBACK

FLYBACK CONVERTER OPERATION AND PRINCIPLE WHEN THE SWITCH IS TURNED ON

At this point, primary winding charges and currents can be generated while the switch is on.

Vin-VL-Vs=0

FLYBACK CONVERTER OPERATION AND PRINCIPLE WHEN THE SWITCH IS TURNED OFF

The operation of the flyback converter in the OFF state when OFF is focused on the secondary. A secondary current may flow when the switch is off.

When doing KLV,

VL secondary-VD-Vout = 0

b) LUO CONVERTER

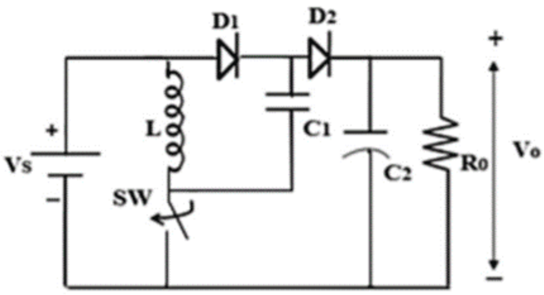

FIG 4. CIRCUIT DIAGRAM OF LUO CONVERTER

Perhaps the most notable strategy used primarily to construct electronic circuits is voltage swing technology, which has recently found a wider range of applications in DC power converters. Such type of converter is the Super lift-Luo converter, which is outlined in Figure 4. Using voltage swing technology, this type of converter tuning results in a positive voltage at a particular voltage and achieves first quadrant operation with a higher voltage gain compared to boost converters. In Figure 4, Vs is the positive DC input voltage, Vo is the corresponding output voltage, SW is the n-channel MOSFET, D1 and D2 are the freewheel diodes, L is the inductor, and C1 and C2 are the capacitors. The converter works with CCM and achieves high power density. Moreover, all the parameters are assumed to be the ideal ones. State model of the positive result Luo converter the dynamic equations describing the system functions are state affine and time invariant which is depicted as follows,

$\dot{x}(t') = A1(t') + B1\ Vs\ (t')$, sw=1

$\dot{x}(t') = A2(t') + B2\ Vs\ (t')$, sw=0

Here SW= 1 implies the on condition of the switch and SW = 0 means the off condition of the switch. A1, A2, B1, and B2 are the coefficient matrices given by,

$$A_1 = \begin{bmatrix} 0 & 0 \\ 0 & \frac{-\alpha}{R_o C_2} \end{bmatrix}; A_2 = \begin{bmatrix} 0 & \frac{\alpha - 1}{L} \\ \frac{1-\alpha}{C_2} & \frac{\alpha - 1}{R_o C_2} \end{bmatrix}; B_1 = \begin{bmatrix} \frac{\alpha}{L} \\ 0 \end{bmatrix} \text{ and } B_2 = \begin{bmatrix} \frac{2-2\alpha}{L} \\ 0 \end{bmatrix}$$

By the discrete equal is obtained by using the corresponding related equations,

$$G' = e^{AT'_s} H' = \int_{\tau=0}^{T'_s} e^{A\tau} d\tau B$$

$$C'_d = CD'_d = D$$

Where G0, H0, C0 d, and D0 d are the coefficient matrices for the discrete-time system. For discrete signs, the situations describing super lift Luo converter are

$$G' = \begin{bmatrix} 0.9998 & -0.0334 \\ 0.0111 & 0.9990 \end{bmatrix}$$

$$H' = \begin{bmatrix} 0.0133 \\ 0.0001 \end{bmatrix}$$

gotten as

4. BLOCK DIAGRAM OF PROPOSED SYSTEM

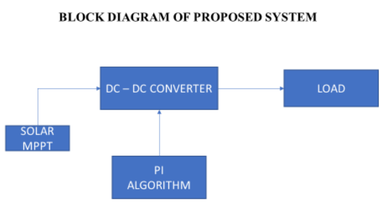

FIG 5. BLOCK DIAGRAM OF PROPOSED SYSTEM

MPPT is attached to the DC-to-DC converter. It includes converters which can be flyback converter and Luo converter. From the PI algorithm pulse is generated and given to the converter it generates a pulse to load.

The proposed flyback combined Luo converter design calculations by considering the switch position are mentioned below.

