Commercial Ultra-High-Field NMR Magnets with HTS Conductors

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***Abstract*— Since the beginnings of NMR spectroscopy, the exceptionally successful method to analyze the chemical structure of solids and molecules in solution, experimentalists requested ever larger magnetic fields for their instruments, primarily to improve their resolution and their signal-to-noise ratio. While a succession of low-Tc superconductors – NbTi and a range of Nb_3Sn wire types – were the base of a remarkable development from 4.7 T (200 MHz) in 1964 to 23.5 T (1.0 GHz) in 2009, only the use of high-Tc superconductors (HTS), discovered in the 1980s, held the promise to generate even higher fields. However, practical HTS conductors of sufficient unit length and quality were made only during the last decade, enabling the development and construction of ultra-high-field NMR magnets that reach fields beyond 1 GHz and meet further demanding requirements.**

Bruker BioSpin, a leading supplier of complete NMR spectrometers with its own magnet R&D and production, followed the evolution of HTS conductors closely with a program to develop HTS coil technologies, quench protection schemes, homogenization methods and jointing techniques. Realizing its potential and trying to leverage expertise and manufacturing capabilities available in the company, the focus soon was on ReBCO coated conductors. After many tests on individual components and coil prototypes confidence in the developed technologies was sufficient to design and build 1.1 GHz and 1.2 GHz NMR LTS-HTS hybrid magnets, the first of which were installed at customer sites in 2019 and 2020 respectively. Four more systems followed since.

After a brief overview of the historic development of UHF magnets, this presentation discusses some of their challenging requirements (homogeneity, drift, force management and quench protection) and how they are met in LTS-HTS hybrid magnets. Following a review of the achieved NMR performance it concludes with the practical needs that commercial NMR systems must also satisfy.

***Keywords (Index Terms)* — NMR, superconducting magnet.**

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