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Stacked Multi-Level Long Pulse Modulator Topology for ESS

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The European Spallation Source (Lund, Sweden) is an under construction multi-disciplinary research facility to be based around a Linear Particle Accelerator which is to provide 2.86 ms long proton pulses at 2 GeV at a pulse repetition rate of 14 Hz, representing an average beam power of 5 MW.

To accommodate the requirements of the proton linac, a large number of klystrons driven by power electronic modulators will be needed. Conventional long pulse modulators are pulse transformer based and commonly exhibit poor efficiency, low power density, large footprint and cost. In addition, these topologies due to their nature in combination with the above cited high peak power requirement for short periods of time commonly produce prohibitive levels of flicker and harmonic content while operating at suboptimal power factor, problems usually corrected by both costly and spacious external grid compensators.

This paper presents the stacked multi-level (SML) klystron modulator topology, a novel, modular concept based on high-frequency transformers and rectifier bridges stacked in series, believed to better suit the application and better satisfy ESS requirements, directly addressing the mentioned shortcomings of conventional topologies.

The development of this new klystron modulator topology has included the design and construction of a reduced scale prototype with the potential of delivering long (3.5 ms) high quality dc pulses (0-99% rise time of less than 100 μ s and flat top ripple less than that of 0.15%) of high voltage (115 kV) and high power (peak power > 2 MW) while on its own maintaining excellent AC grid power quality (low flicker operation < 0.2%, sinusoidal current absorption with total harmonic distortion < 3%, and unitary power factor).

The paper in detail describes the essential features of the topology and outlines the working principle, presenting results from both simulation and experimental work.

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