THE DEPARTMENT OF ELECTRICAL & COMPUTER ENGINEERING SPEAKER SERIES

PRESENTS

Emerging DC Power and DC Fault Protection

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LECTURE ABSTRACT

DC power is coming back long after losing the War of Currents over a century ago. However, DC circuit breakers (DCCBs) must be provided for LVDC (<1kV), MVDC (<40kV), and HVDC (100's kV) power systems. A wide range of DCCB technologies have been investigated for different applications. Presently, solid-state circuit breakers (SSCBs) can quickly interrupt a DC fault current within tens of microseconds but suffer from high conduction losses and weight and cost penalties associated with the cooling and semiconductor components, especially for high power applications. The most distinct advantage of semiconductor switches is their capability of switching current during fault interruption while the most distinct disadvantage is their nonnegligible on-resistance when conducting current. Unfortunately, they are used in SSCBs in the worst way possible—continuously dissipating power except during infrequent fault interruption. Numerous hybrid circuit breaker (HCB) schemes have been proposed to offer an on-state resistance 2-3 orders of magnitude lower than that of SSCBs. All the HCBs are of parallel type, in which an electronic path is in parallel with a main mechanical switch. The fault current in the mechanical switch is initially commutated to the electronic path to create artificial current zero crossings in various forms to aid the opening of the mechanical switch. The electronic path will then be interrupted with varistors (MOV) clamping the transient voltage surge and absorbing the residual electromagnetic energy. However, these HCB solutions offer only a moderate fault response time of several milliseconds. This may be too slow to limit the fast-rising fault current in low-impedance DC power networks. The most distinct disadvantage of all the HCBs is the relatively long opening time of the mechanical switch to achieve a sufficiently wide gap for sustaining the DC voltage, during which the fault

current continues to rise through the electronic path. This talk will provide a review and performance comparison on the state of the art DCCB solutions in a systematic way. It will cover several case studies of various types of DC circuit breakers. The talk will also highlight the fundamental challenges faced by the DCCB technologies and shed some light on future research directions..

SPEAKER BIOSKETCH

Dr. John Shen is a professor and director of the School of Mechatronics at Simon Fraser University, BC, Canada. He was Grainger Chair Professor of Electrical and Power Engineering at Illinois Institute of Technology between 2013 and 2021. He has more than 30 years of industrial, academic, and entrepreneurial experience in power electronics and power semiconductor devices with over 300 publications and 18 issued U.S. patents in these areas. He has been involved in circuit breaker research since 2013, and is an inventor of several patents and an author of over 30 publications on the subject. He served as PI of an ARPA-E CIRCUITS project on low-voltage solid-state circuit breakers, co-PI on an ARPA-E BREAKERS project on MVDC hybrid circuit breakers, and PI on an ARPA-E CABLES project on MVDC superconducting momentary circuit interrupters. He is a recipient of the 2012 IEEE Region 3 Outstanding Engineer Award, the 2012 E. T. Walton Fellowship from Science Foundation of Ireland, and the 2020 Illinois Institute of Technology Senior Faculty Sigma Xi Research Award. He has served the IEEE Power Electronics Society (PELS) in various capacities including Vice President of Products, AdCom member, Chair of Distinguished Lecturers Program, Deputy Editor-in-Chief of IEEE Power Electronics Magazine, Guest Editor-in-Chief of the IEEE Transaction on Power Electronics and the IEEE Journal of Emerging and Selected Topics in Power Electronics. He has been on the organizing or technical program committee of over 30 international conferences in the field, and served as the General Chair of the 2016 Energy Conversion Congress and Exposition (ECCE2016) and the 2018 International Symposium on Power Semiconductor Devices & IC's (ISPSD2018). He is a Fellow of IEEE and the U.S. National Academy of Inventors.