# Theoretical Assessment and Comparative Analysis of Divergence Techniques of DC-DC Converter

R. Felshiya Rajakumari and M. Siva Ramkumar



February 19, 2021

# Speculative Evaluation and Relative Analysis of Divergence Techniques of DC-DC Converter

R.Felshiya Rajakumari, Research Scholar
Department of Electrical and Electronics Engineering
Karpagam Academy of Higher Education
Coimbatore, Tamil Nadu
felshirajan@gmail.com

Dr.M.Siva Ramkumar, Assistant Professor
Department of Electrical and Electronics Engineering
Karpagam Academy of Higher Education
Coimbatore, Tamil Nadu
sivaram0699@gmail.com

***Abstract*— This research paper work predominantly focus on altered types of DC-DC converter, it mainly encompasses theoretical derivations and design equations of the converter. Proceeding, DC-DC converter produces maximum proficiency. The maximum proficiency is achieved by using switched mode power converter or chopper. A large number of DC-DC converter circuit topologies are known and it is preferable for the research work. Since most of the punter loads and stowage components use DC supply, DC-DC converters attain high popularity. The converter topology may upsurge or shrinkage the output voltage or else it will result in flip-flopping polarization of output voltage. The converter will be activating at diverse frequency level to progress the accurate response of the scheme.**

**Keywords—** DC-DC Converter, Converter Operation, Design Equations, Supply Voltage, Load Voltage, Inductor, Capacitor, Diode, Switching frequency.

## INTRODUCTION

DC-DC Converters becoming higher growth rate in the market industry due to low voltage, high power density and affords higher efficiency and it is germane in many applications, viz., computer system, electonic phone devices, medicine applications, laptop, motor system drives, ect.. The world is now familiarizing with the automated devices, without which is very vigorous for the mankind to retainsuccessful [1]. Trendy inupcoming technologies by using converter, it is vital to ripen the devices without blunder and with fast response with high efficiency. The semiconductor strategies employ as a swapping devices due to which converters act as a extraordinary switching frequencies. DC-DC Converters are widely used to yield a structured voltage from the source side that may produce ouput voltage lesser or sophisticatedvalue than the input voltage [1][2]. It will be a high frequency power alteration circuits that use high switching transformers, inductors and capacitors. DC-DC converters are categorized into isolated and non-isolated type. Often DC-DC converters is an unrestrained DC voltage it forms from a didoe rectifier which is an tolerant output voltage. The input to the DC-DC converters is an tolerant due to the flucatuations and harmonics in line volatge, so these fluctuations gets revealed in the output which makes it synchronized. These DC-DC converters results in unfettered DC source voltage into controlled DC output voltage at desired level value. Eventually, isolation transformer may or may not occur in DC-DC converter based on the level of requirement stages. The filter capacitor and regulator stages comprisespacking elements which hoard the input energy and then relief the energy to the output at different voltage level, (i.e) higher or lower output level.The main focus of the research paper work is concerned with the diverse expertise of DC-DC Converters. Division I deals with the Introduction of converter, Division II converse with thedivergence expertise of DC-DC Converter. Division III initates the conclusion of the work.

## I. DIVERGENCE EXPERTISE OF DC-DC CONVERTER

DC-DC converters results into categorization

(a) Isolated Converter

(b) Non-Isolated Converter

Non isolated power converter has a single circuit in which a current can drift from the input to load side, (i.e) input and output will share on the common ground. But in isolated converter, it is delivered with isolation and it splits the circuit from input to output by using a tranformer. Consequently in isoltaed converter the input and output path reoccurrence to their own independent ground and there is no path for direct current from one side to another side.

### A. *Sepic Converter*

Fig.1 illustrates the representation diagram of Sepic Converter.It executes both buck and boost operation. L turns as a filter for input current route , R is the resistive load and C turn as a filter at the output voltage [3]. $C_s$ performs as coupling capacitor and it relocates the energy from input to output. The design equtaions of Sepic Converter illustrate in [3] [4].

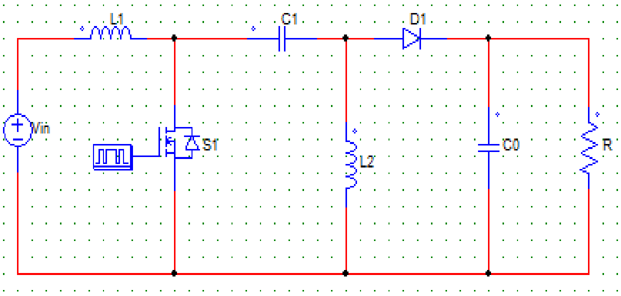


Fig.1 Graphic diagram of Sepic Converter

*Operation 1 of Sepic Converter*

When controller is on state, the inductor $L_1$ gets electric by the input voltage $V_{in}$ and assume that the coupling capacitor $C_s$ is initailly charged to the input voltage $V_{in}$, the coupling capacitor gets expulsions through inductor $L_2$, because the diode is a contrary bias and the load capacitor affords power to the load [3][4]. Fig.2 illustrates the operation 1 of Sepic Converter.

