SEPIC Converter for Low Power LED Applications

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Abstract--Due to the development in light Emitting Diode (LED), white LED are on the whole utilized in homes, industries and business regions to replace the heated bulbs, non-metallic bulbs, and even compact fluorescent lamp (strength saving lamp). The primary choices in those applications are high strength factor, and coffee harmonics. The input line cutting-edge harmonics is decreased and power aspect is high. in order to manipulate the LED brightness a current remarks loop is brought. The benefits of the circuit are strength conversion, no want to sense the enter voltage, voltage step-up and down, simple feedback manage, excessive electricity component and dimmable LED present day. LED performs a critical function within the enterprise and in our existence. The SEPIC converter is to increase the efficiency of LEDs and get the better overall performance than the opposite lighting fixtures utility. There are numerous reasons for the fluctuations inside the deliver voltage, here propose the use of sepic converter this could triumph over that via giving us the deliver voltage without the fluctuation.

Key word-- SEPIC, LED, Voltage Control

1. INTRODUCTION

The changing mode DC-DC strength conversion machine may be produced via unique circuit properties. Buck-improve and Cuk converter are want and the maximum used. Every of the circuit has its very own benefits and disadvantages and it depends on energy conversion gadget. In general, circuits with the transfer referenced to the ground node are chosen to simplify the switch power circuits. Moreover, the rethamic beat enter modern-day is desirable to reduce EMI and decrease the need for added clear out elements [1]. Large benefit of the strength conversion gadget is likewise its ability to generate output voltage either above or beneath the enter voltage. SEPIC is the one that fulfills all above requirement (parent 1-1). The output voltage of the SEPIC is controlled by means of the duty cycle transistor M1. it can be more than, less than, or equal to the enter voltage. The greenback-enhance converter can also step up and step down inside the enter voltage, however the output is reversed. The SEPIC converter can keep the equal polarity and the same ground reference for the output [2]. Different benefits of SEPICs are the input/output isolation given through C1 and real strength off mode, when the switch is grew to become off output drops to zero V. additionally, it has little input modern ripple and easy to increase the more than one-output. SEPIC is useful in programs in which the battery voltage can be above or underneath the controller output voltage. It became popular nowadays the step up or step down voltage relying on the price stage of the battery [3].
Fig. (1): SEPIC Schematic

As an instance, a unmarried lithium ion battery has an output voltage stages from 4.2 volts to 2.7 v. The SEPIC has operative since the battery voltage may have both above and below the regulator output voltage.

2. ANALYSIS OF THE SEPIC CONVERTER

A SEPIC is a DC-DC converter allowing to the yield voltage to be not exactly, more than, or indistinguishable from for its information; the yield of the SEPIC is worked through the commitment pattern of the oversee transistor. SEPIC is ordinarily a lift converter and it saw by utilizing a buck-raise converter, thus it’s far a normally finished by methods for a greenback-raise converter, it has advantages of having non-modified yield (the yield that has indistinguishable voltage polar as the enter), to move a chain capacitor to couple power from the contribution to the yield (and that can react additional style to a concise circuit yield), and having the capacity of concerned shutdown: after the switch S1 is developed to get off, its yield drops to 0 V, following an ephemeral withdraw of charge. SEPIC is advantageous in applications in which a battery voltage can be above and underneath that of the controller's design yield [4].

Fig. 2: Circuit diagram of SEPIC converter

The schematic diagram for a basic SEPIC is appeared in parent 2.1 on the grounds that they did exchanged mode power components are (uncommonly DC-to-DC converters), the SEPIC impact power among the capacitors and inductors are to substitute starting with one voltage then onto the next. the measure of vitality traded is approve in switch S1, which is in vogue a transistor including a MOSFET. MOSFET is more noteworthy higher a decent arrangement rivalry to the current day and lower voltage drop than bipolar intersection transistors (BJTs), it do now not requires biasing resistors as MOSFET exchanging is overseen through contrasts in voltage instead of a present day [5].
3. PROPOSED SINGLE ENDED PRIMARY INDUCTANCE CONVERTER BASED LED DRIVER

The square outline underneath is the segment AC-DC SEPIC converter, on this, air conditioner voltage is given as enter and the scaffold rectifier changes over the air conditioner voltage into dc voltage. The changed over dc voltage is given to SEPIC converter circuit and afterward the fundamental yield voltage is guaranteed. Air conditioning DC converters produce well-known direct front line (DC) from exchanging bleeding edge (AC) inputs. In a converter, the AC enter is amended and associated with an expected DC yield voltage [6].

