Abstract

The induction of solid-state technology in pulsed power generators (PPGs) has significantly improved the generators in terms of size, weight, and performance. Furthermore, this technology has enhanced the system's controllability over critical pulse parameters such as amplitude, width, polarity, shape, and repetitiveness. However, considering the usefulness of the PPGs in a wide variety of applications, other factors such as the 'pulsed output to input voltage conversion ratio (PO-IVCR)' of the PPGs, the number of devices required by them, and utilization of a single generator for different applications have substantial importance and need to be addressed. This thesis investigates solid-state PPGs with the motivation to design and develop such PPGs that can offer enhanced PO-IVCR and that too by requiring fewer devices. Moreover, it is desired that the developed PPG should exhibit features such as precise pulse reproducibility, better controllability over pulse specifications, and the ability to drive different types of loads.

This thesis presents two novel bipolar pulsed power generators, namely Bipolar High-Voltage Pulsed Power Supply (BHVPPS) and Modular Bipolar Pulse Generator (MBPG). BHVPPS is an inductor-based PPG, which achieves high PO-IVCR by utilizing less number of semiconductors and passive devices. Moreover, BHVPPS is suitable for driving various load types such as plasmas, biological cells, gases, etc. The thesis extensively discusses the principle of operation of the BHVPPS and presents a detailed design procedure for the selection of passive components. The thesis also validates the claims and advantages of the BHVPPS through simulations and experiments.

MBPG is an inductor-less PPG, which is suitable for a wide range of operations. Conventionally, two capacitor charging mechanisms, i.e., parallel charging and sequential charging, are employed in the inductor-less PPGs. Both have their own merits and demerits, but a common issue associated with both is the requirement of many capacitors and associated switching devices for achieving a large PO-IVCR and at such PO-IVCRs, PPGs become vulnerable to several challenges. To mitigate these challenges, a charging mechanism for the PPGs, i.e., sequential cum parallel capacitor charging (S+P-CC), is proposed. The working of the "S+P-CC" is simple, and it supports a very high PO-IVCR. MBPG utilizes this charging mechanism and effectively supports a relatively higher PO-IVCR. Moreover, it requires fewer switches and capacitors than its peers. In addition to it, MBPG produces pulses at high repetitiveness and provides flexibility in the adjustment of pulse parameters. The thesis establishes the steady-state and transient analysis to explain MBPG's working and provides the simulation and experimental results in support of the claims made by the MBPG. Further, the thesis provides an exhaustive comparative study between MBPG and reported PPGs to prove MBPG's feasibility and relevance.

The above-discussed PPGs are intended to generate bipolar pulses, which are of utmost importance in electroporation-based cancer therapies. But, several other applications, such as food treatment and particle accelerators, require unipolar high-voltage pulses. Food sterilization requires multipulse output, whereas the particle accelerators require, low-voltage droop long duration pulses. Considering these requirements, a multipulse/ unipolar PPG is designed. This PPG supports a high PO-IVCR and is, given the name: HVMG, i.e., high-voltage multipulse generator. A detailed discussion on the working of the HVMG is provided in the thesis, and to verify the claims made in the thesis, simulation and experiments have been carried out. Further, this thesis proposes a voltage droop compensation technique that effectively compensates the pulsed voltage droop. To verify the effectiveness of this technique, it is implemented on the HVMG. The proposed approach is tested through exhaustive simulations and experiments, and the results, thus obtained, are found in close agreement.