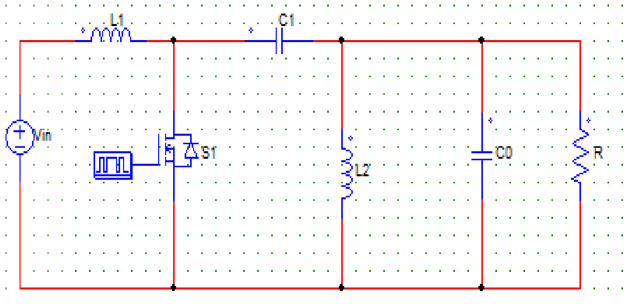


Fig.2 Operation 1 of Sepic Converter, i.e., Switch is in ON state

*Operation 2 of Sepic Converter*

When switch is in off spot, then the inductor $L_1$expulsionsover coupling capacitor $C_s$. Further, the inductor $L_2$deviations the sign polarity to oppose the change in current path, due to this situation, diode turns on and it is aforward bias [3][4]. The inductor $L_2$ discharges through load capacitor and resistor load. Fig.3 Operation 3 of Sepic Converter, i.e., Switch is in ON state.

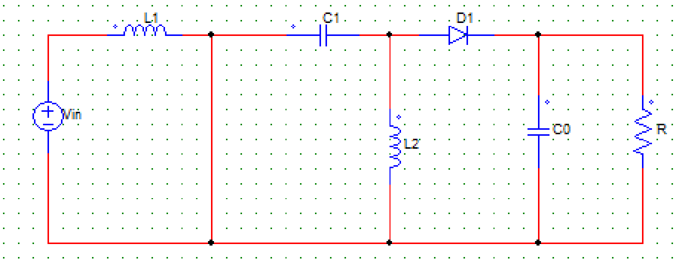


Fig.3 Operation 1 of Sepic Converter, i.e., Switch is in ON state

*B. Luo Converter*

Luo converter executesgreat voltage conversion with high power density and it results into higher efficiency ratio. It sorts from voltage highperformance to super boost and ultra high technique. The luo converter operates in push pull state and can be operate mainly either switched capacitor or switched inductor type.Fig.4 illustrates the representation diagram of Luo Converter.

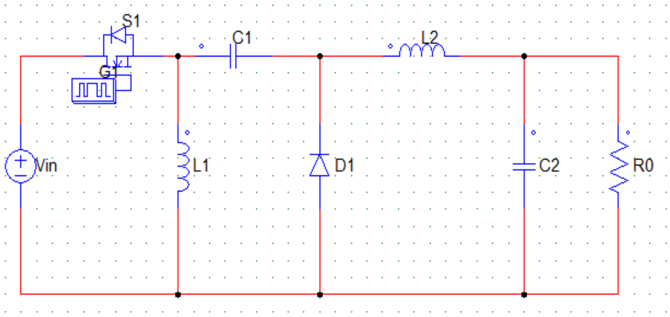


Fig.4 Graphic design of Luo Converter

*Operation 1 of Luo Converter*

In stage 1 operation, when the controller is in ON position, the inductor $L_1$ is indicted by the supply voltage, but the inductor $L_2$ grips the energy from the source to the capacitor $C_1$. Fig.5 depicts the Operation 1 of Luo Converter, i.e., controller is in ON state [5] [6].The current flow operation takes place in stage 1 depicts as $V_1$-S-$C_1$-$L_1$-$R_0$-$V_{in}$

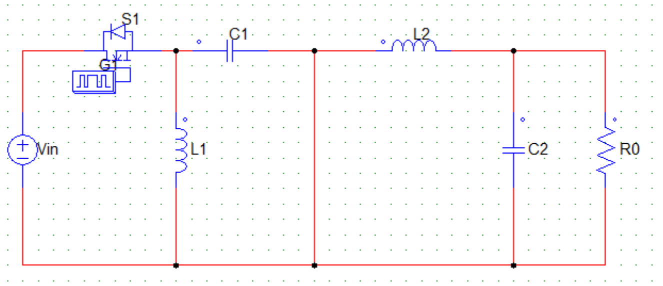


Fig.5 Operation 1 of Luo Converter, i.e., Switch is in ON state

*Operation 2 of Luo Converter*

Fig.6 depicts the Operation 2 of Luo Converter, i.e., Switch is in OFF state.When the controller is in off spot, the current drawn from the input side becomes zero, therefore current $I_{L1}$ flows through the freewheeling diode to charge the input side capacitor [5] [6].The current $I_{L2}$ flows through the output capacitor, resistor and freewheelimg diode.

