# Passive Regenerative and Dissipative Snubber Cells for Isolated S.E.P.I.C. Converters

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**Abstract -** *An isolated converter consisting of SEPIC has excessive high voltage pressure on the primary & secondary transformer because of transformer leakage inductance. To come with this issue clamping of regenerativeactive or passive snubber is necessary. The common regenerative passive solution based on a RCD snubber is simple but however impractical becausethe importance of theleakageinductance is most significant. According to the analysis passive regenerative solution compromises the isolation, searching for a suitable snubber for the isolation would be a bigchallenge. Thispaper explains, an effective passive regenerative snubber cell operating in DCM or CCM. it is diversified & presented to take effective methodology to transfer the power saved in the transformer without leakage. It is supposed to enhance the converter performance through transferring thepowerstored within the transformer leakage inductance to the output. And also the analysis is presented in detail for both Dis-continuous Conduction Modeandalso, extended to Continuous Conduction Mode together in a practical design way. To compare & evaluate with the Resistor-Capacity-Diode snubber, the analysis and design of a conventional cell are arranged in a proper design manner.*

***To validate the idea and quantify its feasibility, experimental outcomes are achieved for each dissipative and regenerative snubbers on a 100 W, 100 V enter and 50 V output voltage converter running.***

***Key Words***: (Transformer, Passive, Regenerative, Snubber Cell, SEPIC Converters, Isolated, RCD snubber, leakage inductance, etc.)

## 1. PROBLEM STATEMENT

An isolated converter consisting of SEPIC has excessive high voltage pressure on the primary & secondary transformer because of transformer leakage inductance. The common regenerative passive solution based on a RCD snubber is simple but however impractical because the importance of the leakage inductance is most significant. According to the analysis passive regenerative solution compromises the isolation, searching for a suitable snubber for the isolation would be a big challenge. After referring several literatures or methods the final one usually provides Zero voltage switching (ZVS), however the predominant disadvantage is the addition of one or greater switches; whichincreasescost, compromises reliability and requires complicated drivers. A stronger solution is the conventional dissipative resistor capacitor- diode (RCD) snubber circuit, whichmaybeplaced at once across the transformer or throughout the transformer primary facet as depicted. RCD means resistor, capacitor & diode, snubber. This is a pre-powerful solution but all of the power saved in the leakage is converted to some heat, which results in lowering the converter efficiency. Besides that, if a better isolation level is required the leakage inductance turns into exceedingly high, making the usage of an RCD snubber impractical due to the high dissipation.

## 2. INTRODUCTION

The electrical potential (voltage) output of single ended primary inductor converter (also referred as Dc/Dc converter) is larger or less or equal to that of its input. The SEPIC is used in the variety of application from industries to modern robustness. Isolation is required when the output voltage of the main switch is equal to the input voltage, this occurs when the power saved in the transformer leakage inductance has no path to further circulate. This output voltage in the inductance leakage of the SEPIC is controlled for the power transformer. Continual low ripple current at the input compared to different standard optimization are some of the benefits of converter, for any operational mode. An isolated converter consisting of SEPIC has excessive high voltage pressure on the primary & secondary transformer because of transformer leakage inductance. To come with this issueclamping of regenerativeactive or passivesnubber is necessary. Due to high voltage spikes in transformer inductance, & to circulate the voltage a snubber is required to stop the damage to the main switch. It is supposed to enhance the converter performancethrough transferring the power stored within the transformer leakage inductance to the output. In this perspective, & to overcome with the problem this article proposes an alternate passive regenerative snubber, which is especially fitted to isolated SEPIC converters mixes the features of active Snubbers, especially ZVS, and therefore the robustness of passive snubber solutions. Each operational Evaluation performance of RCD regenerative Snubbers were considered & also analysed.

The SEPIC converter is a category of DC-DC converters that bucks, boosts or gives output voltage equivalent to input voltage. Output of SEPIC converter is controlled by duty cycle of the power transistor(S) as shown in Fig.1.

