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TUTORIAL

Power Quality Systems: from the State of the Art to Future Trends

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Synopsis

Today we are facing a twofold challenge related to the "quantity" of energy and the "quality" of power. On the one hand, there is not enough energy and its cost is continuously increasing, especially in peak periods. On the other hand, there are more and more power interruptions and power quality events. In this context, power quality systems play a central role. Their key features are reliability, performance and cost. Today, advances in microelectronics, controls, power semiconductors, energy storage systems and power converter topologies influence these features. The tutorial will discuss these underlying disciplines and their current limitations as well as their future trends for more reliable and flexible power quality products with superior performance and reduced cost.

Part One: Controls, Power Electronics, Power Quality Systems

With a microelectronics cost reduction of 30% per year and a computing power doubling every 6 months, it is more and more interesting to realize system features and functions in a digital way. In addition, the software costs nothing in production and the digital world opens the way to preventative maintenance, advanced diagnostics and improved connectivity. It will be shown how a full digital electronics and advanced control algorithms make it possible to realize more reliable and flexible power quality products with superior performance and at a reduced cost. Often, this results in a significant cost advantage for the final customer. The main topics discussed are: UPS topologies (line interactive, delta conversion, double conversion, ..), transformer-less versus transformer based UPS, rectifier control strategies and "clean" input (sinusoidal input currents at a high power factor), inverter control strategies and "output dynamic stiffness" (low electronic impedance), modulation strategies for inverter and rectifiers, control of parallel units (communication based versus wireless paralleling techniques), advanced operating modes (soft bypass transfer, economy mode, synchronization for multiple UPS configurations), control of other power quality systems (active filters, energy storage systems, peak shaving and multi-function devices), preventative maintenance and advanced diagnostics.

Part Two: Energy Storage Systems

The penetration of distributed renewable energy, such as photovoltaic and wind energy may further increase grid stability problems. Grid fluctuations due to the integration of renewable energy production and energy trading will generate more energy storage demand. For these reasons, in the near future, the importance of power quality systems and ESSs (Energy Storage Systems) will grow.Power utilities and large industrial power consumers look at ESSs for grid stabilization. Any storage capacity in the grid does not replace the requirement of UPS, which always has to be closest to the critical load. On the other hand UPS with adequate ESS can introduce energy management at the consumer level and support grid stability. Modern power quality systems based on UPS are almost always backed up by lead-acid batteries and by engine-generator sets for lengthy power outages. Grid stabilization applications require new ESSs, which can be cycled to lower state of charge more often. On this background a technical and economic evaluation is given on the options for Electric Energy Storage Systems with respect to the most important requirements for power quality and grid stabilization applications. The evaluated emerging energy storage technologies include flywheels, super-capacitors for short time power and flow batteries, advanced batteries and systems based on compressed air for longer periods as good alternatives to Lead-Acid batteries.

About the Speakers

Silvio Colombi obtained a MSc Degree in Electrical Engineering and a PhD in Control Engineering from the Swiss Federal Institute of Technology in Lausanne. After some years of Research activities in Lausanne, he joined the Nuclear Fusion project JET in Abingdon (UK) to work on teleoperation. He became lecturer of mechatronics at the Swiss Federal Institute of Technology and worked as an independent consultant on the hybrid Smart car for SMH Automobile in Bienne. He finally joined IMV Invertomatic Technology in Riazzino as responsible for the development of new technologies. When General Electric bought IMV, he became Manager of Advanced Development and then Technology Leader. He lectured several International Tutorials and he is the author of 8 patents and about 40 papers.

Marco Piemontesi obtained a MSc Degree in Electrical Engineering at the Swiss Federal Institute of Technology in Zürich with a graduation work on current-voltage characteristics in ceramic superconductors. He then worked as an assistant at the Institute of High Voltage at ETH and obtained a PhD on SF6 decomposition products. He then joined ABB Corporate Research in the High Voltage Systems Group as project leader working in the field of electrical breakdown mechanisms in gases and development of GIS. Finally, he joined General Electric in Riazzino as Advanced Development manager. He is the author of 4 patents and about 18 papers.