![Block diagram of proposed system](image1)

Fig.3: Block diagram of proposed system

The proposed non-remoted coupled-inductor SEPIC converter utilized as LED load with CC and also improves the quality factor at enters AC mains.

The schematic chart of the exhorted intention power is given in figure 3.1 it is formed the utilization of a solitary stage uncontrolled rectifier watched by means of the proposed SEPIC converter in after design to convey the necessary capacity to a LED load [7].

4. OPERATING PRINCIPLE OF PROPOSED TOPOLOGY

The recommended that to be non-secluded %-LED main thrust controllers in DCM over the all over AC mains ordinary. At low charge of gracefully voltage, the obligation pattern of the converter is over to hold a necessary power to the weight, and the converter works a significant wants to the limit conduction mode.

Since the voltage will build, the obligation cycle is balanced with respect to and proceeds with the PF of the converter extremely near to amicability. Check the concert of the SEPIC converter by current flow through the individual components and shown in figure.4.

![Switching diagram](image2)

Fig.4: Switching diagram
The inductors are too closely coupled; for that, the collision contemporary is divided between them, which conduct to lower EMI. Consequently, this reduces the ohmic drop of the couple inductor which will improve the efficiency of converter. The SEPIC converter operation in a regular nation situation has been defined in 3 different levels as proven in parent 5.1 to 5.3.

Mode I [0 <= t <= dTsw; Figure 5.1]:
The operation of mode-I is shown in figure 5.1. in this , S-ON and D-off state. The L1, L2 and C1 stores the energy and Co continually supplied power to the load resistor.

Mode II [dTsw <= t <= d1Tsw; Figure 5.2]:
While S-OFF and D-On, the voltage all through L2 changes and its extremity are same and accordingly the diode (D) transforms into ahead one-sided and now it's miles straightforwardly connected to the heap. Thus, the voltage across L2 it should be the yield DC voltage (Vdc) and presents solidarity to the heap. The voltage strain to the exchange for a specific cycle will turn into the on the spot input voltage just as the DC yield voltage [8].

Mode III [d1Tsw <= t <= Tsw; Figure 5.3]:
During this time period, S-OFF and D-OFF, flows through a coupled-inductor and coupling
capacitor are inert. The yield capacitor gives vitality to the load.

5. VOLTAGE CURRENT CONTROL FOR THE SEPIC CONVERTER

In a voltage control, the DC-DC converter provides the output voltage in a feedback to a pulse width modulation controller corresponds to the Diagonal of the duty cycle. Fig.6. suggests a DC-DC converter voltage is control set-up voltage mode manage it has a single manage loop.

![Fig. 6: Block diagram of voltage current control](image)

The design of a manage loop layout is depends on a small transferable characteristic of a DC-DC converter power degree, the degree voltage and the benefit of the PWM comparator has its own that to be taken in consideration. The manage loop is stabilized by using adding a every other community.

The square outline of a solitary stage AC-DC converter is to be carried with voltage to that procedure. As appeared in decide three.1, it use as a basic control remarks, it handiest takes yield voltage detecting. The extension rectifier is utilized for the info AC side to a p.c the utilization of an inductor and capacitor blend for it.

Presently, a little estimation of yield voltage is when contrasted with the reference charge and following worth, and afterward it passes through the yield voltage controller, which creates the PWM yield and it's far utilized for exchanging of the converter. It has a critical quality factor of revision characteristics with predictable commitment proportion and exchanging recurrence, it offers an alluring answer for the lessening quality applications [9].

The yield voltage guideline is outfitted by utilizing the criticism circle as appeared in parent.6 wherein the yield is detected and by means of the voltage is in correlation with a reference esteem and the mistake is intensified in a relative vital (PI) controller that to be in examination with a saw-tooth slope, subsequently it gave to the heart beat to the force switch. So, this circuit is constrained by utilizing the trade in the on-time c program language period and the steady exchanging recurrence fs . The points of interest and inconvenience for the voltage mode control are recorded underneath [10].

6. SEPIC MODELING

The following assumption to be made for designing of the DCM based SEPIC converter.

- The String LED lamp acts as a resistor under the turn on state with the steady state condition.
- In a power factor correction mode, the components are ideal.
- The switching frequency is very higher than the supply frequency.

