Contents

Au	Authors' biographies				
Pro	(reface				
LIS	t of s	ymbols		XIII	
1	Intr	oductio	n	1	
	1.1	Introdu	action	1	
	1.2	Voltag	e regulator applications	3	
	1.3	Voltag	e source gate driver and high-frequency-dependent loss	4	
		1.3.1	Switching loss	5	
		1.3.2	Body diode conduction loss	9	
		1.3.3	Reverse recovery loss	10	
		1.3.4	Gate drive loss	10	
	1.4	Summ	ary	10	
	Refe	rences		11	
2	Fundamentals of current source driver				
	2.1	Resona	ant gate drivers	13	
	2.2	Conce	pt of current source driver	17	
	2.3	A prac	tical and accurate switching loss model	19	
		2.3.1	Introduction	19	
		2.3.2	Impact of parasitic inductance and load current	20	
		2.3.3	Proposed switching loss model	24	
		2.3.4	Turn-on switching loss model	25	
		2.3.5	Turn-off switching loss model	32	
		2.3.6	Voltage source drive model verification	37	
		2.3.7	Experimental validation of the voltage source drive model	38	
	2.4	Summ	ary	42	
	Refe	rences		42	
3	Continuous current source driver				
	3.1	Two-channel low-side continuous current source drivers			
		3.1.1	Operating principle	45	
		3.1.2	Loss comparison	49	
		3.1.3	Advantages of the proposed current source driver	52	
		3.1.4	Applications	54	
		3.1.5	Experimental results	56	

	3.2	High-	side and low-side continuous current source drivers	59
		3.2.1	Operating principle of proposed current source drivers	59
		3.2.2	Advantages	63
		3.2.3	Loss analysis	65
		3.2.4	Experimental results	67
	3.3	Accur	ate switching loss model with current source drivers	69
		3.3.1	Proposed MOSFET loss model with current source	
			resonant driver	69
		3.3.2	Analytical modeling and simulation results	73
		3.3.3	Proposed optimal design with the accurate switching	
			loss model	75
		3.3.4	Experimental verification and discussion	79
	3.4	High-	side and low-side current source drivers	86
		3.4.1	Problem of high-side and low-side current source	
			drivers	86
		3.4.2	Proposed decoupled high-side and low-side current	
			source drivers	87
		3.4.3	New current-source gate driver with integrated	
			magnetics	94
		3.4.4	Experimental results and discussion	96
	3.5	Summ	nary	101
	Refe	erences		101
4	Disc	continu	ous current source drivers	103
	4.1	Disco	ntinuous current source driver	103
		4.1.1	Proposed low-side discontinuous CSD	103
		4.1.2	Driver loss analysis	107
		4.1.3	CSD design procedure	115
		4.1.4	Design example	116
		4.1.5	Experimental results	117
	4.2	High-	side discontinuous CSD	123
		4.2.1	Proposed CSD for synchronous buck converter	
			and operation	123
		4.2.2	Design example	125
		4.2.3	Experimental results	125
	4.3	Disco	ntinuous CSD with reduced inductance	132
		4.3.1	Proposed CSD and principle of operation	132
		4.3.2	Proposed high-side CSD and hybrid gate-drive scheme	137
		4.3.3	Experimental results	139
	4.4	Curren	nt diversion	145
		4.4.1	Introduction	145
		4.4.2	Proposed switching loss model considering current	1.0
			diversion	147
		4.43	Experimental results and discussions	154
	4 5	Summ	Darv	157
	Refe	erences)	158
	+			1.00

5	Ada	ptive cu	urrent source drivers	159	
	5.1	Adapti	ve current source driver for buck converters	159	
		5.1.1	Introduction	159	
		5.1.2	Adaptive continuous current source driver	159	
		5.1.3	Adaptive discontinuous current source drivers	161	
		5.1.4	Implementation of the adaptive drive voltage		
			for the current source drivers	163	
		5.1.5	Experimental results and discussion	164	
	5.2	Adapti	ve current source driver for power factor correction		
		application			
		5.2.1	Introduction	166	
		5.2.2	Analysis of current source driver circuits and proposed		
			adaptive current source driver for boost power factor		
			correction converters	166	
		5.2.3	Loss analysis of proposed adaptive current source		
			driver for boost power factor correction converter	168	
		5.2.4	Experimental results and discussion	172	
	5.3	Digital	adaptive power factor correction	173	
		5.3.1	Introduction	173	
		5.3.2	Principle of the proposed digital adaptive		
			discontinuous current source driver	175	
		5.3.3	Design procedure and implementation	176	
		5.3.4	Experimental results and discussion	182	
	5.4	Summ	arv	186	
	Refe	erences		187	
6	Res	onant g	ate drivers	189	
	6.1 Resonant gate drivers for multi-megahertz isolated resonant				
		conver	ters	189	
		6.1.1	Introduction	189	
		6.1.2	Challenges for the SR drive in the multi-MHz isolated		
			resonant converters	190	
		6.1.3	Proposed self-driven RGD for the SR	192	
		6.1.4	Experimental verification and discussion	202	
	6.2	A high	-frequency dual-channel isolated resonant gate driver		
		with lo	by gate-drive loss for ZVS full-bridge converters	206	
		6.2.1	Introduction	206	
		6.2.2	Review of gate-drive circuits	207	
		6.2.3	Proposed resonant gate driver for FB converters		
			and principle of operation	208	
		6.2.4	Loss analysis and optimal design	211	
		6.2.5	The comparison between the proposed RGD		
			and previous gate-drive circuits	220	
		6.2.6	Experimental results and discussion	224	
		~	r		
	6.3	Summ	ary	226	

7 eG	eGaN HEMTs gate drivers		
7.1	Three	-level gate drivers	231
	7.1.1	Introduction	231
	7.1.2	Driving requirements for eGaN HEMTs in resonant	
		SEPIC converters	232
	7.1.3	Proposed three-level gate drivers for eGaN HEMTs	235
	7.1.4	Operation principle of three-level gate driver	237
	7.1.5	Rectifier mathematic modeling and design	241
	7.1.6	Experimental results and discussion	248
7.2	7.2 A digital adaptive driving scheme for eGaN HEMTs in V		
	conve	rters	252
	7.2.1	Introduction	252
	7.2.2	Gate-drive challenges for eGaN VHF converters	254
	7.2.3	Proposed digital adaptive driving scheme	256
	7.2.4	Relationship analysis between gate-drive timing	
		and input voltage	258
	7.2.5	Air-core transformer design	263
	7.2.6	Experimental results and discussion	264
7.3	8 Summ	nary	270
Re	ferences	,	270

Index

273