At ideal condition,

Vs = 0 (voltage drop)

Then Vin – VL = 0

Where, VL = Vin

VL = Lp di/dt

di = (Vin / Lp) x dt

By applying integration on each side,

we get,

Current on the primary winding,

Ipri = (Vin. /Lp) Ton

Where Vin = input voltage

Lp = inductance of the primary winding

Ton = while the switch is turned ON

The total energy stored in the primary winding,

Epri = ½ Ipri2 X Lp

When the switch is OFF, we get

VL (sec) – VD – Vout = 0

The diode voltage drop might be 0 at ideal condition

VL (sec) – Vout = 0

$V_L (sec) = V_{out}$

$V_L = L_s \, di/dt$

$di = (V_{L\,sec} / L_s) / dt$

Since $V_{L\,sec} = V_{out}$

Hence,

$di = (V_{out} / L_s) \times dt$

By making use of integration, we get

$I_{sec} = (V_{sec}/L_s)\,(T - T_{on})$

The total energy transferred is expressed as

$E_{sec} = ½[(V_{sec}/L_s).\,(T - T_{on})\,]2.\,L_s$

Where V_{sec} = secondary winding voltage (total output voltage on the load)

L_s = inductance of the secondary winding

T = PWM signal period

T_{on} = switch ON time

5. MODELING AND SIMULATION

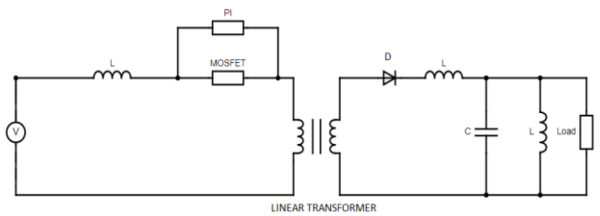

FIG 6.CIRCUIT DIAGRAM OF PROPOSED CONVERTER

The proposed flyback joined Luo converter is extraordinarilybasic and containselectricalcomponents like a proposed flyback combined Luo transformer, switch, rectifier, channel, and a managedgadget to drive the switch and reap regulation. The switch is used to turn ON and OFF the primary circuit. The PWM signal from the regulator controls the activity of the switch. In the extrapart of the proposed flyback combined Luo transformer plans, FET or MOSFET, semiconductor is appliedbecause of theswitch.

The rectifier corrects the voltage of the secondary winding to get DC output and heap from the secondary winding of the transformer. The capacitor channels the rectifier yield voltage and expands the DC yield stageaccording tothe ideal application.

The proposed flyback joined Luo transformer is applied as an inductor to save magnetic energy. It is deliberate as a coupled inductor, which is goingapproximatelybecause of theessential and non-compulsory winding. It works at excessive frequencies 50KHz.

It is important to consider the proposed flyback consolidated Luo converter plan estimations of the turns proportion, obligation cycle, and the flows of primary and secondary windings. Since the turns sharemay alsohave an effect on the current coursing through the primary and secondary winding and moreover the duty cycle. At the pointwhilst the turnproportion is excessive, then, at that factor, the duty cycle moreoverseems to be excessive, and the modern-dayis goingthrough the vital and non-compulsory winding abatements.

As the transformer appliedwithinside the circuit is a custom kind, it is impractical to get a super transformer with a turn share nowadays. Henceforth throughchoosing the transformer with the appropriatevalue determinations and closer to the vitalreviewsmay also make up for the differencewithinside the voltage and output.

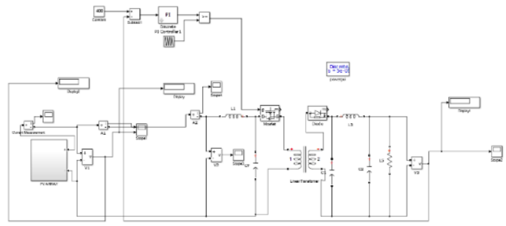

FIG 7. SIMULATION MODEL

The above given FIG 7.is a simulation diagram of flyback converter combined Luo converter design is very simple. It contains electrical components like a flyback combined Luo transformer, switch, rectifier, filter, and a control device to drive the switch and achieve regulation.

The switch is used to ON and OFF the primary circuit, which can magnetize or demagnetize the transformer. The PWM signal from the controller controls the operation of the switch. In flyback combined Luo transformer designs, FET or MOSFET or a basic transistor is used as the switch. Rectifier rectifies the voltage of the secondary winding to get pulsating DC output and disconnects the load from the secondary winding of the transformer. The capacitor filters the rectifier output voltage and increases the DC output level as per the desired application. The flyback combined Luo transformer is used as an inductor to store the magnetic energy. It is designed as a two coupled inductor, which acts as the primary and secondary winding.

