MODULAR MULTILEVEL CONVERTERS – MMC: PRINCIPLES, DESIGN, CONTROL, MODELLING AND CHALLENGES IN VSC-HVDC

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- Hans Peter Nee - Professor, Department of Electrical Engineering, KTH, Sweden
- Lennart Harnefors – Professor, ABB Corporate Research, Västerås and KTH, Sweden
- Staffan Norrga - Associate Professor, Department of Electrical Engineering, KTH, Sweden

SCOPE AND BENEFITS

During the last decade the new Modular Multilevel Converter (MMC) technology adopted by Siemens, ABB and Alstom has demonstrated clear advantages in terms of scalability, reduced losses and footprint in comparison with two-level VSC in HVDC applications and its use is expected to grow rapidly and enter other applications.
This fast development has left a knowledge gap between the technology specialists, academic community, and possible VSC HVDC project developers. In this respect the proposed tutorial is aiming at understanding the fundamental principles, hardware design, control, modelling for applications related to HVDC systems.

CONTENTS

The outline of the tutorial is as follows:

- **Part 1: Fundamentals**
  - MMC principle of operation
  - Steady-state decoupled model
  - Modulation and capacitor voltage balancing
- **Part 2: Main Circuit Hardware Design**
  - Overview of existing industrial designs
  - Valve design
  - Submodule capacitance and arm inductor
  - Fault redundancy design
- **Part 3: Dynamics and Control**
  - Dynamic model
  - Internal and output current control
  - DC voltage control
- **Part 4: Modelling, Simulation and Control under unbalanced conditions**
  - Detailed and reduced order modelling
  - Generic simulation models
  - Control of MMC under grid unbalanced conditions
- **Part 5 Challenges for MMC-HVDC (Shafaribadi – 45´)**
  - Overview of field MMC-HVDC plants

- IEC, Cenelec and Cigre guidelines
- AC and DC Fault management

Schedule is as follows
Monday, 17 September 2018 - Tutorial day (Location: RTU, Riga, Latvia)

09:30 - 11:00	Tutorials Part 1
11:00 - 11:30	Coffee break
11.30 - 12:45	Tutorials Part 2
12:45 - 13:45	Lunch break
13:45 - 15:00	Tutorials Part 3
15:00 - 16:15	Tutorials Part 4
16:15 - 16:45	Coffee break
16:45 - 17:30	Tutorials Part 5

WHO SHOULD ATTEND
This tutorial is intended for both academic and industry people looking for a deeper understanding of MMC technology.

Technical Level: Advanced

ABOUT THE INSTRUCTORS

Kamran Sharifabadi received his M.sc. in Electrical Engineering and PhD. in Control Engineering from the Norwegian Technical University in Trondheim 1990 and 1994. He has 25 years of international experience in the field of HVDC projects. He started out as a research engineer in ABB and Siemens and worked as a consultant for 5 years, before adding 10 years of management experience for the Norwegian TSO. Currently he is working as a senior technology advisor for Statoil`s HVDC projects

Remus Teodorescu received the Dipl.Ing. degree in electrical engineering from Polytechnical University of Bucharest, Romania in 1989, and PhD. degree in power electronics from University of Galati, Romania, in 1994. In 1998, he joined Aalborg University, Department of Energy Technology, power electronics section where he currently works as a professor. He is a Fellow Member of IEEE. Between 2013 and 2017, he has been a Visiting Professor with Chalmers University. He was the coordinator of Vestas Power Program (2007 - 2013, involving 10 PhD projects in the areas of power electronics, power systems and energy storage. His areas of interests are: MMC, design and control of power converters used in wind power systems, PV and HVDC/FACTS and energy storage systems based on Li batteries and multilevel converters.

Hans-Peter Nee was born in 1963 in Västerås, Sweden. He received the M.Sc., Licentiate, and Ph.D degrees in electrical engineering from the Royal Institute of

Technology, Stockholm, Sweden, in 1987, 1992, and 1996, respectively, where he in 1999 was appointed Professor of Power Electronics in the Department of Electrical Engineering. His interests are power electronic converters, semiconductor components, and control aspects of utility applications, like FACTS, HVDC, wind power converter systems, and variable-speed drives. Lately, special attention has been given to multilevel converters for high-power applications and various aspects of SiC power electronics

Lennart Harnefors received the M.Sc., Licentiate, and Ph.D. degrees in electrical engineering from the Royal Institute of Technology (KTH), Stockholm, Sweden, and the Docent (D.Sc.) degree in industrial automation from Lund University, Lund, Sweden, in 1993, 1995, 1997, and 2000, respectively. From 1994 to 2005, he was with Mälardalen University, Västerås, Sweden, where he, in 2001, was appointed as a Professor of electrical engineering. Between 2001 and 2005, he was, in addition, a part-time Visiting Professor of electrical drives with Chalmers University of Technology, Göteborg, Sweden. He is currently with ABB Corporate Research, Västerås, Sweden as Senior Principal Scientist, and with KTH as an Adjunct Professor of power electronics. His research interests include analysis and control of power electronic systems, particularly grid-connected converters and ac drives.

Staffan Norrga was born in Lidingö, Sweden, in 1968. He received the M.Sc. degree in applied physics from Linköping Institute of Technology, Linköping, Sweden, in 1993 and the Ph.D. degree in electrical engineering from the Royal Institute of Technology (KTH), Stockholm, Sweden, in 2005. Between 1994 and 2011, he worked as a Development Engineer at ABB in Västerås, Sweden, in various power-electronics-related areas such as railway traction systems and converters for HVDC power transmission systems. He currently holds a position as Associate Professor in power electronics at the Royal Institute of Technology in Stockholm. His research interests include new converter topologies for power transmission applications and grid integration of renewable energy sources. He is the inventor or co-inventor of 11 granted patents and 14 patents pending and has authored or co-authored more than 100 scientific papers published at international conferences or in journals.