Design and Development of Multi-gap and Multi-aperture Pseudospark Switches for Pulse Power Applications

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Abstract

In the recent decade, a resurgence of interest in high power fast switching devices has occurred in response to their new requirements for civilian as well as strategic applications, such as, Radars, Linacs, Pulsed lasers, Synchrotron sources, Crowbars, Sterilizations, Transient plasma ignition for pulsed detonation engines, High power electron beam sources, etc. [1-2]. CSIR-CEERI has been working for nearly two decades in the field of plasma closing switches, particularly, Thyratron and Pseudospark (PSS) switches to meet the demand of strategic sectors in the country. The thyratron switch is a well-established technology and is commercially available from limited industries. On the other hand, there are many advantages of PSS over the thyratron switch like, low standby power, ruggedness to current reversal and fast rate of current rise. A fast voltage breakdown together with a fast current rise is typical for pseudospark discharge (PSD) resulting in a class of high power gas phase switches used in pulsed power applications. The PSS is a new development and its capability as an alternative to thyratron switch needs to be proven yet at higher voltage ratings [3-4].

In the recent past CSIR-CEERI has successfully developed single gap sealed-off 25kV/5kA PSS which is holding voltage up to 30 kV and delivering current more than 5 kA even at higher ($\geq$ 50Hz) pulse repetition rate (PRR). Keeping the upcoming requirements of strategic sectors for high power plasma switches, demountable and sealed-off versions of double gap 40kV/5kA PSS have been recently designed and developed [5]. The developed PSS have two gaps that are separated by a cavity drift space region. Switching characterization of the developed PSS prototypes have been carried out at different operating conditions, such as, gas pressure, voltage, triggering, and circuit conditions. The PSS have been found performing better than the comparable commercially available thyratron switches for hold-off voltage in the range of 40 kV and current up to 10 kA [5-6]. It employs a single ferroelectric trigger module with a high dielectric constant ferroelectric disc which is inserted in the hollow cathode cavity to provide seed electrons for the efficient discharge ignition in the double gap PSS [7-8]. In preliminary testing, the switch was holding 40 kV with a peak anode current ~10 kA and pulse duration of ~1.5 μs with a resistive load of 2.9 ohm. The switch was operated with deuterium gas reservoir for higher number of discharge shots at different voltages and corresponding peak currents at repetition rate up to 50 Hz without significant decay of switch performance [5]. The design of the developed PSS has been analyzed for higher hold-off voltages with high charge transfer capability at higher repetition rates. The switching performances of the developed PSS validate the design of the double gap pseudospark switch. Recently, CSIR-CEERI has also taken the challenge to design and develop high power 70kV/10kA PSS for crowbar protection circuit applications.

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