6. SIMULATION RESULT

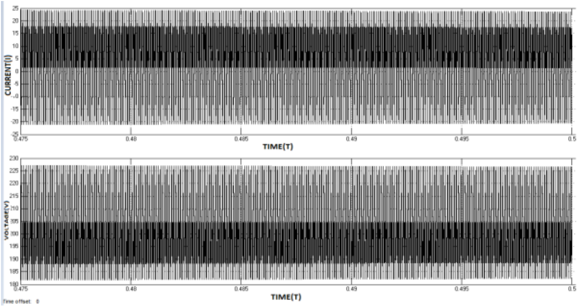

FIG 8. INPUT CURRENT AND INPUT VOLTAGE WAVWFORM

The above given FIG 8is a waveform of input current and input voltage. Input voltage=201.8V and Input current=4.15 A.

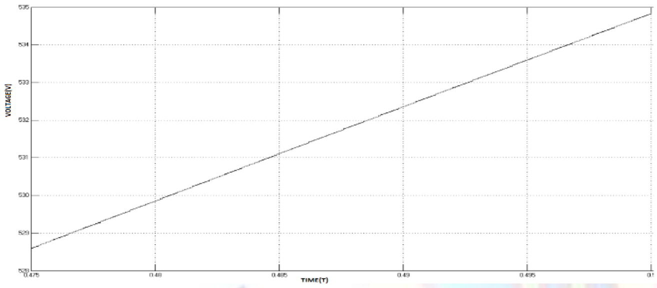

FIG 9 OUTPUT VOLTAGE WAVEFORM

The given FIG 9 is a waveform of output voltage. When input voltage 201.3 V is given output voltage of the system is 534.8 V and current remains constant. The X axis of the waveform is time(t) and the Y axis of the waveform is voltage(v).

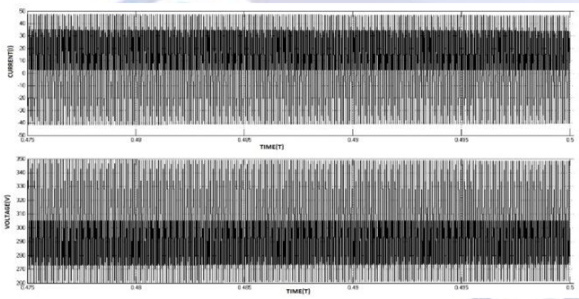

FIG 10. INPUT CURRENT AND INPUT VOLTAGE WAVWFORM

The above given FIG 10 is a waveform of input current and input voltage. Input voltage=299.9 V.

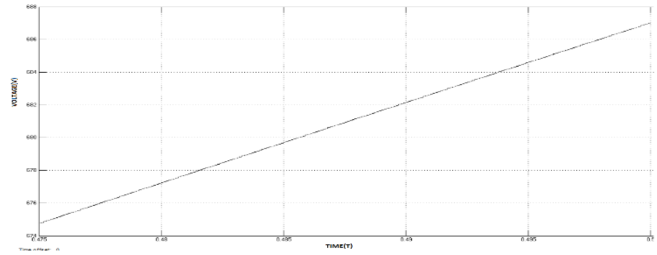

FIG 11 OUTPUT VOLTAGE WAVEFORM

The given FIG 11 is a waveform of output voltage. At the point when input voltage 299.9V V is given output voltage of the framework is 687 V and current remains steady. The X axis of the waveform is time(t) and the Y axis of the waveform is voltage(v).

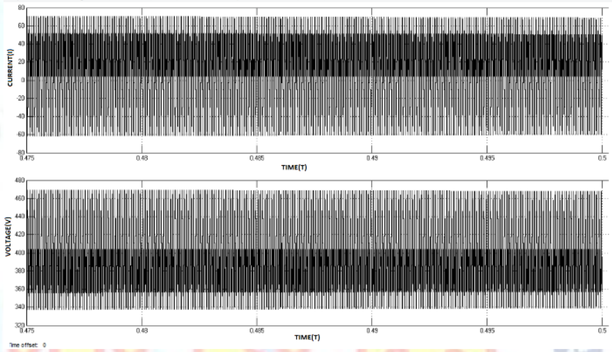

FIG 12. INPUT CURRENT AND INPUT VOLTAGE WAVWFORM

The above given FIG 12 is a waveform of input current and input voltage.

Input voltage=396 V.