The maximum duty cycle value will be calculated from the voltage balance equation. The voltage balance equation depends on stored energy in an inductor and equally share the energy of $L_1$ and $L_2$ to turn on and off period. That is represented in below equation,
\[ \text{Vin(min)} d_{\text{max}} = V_{\text{dc}}(1 - d_{\text{max}}) \]

\[ d_{\text{max}} = \frac{V_{\text{dc}}}{V_{\text{in(min)}} + V_{\text{dc}}} = \frac{66}{0.9 \times 90 \times \sqrt{2} + 66} = 0.3655 \]

\[ L_{1(\text{crit})} = L_{2(\text{crit})} = \frac{(1 - d_{\text{max}}) V_{\text{dc}}}{2 f_s \Delta I_{dc}} = \frac{(1 - 0.3655) \times 66}{2 \times 50000 \times 0.4} = 1.046 \text{ mH} \]

The value of coupling capacitor depends on allowable ripple current flow through it. Coupling capacitor value calculated by the following equation,

\[ C_1 = \frac{l_{dc} \times d_{\text{max}}}{\Delta V_{c1} \times f_s} = \frac{0.425 \times 0.365}{40 \times 50000} = 77.67 \text{ pF} \]

The purpose of DC Capacitor Co is connected across load to minimise or zero distortion in the output load voltage. The Value of Co is calculated by the following equation,

\[ C_0 \geq \frac{V_{\text{dc}} \times d_{\text{max}}}{\Delta V_{c0} \times f_s \times R_{dc}} = \frac{66 \times 0.3655}{0.066 \times 50000 \times 155.29} = 47.07 \mu F \]

Here,

\[ d_{\text{max}} \] - Maximum duty ratio.
\[ V_{\text{dc}} \] - Desired output DC voltage.
\[ V_{\text{in(min)}} \] - Minimum value of controlled supply voltage.
\[ V_{\text{dc}} \] - rated output voltage
\[ f_s \] - Switching frequency
\[ R_{dc} \] - load resistance

7. SIMULATION OF SEPIC OPEN AND CLOSED CONTROLLERS

The simulation for speed manage of Sepic converter is done by way of the use of MATLAB(R2019a). MATLAB® is a completely excessive-degree language and it interacts surroundings to perform computationally included duties and it is faster than with conventional programming languages such as C, C++, and FORTRAN the general activity of the % SEPIC converter is completed by and its general execution is recreated by utilizing MATLAB/SIMULINK and Sim power framework (SPS) tool kits. The assessment, format, and reenactment of the ideal SEPIC LED thought process power have wanted redesigns in PQ boundaries with molding convey mains.
Table 1: Simulation details

| Components          | Parameters                                      |
|---------------------|-------------------------------------------------|
| Universal Bridge    | No of bridge arms : 2                           |
|                     | Snubber resistance Rs : 1e5                    |
|                     | Snubber capacitance Cs : inf                   |
|                     | Ron (ohms) : 1e-3                              |
| Ac voltage source   | Peak amplitude (V) : 230                        |
|                     | Frequency (Hz) : 50                             |
| Capacitor           | C0 = 1000e-6, C1 = 100e-9                      |
|                     | C2 = 47e-6                                      |
| Inductor            | L0 = 1e-3, L1 = 1e-3                           |
| Load resistance     | RL=150                                          |
| Comparator          |                                               |
| PI controller       | Proportional (P) =0.001                         |
|                     | Integral (I) = 0.09                            |
| Repeating Sequence  | Time values : [0 0.00001 0.00002]               |
|                     | Output values : [0 1 0]                         |

Fig 7.1: Open loop simulation model

Fig 7.2: Input voltage(230) graph
Fig 7.3: Input current graph

Fig 7.4: Duty cycle

Fig 7.5: Output voltage (66v) graph

Fig 7.6: Output current (0.48a) graph
Fig 7.7: Closed loop simulation Model

Fig 7.8: Input voltage (100v) graph

BUCK MODE FOR 66V

Fig 7.9: Duty cycle for buck mode

Fig 7.10: Output voltage (66v) graph

Fig 7.11: Output current (0.425a) graph
8. CONCLUSION

A Discontinuous Conduction mode worked by methods for quality component Correction LED driver has been used by non-confined SEPIC converter by methods for PWM procedure has been requested for low power indoor lights bundles. Standard SEPIC converter is proposed to LED main thrust has used a totally low expense of coupling capacitor (eighty two nF, 630 V). Subsequently, a little film inside the capacitor with less scattering thing has been recruited. This improves the all over proficiency of the LED driver in it that in contrast with an electrolytic capacitor. The circuit has done low consonant contortions and exorbitant power thing for a 28 W LED light burden at broad AC voltage adaptations. Inside the exhorted LED thought process power, the general estimated effectiveness is found as 88.82% at appraised convey voltage of 220 V. The DCM worked SEPIC converter has shown progressed PQ by and large execution with 3.60% information current.

Advanced mathematical in conjunction with designed controller is simulated the use of MATLAB/Simulink. Controller performance became checked for distinctive running situations. In each case it turned into found that both output voltage and inductor cutting-edge.
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