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# Comparative Analysis of LUO Converter with and Without MPPT for PV Applications

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## Abstract

*Over a decade, power consumption is increasing rapidly due to anonymous tech growth in industry and residential applications. To balance this requirement, generation needs to stair up which in turn unbalances the economy and environment by conventional power generation. A PV panel can be used as a subsidiary source to meet the extra power consumption. Technology still looks backward to extract the maximum power that the panel can generate. MPPT is a solution that can address this issue with an efficient power electronic converter. This paper presents one such - "Luo converter" which works efficiently compared to other market available converters to extract maximum power from a solar panel. The combination of LUO-MPPT results most efficient to extract Maximum Generation from the panel. This concept is validated with the help of MATLAB simulation, considering all ideal conditions in this paper. Analysis of LUO converter with and without MPPT algorithm is also discussed along.*

***Keywords:*** *Power consumption, Luo Converter, MPPT, Photovoltaic panel*

## 1.0 Introduction

As the population expands, so does the electricity demand. Some newly marketed applications demand huge electricity. Energy can be generated from a wide range of sources, one such efficient is photovoltaic energy. Because it is natural and can be refilled on a timely basis. Solar energy is however renewable and ecologically sustainable, but it is also non-chemical, not hazardous to the environment. Solar energy is employed as a source in this manuscript. Via the use of converters, high stabilized power can be generated from solar energy. Silicon cells make up the PV panel [1]. PV cells are interconnected and parallel to produce significant power and to maximize the power, the cells need to be connected more, which becomes bulky. The MPPT algorithm is employed to harness more energy and the technique is more economical and extracts more power [2]. Based on temperature and irradiance variations, the Boost converter cannot be utilized for MPPT, hence the Luo converter is employed instead. The Super-lift Luo converter, which is a DC-DC converter, is employed here. The Luo converter is aimed at giving higher power than conventional converters. The boost converter produces high output voltage as well, while the Luo converter produces twice as much output voltage with a lone switch [3]. This paper shows a

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comparison between the Luo converter and the MPPT-based Luo converter.

## 2.0 LUO Converter and it Working

DC/DC converters exist to fulfill the requirements of certain applications, such as ramping up or down the input voltage [4]. The voltage lift approach has a long history of application in the fabrication of electronic circuits. One of the best instances of voltage increase technology is the Luo converter. DC/DC switching Mode Boost Converters are known as Luo converters. The super-lift methodology has a remarkable position in DC-DC transformation technology, outperforming the voltage-lift strategy [5][11]. The output voltage boosts up substantially in arithmetic progression with the voltage lift technique. The Super-lift Luo converter operates by enhancing the voltage transfer gain in a geometric progression from stage to stage [6][9]. The ripple voltage and current will be mitigated with the Super-lift Luo converter [12].

