



## Multilevel Converters: Recent Development of Topologies and PWM Control Methods

### Abstract:

Multilevel converters have become the enabling power conversion technology for high voltage high power applications in power systems and large motor drives. Since the mid of 1990s, many contributors have made great effort in developing new multilevel inverter topologies because the existing multilevel topologies have certain limitations and are not operable in some applications. In this tutorial, the relationship between the existing topologies of multilevel converters, like NPC, flying capacitor, cascaded, MMC and next generation multilevel converters will be analyzed and the different control methods be summarized, and their pros and cons in practical applications are reviewed by the world-class specialists. The emphasis of the tutorial is given to recent development of topologies and their control methods, and the following issues will be covered:

- 1) Multilevel inverters: a survey of topologies, controls, and application
- 2) Recent Advances in Multilevel Converter/Inverter Topologies and Applications
- 3) Topologies of Multi-level Converters and their development
- 4) Classification, and Application of Modular Multilevel Cascade Converter
- 5) Multi-level conversion: SMC high voltage inverters

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### Instructor Bios

**Dr. Yongdong Li** received the Engineer degree and Ph.D degree in 1984 and 1987 respectively from Department of Electrical Engineering of Institut National Polytechnique de Toulouse, France. He has been with the Department of Electrical Engineering of Tsinghua University, China since 1988, where he is currently a full professor. In 1996, he was a visiting professor in VPEC of Virginia Polytechnique Institute, United States. He is currently Deputy Director of Power Electronic ERC of Tsinghua University, and Vice chairman of China Power Electronics Society, Chairman of Beijing Chapter of IEEE IA Society. His works include the first industry product of multilevel inverter in China(1998), now representing 60% of Chinese market, and the first monograph on fully digital sensorless vector control and DTC of AC motors in Chinese(2002); the first monograph on high-power multilevel converters for motor drives application in Chinese(2005), and more than 200 papers in national and international conferences and journals.

**Dr. J. Rodríguez** (M'81-SM'94) Received the Engineer degree in electrical engineering from the Universidad Federico Santa Maria (UTFSM), Valparaiso, Chile, in 1977 and the Dr.-Ing. degree in electrical engineering from

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Prof. Rodríguez is Associate Editor of the IEEE TRANSACTIONS ON POWER ELECTRONICS and IEEE TRANSACTIONS ON INDUSTRIAL ELECTRONICS since 2002. He received the Best Paper Award from the IEEE TRANSACTIONS ON INDUSTRIAL ELECTRONICS in 2007 and the Best Paper Award from the IEEE INDUSTRIAL ELECTRONICS MAGAZINE in 2008. Dr. Rodríguez is member of the Chilean Academy of Engineering and Fellow of the IEEE.

**Dr. Hirofumi Akagi** (M'87-SM'94-F'96) received the M. S. and Ph. D. degrees from the Tokyo Institute of Technology, Japan, in 1976 and 1979, respectively, all in electrical engineering. In 1979, he joined the department of electrical engineering of Nagaoka University of Technology, Japan. From 1991 to 1999, he was a Professor in the department of electrical engineering at Okayama University, Japan. Since January 2000, he has been a Professor in the department of electrical and electronic engineering at the Tokyo Institute of Technology.

He has authored and coauthored more than 90 IEEE Transactions papers and two invited papers published in Proceedings of the IEEE in 2001 and 2004. He has received five IEEE Transactions Prize Paper Awards and nine IEEE Conference Prize Paper Awards. He is the recipient of the 2001 IEEE William E. Newell Power Electronics Award, the 2004 IEEE Industry Applications Society Outstanding Achievement Award, and the 2008 IEEE Richard H. Kaufmann Technical Field Award.

**Thierry Meynard** (M'94) graduated from the Ecole Nationale Supérieure d'Electrotechnique, d'Electronique, d'Hydraulique de Toulouse, Toulouse, France, in 1985. He was a Doctor at the Institut National Polytechnique de Toulouse, Toulouse, during 1988. He was an Invited Researcher at the Université du Québec à Trois Rivières, Canada, in 1989. He joined the Laboratoire d'Electrotechnique et d'Electronique Industrielle as a Full-Time Researcher in 1990. From 1994 to 2001, he was the Head of the Static Converter Group in the Laboratoire d'Electrotechnique et d'Electronique Industrielle (LEEI), Institut National Polytechnique de Toulouse-Ecole Nationale Supérieure d'Electrotechnique, d'Electronique, d'Informatique, d'Hydraulique et des Télécommunications (INPT-ENSEEIH), Toulouse, France, where he is currently the Director of Research. He is also a Part-Time Consultant with Cirtem on a regular basis. His research interests include soft commutation, series and parallel multicell converters for high-power and high-performance applications, and direct ac/ac converters.

**Dr. Fang Zheng Peng** (M'92-SM'96) received the M.S. and Ph.D. degrees from Nagaoka University of Technology, Nagaoka, Japan, in 1987 and 1990, respectively, all in electrical engineering. From 1992 to 1994, he was a Research Assistant Professor with Tokyo Institute of Technology. From 1994 to 2000, he was with Oak Ridge National Laboratory (ORNL) and, from 1994 to 1997, he was a Research Assistant Professor at the University of Tennessee, Knoxville. He was a Staff Member and Lead (Principal) Scientist of the Power Electronics and Electric Machinery Research Center at ORNL from 1997 to 2000. In 2000, he joined Michigan State University, East Lansing, as an Associate Professor in the Department of Electrical and Computer Engineering. Dr. Peng has received the 1996 First Prize Paper Award and the 1995 Second Prize Paper Award at the IEEE Industry Applications Society Annual Meeting, the 1991 First Prize Paper Award from the IEEE TRANSACTIONS ON INDUSTRY APPLICATIONS.