High Frequency Resonant SEPIC Converter for power line carrying communication (PLCC) with Wide Input and Output Voltage Ranges controlled by fuzzy logic

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Abstract—

Here I to presents a new method of the power line communication with resonant Single-Ended- Primary-Inductor-Converter (SEPIC) converter. The proposed design features high performance along with any range of the voltage level of the transmission line, small size, and excellent for the communication clarity. To this there have a gate drive scheme is provided which provides instant start for converter and low-loss at HF and VHF frequencies which used for the communications. The converter regulates the output using a fuzzy logic control scheme modulating at a constant frequency (200 kHz). This control method enables most sudden transient response and efficient light load operation while providing controlled fuzzy based characteristic of the input and output communication and power waveforms. To enable the varying harmonic in the wave form A hysteretic override technique is also introduced which with a bandwidth much greater than the carrying frequency of the communication, limiting output voltage harmoniC12 to within a constant value. An experimental prototype has been built and evaluated. The prototype converter, built with two commercial vertical IGBT, operates at a constant switching frequency of 20 MHz, with an input voltage range of 11 kV to 200V, an output voltage range of 11 V to 220 V and an output power rating of up to 3W. The converter achieves higher than 85% performance across the entire input voltage range at nominal output voltage, and maintains good performance across the whole operating range with fuzzy logic control.

1 INTRODUCTION

MANY power line communication have a applications could benefit from a power converter able to maintain high performance across wide input and output voltage ranges also for the frequency range at a portable size. For the mentioning the fact that the size of the converter that hardly affect the performance of the transmission power. especially in
the transmission operation that handled both up-and-down voltage conversion is to be achieved. Furthermore, the large capacitor bank is used for the energy storage required at switching operation of a few varying range of the frequency and below limits the degree of miniaturization that can be achieved a most suitable fast transient response for high speed communication. Therefore, by the use of the low pass filter design methods that reduce energy storage requirements by the and expand efficient operation range are desirable. In this paper, we eliminate the use controlling techniques such as resonant switching and gating along with fuzzy logic control techniques to achieve these goal.

Here we operate the communication wave through a quasi-resonant SEPIC converter, resonant gate drive and associated control methods suitable for converter designs at frequencies above 20 MHz. Not like many power line communication converter designs the proposed approach provides high performance over very wide input and output voltage ranges and power level \( L_1 \). It also provides up-and- down conversion of the voltage in the sub station and the switching stations, and requires little energy storage which replace by the coupling capacitor that are used. and also the method which are used in the quasi-resonant and multi-resonant converters no bulk inductor is used and the converter operates for the modulating the communication signal at constant frequency and duty ratio. These attributes reduce passive component size, improve response speed, and enable the use of low- loss sinusoidal resonant gating for the inductive operation that are to be used for the low pass filter operation for the power signal. And also a new constant-frequency fuzzy logic control is introduced which provides good control over input and output frequency at the desirable level for the communication channel. The proposed design is discussed in the context of a prototype converter operating over wide input voltage (11-200 kV), output voltage (11-220 kV) and power (0.3 - 3W) ranges. The proposed system is mainly suitable, for example, for a power supply to provide communication between substations and the switching station with the generating station of an RF power amplifier from a battery input. The biasing operation that are to be handled by the DC source that are to be enabled by the battery source through the converter. The following are the descriptions that are to explain the components of the system.

IIA SEPIC CONVERTER DESIGN FOR SYSTEM

Below shows are the schematic diagram for the power stage of the proposed converter. For the explanation of the communication through the power line by using the SEPIC converter by the conventional SEPIC converter and with the multi-resonant SEPIC converter proposed in. However, the detailed component placement and sizing, operating characteristic \( C_{12} \) along with the quality and the quantity of the communication data that are to be transfer through the communication channel.