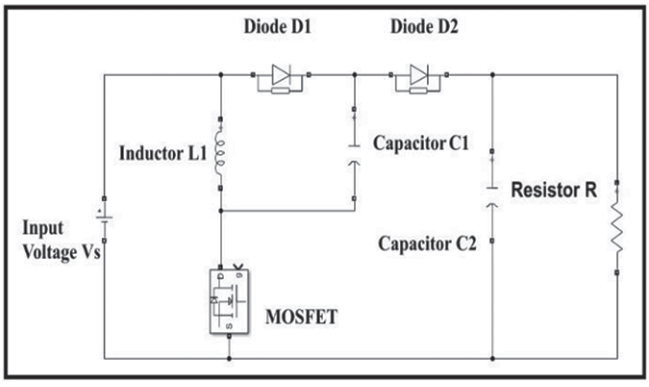


**Figure 1:** Schematic diagram of Luo converter

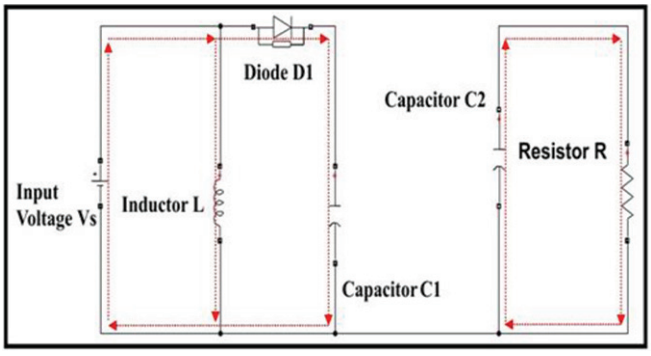


**Figure 2:** Schematic diagram of the Luo converter when Switch is turned ON

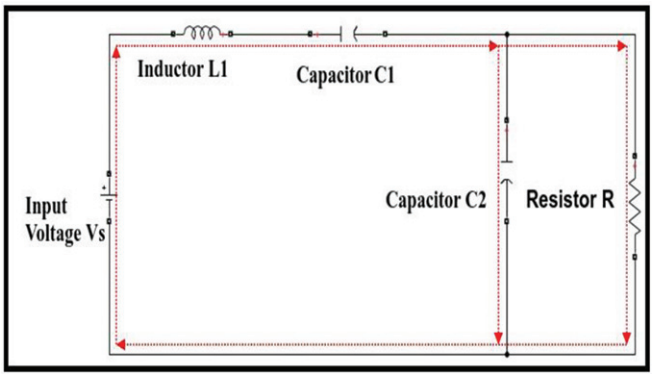


**Figure 3:** Schematic diagram of Luo converter when the switch is turned off

The Super-lift Luo converter's schematic diagram can be seen in Figure 1. One switch, one inductor, 2 capacitors C1 & C2, and 2 diodes D1 & D2 make up the circuit. The load is a resistive load R, the conduction duty ratio is d and the switching frequency is f (period T= 1/f) [10][9]. Depending on the switch, it has two functioning stages - when MOSFET is ON & OFF.

When the MOSFET switch is turned ON, diode D1 is forward biased and diode D2 is reverse biased. C1 is getting charged and C2 is delivering the energy to the load.

When the MOSFET switch is turned OFF, diode D1 is reverse biased and diode D2 is forward biased.

## 3.0 Design of LUO Converter

The converter output voltage equation is given by the equation (1)

$$Vo = \frac{2-D}{1-D}\text{Vs} \quad \text{... (1)}$$

∴ Then gain of the converter is given by the equation (2)

$$G = \frac{Vo}{Vs} = \frac{2-D}{1-D} \quad \text{... (2)}$$

The current ripple is given by the equation (3)

$$\Delta Il1 = \frac{VsD}{Lf} \quad \text{... (3)}$$

Where Vs is the input voltage, Vo is the output voltage, D is the duty ratio, G is voltage gain, L is an inductor and f is switching frequency.

