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Wed-Af-Po.12-01: Conduction Cooled Cryogenic Current Drive with HTS Filter

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Supplying high current to a superconducting magnet incurs significant conduction losses through current leads. Due to the limitations imposed by the Wiedemann-Franz Law, the minimum loss is independent of the lead material and is ⊠ 45 W per 1,000 A of DC current.
Here we propose and demonstrate a synchronous rectifying DC current drive with no thermal linkage between room temperature and cryogenic environments. The high-voltage signal is stepped down by an in-vacuum transformer and converted to DC by a cryogenic synchronous rectifier circuit operating at 18 K and a maximum current of 1,000 A. The key component of the current drive is a HTS filter, which ensures < 10 mV voltage ripple on the coil. We discuss the design of the filter inductance and identify off-shelf capacitors that can operate below 20 K.
We analyze the source of both conduction and switching losses. The switching losses originate from the discharge of leakage inductance of the secondary winding. Proper management of the gating sequence significantly reduces the switching loss, thus making it possible to design a cryocooled magnet system rated for 1,000 - 4,000 A capacity that is cooled with a single cryocooler.
The source operation is demonstrated on a 2 Tesla second-generation HTS magnet operating at 18 K.

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