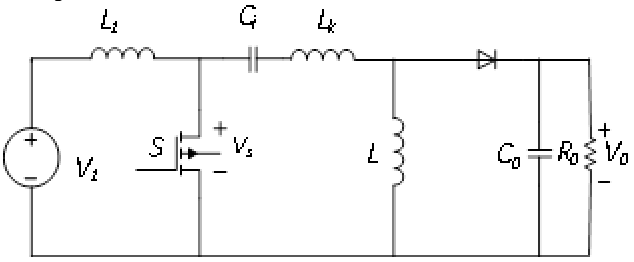



Fig. 1. SEPIC Converter

Galvanic isolationin DC-DC converters separates the input and output physically and electrically using isolated transformer as a result of which the circuit can have two separate ground references another advantages of isolation are safe operation with respect to hazardous input voltages, level shifting. Also the direct current flow from input to output is prevented with the help of this isolation transformer etc. Because of leakage inductance of transformer on primary side high voltage appears on power transistor. To mitigate this, active or passive snubber circuit need to be implemented. Sudden voltage rise during operation may leads to harm the switch. The efficiency of converter can be enhanced by transferring the energystored in the magnetic components (leakageinductance) to the load side.

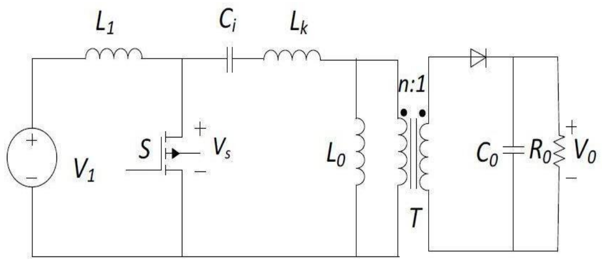



Fig. 2. Isolated SEPIC Converter

The single ended primary inductance can be used with switched mode power supplies (SMPS) and power factor correction unit (PFC), photovoltaic application's as well as ease as buck, boost or buck-boost topology and able to provide isolated output in specified conditions. An Isolated SEPIC converter has following prominent features.

- Low input current ripple
- Low Electromagnetic interference (EMI) at input side
- Step-up and Step-down operatingmodes
- Galvanic isolation between input andoutput

When switch is ON input voltage is applied to inductor L1and current in it starts to increase following equation:

VL= L (di/dt) (1)

In this mode, output diode on secondary side is reverse biased so it will not conduct and output capacitor provides the load current.

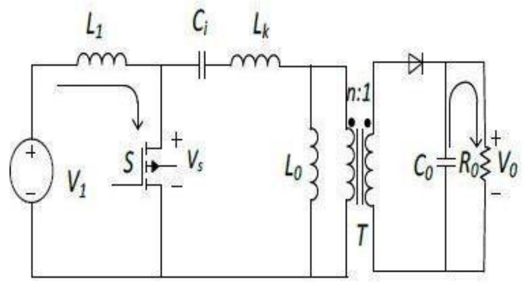



Fig. 3. SEPIC with switch ON

When switch is turned OFF energy stored in L1 and L0 gets transferred to the secondary side. During this energy transfer process voltage stress appears across theswitch.

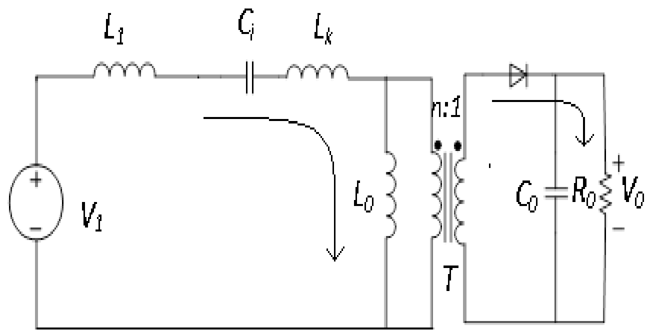



Fig. 4. SEPIC with switch off

## 3. IMPLEMENTATION

To provide online study material, career guidanceand result of examination as well as generate a graph of student to get his/her interest point of view. To analyze growth of student, class i.e. Students Performance Analysis Screen Shots

