

10th IET International Conference on AC and DC Power Transmission

(ACDC 2012)

IET Conference Publications 610

**Birmingham, United Kingdom
4-5 December 2012**

ISBN: 978-1-62748-387-2

Printed from e-media with permission by:

Curran Associates, Inc.
57 Morehouse Lane
Red Hook, NY 12571



Some format issues inherent in the e-media version may also appear in this print version.

Copyright© (2012) by the Institution of Engineering and Technology
All rights reserved.

Printed by Curran Associates, Inc. (2013)

For permission requests, please contact the Institution of Engineering and Technology
at the address below.

Institution of Engineering and Technology
P. O. Box 96
Stevenage, Hertfordshire
U.K. SG1 2SD

Phone: 01-441-438-767-328-328
Fax: 01-441-438-767-328-375

www.theiet.org

Additional copies of this publication are available from:

Curran Associates, Inc.
57 Morehouse Lane
Red Hook, NY 12571 USA
Phone: 845-758-0400
Fax: 845-758-2634
Email: curran@proceedings.com
Web: www.proceedings.com

TABLE OF CONTENTS

SESSION A1: NEW LCC PROJECTS / NEW VSC PROJECTS

Increasing the GB Electricity Transmission Networks' Power Transfer Capability Between North and South - the Western HVDC Link	1
<i>S. Achenbach, V. Barry, C. H. Bayfield, P. F. Coventry</i>	
Limitations to Loading the Manitoba Hydro Future Three-Bipole, Multi-egress, Multi-infeed HVdc System and Mitigation Strategies	5
<i>I. T. Fernando, P. Wang, R. W. Mazur</i>	
Investigation of Paralleling Bipole II and the Future Bipole III in Nelson River HVDC System	11
<i>S. Zoroofi, D. H. R. Suriyaarachchi, D. Kell, M. Mohaddes, P. Wang, D. Jacobson</i>	
System Design of MMC VSC-HVDC Demonstration Project for Windfarm Connection	17
<i>Jie Yang, Yuefeng Yang, Zhiyuan He, Haitian Wang</i>	
The South – West Scheme : A New HVAC and HVDC Transmission System in Sweden	23
<i>D. Ingemansson, J. D. Wheeler, N. M. Macleod, F. Gallon, O. Ruiton</i>	

SESSION B1: DC GRIDS 1

Next Generation HVDC Network for Offshore Renewable Energy Industry	28
<i>Chong Ng, Paul McKeever</i>	
Influence of DC Voltage Droop Settings on AC System Stability	35
<i>J. Beerten, R. Eriksson, R. Belmans</i>	
DC Fault Analysis of VSC based Multi-Terminal HVDC Systems	40
<i>J. Rafferty, L. Xu, D. J. Morrow</i>	
An Alternative Approach to HVDC Grid Protection	46
<i>C. D. Barker, R. S. Whitehouse</i>	

SESSION A2: LCC VS VSC

VSC Transmission Limitations Imposed By AC System Strength And AC Impedance Characteristics	52
<i>Jemy Z. Zhou, Aniruddha M. Gole</i>	
Apparent Increase in Short Circuit Ratio (AISCR) As a Measure of the Impact of VSC Converters on LCC Converters in Multi-infeed HVDC Systems with VSC and LCC Infeeds	58
<i>Chunyi Guo, Chengyong Zhao, Ani Gole, Xiuyu Chen</i>	
Comparison of HVDC Light (VSC) and HVDC Classic (LCC) Site Aspects, for a 500MW 400kV HVDC Transmission Scheme	63
<i>R. L. Sellick, M. Akerberg</i>	

SESSION B2: DC GRID MODELLING 1

Droop Control Modelling and Analysis of Multi-terminal VSCHVDC for Offshore Wind Farms	69
<i>W. Wang, M. Barnes, O. Marjanovic</i>	
Dynamic Performance of a Modular Multi-level Converter based HVDC Terminal under Unbalanced AC Grid Conditions	75
<i>Pranav B. Darji, Anil M. Kulkarni</i>	
A Screening Technique for Anticipating Network Instabilities in AC-DC Systems using Sequence Impedances obtained by Frequency Scanning	81
<i>Mukesh Kumar Das, A. M. Kulkarni, A. M. Gole</i>	

SESSION A3: OFFSHORE

Offshore DC Grids: Impact of Topology on Power Flow Control	87
<i>O. Despouys</i>	