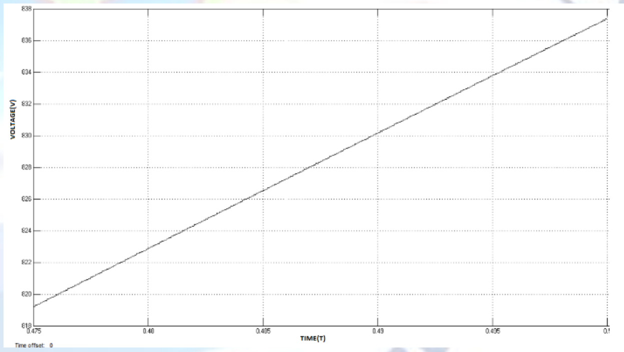

FIG 13 OUTPUT VOLTAGE WAVEFORM

The given FIG 13 is a waveform of output voltage. At the point when input voltage 396 V is given output voltage of the framework is 837.3 V and current remains steady. The X axis of the waveform is time(t) and the Y axis of the waveform is voltage(v).

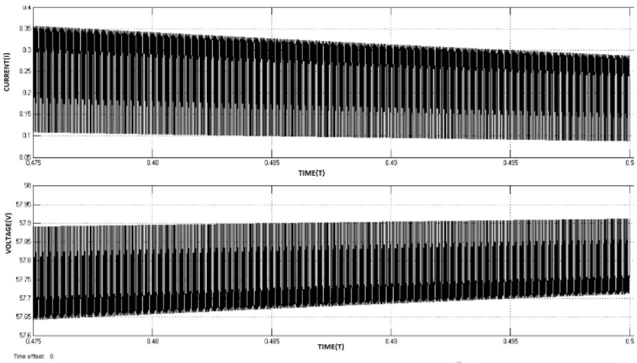

FIG 14. INPUT CURRENT AND INPUT VOLTAGE WAVWFORM

The above given FIG 14is a waveform of input current and input voltage.

Input voltage=57.75 V.

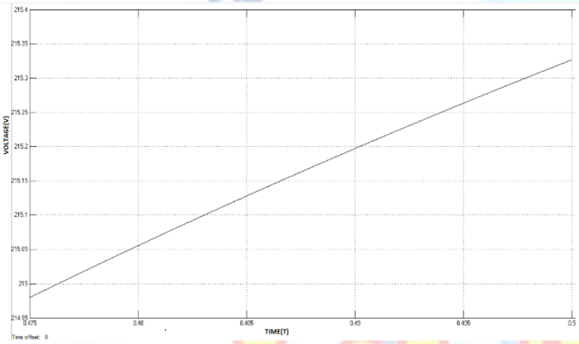

FIG 15 OUTPUT VOLTAGE WAVEFORM

The given FIG 15 is a waveform of output voltage. At the point when input voltage 57.75 V is given output voltage of the framework is 215.3 V and current remains steady. The X axis of the waveform is time(t) and the Y axis of the waveform is voltage(v).

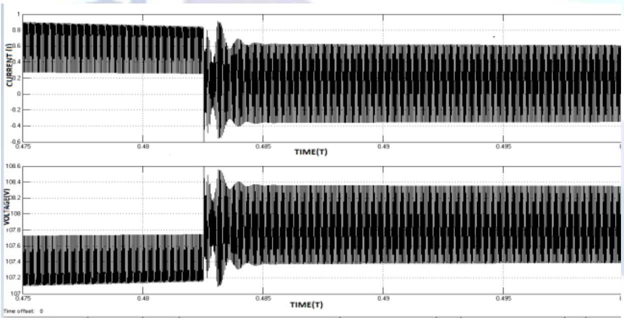

FIG 16. INPUT CURRENT AND INPUT VOLTAGE WAVWFORM

The above given FIG 16 is a waveform of input current and input voltage.

Input voltage=108.2 V.

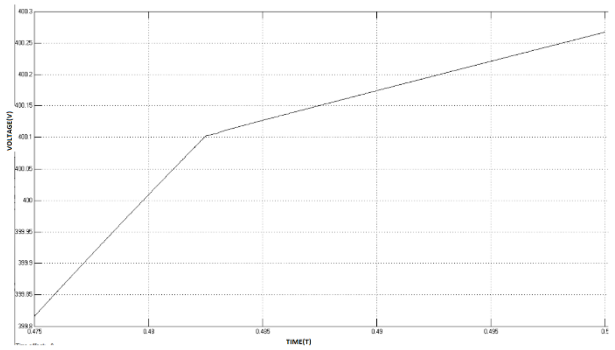

FIG 17 OUTPUT VOLTAGE WAVEFORM

The given FIG 17 is a waveform of output voltage. At the point when input voltage 108.2 V is given output voltage of the framework is 400.3 V and current remains steady. The X axis of the waveform is time(t) and the Y axis of the waveform is voltage(v).