## 4.0 MPPT and Block Diagram

### 4.1 MPPT Flow Chart

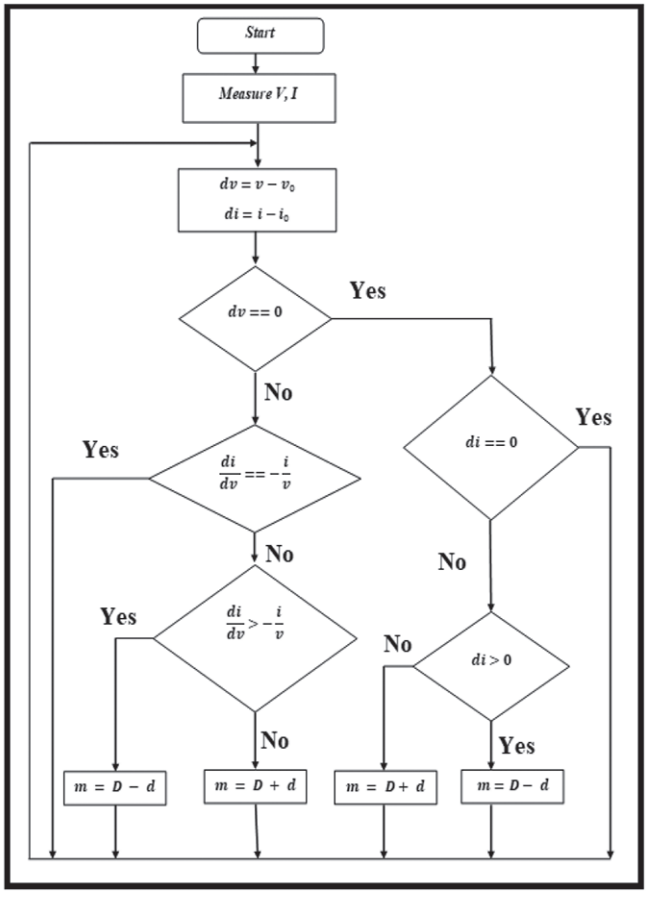


**Figure 4:** Flow chart of incremental conductance MPPT

In general, the internal impedance of the panel differs when the load and external factors such as temperature and insulation change, resulting in variations in output power [1]. The impedance can be changed by adjusting the activation of the DC-DC converter integrated with the support of MPPT algorithms, thereby ramping up the panel's conversion efficiency. The MPPT's major purpose is to bring the voltage level of the module as close as possible to the voltage at which the PV produces the most energy under all conditions. Among the numerous MPPT strategies available, the Incremental Conductance (I&O) approach is employed for analysis that flow chart is shown in Figure 4. The incremental conductance methodology is based on measuring and comparing incremental conductance (I/V) and instantaneous conductance (I/V) of PV modules to detect the variation in direction of the terminal voltage [7]. The MPP is produced when the incremental conductance equals the instantaneous conductance [8]. the MPPT algorithm calculates the optimum duty cycle D to maximize power flow.

### 4.2 Block Diagram

The Figure 5 shows the block diagram of the proposed system. It contains Solar Panel, MPPT Controller, Luo converter, and load. The solar panel is used as a source to generate energy. MPPT is provided with the energy, generated by solar panels as inputs. The MPPT acts as a controller between Solar Panel and the Luo converter. From MPPT the energy is given to the Luo converter, to maintain the high efficiency. Then the energy is consumed by the Load.

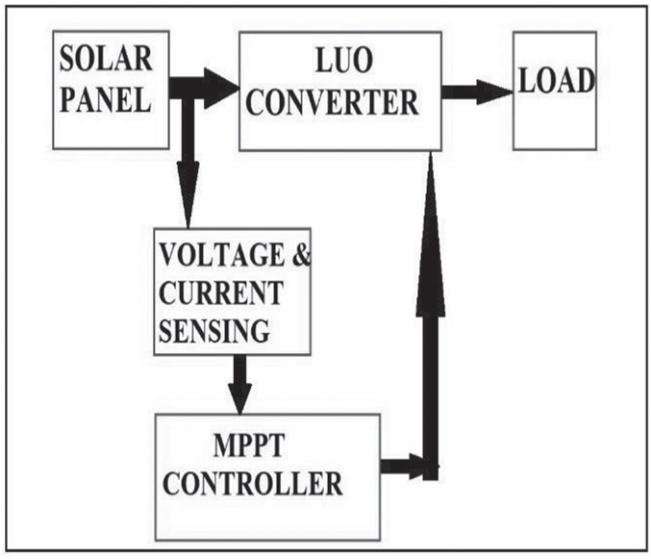


**Figure 5:** Block diagram

## 5. Matlab Model and Simulation Results

### 5.1 Matlab Model Luo Converter with MPPT (Figure 6)

### 5.2 Simulation Results of Luo Converter with MPPT (Figure 7)

The simulation results of a Luo converter with MPPT are shown in Figure 7. Figure 7 V_PV shows the output voltage 184.2V of the PV panel, which has less ripple. I_PV shows output current of 18.35A and I_diode shows the diode current of 0.8132A.

