RESONANT DUAL ACTIVE BRIDGE BASED MULTI-MODE POWER PROCESSORS FOR ELECTRIC VEHICLE CHARGING APPLICATIONS

Thesis submitted in partial fulfilment for the

Award of Degree

Doctor of Philosophy

By

Warda Matin Khan

DEPARTMENT OF ELECTRICAL ENGINEERING
INDIAN INSTITUTE OF TECHNOLOGY
(BANARAS HINDU UNIVERSITY)
VARANASI – 221005
INDIA

ROLL NO.: 20081502

2025

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Prof. Rajeev Kumar Singh

(Supervisor)

Department of Electrical Engineering
Indian Institute of Technology
(Banaras Hindu University)
Varanasi, India – 221005

Prof. Ranjit Mahanty

(Co-Supervisor)

Department of Electrical Engineering
Indian Institute of Technology
(Banaras Hindu University)
Varanasi, India – 221005

DECLARATION BY THE CANDIDATE

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Signature of the Student

(Warda Matin Khan)

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Prof. Rajeev Kumar Singh
Department of Electrical Engineering
Indian Institute of Technology (BHU)
Varanasi-221005

Prof. Ranjit Mahanty
Department of Electrical Engineering
Indian Institute of Technology (BHU)
Varanasi-221005

Head of the Department
Department of Electrical Engineering
Indian Institute of Technology (BHU)
Varanasi-221005

आचार्य व विभागाध्यक्ष / PROFESSOR & HEAD
विद्युतीय अभियांत्रिकी विभाग / Department of Electrical Engineering
भारतीय प्रौद्योगिकी संस्थान / Indian Institute of Technology
(काशी हिन्दू विश्वविद्यालय) / (Banaras Hindu University)
Varanasi, U.P. (INDIA)

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Dedicated to

My Parents

(Mohammed Matin Khan & Nahid Matin Khan)

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Warda

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List of Acronyms

ADC	Analog to digital converter
APM	Auxiliary power module
BESS	Battery energy storage system
CC	Constant current
CCS	Combined charging system
CV	Constant current
DAB	Dual active bridge
DPS	Dual phase shift
DSP	Digital signal processor
EMI	Electromagnetic interference
EPS	Extended phase shift
ESR	Equivalent series resistance
EU	European Union
EV	Electric vehicle
FC	Fast Charging
FPP	Fractional power processing
G2V	Grid to vehicle
KCL	Kirchoff's current law
LC	Inductor capacitor
LUT	Look-up table
LV	Low voltage
MDCS	Moving discretized control set
MOSFET	Metal oxide semiconductor field effect transistor
MPC	Model predictive control
MSCC	Multi stage constant current
MTBF	Minimum time between failure
MVAC	Medium voltage AC
OBC	On-board charger
PCR	Parallel current regulator

PFC	Power factor correction
PFM	Pulse frequency modulation
PI	Proportional integrator
PSFB	Phase-shifted full bridge
PSM	Phase shift modulation
PV	Photovoltaic
PWM	Pulse width modulation
RESS	Renewable energy storage system
RMS	Root mean square
SAE	Society of automotive engineer
SiC	Silicon carbide
SMC	Sliding mode control
SOC	state of charge
SPS	Single phase shift
SVR	series voltage regulator
TPS	Triple phase shift
UF	Ultra-fast
UFC	Ultra-fast charging
V2Aux	Vehicle to auxiliary
V2G	Vehicle to grid
V2V	Vehicle to vehicle
ZCS	Zero current switching
ZVS	Zero voltage switching

Symbols Used

C_{out}	Output capacitor
C_r	Resonant capacitor
F	Normalized switching frequency
F_{base}	Base frequency
F_r	Resonant frequency
F_s	Switching frequency
I_{base}	Base current
I_{bat}	Battery current
I_{bat2}	Battery current of another EV under V2V charging
I_{dc}	DC source current
I_{in}	Converter input current
I_{out}	Converter output current
i_r	Resonant inductor current
J	Normalized Input current
j_{Lr}	Normalized inductor current
J_{ro}	Normalized inductor current at ωt=0
$J_{r\phi}$	Normalized inductor current at ωt=ϕ
K	Fractionality ratio
L_f	Filter inductor
L_{in}	Input inductor
L_r	Resonant inductor
M	Normalized Input voltage
M_{Cr}	Normalized Capacitor voltage
M_{cro}	Normalized Capacitor voltage at ωt=0
$M_{cr\phi}$	Normalized Capacitor voltage at ωt=ϕ
N	Transformer turn ratio
η_{sys}	System efficiency
P_{bat}	Battery power
P_{dc}	DC input power
P_{in}	Converter input power

P_{out}	Converter output power
$R_{ds\text{-}on}$	MOSFET on resistance
$V_{(s\text{-}peak)}$	Voltage stress across the switch
V_{base}	Base voltage
V_{aux}	Auxiliary voltage
V_{bat}	Battery voltage
v_{cr}	Resonant capacitor voltage
V_{dc}	DC source voltage
V_{DS}	Drain to source voltage
V_{GS}	Gate to source voltage
V_{in}	Converter input voltage
V_{out}	Converter output voltage
V'_{out}	Output voltage referred to the transformer's primary side
v_p	Transformer primary voltage
v_s	Transformer secondary
V'_s	Transformer secondary voltage referred to primary side
Z_{base}	Base impedance
Z_o	Characteristics impedance
H	Converter efficiency
Φ	Phase shift between primary and secondary bridge
ω_o	Resonant angular frequency