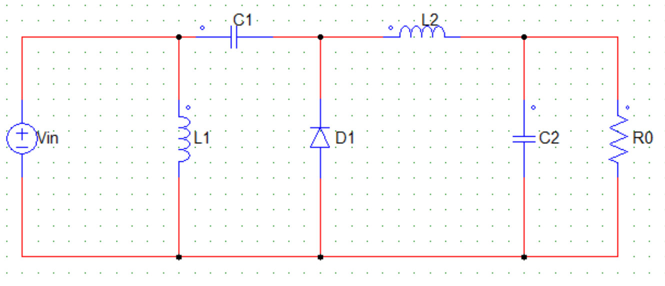


Fig.6 Operation 2 of Luo Converter, i.e., Switch is in OFF state

*Design Equations for Luo Converter*

Load voltage for the Luo converter is signposts in balance equation. (1)

$$V_0 = \frac{DV_s}{1 - D} \qquad (1)$$

The inductor current ripple formula is indicated in balance equation. (2)

$$\Delta I = \frac{V_s DT}{L_1} \quad (2)$$

The capacitors ripple voltage formula is stated in balance equation. (3)

$$C_1 = \frac{1-D}{\Delta V_c} TL_1 \quad (3)$$

### *C. Zeta Converter*

Zeta Converter operating in continuous conduction mode which is operates in two state switching periods [1][7]. It is tied with double inductors and capacitors, with resistive load, switch and diode. Fig.7 elucidates the representation diagram of zeta converter.

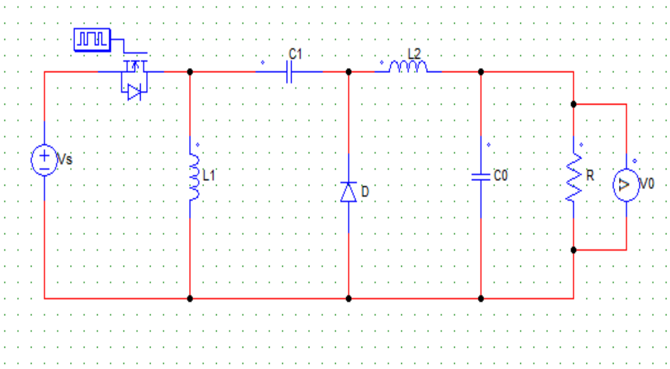


Fig.7 Representation diagram of Zeta converter

*Operation 1 of Zeta Converter*

Fig.8 portrays the Operation 1 of Zeta Converter, i.e., Switch is in ON state. In first spot of operation condition 1, controller is in ON position, in this state energy will be stored in the inductor, consequently inductor point of current starts increasing [8][9]. Atonce when the controller stops it operation, the energy stored in input will be transfer to output indcutor and the diode becomes reverse bias.

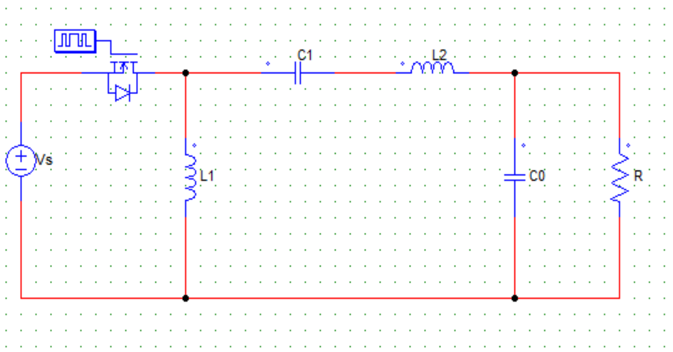


Fig.8 Operation 1 of Zeta Converter, i.e., Switch is in ON state

*Operation 2 of Zeta Converter*

Once the controller gets clogged, the diode will become alternative bias, the inductor L1 starts discharging input and the output capacitor is charged to the load voltage [8][9]. The energy deposited in the inductor will be passed to the load resistor. Fig.9 demonstrates the operation 2 of Zeta converter, i.e., Switch is in OFF state.

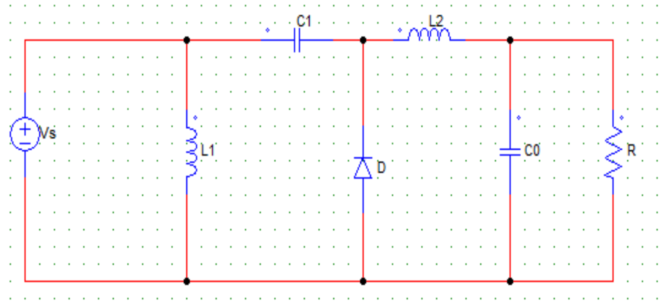


Fig.9 Operation 2 of Zeta Converter, i.e., Switch is in OFF state

*Design equations for Zeta Converter*

The gain conversion ratio for the zeta converter is depicted in Equation.4.

$$\alpha = \frac{V_0}{V_0 + V_s} \quad (4)$$

The wave current for the inductor $L_1$ and $L_2$ is planned in Equation.5.

$$L_1 = L_2 = \frac{\alpha V_s}{f \Delta I} \quad (5)$$

The voltage for the input and output capacitor is identified in Equation.6 & 7.

$$C_1 = \frac{\alpha V_0}{f R \Delta V} \quad (6)$$

$$C_0 = \frac{\alpha V_s}{8 f^2 L_2 \Delta V} \quad (7)$$

### *D. Boost Converter [2] [10]*

A boost converter is type of dc-dc converter which simplifies the output voltage higher than the input voltage. Fig.10 modifies the diagram of boost converter. The design equations for the boost converter are given in detail [10].

