

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

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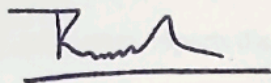
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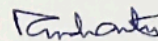
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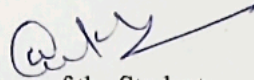
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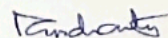
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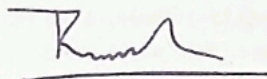
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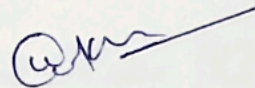
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Dedicated to

My Parents

*(Mohammed Matin Khan & Nahid Matin
Khan)*

Acknowledgement

I am deeply grateful to my supervisor, ***Prof. Rajeev Kumar Singh***, for his invaluable guidance, support, and wise suggestions throughout my Ph. D. journey. His encouragement motivated me to take up this ever-dynamic path in the research world. His expertise and encouragement have been instrumental in shaping the direction and quality of this research work and giving me full freedom to carry out the research work independently. Being surrounded by his energy and passion for power electronics, I never had a dull day during this course. As he says, ‘a Ph. D. is not just a degree but a philosophy, that should reflect in one’s personality’. His teachings not just helped me grow technically but also taught me many invaluable life lessons that will continue to shape the course of my life.

I further extend my sincere gratitude to my co-supervisor, ***Prof. Ranjit Mahanty***, whose insightful feedback and constant support have been a source of inspiration. His thoughtful advice and constructive criticism have greatly enriched me and my research work.

I wish to express my heartfelt gratitude to ***Dr. Vivek Nandan Lal*** for his constant support and guidance during this journey. He has always been the pillar of support and motivated me to stay positive in every odd situations. I am extremely blessed to have such persons with amazing guidance, who have been actively involved with the topics, listened to my doubts patiently, and given suggestions that shaped my research work. I will definitely remember his every piece of advice in my upcoming days.

I would like to extend my gratitude to ***Prof. Sanjay Kumar Singh***, Department of Computer Science Engineering, for his encouragement, insightful comments, and suggestions in various presentations during my research. I would like to acknowledge ***Prof. Devender Singh***, Head, Department of Electrical Engineering, for his help and advice from time to time during my tenure in the doctoral program. Further, I am highly obliged to owe my sincere thanks to the technical, non-technical, and administrative staff of the Department of Electrical Engineering, who helped me in all possible ways during this period.

I appreciate the efforts made by all my lab mates, who have been an integral part of this journey. Starting from the super seniors, I would like to express my heartfelt thanks to *Dr. Soumya Ranjan Meher, Dr. Simanta Samal, Dr. Pawan Kumar, and Dr. Manash K. Mishra* for providing the starting torque and a friendly environment during my initial days in the lab. I am thankful to my seniors who are very soon turning doctors, and my batchmates *Priyatosh Jena, Prakash Ji Baranwal, Rajat Kumar Keshari, Virendra Maurya, Anantha Padmanabhan N K, Ankit Kumar Pratihasta*. Also, I am glad to have juniors like *Arya, Manish, Aman, Sagar, and Sudeep Sir* for maintaining an excellent work culture in the laboratory. I would like to have special mentions about *Dr. Soumya Ranjan Meher* and *Priyatosh Jena*, whom I fondly call *bhaiya*. They have always treated me like their own little sister and have become saviors in times of trouble. It was a great moment to thank the M. Tech and IDD students, *Manshi* and *Souvik*, for their help during different phases of this journey. I am thankful to the lab staff *Chandra Pratap Bhaiya* and *Suresh Bhaiya*, for all the help that can't be described in words. Thank you, everyone for making this journey a sweet and memorable one.

I also want to express my sincere gratitude to my incredible friends—*Ranveer, Eram, Neha, Sheela Mam, Kirti mam, Priya Mam, Sakshi, Kusum, Paridhi, Ritika*—for their unwavering support and encouragement. *Ranveer, Kusum and Paridhi*, your consistent presence throughout both the successes and failures in my journey has been invaluable. Your belief in me has served as a significant source of strength, and I truly appreciate everything you have done for me. Thank you for always being there.

I also wish to make special mention of *Arunima mam* and *Shilpi mam* who have always showered me with their motherly love and blessings. I further wish to specially thank *Mrs. Chandra Mohini Chaturvedi*, Professor Emeritus, zoology department, BHU, Varanasi for her kind help during initial days of my stay in Varanasi.

Last but not the least; I would like to acknowledge my family members, for whom no words can express my gratitude and love. I will always be indebted to my parents *Mr. Mohammed Mateen Khan* and *Mrs. Nahid Matin Khan* for their all-round support and blessings. I am also equally indebted to my Grandparents for their love and prayers, and my grandfather *Prof. M. S. K Khokhar*, for taking strict decisions time to time, and sending me for higher studies and grooming from childhood to this phase of life. I am

also thankful to my sister *Dr. Sumna Matin Khan* and brother-in-law *Dr. Mohammed Ilyas* for being a backbone and providing moral support throughout this Ph.D. journey. I wish to mention *Faiz* and *Aayra* who always kept sending their cute encouragements.

I am also thankful to everyone; those who are associated with this journey and whose name could not be mentioned in this section.

Once again, Thankyou everyone for making this journey a memorable one.

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_{r0}	Normalized inductor current at $\omega t=0$
$J_{r\phi}$	Normalized inductor current at $\omega t=\phi$
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 $\omega t=0$
$M_{cr\phi}$	Normalized Capacitor voltage at $\omega t=\phi$
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-on}	MOSFET on resistance
$V_{(s-peak)}$	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