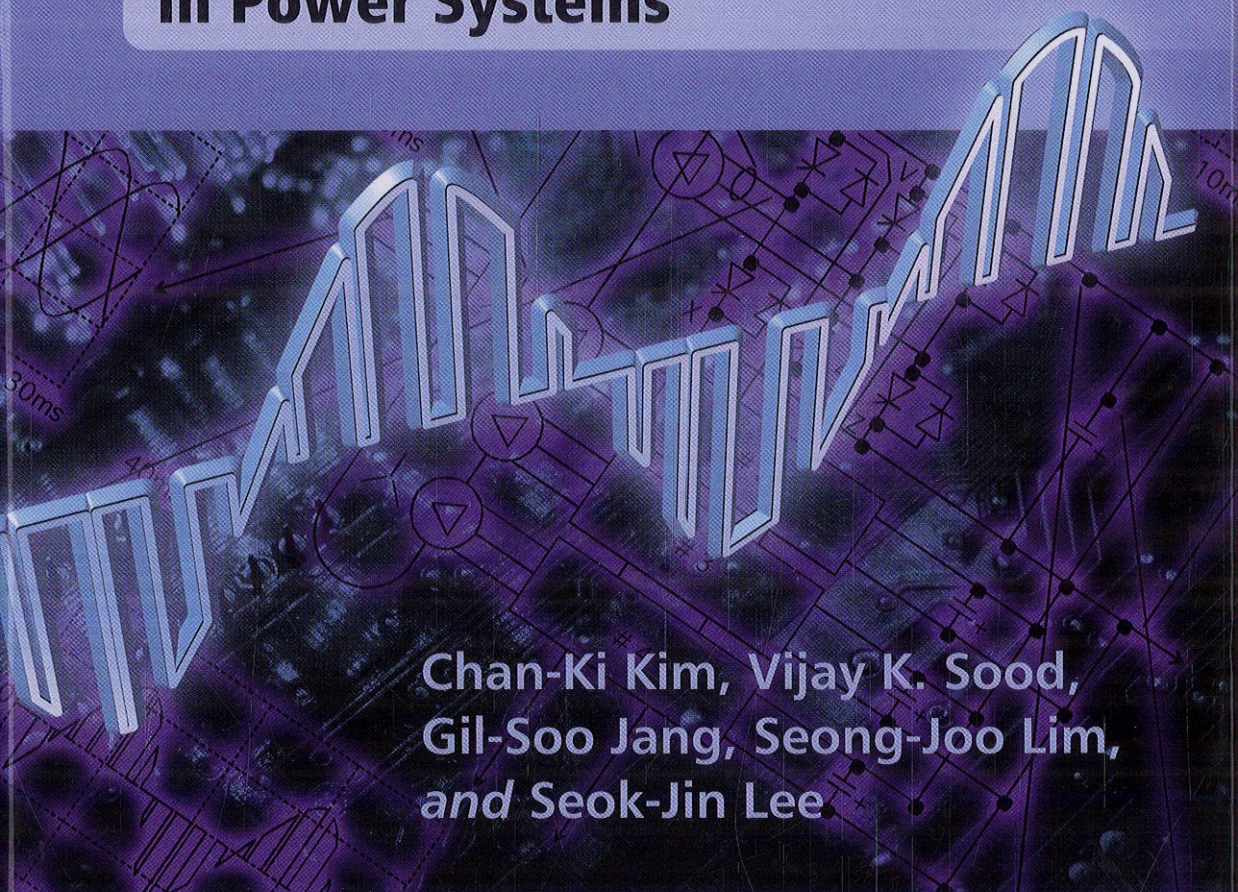


HVDC TRANSMISSION

**Power Conversion Applications
in Power Systems**



**Chan-Ki Kim, Vijay K. Sood,
Gil-Soo Jang, Seong-Joo Lim,
and Seok-Jin Lee**

Contents

Foreword	ix
Preface	xi
Acknowledgments	xiii
Author Biographies	xv
List of Symbols	xix
1 Development of HVDC Technology	1
1.1 Introduction	1
1.2 Advantages of HVDC Systems	3
1.3 HVDC System Costs	7
1.4 Overview and Organization of HVDC Systems	13
1.5 Review of the HVDC System Reliability	19
1.6 HVDC Characteristics and Economic Aspects	30
References	34
2 Power Conversion	37
2.1 Thyristor	37
2.2 3-Phase Converter	47
2.3 3-Phase Full Bridge Converter	54
2.4 12-Pulse Converter	58
References	61
3 Harmonics of HVDC and Removal	63
3.1 Introduction	63
3.2 Determination of Resulting Harmonic Impedance	81
3.3 Active Power Filter	87
References	95
4 Control of HVDC Converter and System	97
4.1 Converter Control for an HVDC System	97
4.2 Commutation Failure	110

4.3	HVDC Control and Design	116
4.4	HVDC Control Functions	130
4.5	Reactive Power and Voltage Stability	137
4.6	Summary	145
	References	145
5	Interactions between AC and DC Systems	149
5.1	Definition of Short Circuit Ratio and Effective Short Circuit Ratio	149
5.2	Interaction between HVDC and AC Power System	159
	References	184
6	Main Circuit Design	187
6.1	Converter Circuit and Components	187
6.2	Converter Transformer	193
6.3	Cooling System	200
6.4	HVDC Overhead Line	213
6.5	HVDC Earth Electrodes	229
6.6	HVDC Cable	235
6.7	HVDC Telecommunications	243
6.8	Current Sensors	249
6.9	HVDC Noise and Vibration	251
	References	255
7	Fault Behavior and Protection of HVDC System	257
7.1	Valve Protection Functions	257
7.2	Protective Action of an HVDC System	260
7.3	Protection by Control Actions	268
7.4	Fault Analysis	274
	References	277
8	Insulation Coordination of HVDC	279
8.1	Surge Arrester	279
8.2	<i>Functions of the Arresters in an HVDC Station</i>	282
8.3	Insulation Coordination of the Cheju HVDC System	288
	References	293
9	A Practical Example of an HVDC System	295
9.1	Introduction	295
9.2	System Description	301
9.3	Phase Control	304
	References	327
10	Other Converter Configurations for HVDC Transmission	329
10.1	Introduction	329
10.2	Voltage Source Converter (VSC)	329

10.3 CCC and CSCC HVDC System	340
10.4 Multi-Terminal DC Transmission	349
References	357
11 Modeling and Simulation of HVDC Systems	359
11.1 Simulation Scope and Range	359
11.2 Fast Methods for Accurate Simulation	363
11.3 HVDC Modeling and Simulation	368
11.4 Cheju–Haenam HVDC Real-Time Digital Simulator	373
References	381
12 Present and Proposed Future Installations of HVDC Systems	383
12.1 USA	383
12.2 Japan	387
12.3 Europe	389
12.4 China	396
12.5 India	397
12.6 Malaysia/Philippines	398
12.7 Australia/New Zealand	399
12.8 Brazil	400
12.9 Africa	401
13 Trends for HVDC Applications	403
13.1 Wind Farm Technology	403
13.2 Modern Voltage Source Converter (VSC) HVDC Systems	413
13.3 800 kV HVDC System	422
References	431
Index	433