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Tutorial Title

Electrosurgery Power Electronics: A Revolution in the Making

Instructor Team

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Abstract

Note 1: References: Provided in the attachment Note 2: Figs. provided in the attachment Electrosurgery [1] involves the passage of high-frequency (HF) current through the tissues of the body to raise intracellular temperature to achieve vaporization or the combination of desiccation and protein coagulation thereby yielding a controllable surgical effect [2]. These effects, presumably guided by exploding cell theory [3] (which suggests that the heat generated by the resistance of soft tissue to the passage of HF electrical energy causes molecular disintegration of cells in the line of the surgical incision) or microscopic bubble theory [4] (which suggests that cutting results from the formation of microscopic bubbles in the line of electrosurgical incision) can be translated into cutting or coagulation of tissue, as shown in Fig. 1 [5]-[9]. The latter is usually employed for attaining hemostasis, but also for occluding lumen-containing structures, or destroying large volumes of tissue such as soft tissue neoplasms [2]. Fig. 2(a) illustrates a conventional approach to surgery typically leveraging mechanical instrumentation (e.g., sharp metallic scalpel). In contrast, in Fig. 2(b), the idea of electrosurgery is illustrated and the HF inverter together with the galvanic step-up transformer is abbreviated as the electrosurgery generator (ESG). Unlike the conventional approach, in the latter, the surgery is achieved by controlling the heat generated for instance by an “electro-scalpel” powered electrically using an HF inverter [7]-[9] and references therein. It is also promising to reduce collateral tissue damage autonomously through thermal feedback (see Fig. 3), which is used in [9] as the outer loop in the SISO (single-input/single-output) nested loop configuration to adjust the setpoints to the inner power loop, and in [11] in the MIMO (multi-input/multi-output) to both adjust the power setpoints (to a commercial electrosurgical unit) and simultaneously perform the damage-conscious motion planning of the cutting probe. Viewing that, there lies the radical departure from conventional surgery. Moreover, the surgeon can achieve disparate surgical operations by controlling how the electro-scalpel is electrically excited by the HF inverter (see Fig. 1 for illustration). All merits mentioned above allow electrosurgery power electronics supported by feedback to make a radical revolution from the conventional method to surgery. Given this backdrop, this tutorial provides fundamental insights into the wide-bandgap multi-functional inverter and precision-power control technologies for safer electrosurgery with a plurality of practical experimental results (in vivo and ex vivo) and is expected to be of great interest to power electronic engineers, surgeons, professionals, educators, and students. Many new materials are planned for this tutorial with several recent developments. The tutorial will start with basics for researchers, engineers, biomedical professionals, and students and gradually work its way through to intricacies in advanced interdisciplinary concepts,

realizations, design, and practical implementations on new power electronics technologies for electrosurgery.

Instructor Team Biographies

Sudip K. Mazumder is a University Distinguished Professor and the Director of the Laboratory for Energy and Switching-Electronic Systems (LESES) at UIC, Chicago, IL, USA. He is a Fellow of IEEE, AAAS, and AAIA, and the Editor-at-Large for IEEE Transactions on Power Electronics.

Congbo Bao is a Senior R&D Power Electronics Engineer at Hitachi Energy, PA, USA. His research interests encompass high-frequency inverters/converters, electrosurgery, biomedical electronics, and wideband gap semiconductor devices, etc.

Ankit I. Mehta is an American Board of Neurological Surgeons Board-Certified Neurosurgeon who practices with the Department of Neurosurgery at the University of Illinois Health, Chicago, IL, USA. He is a Fellow in the American Association of Neurological Surgeons (FAANS) and Fellow of the American College of Surgeons (FACS).

Steven D. Schwaitzberg (MD, FACS MAMSE) is Chairman of the Department of Surgery at the University at Buffalo School of Medicine and Biomedical Sciences He is SUNY Distinguished Service Professor of Surgery and Bioinformatics. He also serves as the Medical Director, Surgical Program Development, at Great Lakes Health. He previously served as the Chief of Surgery at the Cambridge Health Alliance where he was Professor of Surgery at Harvard Medical School.