Let initially explain with. The conventional SEPIC converter has more than one bulk inductors for the low passing operation of the power signal, and yields difficult operations for the biasing of the switch and diode. As the reason above mention in the conventional quasi-resonant SEPIC converter \( L_1 \) is a choke inductor, selected to provide nearly constant current over a switching cycle.
And the another converter which we care used for the explain the existing is that The multi-resonant SEPIC operated with a bulk inductors for the communications, and these are used for the wave trapper in the system, but explicitly introduces a coupling capacitor capacitances in parallel with the switch and diode switching device along with a resonant inductor in series with the coupling capacitor $C12$ to get a very efficient zero-voltage soft switching of the switch and diode for the better enrichment of the reduced rate of the switching loss. The low passed filter design that are introduced here supported with capacitances in parallel with the switch and diode. This type of the low pass filter that are entirely make a change over to previous type of resonant SEPIC designs, however in the design here has no bulk inductors are to used for the wave trapping operation of the power signal that are to be transmitted through the line to the substations. Rather, it uses only two resonant inductors: one inductor, $L1$, resonates with the net switch capacitance, $C_{OSS} + C1$, for resonant inversion, while the other inductor, $L_{RS}$, resonates with the rectifier capacitance, $C12$, for resonant rectification. By the way of the design procedures that we are followed though we can eliminate the magnetic components in the system. Controlling operations that operated in the converter proposed here and previous resonant SEPIC converters further major difference mode of controlling. The conventional resonant SEPIC converter control the output voltage by keeping tuning the duty cycle in such a mode that the on-time pulle constant while varying the off time duration, leading to variable-frequency, variable- duty-ratio operation. But in conventional designs which are used variable frequency control to regulate the output the design here operates at constant switching frequency for the diode and duty ratio., output control is instead achieved through duty ratio control, in which the entire converter is modulated on and off at a modulation frequency that is maintained at the rate which is below the switching frequency. Operation at a constant frequency and duty ratio enables for the most reasonable factor that help to the elimination of bulk magnetic components and facilitates the use of highly efficient sinusoidal resonant gating for the on\off operation of the diode. Moreover, an another specification in the switching zero-voltage soft switching(ZVS) to be maintained over wide input and output voltage ranges, and reduces the switching losses and also the variation in device switching stress with converter load that occurs in many resonant designs. To explain the Operation of this
converter in the easiest way that are to be divided into two subsystems: a resonant inverter system and a resonant rectifier system. To the design procedure for the proposed system we involves designing the rectifier and inverter individually, and there is a necessity of coupling the inverter and rectifier together, then retuning as necessary to account for nonlinear interactions between the inverter and rectifier. That are to be follows…

A. Rectifier Design

The SEPIC converter that are to be explain withy rectifier and the design procedure of a full dc-dc converter starts with the rectifier. The particular resonant rectifier model of interest here is illustrated in Fig. 2 (along with a sinusoidal drive source used in tuning the rectifier design). A similar rectifier structure was illustrate3d in the existing method but under different driving conditions are implemented in these methods. The rectifier which we are implemented have utilizes a resonant tank comprising a resonant inductor $LR$ which provides a dc path for the output current and a capacitance including an external capacitor $C12$ along with additional parasitic junction capacitance from the diode which act as the low pass filter that we have mention..

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Fig.2 a sinusoidal drive source used in tuning the rectifier design