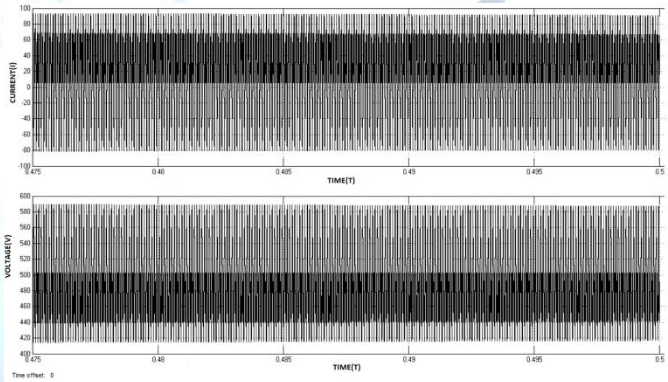

FIG 18. INPUT CURRENT AND INPUT VOLTAGE WAVWFORM

The above given FIG 18 is a waveform of input current and input voltage.

Input voltage=492.1 V.

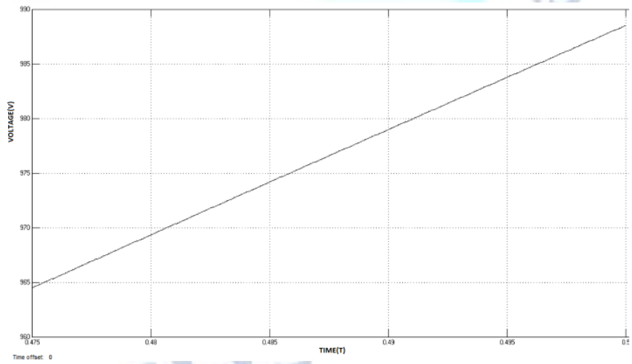

FIG 19 OUTPUT VOLTAGE WAVEFORM

The given FIG 19 is a waveform of output voltage. At the point when input voltage 492.1 V is given output voltage of the framework is 988.5 V and current remains steady. The X axis of the waveform is time(t) and the Y axis of the waveform is voltage(v).

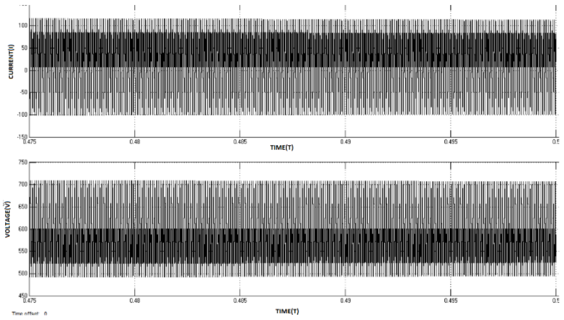

FIG 20. INPUT CURRENT AND INPUT VOLTAGE WAVWFORM

The above given FIG 20 is a waveform of input current and input voltage.

Input voltage=588.2 V.

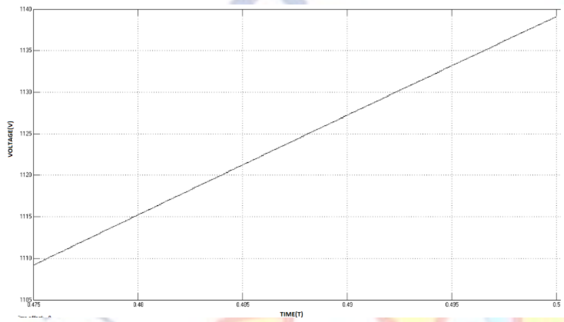

FIG 21 OUTPUT VOLTAGE WAVEFORM

The given FIG 21 is a waveform of output voltage. At the point when input voltage 588.2 V is given output voltage of the framework is 1139 V and current remains steady. The X axis of the waveform is time(t) and the Y axis of the waveform is voltage(v).

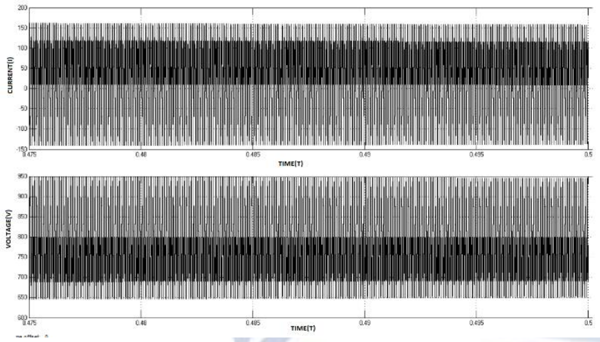

FIG 22. INPUT CURRENT AND INPUT VOLTAGE WAVWFORM

The above given FIG 22is a waveform of input current and input voltage.