## 4. ADVANTAGES, LIMITATIONS & FUTURE SCOPE

**Advantages**

- Reduces switching losses (voltage stress on switches decreases)
- Increases converter efficiency
- Minimize the losses caused by the snubber addition
- Reducing the component count
- Cost effective

**Limitation**

- Requires complex drivers
- Increases cost
- Compromises reliability

**FUTURE WORK**

The future scope of the project is that it can be makeuseful for the High power conversion applications.

## 5. SYSTEM DESCRIPTION

Fig. 5 shows the block diagram of isolated SEPIC converter with LCD snubber. This system mainly consists of DC input, input filter, isolated SEPIC converter, output filter and load, 12V DC is generated from filtered DC input to drive the MOSFET of SEPIC converter. 5V of power is generated when the input DC is turned ONN which wakes up the Micro-controller. Depending on load conditions pulse setting is adjusted based on this microcontroller will control the duty cycle of MOSFET. And also the analysis is presented in detail for both Dis-continuous Conduction Modeandalso, extended to Continuous Conduction Mode together in a practical design way.

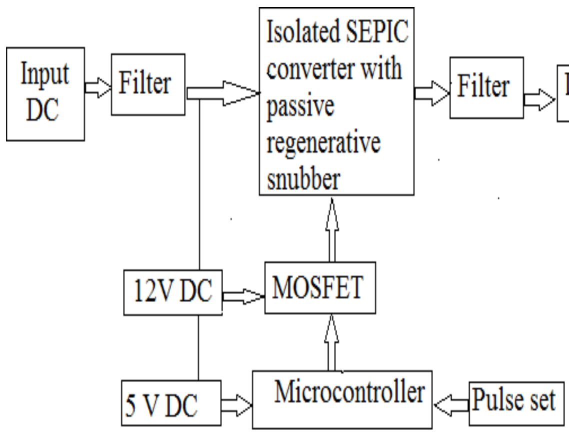



Fig. 5. Block Diagram

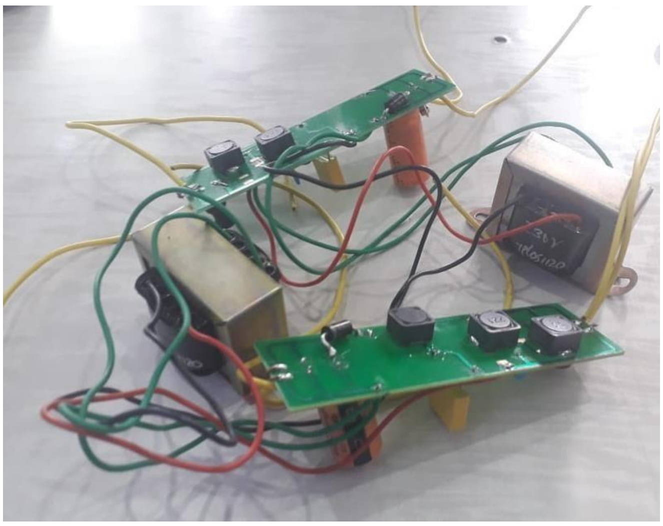


Fig. 6. Proposed System

## 6. EXPERIMENTAL RESULT

In order to validate the planned snubber construction, a convertor example was designed as shown in Fig. 7. The convertor was initial designed to control in DCM. And then Later operation for CCM were achieved by commutation the input and magnetizing inductors. The regenerative snubbers cell are highlighted in the Fig.7 shown below and are often replaced by the RCD snubber cell shown in Fig. 7 or by the regenerative snubber with coupled inductors delineate in Fig.7. Table I shows the convertor specifications whereas Table III summarizes the most designed parametersfor each DCM and CCM. For the switch S a 600 V MOSFET has been used and also the most voltage to style the snubber parts as per VS, max = 400 V. Components' half variety square measure shown in Table III. each snubbers in DCM and CCM were designed as per the required rules, specification, and obtained convertor parameters. The calculateddutycycle for nominal power is δ = 0.477 for DCM and δ = 0.5 for CCM. The snubbers designed parameters square measure provided in Table II conjointly. The experimental results summarized during this section were obtained in open loop for each operational modes and snubber choices.