For the design procedure of the rectifier, we start by assuming that it is magnitude of the driven by a sinusoidal current source $IIN$ at a given output voltage $VOUT$, as illustrated in Fig. 2. It is recognized that the actual drive waveform is not in sinusoidal waveform, which may have some harmonics components. this fact is addressed in a later tuning step. For a desired output power level and operating frequency which is applicable for the power line communication, the rectifier is tuned to appear resistive in a describing function sense by adjusting $C12$ and $LR$. That is, we adjust $C12$ and $LR$ such that the fundamental component of $VR$ is in phase with the drive waveform $IIN$ or alternatively has some phase shift, thus presenting an equivalent reactive component. Which make the disturbances to the waveform frequency. In doing this, we start by assuming a drive amplitude $IIN$. We also adjust the values of $LR$ and $C12$ and/or the assumed drive level $IIN$ to ensure that the desired power is delivered through the rectifier. The
equivalent rectifier impedance which are detected by the help of the distance relay that are linked with the sub stations. at the operating frequency is calculated as the complex ratio \( Z_{EQV} = \frac{V_R,1}{I_{IN}} \), where \( V_{R,1} \) is the fundamental of \( V_R \). There the equivalent impedance from the relay that can be used in place of the rectifier for designing the resonant inverter, assuming that the majority of the output power delivered to the load is transferred through the fundamental.

![Graph](image)

Fig.3 Fundamental voltage, \( V_R \) and current, \( I_{IN} \) of the resonant rectifier

**TABLE I**

<table>
<thead>
<tr>
<th>( LR )</th>
<th>90 nH</th>
<th>118 nH</th>
<th>118 nH</th>
</tr>
</thead>
<tbody>
<tr>
<td>( CEX2 )</td>
<td>150 pF</td>
<td>50 pF</td>
<td>150 pF</td>
</tr>
<tr>
<td>( jZ_{EQV} )</td>
<td>18.07</td>
<td>19.08</td>
<td>18.12</td>
</tr>
<tr>
<td>( \sqrt{Z_{EQV}} )</td>
<td>36.9°</td>
<td>47.69°</td>
<td>0</td>
</tr>
<tr>
<td>( P_{OUT} )</td>
<td>2.28 W</td>
<td>2.97 W</td>
<td>4.12 W</td>
</tr>
<tr>
<td>Efficiency</td>
<td>89.6%</td>
<td>90.6%</td>
<td>91.4%</td>
</tr>
</tbody>
</table>
B Inverter Design
The second main part of the converter that we are plan to operate is inverter and let us consider the inverter structure of Fig. 4, which includes impedance matching from the inverter to the equivalent rectifier impedance. Inverter design procedure begins by choosing appropriate matching components. The matching inductance that we are obtained become later absorbed as same as the design values follows for the rectifier, with \( L_{RS} \) being the parallel combination of the inverter inductor for the wave trapping operation \( L_1 \) and the rectifier inductor \( L_R \). Let we take that most power frequency is transferred through the fundamental, the maximum equivalent resistance \( R_{\text{MAX}} \) needed to deliver an output power level of \( P_{\text{OUT}} \) with a fundamental frequency at the MOSFET drain, \( V_{DS;1} \) can be calculated, we have many class of converters are therer but we choose Class-E inverter. Therefore, one possible starting point to obtain \( R_{\text{MAX}} \) is to approximate the fundamental voltage as in the Class-E inverter case, \( V_{DS;1} = 1:8 \_ V_{\text{IN}} \). It is recognized that the actual \( V_{DS;1} \) of the resonant SEPIC converter is not exactly \( 1:6 \_ V_{\text{IN}} \) the effects of which can be addressed by adjusting output power when coupling the inverter and rectifier together.

![Resonant inverter for tuning](image)

Fig4. Resonant inverter for tuning
A successful implementation of fuzzy controllers for DC-DC converters is presented in this paper. Two different fuzzy logic control topologies are developed and implemented using different types of DC-DC converters such as the buck, the boost, the buck-boost, and the SEPIC converters. Issues of sudden changes in the load or parametric uncertainties control and communication interface, among many other issues, are discussed and presented.

Our goal is to implement a robust fuzzy controller that can achieve the following properties: 1) Robustness around the operating point (e.g. in the case of a load change; 2) Good dynamic performance (i.e. rise time, overshoot, settling time and limited output ripple) in the presence of input voltage variations (and load changes); and 3) Invariant dynamic performance in presence of varying operating conditions.