The simulation results of a PV array are shown in Figure 8 and in Figure 9 Irradiance of a PV system is 1000 watts per square meter and the temperature of a PV system is 25 degrees Celsius.

The load power of a Luo converter employing MPPT is 3496 W, which is significantly higher than the

load power of a Luo converter without MPPT as displayed in Figure 10.

Figure 11 illustrates the load voltage of a Luo converter with MPPT, which is 182V, which is much higher than the load voltage of a Luo converter without MPPT.

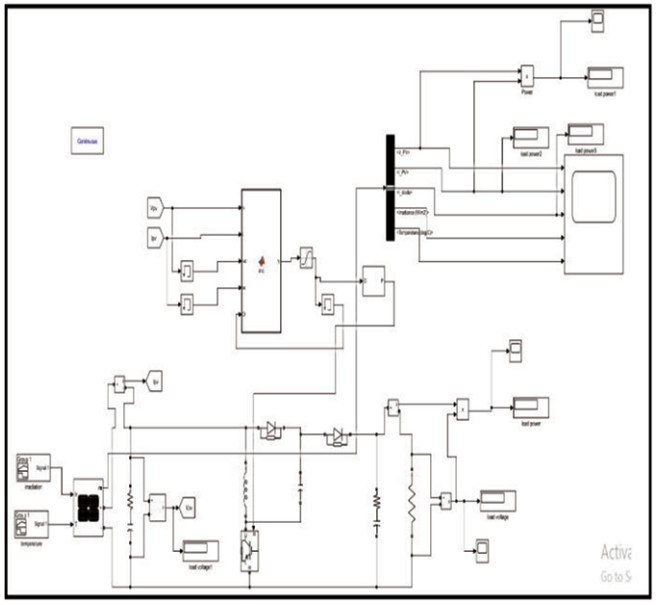

**Figure 6:** Simulation model of Luo converter with MPPT

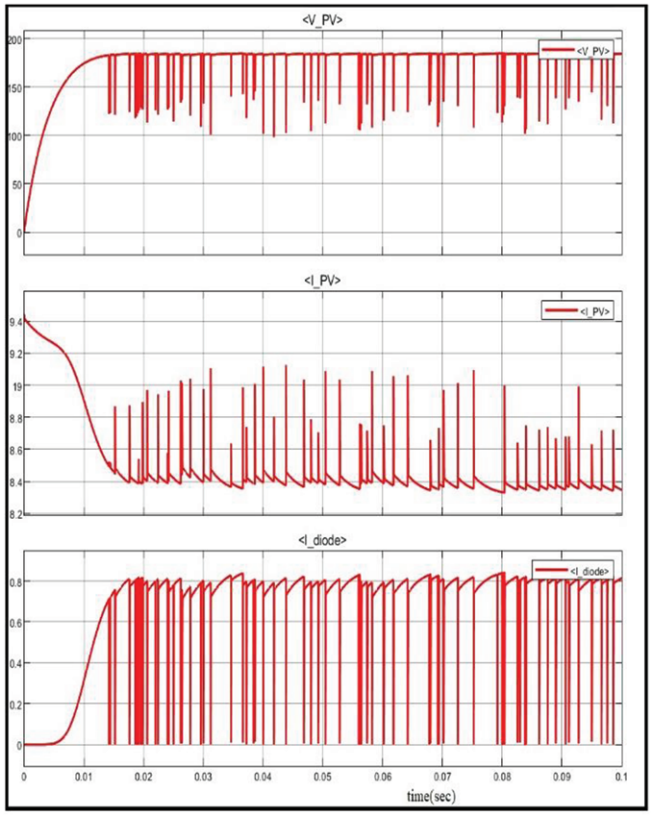