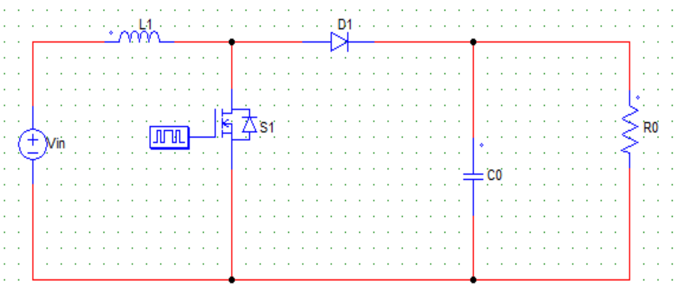


Fig.10 Graphic diagram of Boost Converter

*Operation 1 of Boost Converter [2][10]*

Operation 1 predicts the controller is in ON position,at that particular time the current in the inductor rising linearly, the output current delivered to the output capacitor is greater enough to supply the load current and the diode becomes reverse bias. Fig.11 portrays the Operation 1 of Boost Converter, i.e., Switch is in ON state.

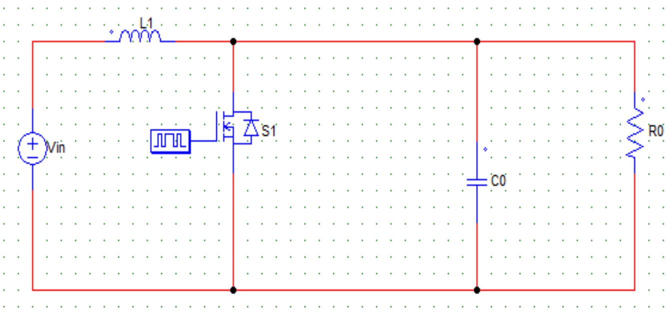


Fig.11 Operation 1 of Boost Converter, i.e., Switch is in ON state

*Operation 2 of Boost Converter [2][10]*

Fig.12 portrays the Operation 2 of Boost Converter, i.e., Switch is in OFF state. In this methodology, controller is in off spot, therefore inductor current decreases suddenly and the current will flow through the capacitor and the load side. Thee energy stay in the inductor will now transfer to the load.

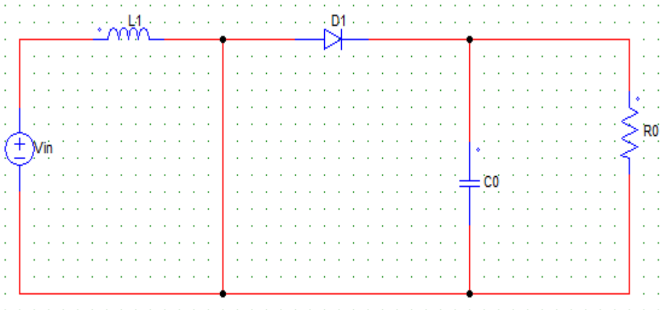


Fig.12 Operation 2 of Boost Converter, i.e., Switch is in OFF state

*E. Buck-Boost Converter*

The buck boost converter is designed with buck and boost operation. So the result produce will be higher or lower than the input or output value. Fig. 13 predicts the diagram of buck-boost converter.

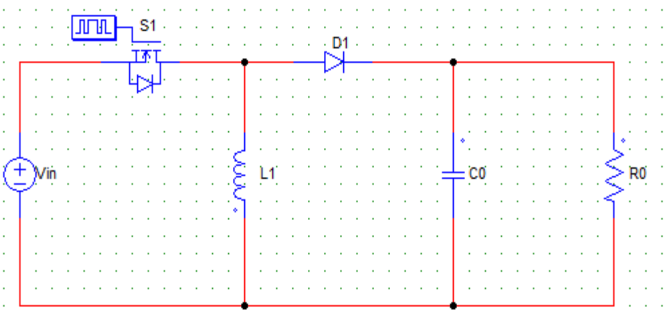


Fig.13 Schematic diagram of Buck-Boost Converter

*Operation 1 of Buck- Boost Converter*

In this site, controller is in on spot position spontaneously diode becomes reverse bias. At the same time, the input side of the current increasing higher and pass through inductor and regulator [2][11]. This converter produce efficient solution when operating with low duty cylce value and it promotes less expensive when compare with other converters. But the major problem is it yields input current in discontinous. Fig.14 portrays the Operation 1 of Buck-Boost Converter, i.e., Switch is in ON state. The design of buck-boos converter will explain in [11].

