DESIGN OF DUAL-INPUT TWO PHASE DC/DC CONVERTER WITH MODIFIED PULSE WIDTH MODULATION (MPWM)

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Specially dedicated to my beloved family

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ABSTRACT

Recently, hybrid energy source/renewable energy has attracted interest as the next-generation energy system capable of solving the problems of global warming and energy exhaustion caused by increasing energy consumption. Energy sources such as wind turbines and photovoltaic (PV) systems are intermittent, unpredictable and unregulated. For such systems, the use of multiple-input converter (MIC) has the advantage of regulating and controlling multiple-input sources. With multiple Pulsating Voltage-Source Cells (PVSC) configurations, the proposed converter can deliver power to the load individually and simultaneously. Also, it has the capability of operating either in buck, boost or buck–boost mode of operation. In addition, by proposing the enhanced Modified PWM (MPWM) switching scheme, it is able to solve the issues of the overlapping unregulated input sources. Furthermore, with the proposed multiphase configuration, the input current stresses in the switching devices are reduced and it has the benefit of a reduction in conduction losses. In addition, Zero-Voltage Switching (ZVS) technique is also employed in the proposed converter to reduce the switching loss. The proposed converter circuit is simulated by using MATLAB/Simulink and PSpice software programs. The duty cycle employed to regulate output voltage is reached from Altera DE2-70 board through dSPACE DS1103 board using by Proportional-Integral (PI) controller. The dual-input converter circuit model specification with output power at 200 W, input voltages that range from 10 to 60 V, and operating with dual switching frequencies of 50 kHz and 100 kHz is simulated to validate the designed parameters. Design guidelines, simulation and experimental results are presented. The results show that the proposed two-phase DC/DC converter with ZVS technique achieves 94% efficiency for all ranges of loads compared with the multiphase hard-switching. The total power losses across the power switches are reduced by approximately 37% in the proposed

converter. Thus, the proposed converter circuit model offers advantages on input current stress and switching loss reductions. The proposed circuit configuration can be used in a standalone hybrid energy system under unregulated DC input voltages. However the major disadvantages of resonant circuit are increased peak current and voltage stress and not suitable for variable frequency operation.

ABSTRAK

Baru-baru ini, sumber tenaga hibrid/tenaga boleh diperbaharui telah menarik minat sebagai sistem tenaga generasi seterusnya, mampu menyelesaikan masalah pemanasan global dan kekurangan tenaga yang disebabkan oleh peningkatan penggunaan tenaga. Walau bagaimanapun, sumber tenaga seperti sistem turbin angin dan sistem fotovoltaik (PV) adalah berselang, tidak menentu dan tidak terkawal. Bagi sistem sedemikian, penggunaan penukar pelbagai input (MIC) mempunyai kelebihan untuk mengawal dan menyelia sumber-sumber masukan yang banyak. Dengan pelbagai konfigurasi Sel-Sumber-Voltan (PVSC), penukar yang dicadangkan boleh menyampaikan kuasa untuk memuatkan secara individu dan secara bersamaan. Selain itu, ia mempunyai keupayaan untuk mengendalikan sama ada dalam mod operasi menaik, menurun atau menaik dan menurun. Di samping itu, dengan mencadangkan skim penukaran PWM yang diperbaharui (MPWM), ia dapat menyelesaikan isu-isu sumber input bertindan yang tidak terkawal. Selain itu, dengan konfigurasi berbilang fasa yang dicadangkan, tegasan arus input dalam peranti pensuisan dikurangkan dan ia mendapat manfaat untuk pengurangan kehilangan pengaliran. Di samping itu, teknik penukaran Zero-Voltage Switching (ZVS) juga digunakan dalam penukar yang dicadangkan untuk mengurangkan kehilangan pensuisan. Litar penukar yang dicadangkan telah disimulasikan dengan menggunakan program perisian MATLAB/Simulink dan PSpice. Kitaran tugas yang digunakan untuk mengawal voltan keluaran dicapai dari papan Altera DE2-70 melalui dSPACE DS1103 yang menggunakan pengawal Proportional-Integral (PI). Spesifikasi model litar penukar dua masukan dengan daya output pada 200 W, voltan masukan adalah dari 10 ~ 60 V, dan beroperasi pada dua frekuansi iaitu 50 kHz dan 100 kHz disimulasikan untuk mengesahkan parameter yang dirancang. Garis panduan reka bentuk, simulasi dan hasil percubaan dibentangkan dengan jelas. Keputusan menunjukkan bahawa cadangan litar penukar dua fasa DC/DC dengan teknik ZVS yang dicadangkan mencapai 94% kecekapan untuk semua julat beban. Jumlah kehilangan kuasa di seluruh suis kuasa dikurangkan oleh kira-kira 37% daripada penukar yang dicadangkan. Oleh itu, model

litar penukar yang dicadangkan memberikan kelebihan kepada tegasan arus input dan mengurangkan kehilangan kerugian kuasa. Walau bagaimanapun kelemahan utama litar resonans peningkatan tekanan puncak semasa dan voltan dan tidak sesuai untuk operasi frekuensi pembolehubah.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS AND ABBREVIATIONS