Computers can only understand either '0' or '1', and 'HIGH' or 'LOW'. Those data are called crisp or classic data and can be processed by all machines. The output of a fuzzy controller is derived from fuzzifications of both inputs and outputs using the associated membership functions.

Fuzzy ideas and fuzzy logic are so oftenutilized in our routine life that nobody even pays attention to them. For instance, to answer some questions in certain surveys, most time one could answer with 'Not Very Satisfied' or 'Quite Satisfied', which are also fuzzy or ambiguous answers. Exactly to degree is one satisfied or dissatisfied with some service or product for those surve
HYSTERIC OVERRIDE TECHNOLOGY

This is the advanced and suitable method that used to illuminate the load disturbance in the output voltage waveform. These are to be worked on the upper bound of a pre-determined hysteresis voltage band the hysteretic controller output overrides the fixed frequency PWM output become compare with the power stage off until the output voltage falls below the upper limit of the voltage band. If the output voltage falls at one time below the upper limit of the voltage band the fixed-frequency controller takes overhand the controller operates as the already written programs in the fuzzy logic controller.. and also in the condition which, a large load step where the transient output voltage drops below the pre-determined lower value that set in the hysteresis voltage band. The hysteretic controller output again overrides the fixed-frequency controller output keeping the power stage on until the output voltage retain to back above the lower limit of the hysteresis voltage band that required for the normal operation.
**EXPERIMENTAL RESULTS**

This section presents the design and experimental evaluation of the proposed resonant SEPIC converter which are to be applicable for power line communication with the help of the fuzzy logic control. The converter operates at 200 MHz and utilizes two commercial 10 V vertical MOSFETs in parallel.

Converter waveforms are presented, which shows measured drain, gate and rectifier voltages for minimum $V_{in}$ corresponding voltage range and maximum $V_{in}$ at nominal $V_{out}$. From the experimental waveforms of the voltage that shown, the topology indeed provides good zero voltage switching characteristics.
which increases the reliability of the output waveforms of the communication signals.

A photograph of the prototype of a dc-dc converter sepic based are shown below

![Photograph of 20 MHz experimental prototype](image)

**Fig. 10-** Photograph of 20 MHz experimental prototype

The modulation frequency at which the converter is turned on and off is 200 kHz and the output waveform effect of the modulation frequency with the communication signal are shown below

![Experimental controller output signal and gate drive](image)

**Fig. 11.** Experimental controller output signal and gate drive.

![Experimental load step transient response with a fixed-frequency fuzzy logic controller with hysteresis override](image)

**Fig. 12.** Experimental load step transient response with a fixed-frequency fuzzy logic controller with hysteresis override
CONCLUSION

The data which presents a resonant SEPIC which controlled by a fuzzy logic converter suitable for extremely high frequency operation and for operating across a wide input and output voltage range and also we range of the frequency for the power line carrying communication the topology that handled with the most suitable advantages of the SEPIC converter with high efficiency, with gate drive method and fuzzy logic control scheme. The merits of these design methods are varied via a 200 MHz and also the system with an input voltage range from 11 kV to 200 kV, an output voltage range of 11kV to 220kV and a rated output power of 3W. The converter utilizes a low-loss sinusoidal gate drive and an fuzzy control method modulating at fixed frequency, provides both fast transient response and good control of the power and communication signal over spectral characteristics of the input and output voltage. A hysteretic override technique is also introduced which enables the converter to reject load disturbances of the signal transmitted through the power line, with a bandwidth much greater than the modulation frequency, limiting output voltage disturbances within a fixed value. This extremely rapid load disturbance rejection is enabled by the small passive component values and magnetic energy storage required known as wave trapper., the slew rate of the output voltage is limited by the output capacitance by the rate to be maintain constant, which is sized by the desired modulation ripple voltage and modulation frequency. As the size become reduced which cane be used in the sub station and generating station. and also it help to improve the efficiency of the entire system.

REFERENCES