Input voltage=780.5 V.

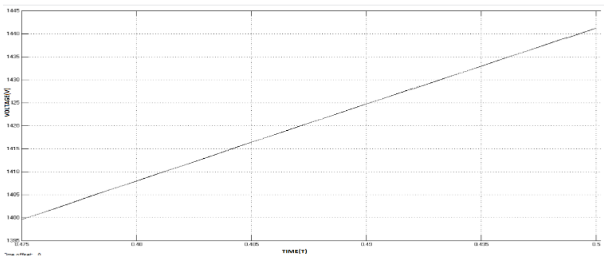

FIG 23. OUTPUT VOLTAGE WAVEFORM

The given FIG 23 is a waveform of output voltage. At the point when input voltage 780.5 V is given output voltage of the framework is 1441 V and current remains steady. The X axis of the waveform is time(t) and the Y axis of the waveform is voltage(v).

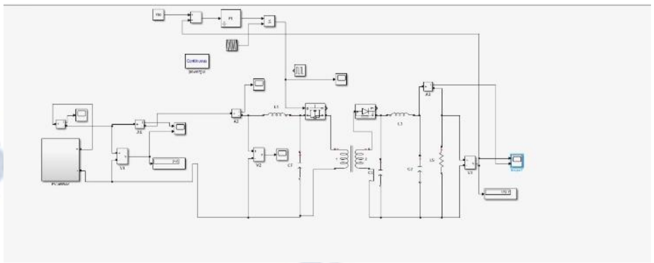

FIG 24. SIMULATION DIAGRAM WITH CONTINUOUS

The above given FIG 24.is a simulation diagram of flyback converter combined Luo converter with continuous design is very simple. It contains electrical components like a flyback combined Luo transformer, switch, rectifier, filter, and a control device to drive the switch and achieve regulation.

FIG 25. OUTPUT VOLTAGE WAVEFORM OF CONTINUOUS

The given FIG 25 is a waveform of output voltage. Input voltage=216V and Input current=1.7A.

When input voltage 216V is given then output voltage of the system is 172V and current remains constant. The X axis of the waveform is time(t) and the Y axis of the waveform is voltage(v).

TABLE 1 SIMULATION OUTPUTS

S.NO	INPUT VOLTAGE	OUTPUT VOLTAGE
1	201.8	534.8
2	299.9	687
3	396	837.3
4	57.75	215.3
5	108.2	400.3
6	492.1	988.5

7	588.2	1139
8	780.5	1441

7. HARDWARE PROCESS

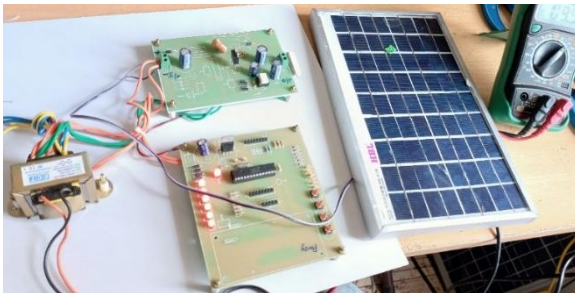

FIG 26. HARDWARE WORKING

The proposed flyback combined luo converter design is very simple and contains electrical components like a proposed flyback combined luo transformer, switch, rectifier, filter, and a control device to drive the switch and achieve regulation.

The switch is used to ON and OFF the primary circuit, which can magnetize or demagnetize the transformer. The PWM signal from the controller controls the operation of the switch. In most of the proposed flyback combined luo transformer designs, FET or MOSFET or a basic transistor is used as the switch.

Rectifier rectifies the voltage of the secondary winding to get pulsating DC output and disconnects the load from the secondary winding of the transformer. The capacitor filters the rectifier output voltage and increases the DC output level as per the desired application.

The proposed flyback combined luo transformer is used as an inductor to store the magnetic energy. It is designed as a two coupled inductor, which acts as the primary and secondary winding. It operates at high frequencies of nearly 50KHz.

In this hardware circuit, we have given input from a solar panel, and the output is connected to the rectifier load. This is a combined structure of a luo converter and a flyback converter is connected to a microcontroller and output is shown in a multimeter. MOSFET switch is used in this circuit. It is the main component of power electronics circuits. MOSFET driver is dedicated to integrated circuits that are used to drive gate terminals of power switches both in the low side and high side configuration.

