Design and planned application of high efficiency magnetrons for SCRF proton linacs

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Abstract

One option to provide the proton beam for accelerator driven subcritical reactors is to use a superconducting linac. The first application of a superconducting radio frequency (SCRF) proton linac was for the BNL neutron spallation source [1] and others now are planned [2]. Other high energy and nuclear physics research might in the future utilise beams from SCRF proton linacs [3] and hence there is worldwide interest in their development. Key development issues for suitable SCRF proton linacs are to reduce costs, increase efficiency and reduce trip rates. A major cost component for the linac is the RF source. This paper considers the use of magnetrons as the main RF source for the linac.

Making assumptions on the linac and justified in this paper a 1 GeV proton beam for a 1 GW thermal sub-critical reactor with k = 0.98 requires a beam power of 5 MW. The beam should either be continuous wave CW or have a high repetition rate depending on the lifetime of neutrons in the reactor. Along the linac the protons will have a relativistic gamma factor well below one and hence there is a requirement for independent phase and amplitude control of relatively short linac sections. Assuming similar optimizations as for spallation sources then between 50 and 70 cavities driven at CW power levels between 50kW and 200kW are required. The power should be supplied at the lowest possible cost and the highest possible efficiency. CW magnetrons have been demonstrated to have efficiencies near to 90% at 915 MHz and operate reliably at CW power levels to 100kW. The manufacturing cost of magnetrons at this power level is a small fraction of that of that for klystrons and IOTs.

The driving and phase control of a superconducting accelerating cavity with imposed microphonics and an external factor Q of 2.6×10^6 has been demonstrated using an injection locked low power CW "cooker" magnetron with phase modulation on the injection signal [4]. The next step in this development is to demonstrate the technique at much higher power levels and with the appropriate efficiency. As there is considerable current interest in superconducting linacs for neutron spallation sources at 704 MHz a high power magnetron for this frequency is being designed that is optimised for ease of injection locking and high efficiency.

This paper reports on the initial magnetron design calculations, some cost calculations, how the injection locking would be implemented and future plans.

References

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