the advanced flux concentrator

Abstract

A new Cryogenic Current Comparator with extended Dimensions (CCC-XD), compared to earlier versions built for GSI, is currently under development for a highly-sensitive, highly-dynamic measurement of nano-amperes intensities of beams for larger beamline diameters planned for the new FAIR accelerator facility at GSI. The CCC consists of a:

1. flux concentrator,
2. superconducting shield against external magnetic field and
3. superconducting toroidal coil of niobium which is read out by
4. Superconducting Quantum Interference Device (SQUID).

The new flux concentrator (1) comprises a specially designed highly-permeable core made of nanocrystalline material, in order to assure low-noise operation with high system bandwidth of up to 200 kHz. The superconducting shielding of niobium (2) is extended in its geometric dimensions compared to the predecessor CCC and thus will suppress (better ~200 dB) disturbing magnetic fields of the beamline environment more effectively. For the CCC-XD readout, new SQUID sensors (4) with sub-μm Josephson junctions used which enable the lowest possible noise-limited current resolution in combination with a good suppression of external disturbances.

The CCC-XD system, together with a new dedicated cryostat [IBIC2016-Poster WEPG40], will be ready for testing in the CRYRING at GSI in spring 2017. For the application of a CCC in the antiproton storage ring at CERN a pulse shape correction has been developed and tested in parallel. Results from electrical measurements of two components (1 and 4) of the new CCC-XD setup will be presented in this work.

(1) The advanced flux concentrator

The larger beamline diameter of the new FAIR accelerator facility leads to an inner diameter of 274 mm for the flux concentrator. A special three-piece core package was composed by wrapped ribbons of nanocrystalline Soft Magnetics. The ribbon thickness itself is very small – on about $15 \pm 3 \text{ g} \mu \text{m}$.

The material is produced by a specific thermo-magnetic annealing process of amorphous Fe-alloy (NANOPERM® Fe73,5 Cu1 Nb3 Si15,5 B7 [1]) ribbons which defines the magnetic parameters and the temperature dependencies. More than 1000 layers are necessary to create a single core.

A precision $L_r/R_p$-measurement setup and a wide-neck cryostat with a temperature range from 2 K to 300 K was developed to characterise the core packages concerning the variation of the electrical parameter due to annealing process.

<table>
<thead>
<tr>
<th>Temperature /K</th>
<th>Core GSI328plus No. 1 and No. 2 @ 4.2K</th>
<th>Core GSI328plus No. 4a @ 4.2K</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$L_r$ [μH]</td>
<td>$R_p$ [Ω]</td>
</tr>
<tr>
<td>2</td>
<td>0.30</td>
<td>0.18</td>
</tr>
<tr>
<td>4.2</td>
<td>0.32</td>
<td>0.21</td>
</tr>
</tbody>
</table>

The same recipes does not lead to identical thermo-magnetic annealing process to create different nano-crystalline characteristics.

The same recipes does not lead to identical thermo-magnetic annealing process to create different nano-crystalline characteristics.

Conclusion and Outlook

The CCC in operation already have demonstrated their potential at beam lines at GSI and CERN [2,3]. The newly developed core materials will allow for higher signal frequencies and lower noise. The use of new sub-μm-SQUIDS will enable a decreased noise and higher system bandwidth. Within the current research project supported by the BMBF the magnetic and acoustic disturbing signals shall be reduced to improve the CCC operations in critical environment. Alternative shielding constructions and their magnetic field suppression will be evaluated.

In the meantime the CCC-XD for CRYRING is still under construction, the related cryostat - considering AD CCC measuring results - is in preparation (see Posters WEPG40, TUPG50).

References


Paper ID: TUPG43

Mail to volker.tympel@uni-jena.de, ralf.neubert@uni-jena.de

This project is supported by the BMBF; project number 05P15SJRBA.