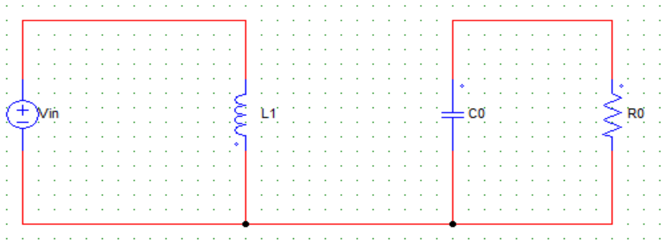


Fig.14 Operation 1 of Buck-Boost Converter, i.e., Switch is in ON state

*Operation 2 of Buck- Boost Converter*

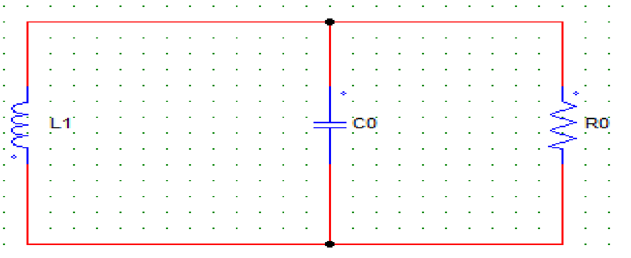


Fig.15 Operation 2 of Buck-Boost Converter, i.e., Switch is in OFF state

Fig.15 specifies the Operation 1 of Buck-Boost Converter, i.e., Switch is in OFF state.In this stage, controller opeartes in off spot place and the diode becomes forward bias and the current flowing throigh the inductor will now flow through capacitor, diode and output path [2][11]. The energy place in the inductor will now transfer to the load.

*F. Buck Converter*

Fig.16 depicts the buck converter diagram.A buck converter is a step down voltage regulator that provides output voltage lower when compare with input voltage. It operates in double operation stage:

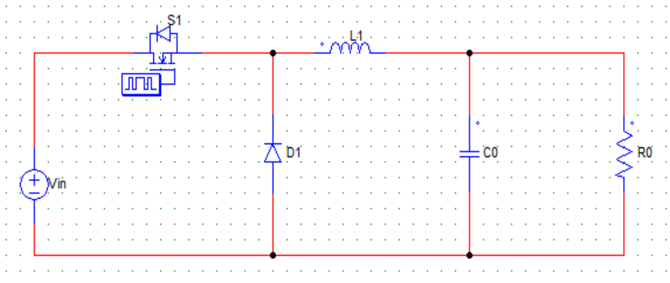


Fig.16Circuit Diagram of Buck-Boost Converter

*Stage 1 Operation of Buck Converter*

When the controller is in ON state, the diode gets inverse bias and provide energy to the load and inductor, eventually the current will flow through the inductor side and it gets starts increasing. Fig.17 displays the Stage 1 Operation of Buck Converter, i.e., Switch is in ON state.

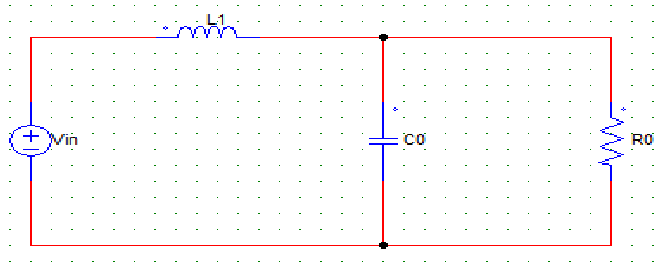


Fig.17 Stage 1 Operation of Buck Converter, i.e., Switch is in ON state

*Stage 2 Operation of Buck Converter*

Fig.18 displays the Stage 2 Operation of Buck Converter,i.e., Switch is in OFF state . When the regulator is in OFF condition, the freewheeling diode starts to conduct, yet the inductor current which is rising in ON state will get decrease in OFF state.The ductor current will flow through the path of diode. The energy stored in the inductor will now deliver to the load.

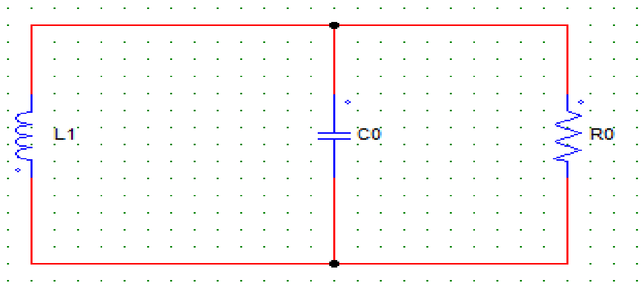


Fig18 Stage 2 Operation of Buck Converter, i.e., Switch is in OFF state

*G. Flyback Converter*

Flyback converter operation is based on buck boost converter. The inductor winding is constructed with two wires, one winding is allied to switch S1and the second winding is allied to diode D2 [13][14]. Fig.19shows the schematic Diagram of Flyback Converter. Mutually the windings of the transformer are having good coupling, so ittransmit a magnetic flux. The primay winding of the transformer swapswith the inductor while secondary winding affords the output. When the current flowing through the inductor is drop up, the energy stored in the magnetic field is released by the sudden reversal of the voltage. Suppose, if a diode takes place to conduct the energy stored in the inductor will now transfer to the load. This is termed as “Flyback Diode”. The transformer polarity gets reversed when the controller is in ON state, i.e., current curving in the primary winding, yet the diode action takes place in contrary bias and the current does not stream in the secondary winding. Therefore, energy stored in the transfomer will be stay until the controller is in ON state. The stored energy produces current when the diode is in onward bias so that it produces DC voltage. To reduce ripple techniques LC filter is added in the converter, but it produces more EMI noises, high losses and ripple current.