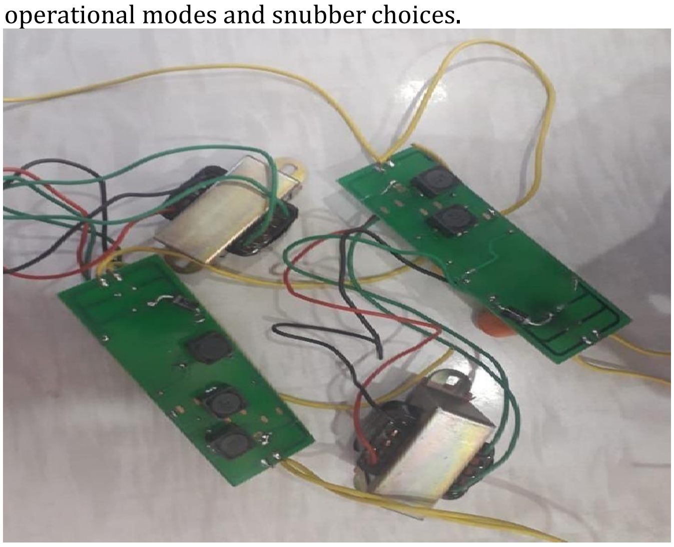


Fig. 7. Proposed System

In Fig. 7. 100 W experimental prototype including the proposed regenerative snubber cell (highlighted). Regenerative snubber cell using coupled inductors. RCD snubber cell.

**Table 1 GENERAL SPECIFICATIONS**

Rated power (Po) 100 W
Input voltage (Vi) 100 V
Output voltage (Vo) 50 V
Switching frequency (fs) 50 kHz

**Table 2 DESIGNED PARAMETERS (researched)**

| **Converter Parameters** | **DCM** | **CCM** |
|---|---|---|
| Decoupling capacitor (Ci) | 22 µF | 22 µF |
| Output capacitor (Co) | 1120 µF | 1120 µF |
| Input inductance (Li) | 3.84 mH | 3.09 mH |
| Magnetizing inductance (Lo) | 211.7 µH | 1.43 mH |
| Transformer turns ratio (n) | 2 | 2 |
| Leakage inductance (Lk) | 8.7 µH | 32.55 µH |

| **Regenerative Snubber Parameters** | **DCM** | **CCM** |
|---|---|---|
| Snubber capacitors (Csa and Csb) | 10 nF | 10 nF |
| Snubber inductors (Lsa and Lsb) | 220 µH | 1 mH |

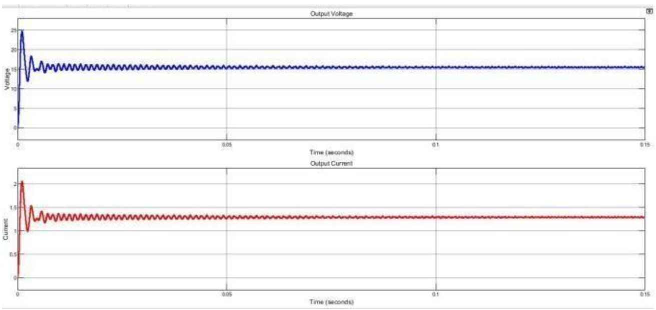
| **RCD Snubber Parameters** | **DCM** | **CCM** |
|---|---|---|
| Snubber capacitor (Csn) | 20 nF | 20 nF |
| Snubber resistor (Rsn) | 10 kΩ | 10 kΩ |