**Figure 7:** Simulation results of Luo converter with MPPT

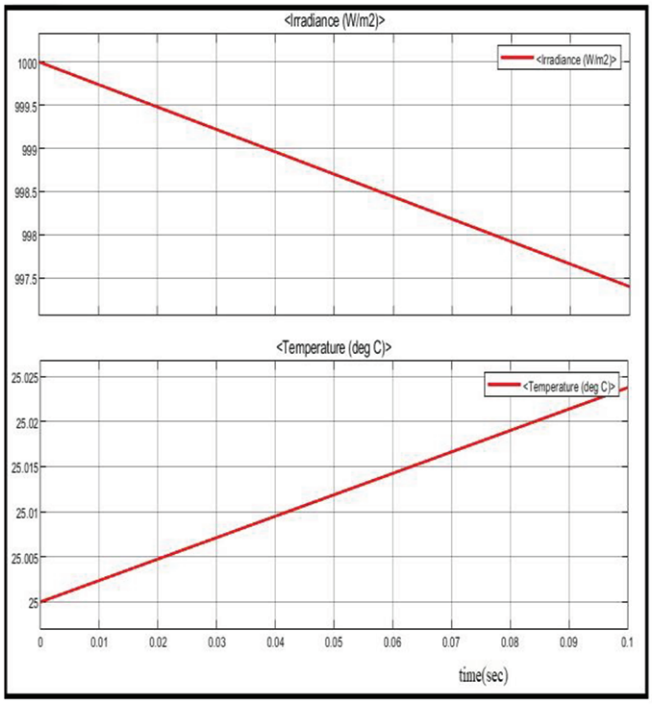


**Figure 8:** Simulation results of PV

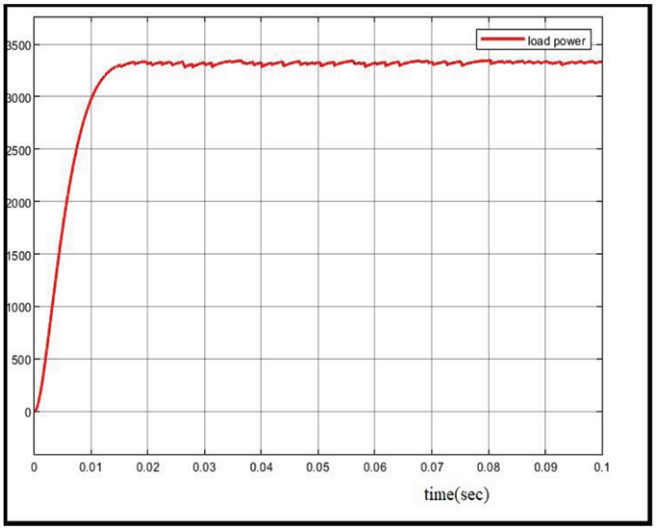


**Figure 9:** Simulation result of load power with MPPT

## 5.3 Matlab Model of Luo Converter without MPPT

The simulation results of a Luo converter without MPPT are shown in Figure 12. In figure 12 V_PV shows the output voltage 23.24V of the PV panel,

which has a greater ripple. I_PV shows output current 19.28A and I_diode shows the diode current 7.486e-8A.

The simulation results of a PV array are shown in Figure 13 and in the Figure 13 Irradiance of a PV system is 1000 watts per square meter and temperature of a PV system is 25 degrees Celsius.