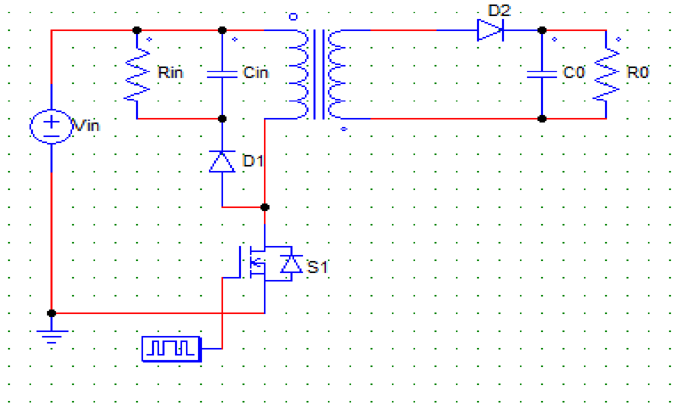


Fig.19 Circuit Diagram of Flyback Converter

*H. Push Pull Converter*

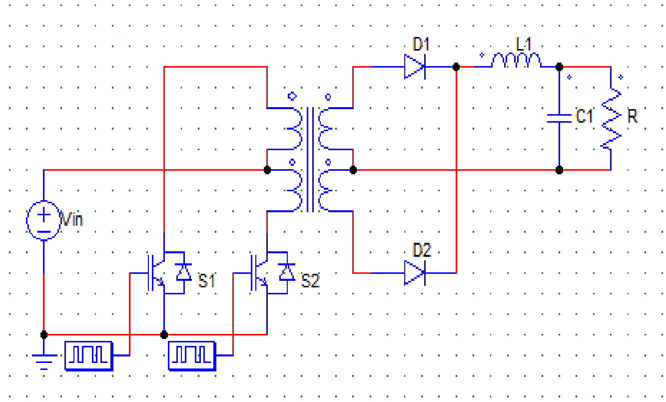


Fig.20 Circuit Diagram of Push Pull Converter

Fig.20 depicts the push-pull converter scheme. A push-pull converter coupled with transformer winding so that primary winding supply current from the input side by using regulator [15]. When the regulator actions takes place ON and OFF condition, current will ony drawn from the first portion of the switching cycle. In the second half portion, the output power delivers the energy stockpiled in the inductor is transfer to the load now.The main benefits of push pull converter steady input current, generate fewer noise and it is more effectual when equated to other types of converter.

*I. Cuk Converter*

It is a cascaded mixture of boost converter followed by buck converter [16]. Fig.21 describe the Cuk converter diagram. It is operated in two stages of operation. It produces continuous current both in input and voltage value, but it suffers from high current stress from the switch component. Fig.22 shows the Stage 1 Operation of Cuk Converter. In stage 1 operation, Controller will be in ON spot status, at that time supply voltage stores energy to the inductor, diode D convertsconverse bias and it shot off [17][18].The capacitor $C_1$ discharges to $L_2$, $C_0$ and load. Fig.23 shows the Stage 2 Operation of Cuk Converter. During stage 2, when the regulator is in OFF spots, diode $D_1$ will be accelerative bias and the capacitor $C_1$ is charged to $L_1$, $D_1$ and $V_s$. The energy stowed in the inductor will now transferal to the load.

