Design of Three-Phase Active PFC Rectifiers

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Computer servers, communication equipment, and motor drives all require front-end rectifiers to convert AC power to DC power. For high power applications from several kW to MW, 3-phase rectifiers are more advantageous over their single-phase counterparts, due to their reduced component count, reduced capacitance, and improved efficiency. Further, military field vehicles, aircraft, and ships use alternators to generate wide frequency and voltage three-phase AC power. Thus, high performance 3-phase rectifiers are required to convert the AC to DC to power various subsystems.

When rectifiers draw sinusoidal current from AC power sources that is in phase with the voltage, the power sources operate at their highest efficiency with the maximum power capacity. Traditional passive diode rectifiers draw non-sinusoidal currents from power sources, which introduces harmonic and reactive current into the transformers and alternators, reducing their capacity, efficiency, and lifetime. Passive 12 pulse and 18-Pulse Transformer Rectifier Units (TRUs) employ transformers and multiple 3-phase diode-rectifier bridges to increase the number of current pulses and decrease the harmonic content; however, this is achieved with the penalty of increased weight and raw material use. Furthermore, the introduction of transformers results in a narrow frequency range for effective and efficient power conversion, which is not suitable for modern mobile power systems where the alternator is connected directly to the engine to generate "wild" voltage and frequency output power.

Three-phase active PFC rectifiers are needed to serve these markets. However, development of 3-phase rectifier products requires substantial research and development capital and time. Most companies can't justify the investment. This tutorial presents breakthrough One-Cycle Control (OCC) technology and design methods that enable rapid development of high-performance three-phase active rectifiers, featuring great simplicity, wide frequency range (45-800Hz), high power quality (PF>0.99, THD<3%), and robust stability (from zero-100% load), without the requirement of DSP and software. Step by step design instruction will be provided based on commercially available OCC controller modules, OCC protection modules, and OCC driver modules.

About the Speaker: Keyue Ma Smedley, (IEEE Fellow) received her BS. and MS. degrees in EE from Zhejiang University, Hangzhou, China, in 1982 and 1985 respectively, and MS. and Ph.D. degrees in EE from the California Institute of Technology, Pasadena, CA, USA, in 1987 and 1991 respectively.

Dr. Smedley was employed at the Superconducting Super Collider from 1990 to 1992 where she was responsible for the design and specification of 100-8000A ac-dc converters for all accelerator rings. Dr. Smedley is currently a professor in the Department of Electrical Engineering and Computer Science at the University of California, Irvine, and Founder/Director of the UCI Power Electronics Laboratory. Her research interest includes topologies, control, and integration of high efficiency dc-dc converters, high fidelity class-D audio amplifiers, active and passive soft switching techniques, single-phase and three-phase power factor corrected rectifiers, active power filters, and grid-connected inverters for alternative energy sources, etc. Dr. Smedley has published more than 100 technical articles and holds nine US patents.

Dr. Smedley is a recipient of UCI Innovation Award 2005. She is a Co-Chair of Industry/Education Committee of the Power Sources Manufacturer's Association, and was the General Chair of IASTED and IEEE Power Electronics Society International Conference on Power and Energy Systems 2003, a General Co-chair of the Industrial Conference on Power Electronics for Distributed and Cogeneration, 2004, and a keynote/plenary speaker of many International Conferences.

Intended Audience: Students and engineers with basic to advanced knowledge in three-phase power systems and power electronics.