An Assessment of Transient Assistive Measures Using HVDC for Special Protection Schemes: Case on the GB Transmission System	93
<i>Yousef Pipelzadeh, Rodrigo Moreno, Balarko Chaudhuri, Goran Strbac, Tim C. Green</i>	
Offshore Wind Farm Cluster Based DC Collection Network – Operation And Design Considerations	99
<i>D. W. Elliott, C. E. Jones, S. J. Finney</i>	
SUBSEA CABLE Projects - Minimising RISKS	105
<i>R. Goldring, R. Svoma</i>	

SESSION B3: DC GRIDS 2

Assessment of DC/DC Converters for use in DC Nodes for Offshore Grids	111
<i>C. E. Sheridan, M. M. C. Merlin, T. C. Green</i>	
Power Control of VSC HVDC Converters for Limiting the Influence of AC Unbalanced Faults on Multi-Terminal DC Grids	117
<i>J. A. Suul, A. Luna, P. Rodriguez</i>	
Control Strategy Requirements for Connection of Offshore Windfarms using VSC-HVDC for Frequency Control	124
<i>Ashish Bangar, Vandad Hamidi</i>	
Research on Control and Protection System for Shanghai Nanhui MMC VSC-HVDC Demonstration Project	130
<i>Yuefeng Yang, Jie Yang, Zhiyuan He, Haitian Wang</i>	

SESSION A4: TECHNICAL DEVELOPMENT FACTS & SSR

A Three-Phase Four-Wire Statcom With Reduced Number of Switches For Unbalanced Loads	136
<i>A. Balikci, E. Akpinar</i>	
Consideration of Inertia for Design of Reactive Power Compensation Devices for HVDC Transmission Systems	142
<i>Yi Zhang, Aniruddha M. Gole</i>	
Dynamic Energy Storage – A UK first	148
<i>P. Lang, M. Michel, N. Wade, R. Grunbaum, T. Larsson</i>	
New Type Test Requirements For Forced Triggered Spark Gap In Series Capacitor Bank Applications	155
<i>L. Ebbers, T. Hanninen, J. Poyhonen, P. Riffon</i>	

SESSION B4: DC GRID EQUIPMENT

DC Transmission Grids with Fault Tolerant LCL VSC Converters and Mechanical DC Circuit Breakers	161
<i>D. Jovcic, M. Hajian, L. Zhang</i>	
Performance of a DC/AC/DC VSC System to Interconnect HVDC Systems	167
<i>T. Luth, M. M. C. Merlin, T. C. Green, C. D. Barker, F. Hassan, R. W. Critchley, R. W. Crookes, K. Dyke</i>	
Power Flow Control In DC Transmission Grids Using Mechanical And Semiconductor Based DC/DC Devices	173
<i>D. Jovcic, M. Hajian, H. Zhang, G. Asplund</i>	
A Current Flow Controller for Use in HVDC Grids	179
<i>C. D. Barker, R. S. Whitehouse</i>	

SESSION A5: AC GRID INTERACTION 1

Control of VSC HVDC System Integrated with AC Network	184
<i>L. Shen, M. Barnes, J. V. Milanovic, R. Preece</i>	
The Impact of New Technology on Network Resilience	190
<i>M. M. Osborne, A. Carter, B. Marshall, V. Hamidi</i>	
A Framework for Coordinated Stability Control in the Future GB Transmission System Using HVDC and Power Flow Controller Devices	197
<i>Shadi Khaleghi Kerahroudi, Gareth A. Taylor, Martin Bradley, Ahmed F. Zobaa</i>	

SESSION B5: DC GRIDS 3

A Novel Operation Method For Meshed HVDC Overlay Grids And Corresponding Steady State And Dynamic Power Flow Calculation Principle	203
<i>A. K. Marten, D. Westermann</i>	
Dynamic Active Power Control with Improved Undead-Band Droop for HVDC Grids	209
<i>T. K. Vrana, L. Zeni, O. B. Fosso</i>	
Further Developments in Autonomous Converter Control in a Multi-Terminal HVDC System	215
<i>C. D. Barker, R. S. Whitehouse</i>	

SESSION A6: AC GRID INTERACTION 2

Ensuring Grid Code Harmonic Compliance Of Wind Farms	221
<i>D. M. Joseph, P. Haigh, J. McCullagh</i>	
Harmonic Distortion Specification and Compliance of an Offshore Wind Generation	227
<i>Z. Emin, F. Fernandez, M. Poeller, G. E. Williamson</i>	