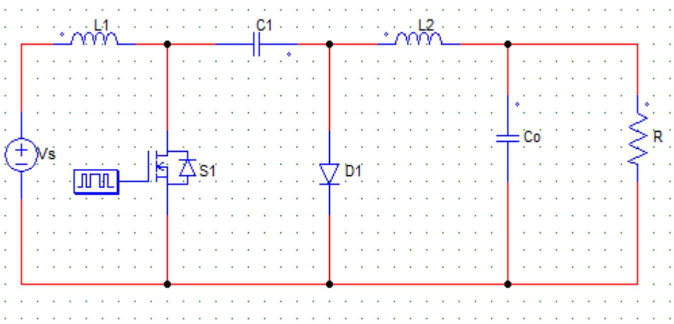


Fig.21 Cuk Converter Diagram

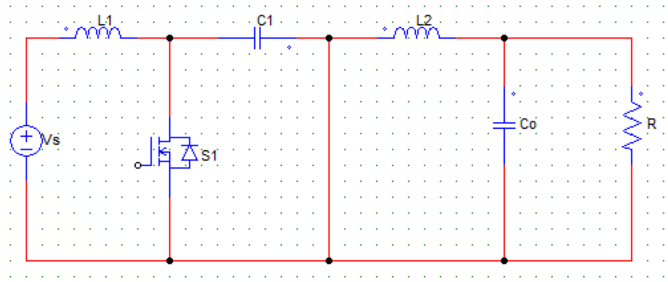


Fig.22 Stage 1 Operation of Cuk Converter, i.e., Switch is in ON state

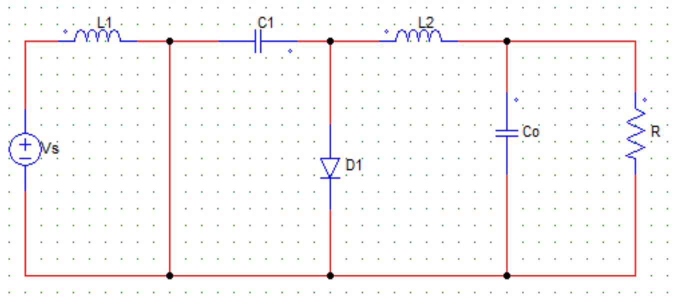


Fig..23 Stage 2 Operation of Cuk Converter, i.e., Switch is in OFF state

*K. Landsman Converter*

Fig.24 depicts the landsman converter diagram. This converter performs like buck and boost converter but provides an inverted output [1]. It divides in two stages of operation. Fig.25 shows the Stage 1 Operation of Landsman Converter.In stage 1, regulator operation takes place, didoe becomes inverse bias,voltage Vs charge the capacitor, inductor $L_1$& $L_2$ . But when the regulator doesn't take place, didoe D form forward bias [1]. At this condition energy stored in the inductor will transfer to $C_o$ and load ($R_o$). Fig.27 shows the Stage 2 Operation of Landsman Converter.

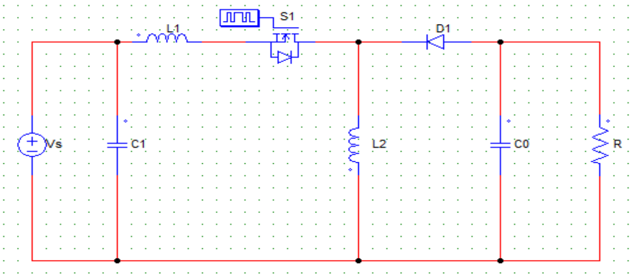


Fig.24 Landsman Converter Diagram

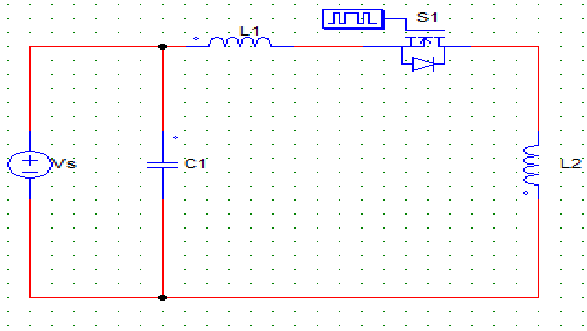


Fig.25 Stage 1 Operation of Landsman Converter, i.e., Switch is in ON state

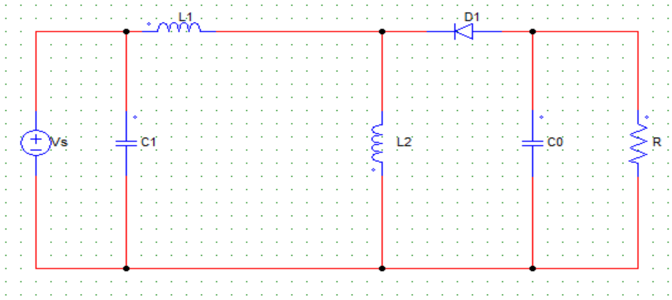


Fig.26 Stage 2 Operation of Landsman Converter, i.e., Switch is in OFF state

## III. COMPARATIVE ANALYSIS OF DIVERGENCE EXPERTISE OF DC-DC CONVERTER

*A. SEPIC Converter*

Since SEPIC converter transferals all its energy over capacitor, high current usage capacity is required. Unlike buck boost converter, Sepic converter have a vivacious output current and it requires high current usage competence.

*B. LUO Converter*

While LUO Converter performs maximum conversion efficiency, high power density and the structure is simple when compared to other converters. By comparing to other converters it can reduce the ripple voltage and current performance operation level.

*C. ZETA Converter*

Zeta converter operation is similar to buck-boost converter techniques, it produces maximum output current but the major drawback, it is difficult to control the converter.

*D. CUK Converter*

It produces continuous current both in input and voltage value, but it suffers from high current stress from the switch component.

*E. BOOST Converter*

It gives higher output voltage value than the input voltage, the major benefit is, it give higher efficiency value when operates with single switch value. But it produces high peak current from the switch side.

*F. Buck-Boost Converter*

The input current and the charging current of the load side capacitor is blinking and it reults in heftystrain size and more EMI issues because output conduiteffect in inverted polarity due to intricate sensing circuit.

*G. Buck Converter*

The main drawbacks of the buck converter is input current is contiuous. It is a non-isolated converter and it is equipped with so many benefits such as simplicity structure and low cost. But it provokes high output voltage ripple.

*H. Flyback Converter*

It produces more ripple current and privileged losses when compare with other converter. It consequences in a superior output capacitor due to second order filter requirement.

*I. Push Pull Converter*

This topology generate switch stresses in a very high position becauses double switches are indicated in the circuit. Central Tap Transformer is used in the circuit and it is one of the foremost negative aspect because current surge will not take place in straight path. One of the major problem in push pull converter is primary and secondary winding becomes unbalanced and cause heating problems due to center tap transformer.