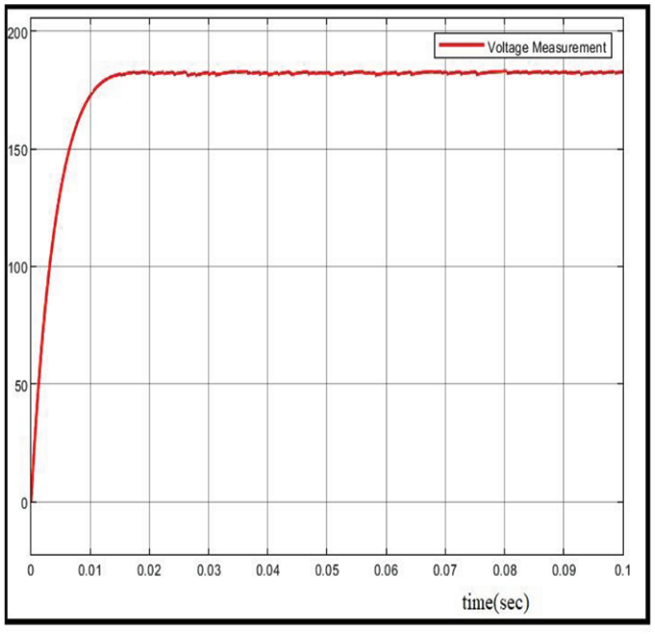


**Figure 10:** Simulation result of load voltage with MPPT

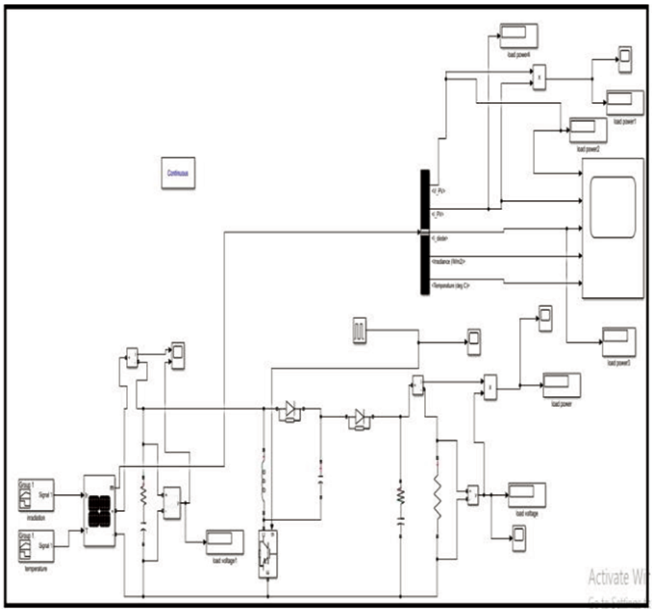

**Figure 11:** Simulation result of Luo converter without MPPT

Figure 14 illustrates the load voltage of a Luo converter without MPPT, which is 62.41V, that is lower than the load voltage of a Luo converter with MPPT.

A Luo converter with MPPT has a load power of 389.6W, which is much lower than that of a Luo converter with MPPT and is displayed in Figure 15.