**Table 3 DESIGNED PARAMETERS (CALCULATED)**

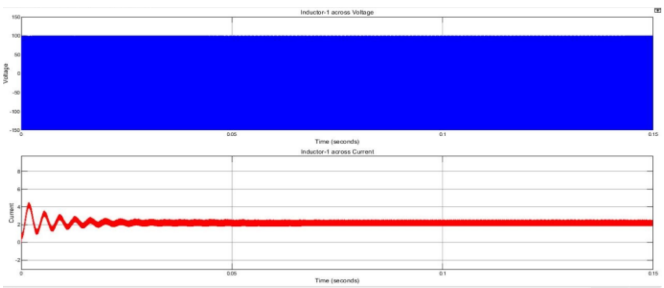
| **Converter Parameters** | **DCM** | **CCM** |
|---|---|---|
| Decoupling capacitor (Ci) | 20.2 µF | 22.3 µF |
| Output capacitor (Co) | 1124 µF | 1124 µF |
| Input inductance (Li) | 3.84 mH | 3.09 mH |
| Magnetizing inductance (Lo) | 201.7 µH | 1.23 mH |
| Transformer turns ratio (n) | 2 | 2 |
| Leakage inductance (Lk) | 7.2 µH | 30.50 µH |

| **Regenerative Snubber Paramete :s** | **DCM** | **CCM** |
|---|---|---|
| Snubber capacitors (Csa and Csb) | 8.2 nF | 8.2 nF |
| Snubber inductors (Lsa and Lsb) | 210 µH | 0.72 mH |

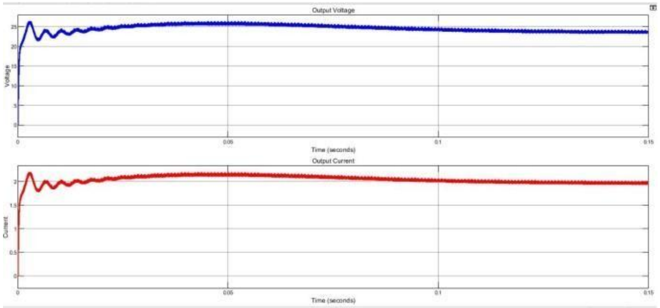
| **RCD Snubber Parameters** | **DCM** | **CCM** |
|---|---|---|
| Snubber capacitor (Csn) | 25 nF | 20 nF |
| Snubber resistor (Rsn) | 14.7 kΩ | 10 kΩ |




Graph .1 Voltage & Current Vs Time In Sec




Graph .2 Inductor Voltage & Current Vs Time In Sec




Graph .3 Voltage & Current Vs Time in Sec

## 7. CONCLUSION

For SEPIC converter different kinds of snubber are studied and compared based on their characteristics, circuit complexities, efficiency, features. The cost of snubber components and needful reduction in power loss are important factors need to be considered while choosing between dissipative and passive regenerative snubber. An appropriate snubber selection for SEPIC improves overall circuit operation resulting in reduction of switching losses, EMI, temperature of switch which helps for high frequency operation with reduced component count and weight of the system. The major advantage of RCD over basic RC snubber is that it reduces both the switching and snubber losses. The converter efficiency is improved by replacing RCD snubber with a LCD snubber who is generally referred as a lossless snubber. Based on the general specification of the example. Active & Passive snubber cells were designed and tested to pre-validate the concept. And, also the results obtained during testing were compared with the RCD snubber to ratify the efficiency. Analytical descriptions and design guidelines for regenerative snubbers are presented in this article as shown in the result table 3. Results obtained while testing are in quite good agreement and meets the demand with the expectations to exact solution, Proving, that the concept and the design methodology of the Passive snubber (regenerative) is preferable because its ability to improve the converter efficiency in good manner.

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