*J. Landsman Converter*

The main function of a Landsman Converter is to optimize the power output from PV array. Landsman Converter is suitable for renewable energy application it meets with the desired performance system.

## IV. CONCULSION

Nowadays power electronics converter plays a vital key role in modern applications particularly electric vehicle applications. The operation of power electronics converter is very demanding structure context and these converters performs a real time hard constraints in the world. In this study various converter schemes have been analyzed with different stages of operation and design equations. Finally non-isolated dc-dc converter shows the good techniques when compare with isolated converter.

## References


[1] K.Manikandan, A.Sivabalan, etal, "A Study of Landsman, Sepic and Zeta Converter by Particle Swarm Optimization Technique", 2020, 6th nternational Conference on Advanced Computing & Communication System.

[2] Ahana Malhotra, Dr.Prerna Gaur, "Comparative Study of DC-DC Converters in Dolar Energy Systems", 2014 International Conference on Advances in Computing, Communications and Informatics.

[3] Trivedi Bhavin, Bhavesh Patel, etal, "Analysis of SEPIC Converter", International Journal of Engineering Development and Research", ISSSN:2321-9939,Volume 6, Issue 2, IJEDR 2018.

[4] Mriduwani Verma, S.Shiv Kumar," Hardware Design of SEPIC Converter and its Analysis", Proceeding of 2018 IEEE International Conference on Curent Trends Toward Converging Technologies.

[5] Saravanan R, Chandrasekaran N, etal, "Design and Simulation Analysis Of Various Luo Converter Topologies fed BLDC Drive for Solar PV Applications", 2020 6th International Conference on Advanced Computing & Communication Systems.

[6] J.Vidya Sagar, I.Srinu, etal, "Luo Converter for Low-Power Applications Using a Super Capacitor", International Journal of Research and Analytical Reviews", E ISSN: 2348-1269, PRINT ISSN: 2349-5138, Volume 5, Issue 1, July-Sept 2018.

[7] Sneha A.Shende, Prof.Radharaman Shaha, "MPPT Based Photovoltaic Sysetm with Zeta Converter for DC Load", International Research Journal of Engineering and Technology, e-ISSN"2395-0056, p-ISSN:2395-0072, Volume 07, Issue 02, Feb 2020.

[8] G.G.Gadhave, S.B.Patil, Ïmplementation on PF Improvement of Brushless DC Motor Drives Using Zeta Converter", International Conference on Communication and Signal Processing, July 28-30, 2020.

[9] Sujo Oommen, Adithya Ballaji, "Zeta Converter Simulation for Continuous Current Mode Operation", International Journal of Advanced Research in Engineering and Technology, Volume 10, Issue 1, Jan-Feb 2019.

[10] Dr.Jitendra Nath Rai, " Design and Analysis of DC-DC Boost Converter", Research Gate, September 2016.

[11] Mahir Dursun, Alper Gorgun. " Analysis and Performance Comparison of DC-DC Power Converter Used in Photovoltaic Systems", 2017, 4th International Conference on Electrical and Electronics Engineering.

[12] N.H.Baharudin, T.M.N.T Mansur, etal, "Performance Analysis of DC-DC Buck Converter for Renewable Energy Application", 1st International Conference on Green and Sustainable Computing, 2017.

[13] Vignesh Nayak, "Design and Development of Flyback Converter", Research Gate, June 2018.

[14] Swati Kunkolkar, V.N.Shet, " Flyback Converter Design and Simulation", International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, ISSN Print: 2320-3765, ISSN(Online):2278-8875, Volume 6, Issue 5, May 2017.

[15] TAngie Alejandra Rojas Aldana, etal, "Design, Modelling and Implementation of Push-Pull Converter used in Grid Connected Photovoltaic Systems", Journal of Engineering Science and Technology Review, ISSN:1791-2377, August 2,2018.

[16] A.Karaarslan,"Modeling and Performance Analysis of Cuk Converter Using PI and OCC Method", International Journal on Technical and Physical Problems of Engineering", ISSN:2077-3528, Volume 10, Issue 36, No:3, September 2018.

[17] S.Sivajanani, N.Veeramuthulingam, etal, Änalysis of Cuk Converter for Power Fcator Correction Applications", International Journal of Engineering Research & Technology, ISSN:2278-0181, Volume 3, Issue 5, May 2014.

[18] Parastoo Khademi Astaneh, Khalil Valippor, "Study of Developed Cuk Converter for Renewable Energy Sources", International Jounal of Scientific & Engineering Research,ISSN:2229-5518, Volume 4, Issue 3, March 2013.

[19] Emelda. V.Beulin, Jayarama Pradeep, " Design of Ultra-Lift Luo Converter for Pumping Applications",2018 International Conference on Power, Energy, Control and Transmission System.

[20] Ramanjaneya Reddy,etal, " Single Stage Electrolytic Capacitor Less Non-Inverting Buck Boost PFC based AC-DC Ripple free LED Driver", IET Power Electronics, 2017, Issue 1, No:1, pp:38-4.