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SQA02-2019-009
QA department
Superconductivity Technology Division

Answer to Request_2019-3_Sumitomo_Questionnaire1_Clarification

1. You mention higher magnetic field ramp rates in case an MRI – or possibly also an NMR -has to be restarted. How relevant are such restarts in the daily use practice, e.g. how often do they actually occur in practice, and given the fact that even for devices operating with 10 T the time difference is only 8 minutes?

(Answer)

The energization / de-energization period of the magnet depends on the size of the magnet and the generated magnetic field, so it cannot be generally stated, but generally the AC loss of BSCCO wire is smaller than that of LTS wire, so the energization period of the magnet using BSCCO wires is smaller than that of using LTS wires.
In addition, since the BSCCO wire has a higher current density than the LTS wire, the volume of the entire coil will be reduced when the same magnetic field is generated, and the heat generated by the AC loss from the entire coil will be reduced. The magnet energization period using BSCCO wire will be smaller compared with the magnet made from LTS wire.
However, since NMR and MRI magnets are normally operated in the persistent current mode, no energization/de-energization is necessary during normal operation for customers, therefore the above-mentioned advantages would be enjoyed at the first startup, at the time of magnet transportation, after magnet quenching if it happens. It is expected to be about once every few years, such as at the time of re-startup.

2. You state that your BSCCO-superconductors will allow stronger magnetic fields and improve image quality in MRI. MRIs with 7 Tesla or maybe even more without your technology are, however, already available on the EU market. The same may apply to NMRs, at least for lower magnetic field strengths.

    a. Aside from the higher field ramp rates, what would be the added benefit of your superconducting technology given the fact that high-T MRIs and NMRs that do not depend on your requested exemption are already in operation in the EU? Please also explain whether and how far these advantages would also apply to MRIs and NMRs with lower magnetic field strengths.

(Answer)

The most powerful commercially available MRI that use niobium alloy superconducting coils have 7Tesla (7T) magnets*1, although most on the EU market are 1T or 3T. These are able to visualize fairly small features such as tumors, blood clots, etc., but more powerful superconducting magnets of 20T or more will enable medical doctors to see even smaller features that are currently too small to be seen. This will, for example, enable cancerous tumors to be seen at an even earlier stage than today giving improved prospects for survival (see page 6 and reference 7 of the exemption request).

NMR that use superconducting magnets are needed to analyse very complex molecules such as proteins. Complex molecules contain many different substituent groups each having hydrogen atoms in different situation and each giving a peak at a different position in the spectrum. When there are many hundreds or thousands of hydrogen atoms in a molecule, each having a peak at a different location, these will tend to merge into a broad band when the magnet power is low and is not sufficiently powerful to resolve these many peaks. These broad bands are useless for identification of molecular structure. By increasing magnet power, the spectrum is, in effect, “stretched out” so the broad band becomes many individual peaks which are useful for molecular analysis. This is explained in our exemption request (page 6) and in reference 6. As the powerful of the magnetic field is increased, this enables more and more complex molecules to be analysed. The most powerful niobium alloy superconducting magnet NMR is not able to analyse very complex moecules, but even more powerful BSCCO magnets will be able to analyze more complex molecules

b. What do you consider the highest magnetic field strengths that can be achieved with the current technologies now and in the near future?

(Answer)

When LTS wire is used, NMR is predicted to be 23.5T at present and also in the future. In MRI, the current maximum magnetic field is expected to be 11.7T for the moment and 14.1T in the near future.

c. Where do you see the current and near future field strength limits of your technology?

(Answer)

It is expected to be 40T*2 by NMR and 14.1T*3 by MRI.
However, the advantage of adopting BSCCO wire is not only for the record of the maximum magnetic field, but the magnet can be made compact, the ease of installation would be improved, and the environment using high magnetic field would be increased without increasing the environmental load. In many scientific and engineering fields, the environment for using high magnetic fields will expand, which will help create a rich society for human being.
For MRI, the maximum magnetic field that can be achieved safely for patients is considered to be 14.1T with LTS and for BSCCO. However, the magnets are smaller and lighter-weight with BSCCO which has advantages in hospitals where space is limited and if the hospital wants to use the MRI on an upper floor, closer to patient's wards, where there is a limitation on the weight that the floor can withstand

References

*1
https://www.nature.com/articles/d41586-018-07182-7
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