SESSION B6: DC GRID MODELLING 2

Parallel Processing and Hybrid Simulation for HVDC/VSC PSCAD Studies	233
<i>Garth D. Irwin, Chaminda Amarasinghe, Nathan Kroeker, Dennis Woodford</i>	
Applications of Simplified Models to Investigate Oscillation Damping Control on the GB Transmission System	239
<i>Ronak Rabbani, Ahmed F. Zobaa, Gareth A. Taylor</i>	
Validation Of The Continuous Model Of The Modular Multilevel Converter With Blocking/Deblocking Capability	245
<i>Noman Ahmed, Lennard Angquist, Staffan Norrga, Hans-Peter Nee</i>	
Generic Models of Wind Turbine Generators for Advanced Applications in a VSC-based Offshore HVDC Network	251
<i>L. Zeni, I. Margaritis, A. D. Hansen, P. E. Sorensen, P. C. Kjaer</i>	

POSTER SESSION

Low Switching Frequency Modulation Strategies With Low Impact On The Mains, Suitable For A For A Large Power Voltage Sourced Converter That Employs Reduced VA-Rating Coupling Magnetic Elements	257
<i>F. J. Chivite-Zahalza, M. A. Rodriguez, P. Izurza, G. Calvo, D. Madariaga, I. Larrazabal</i>	
Studies On The Response Characteristics Of Z-Unified Power Flowcontroller(Z-UPFC)	263
<i>Meera Murali, N. Gopalakrishnan, V. N. Pande</i>	
A Phase Correction Method of HVDC Supplementary Subsynchronous Damping Controller	268
<i>Niang Tang, Xiangning Xiao, Jian Zhang, Yunfen Xu, Qiushuo Li</i>	
IGBT Based High Power DC-DC Converters	273
<i>Na Deng, Xiao-Ping Zhang</i>	
Design and PSPICE Analysis of A Grid Connected Multilevel Converter with Reduced Number of Switches	279
<i>A. Balikci, E. Akpinar, K. Vardar, B. Turan Azizoglu</i>	
Operating Region Extension For Multilevel Converters In HVDC Applications By Optimisation Methods	285
<i>Staffan Norrga, Lennart Angquist, Kalle Ilves</i>	
Fault Ride-through Capability Enhancement Based on Flywheel Energy Storage System for Wind Farms Connected via VSC High Voltage DC Transmission	291
<i>K. H. Ahmed, A. S. Abdel-Khalik, A. Elserougi, A. Massoud, S. Ahmed</i>	
Primary And Secondary Power Control Of Multiterminal HVDC Grids	297
<i>A. Egea-Alvarez, J. Beerten, D. Van Hertem, O. Gomis-Bellmunt</i>	
Future Wide Area Monitoring Requirements for the GB Transmission System	303
<i>P. M. Ashton, G. A. Taylor, A. M. Carter</i>	
Assessment of Disturbance Propagation between AC Grids through VSC HVDC Links using Reduced Great Britain Model	309
<i>C. E. Spallarossa, Y. Pipelzadeh, B. Chaudhuri, T. C. Green</i>	

On-Site Testing Of Special Transformers	315
<i>Simanand Gandhi Jeyaraj, Robert Milne, Grant Mitchell</i>	
Real-Time Simulation of a Wind Connected HVDC Grid	321
<i>Pinaki Mitra, Lidong Zhang</i>	
Fault Current Limiters for VSC-HVDC Systems	327
<i>D. M. Larruskain, I. Zamora, O. Abarrategui</i>	
Capacity of Energy Storage Based on Probabilistic Power Flow and the Hps0 Algorithm for Distribution Network with Photovoltaic Power Generation	333
<i>Shujun Yao, Luyao Ma</i>	
A Coordinated Control Strategy of Series Multi-terminal VSC-HVDC for Offshore Wind Farm	339
<i>Xiang Li, Minxiao Han, Xuan Zhang</i>	
Saturated Core High-Temperature Superconducting Fault Current Limiters as an Alternative to Conventional Series Reactors in a Distribution Grid	345
<i>Jaime Cabanes Aracil, Jose Lopez-Roldan, Jacob Carl Coetzee, Frank Darmann, Tee Tang</i>	
Multi-infeed HVDC System with Inverter and Rectifier Infeeds	351
<i>Xiuyu Chen, Ani M. Gole, Chunyi Guo</i>	
Robust Damping Control Of Power System With TCSC Using A Multi-Model System Approach	357
<i>J. Deng, X. P. Zhang</i>	
Post - DC Fault Recharging of the H-bridge Modular Multilevel Converter	363
<i>Chao Chen, G. P. Adam, S. J. Finney, B. W. Williams</i>	
Laboratory-Based Deployment and Investigation of PMU and OpenPDC Capabilities	368
<i>Mohammad Golshani, Ioana Pisica, Gareth A. Taylor, Phillip Ashton</i>	
HVDC Networks for Offshore Wind Power: Current Ripple and Cables	374
<i>T. Wood, D. E. Macpherson, C. Smith, S. Finney</i>	
Author Index	