A	-	Normalised switching frequency
ADC	-	Analog-to-digital converter
AC	-	Alternating Current
C	-	Capacitor
CCM	-	Continues Conduction Mode
C_{r1}	-	Resonant capacitor 1
C_{r2}	-	Resonant capacitor 2
CCTV	-	Closed-Circuit Television
D	-	Duty cycle
DPLL	-	Digital phase-locked loop
DC	-	Direct Current
D_{min}	-	Minimum duty cycle
D_1	-	Diode 1
D_2	-	Diode 2
DSP	-	Digital Signal Processing
DCM	-	Discontinous Current Mode
DSC	-	Digital Signal Controller
EMI	-	Electromagnetic Interference
FPGA	-	Field Programmable Gate Arrays
f_o	-	Resonant frequency
f	-	Frequency

f_s	-	Switching frequency
f_{min}	-	Maximum frequency
h	-	Normalised initial resonant
HEV	-	Hybrid Electric Vehicles
Hz	-	Hertz
I_{max}	-	Maximum current
I_{min}	-	Minimum current
I_{ds}	-	Drain-source current
$I_{ds(on)}$	-	Drain-source current (on)
$I_{ds(off)}$	-	Drain-source current (off)
$I_{L(average)}$	-	Average inductor current
i_s	-	Current through switch
i_c	-	Current through capacitor
i_D	-	Current through diode
I_{SM}	-	Peak switch current
I_{omax}	-	Maximum output current
I_L	-	Inductor current
I_{L1}	-	Inductor current through L_1
I_{L2}	-	Inductor current through L_2
K_P	-	Proportional gain
K_I	-	Integral gain
L_{r1}	-	Resonant inductor 1
L_{r2}	-	Resonant inductor 2
L_{max}	-	Maximum inductor
L_{min}	-	Minimum inductor
L	-	Inductor

L_1	-	Inductor 1
L_2	-	Inductor 2
M	-	Input/output gain
MIC	-	Multiple-Input Converters
MISO	-	Multiple-Input Single-Output
MIMO	-	Multiple-Input Multiple-Output
MOSFET	-	Metal–Oxide–Semiconductor Field-Effect Transistor
MPWM	-	Modified Pulse Width Modulation
η	-	Efficiency
P	-	Power
PID	-	Proportional Integral Derivative
PV	-	Photovoltaic
PCWI	-	Pumping Capacitor Wire Inductance
PCCM	-	Pseudo-Continuous Conduction Mode
PCSC	-	Pulsating Current-Source Cell
PVSC	-	Pulsating Voltage-Source Cell
PWM	-	Pulse-Width Modulation
PFC	-	Power Factor Correction
P_T	-	Total power losses (watt)
P_{cond}	-	Conduction losses (watt)
P_{sw}	-	Switching losses (watt)
$P_{L(cu)}$	-	Copper loss (watt)
$P_{cond(switch)}$	-	Switch conduction losses (watt)
$P_{cond(diode)}$	-	Diode conduction losses (watt)
P_{Lon}	-	Switch turn-on power loss (watt)
P_{Loff}	-	Switch turn-off power loss (watt)

P_{in}	-	Input Power (watt)
P_{out}	-	Output Power (watt)
Q	-	Quality factor
Q_{min}	-	Maximum quality factor
Q_{max}	-	Minimum quality factor
r	-	Ripple factor
R	-	Resistor
R_{Lmin}	-	Maximum load resistance
R_{Lmax}	-	Minimum load resistance
RMS	-	Root-mean-square
RTI	-	Real-Time Interface
$R_{ds(on)}$	-	Drain-source on-state resistance
S	-	Power switch
SMPS	-	Switch-Mode Power Supply
S_1	-	Power switch 1
S_2	-	Power switch 2
T	-	Switching period
T_{off}	-	Switch off time
T_{on}	-	Switch on time
t_f	-	Fall time
t_r	-	Rise time
V_{in}	-	Input line voltage
V_s	-	Supply voltage
V_o	-	Output voltage
V_1	-	Input voltage source 1
V_2	-	Input voltage source 2

V_{ds}	-	Drain-source voltage
V_{ds1}	-	Drain-source voltage (switch 1)
V_{ds2}	-	Drain-source voltage (switch 2)
V_{gs}	-	Gate-source voltage
V_{gs1}	-	Gate-source voltage (switch 1)
V_{gs2}	-	Gate-source voltage (switch 2)
V_L	-	Inductor voltage
V_{L1}	-	Voltage across inductor 1
V_{L2}	-	Voltage across inductor 2
V_{out}	-	Output load voltage
V_{max}	-	Maximun voltage
V_{min}	-	Minimun voltage
V_{ref}	-	Reference voltage
V_F	-	Forward voltage drop
V_x	-	Voltage across diode
ZCS	-	Zero-Current Switching
ZVT	-	Zero- Voltage Transition
ZCT	-	Zero-Current Transition
ZVS	-	Zero-Voltage Switching
ΔQ	-	Ripple factor

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