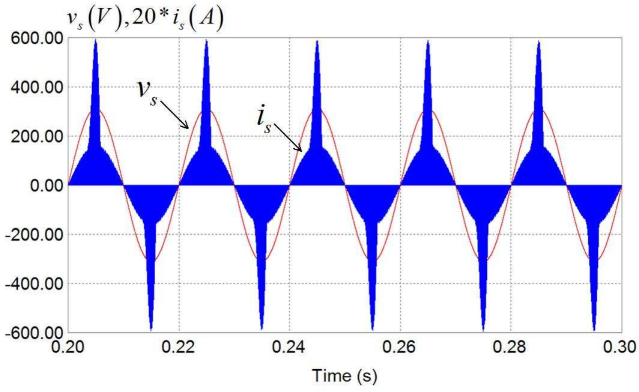
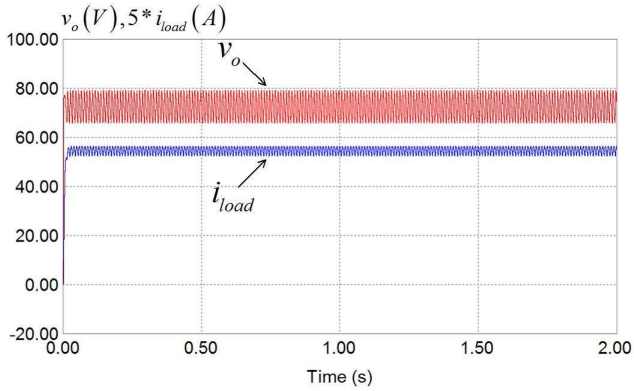
Table 2 Design results (converter with an RL load).

Parameters	Values
peak input voltage (V_g)	311 V 50 Hz
avg. output voltage (V_o)	72.73 V
avg. output current (I_o)	11 A
switching frequency (f_s)	50 kHz
L_m , L_o	700 uH, 40 uH
C_1 , C_o	100 uF, 4.4 mF
turns ratio of hf transformer (n)	0.2
duty cycle (d_1)	0.5391
M	0.2339



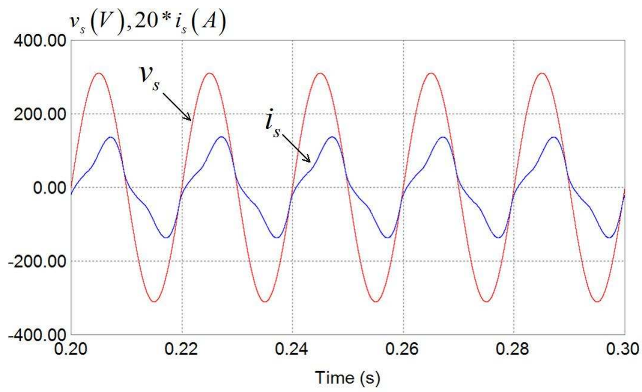
(a) source voltage and current waveforms



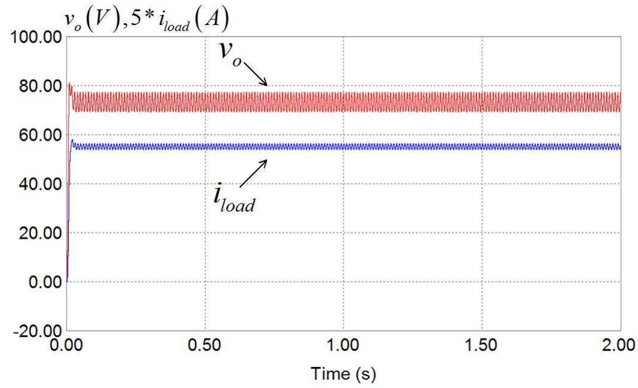
(b) output voltage and current waveforms

Fig. 7 Simulation results (RL load, without LC filter).

The voltage and current waveforms obtained from PSIM are illustrated in Fig. 7. With the assumed RL load, the average output voltage and current of the converter are 72.83 V_{dc}, and 10.93 A_{dc}, respectively, according to the expectation. Without a filter, the current harmonic is as high as 143%, and the power factor is 0.5844 (lagging). An LC filter having L_f = 50 mH and C_f = 137 nF is added to the input frontend. The duty cycle is also increased to 0.5861 to compensate for the associated voltage drop. The simulation results indicate that the average output voltage is 72.34 V_{dc}, the average output current is 10.86 A_{dc}, with 28.83 %THDi and power factor of 0.8842 (lagging). It is observed that the LC filter significantly decreases the pulsation of the source current, in turn drastically reduces the harmonic distortion, and increases the power factor of the circuit.



(a) source voltage and current waveforms



(b) output voltage and current waveforms

Fig. 8 Simulation results (RL load, with LC filter).

7 Conclusion

This paper has explained the principle of operation of the zeta converter with the design formulas for the continuous current mode (CCM) of operation. It also presents the development of the state-variable, and the transfer function models of the isolated zeta converter. Two design examples are given for the cases of R, and series RL loads. Detailed simulation results are presented, and the following conclusions are drawn: (i) the output voltage and current contain a considerable amount of ripples which have to be limited in practice, (ii) the converter without an input filter produces a great deal of current harmonic, and possesses a low power factor, and (iii) a simple LC input-filter can be used at first sight to reduce the harmonic, and to increase the power factor. The issues concerning the discontinuous current mode (DCM), the control of the output power, the power factor correction, and the harmonic reduction are under investigations.

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LIST OF SYMBOLS

d_1	=	"on" duty cycle of switch S
d_2	=	"off" duty cycle of switch S
f_s	=	switching frequency (Hz)
i_{C1}	=	current of capacitor C_1 (A)
i_{Co}	=	current of capacitor C_o (A)
i_D	=	current of diode D (A)

i_g	=	output current of rectifier (A)
i_{Lm}	=	current of inductance L_m (A)
i_{Lo}	=	current of inductance L_o (A)
i_o	=	output current (A)
i_p	=	primary current of transformer (A)
i_s	=	input current (A)
n	=	turns ratio of high frequency transformer
v_{C1}	=	voltage of capacitor C_1 (V)
v_g, V_g	=	output voltage of rectifier (time domain), peak value (V)
v_{Lm}	=	voltage of inductance L_m (V)
v_{Lo}	=	voltage of inductance L_o (V)
v_o, V_o	=	output voltage (time domain), average value (V)
v_s	=	sinusoidal source voltage (V)
$G_{vd}(s)$	=	transfer function of duty cycle to output voltage
$G_{vv}(s)$	=	transfer function of input to output voltages
M	=	voltage gain of peak input to output voltages
THDi	=	total harmonic current distortion
T_s	=	switching period (s)
Δi_{Lm}	=	current ripple of inductor L_m (A)
Δi_{Lo}	=	current ripple of inductor L_o (A)
ΔV_{C1}	=	voltage ripple of capacitor C_1 (V)
ΔV_{Co}	=	voltage ripple of capacitor C_o (V)
γ	=	output ripple factor
$\sim$	=	small-signal perturbation
$'$	=	transferred circuit parameters from secondary to primary