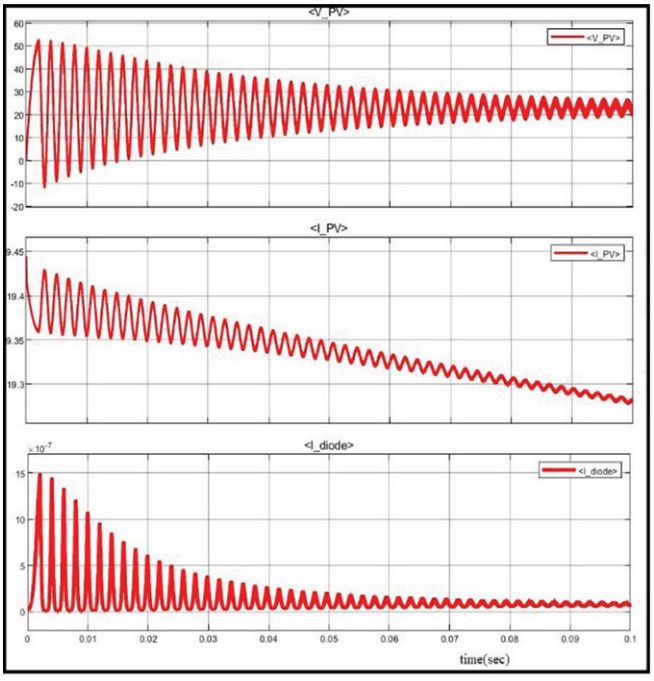


**Figure 12:** Simulation results of Luo converter without MPPT

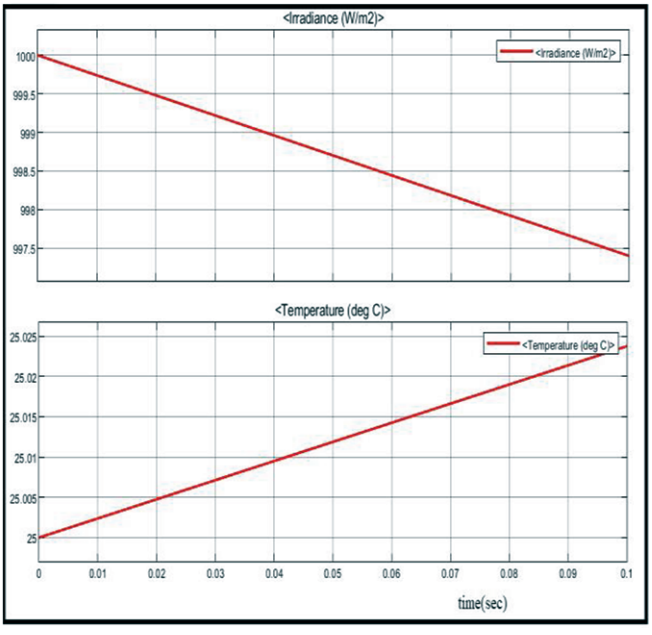


**Figure 13:** Simulation results of PV

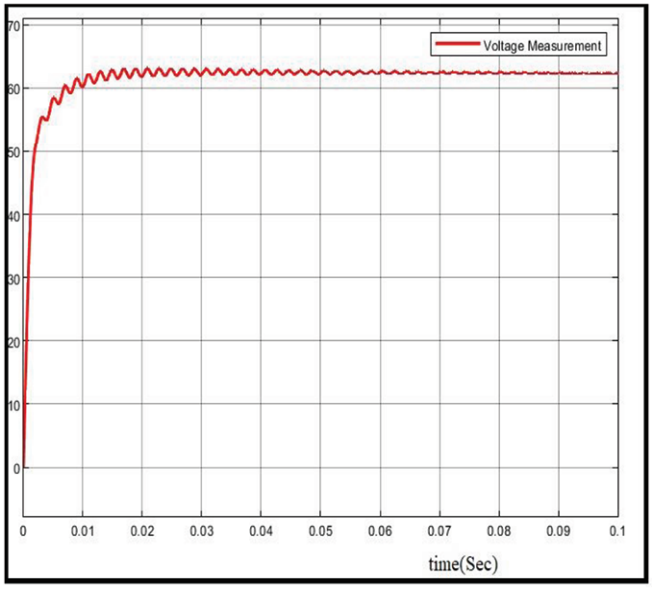


**Figure 14:** load voltage of Luo converter without MPPT

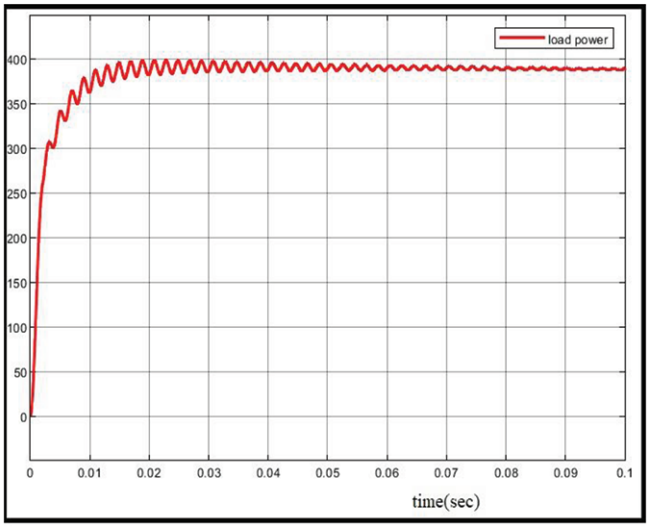


**Figure 15:** load power of Luo converter without MPPT

## 6. Comparison of LUO Converter with and without MPPT

| Parameters | Luo converter | Luo converter with MPPT |
|---|---|---|
| Input voltage | 23.24 | 184.2 |
| Frequency | 50k | 50k |
| Duty cycle | 0.5 | 0.5 |
| Resistor | 10 | 10 |
| Load power | 389.6 | 3334 |
| Output voltage | 62.41 | 182.6 |

