Abstract

The performance of systems used in various high voltage applications depend majorly on the output voltage ripple of High Voltage Power Supplies (HVPS). One of the failure mode of microwave tube (MWT) commonly used in these applications is due to the energy accumulation above the specified limit during fault events due to higher stored energy in HVPS. This demands either a protection for MWT or reduced ripple voltage without increasing the stored energy.

This thesis investigates a protection device for MWT that operate with MW power level HVPS, and design method to reduce the output voltage ripple for medium power HVPS.

A crowbar is an energy diverting device connected in parallel with the MWT. It protects the tube during fault by providing an alternative path for the ow of energy. Conventional crowbars are built using either mercury or nitrogen gas-based switches. Due to the environmental concern and higher operational cost, the state-of-the-art is to replace these devices with semiconductor devices, referred to as solid state crowbar (SSC). This research, models and designs the subcomponents of an SSC, including: (i) Modelling of fault current, and a fuse wire that is used to emulate a MWT during internal arc (ii) Design of di=dt limiting inductor (iii) Design of static and dynamic voltage balancing network for the thyristor (iv) Mechanical assembly design that ensures meeting the required crowbar electrical characteristics (v) Selection of cost-effective semiconductor device for crowbar application (vi) Thermal modelling of crowbar for pulse power applications (vii) Selection of cable for the pulse power application.

In a switched converter topology, the causes of output voltage ripple are: the switch action, input dc ripple, and variations in the load. In this thesis the influence of input voltage ripple on the output dc voltage, called Audio Susceptibility (AS), is discussed. AS of load resonant converters has not been widely studied in literature. This research uses exact discretization method to obtain: (i) The analytical large signal and cyclic steady state model of the Series Resonant Converter (SRC) considering the resonant tank and output filter states (ii) The analytical small signal AS model of the SRC, and resonant gain condition for input ripple (iii) The design of an SRC for superior AS performance (iv) A comparison of SRC design for (a) superior AS performance and (b) maximum power transfer capability (v) A selection of SRC components including the high voltage high frequency magnetics and selection of the MosFET.

All the modelling and design method considered in this work has been verified by experimental studies on two 10MW, 10kV peak power SSC and a 10kW, 10kV SRC that has been fabricated as a part of the research.