One switch used in the operating system When a switch is turned OFF, then the inductor is energized at that time input is equal to output. When a switch is in turned OFF state pulse is coherent at that time input is 15.5A and output is 15.9 A. TLP250 IC is used to convert 5v signal to 12v signal.

When a switch is turned on, the inductor is de-energized. when the system is de-energized at that time voltage boost multi times depends upon inductor range and switching frequency. Input is 10 A and Output is 75 A it boosts 7.5 times. when we increase the switching frequency and inductor turns, we can boost more voltage.

Then dspic30f2010 microcontrollers are used in a system. It generates only one PWM because one switch is used in this circuit. Generated PWM is given to the isolated driver through MOSFET.

INPUT VOLTAGE

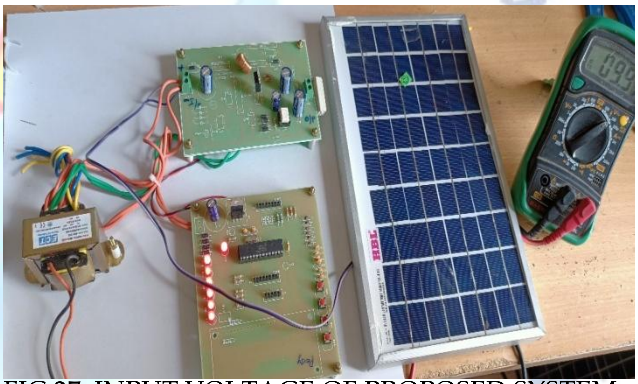

FIG 27. INPUT VOLTAGE OF PROPOSED SYSTEM

When a switch is turned ON, the inductor is de-energized at that time voltage boost multi times depends upon inductor range and switching frequency. Multimeter is used to measure voltage. Input voltage of the system is 9.9A.

OUTPUT VOLTAGE

FIG 28. OUTPUT VOLTAGE OF PROPOSED SYSTEM

When a switch is turned ON, the inductor is de-energized at that time voltage boost multi times depends upon inductor range and switching frequency. Multimeter is used to measure voltage. Output voltage of the system is 75.5A.

PULSE WAVEFORM

The above given FIG 29 is a pulse waveform. The pulse wave is a kind of non-sinusoidal waveform that includes square wave and similarly periodic but asymmetrical waves. It is a term used in synthesizer programming and is typical waveform available on many synthesizers. Above given waveform is a switching pulse.

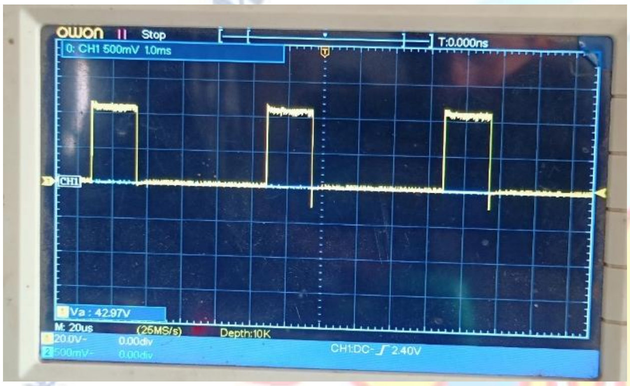

FIG 29. PULSE WAVEFORM

8. CONCLUSION

The practical block diagram and the certain MPPT algorithms the use of PI is providedon this project. The solarcell efficiently modelled the use of MATLAB 2016. The overall performance of the proposed MPPT strategies is examinedvia means of simulation at different irradiation and temperature. The effects are analysed and compared. Solving the problem of energy availability in DC buses may beachievedvia means ofthe use of a version of the battery unit garage system. The powersupply of the PV array and AC grid, one after the other charging every battery unit. By the use of PID controllers, it maycorrectlyboost the voltage at the unidirectional converter enhance and bidirectional converter enhance. The simulation effectsshow that PI for FLYBACK-primarily based totally MPPT controller is simple, fast, efficient, and has quicker convergence. The MPPT's mentioned are around 92-97%efficient. Typically, 20 to 35% energyadvantage in iciness and 10-20% in summertime seasonmay be achieved. The virtual examination, simulated effects, and experimental readings display that the discrete observer controller designed for Flyback primarily based totally LUO converter accomplishes inflexible voltage regulation, excellentvibrant characteristics, and higher effectiveness. The Flyback-based Luo converter with a discrete observer controller may be used for any of the packages like present-daytransportabledigital devices, laptop peripherals, clinical equipment, energycomponent correction, or gasolinecellpackages.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

References

[1] Yan, J.Yuan, L.Xu, "Fuzzy Logic Control Of Mppt For Photovoltaic Power System ", In Ieeeninth Int. Conf. Fuzzy Systems And Knowledge Discovery (Fskd 2012), 2012. [Online]. Available: Http://Dx.Doi.Org/10.1109/Fskd.2012.6234208.