## 7. Conclusion

1. This research compares the Luo converter with the Luo converter with MPPT algorithm in depth.
2. The MATLAB/SIMULINK software is used to obtain the findings, which are then compared to determine the optimum solution.
3. In order to acquire the most output power for PV applications, an LUO converter with MPPT is preferable than a LUO converter alone.
4. As a result of utilizing the MPPT algorithm with the Luo converter, the voltage level shoots up, increasing the amount of power generated by solar panels.

## References

1. P. Dhivya, I. Cephas, M. DhanunjayaRao, "Comparative Analysis of MPPT Techniques for Negative Output Super-Lift Luo Converter and Hardware Implementation of NOSLC", *International Conference on Power, Energy, Control and Transmission Systems* (ICPECTS), 2018
2. M. Latha Devi, P.Abhirami, M.R. Faridha Bhanu, "Design and Hardware Implementation of Self Lift Negative Output Luo Converter Using MPPT for PV Applications", International Conference on Power, Energy, Control and Transmission Systems (ICPECTS), 2018
3. Chaitanya Pansare, Shailendra Kumar Sharma, Chinmay Jain, Rakesh Saxena, "Analysis of a modified positive output Luo converter and its application to solar PV system", *IEEE Industry Applications Society Annual Meeting*, 2017
4. Malek Guizani, Rabeb Abid, Ferdaous Masmoudi, Mohamed Djemel , Nabil Derbel, "Performance analysis of Luo converter for PV application", 15th International Multi-Conference on Systems, Signals and Devices (SSD), 2018
5. P. Elangovan, V. Maheswari, P.Manigandan, "Performance Analysis of Solar Energy Conversion System Using Super-Lift Luo Converter", IEEE International Conference on Advances and Developments in Electrical and Electronics Engineering (ICADEE), 2020
6. Archana Nath. S, Jayarama Pradeep, "PV Based Design of Improved Positive Output Super-Lift Luo Converter", Second International Conference On Science Technology Engineering and Management (ICONSTEM), 2016

7. Abdullah M. Noman, Khaled E. Addoweesh, Hussein M. Mashaly "Simulation and dSPACE Hardware Implementation of the MPPT Techniques Using Buck Boost Converter", IEEE 27th Canadian Conference on Electrical and Computer Engineering (CCECE) 2014
8. Vineeth Kumar P.K, Dr. K. Manjunath," Analysis, Design and Implementation for Control of Non-Inverted Zeta Converter using Incremental Conductance MPPT Algorithm for SPV Applications", International Conference on Inventive Systems and Control (ICISC) 2017
9. Ms. Anushka S. Tekade, Mr. Rahul Juneja, Mr. Manish Kurwale , Prof. Prashant Debre, "Design of Positive Output Super-Lift Luo Boost Converter for Solar Inverter", International Conference on Energy Efficient Technologies for Sustainability (ICEETS) , 2016
10. Josily Jose, B Jayanand, "Simulation and implementation of superlift Luo converter", International Conference on Renewable Energy and Sustainable Energy, 2013
11. Zeng-li Shan, Shuo Liu, Fang-lin Luo, "Investigation of a super-lift Luo- converter used in solar panel system", China International Conference on Electricity Distribution, 2012
12. K. Sarasvathi, K. Divya, "Analysis and Design of Superlift Luo Boost Converter", 4th International Conference on Electrical Energy Systems (ICEES), 2018