[2] N. Coruh, S. Urgun, T. Erfidan, "Design and implementation of flyback converters", fifth IEEE conf. Industrial Electronics And Applications, Pp.1189–1193,2010.[Online].Available:Http://Dx.Doi.Org/10.1109/Iciea.2010.5515894

[3] Amit, M.Kumar, "Design And Implementation Of Multiple Output Switch Mode Power Supply", International Journal Of Engineering Trends And Technology(Ijett), Vol. 4, No.10,Pp.4540–4543,2013.

[4] A. Dogra, K. Pal, "Designing and Tuning of Pi Controller for Flybackconverter", International magazine of engineering traits and technology (Ijett), Vol. 13, No. 3, Pp.117–122,2014. [Online]. Available: Http://Dx.Doi.Org/10.14445/22315381/Ijett-V13p225.

[5] Titus Sigamani, Ram Prakash Ponraj, "Modified Multilevel Boost Inverter for Hybrid Energy Systems" International Journal of Scientific & Technology Research Volume 9, Issue 04, Pp. 554-558, April 2020.

[6] S. Rajalakshmi, Dr. S. Titus "Optimal Slewing Mode Converter-Based Energy Management System for Renewable Energy Sources" International Journal of Advanced Trends In Computer Science And Engineering, Volume 9, No.3, pp. 2493 – 2502, May – June 2020.

[7] Titus Sigamani, Ram Prakash Ponraj, Vijay Ravindran "Modified Single-Phase Matrix Converter With Z-Source for Renewable Energy Systems" Published in Ieee Xplore, Third International Conference on Smart Systems and Inventive Technology (Iccsit 2020), Doi: 10.1109/Icssit48917.2020.9214138, Pp. 601-607, sixth October 2020.

[8] Ram Prakash Ponraj, Titus Sigamani, "A Novel Design and Performance Improvement of Symmetric Multilevel Inverter with Reduced Switches Using Genetic Algorithm" Published in International Journal of Soft Computing, Springer Publication, Volume 25, Issue 06, Pp. 4597 - 4607, March 2021. (Published Online In twenty fifth November 2020), Doi 10.1007/S00500-020-05466-7. (Sci Indexed)

[9] Ram Prakash Ponraj, Titus Sigamani, Vijayalakshmi Subramanian, “A Developed H-Bridge Cascaded Multilevel Inverter with Reduced Switch Count” International Journal of Electrical Engineering & Technology, Springer Publication, Volume 16, Issue 03, Pp. 1445 - 1455, (Published Online February 2021), May 2021. Https://Doi.Org/10.1007/S42835-021-00680-1. (Scie Indexed)

[10] S. Titus, S. Rajalakshmi, and G. G. Santhosh Kumar, "Optimal Sliding Mode Converter with Energy Management System for Hybrid Electric Vehicle," 2021 International Conference on Advances in Electrical, Computing, Communication and Sustainable Technologies (Icaect), Bhilai, India, April 2021, Pp. 1-12, Doi: 10.1109/Icaect49130.2021.9392466. (Ieee Xplore)

[11] Titus.S&Rajalakshmi.S “Fitf-PDM: Unified Controller Design for Non-remoted Bidirectional Dc-dc Converter” International Transactions on Electrical Energy Systems (John Wiley & Sons), Vol.28, Issue.3, Pp.1-19, December 2017. (Scie Indexed) Annexure-1

[12] S. Titus and S. Edwin Jose “A Zig-Zag Concat Double Rung H-Bridges Based Multilevel Voltage Source Inverter Structure” In Journal of Electrical Engineering, Vol. 18, No. 1, Pp. 01-08, March 2018, (Sci Indexed) Annexure-1

[13] V. Quaschning. Understanding Renewable Energy Systems. Earthscan Canada, 2005.

[14] “Trends in Photovoltaic Applications. Survey Report of Selected IEA Countries Between 1992 And 2009”, International Energy Agency, Report IEA-Pvps Task 1 T1-19:2010, 2010.

[15] “Sunny Family 2010/2011 - The Future of Solar Technology”, Sma Product Catalogue, 2010.

[16] L. Piegari, R. Rizzo, "Adaptive Perturb and Observe Algorithm for Photovoltaic Maximum Power Point Tracking," Renewable Power Generation, It, Vol. 4, No. 4, Pp. 317-328, July 2010.