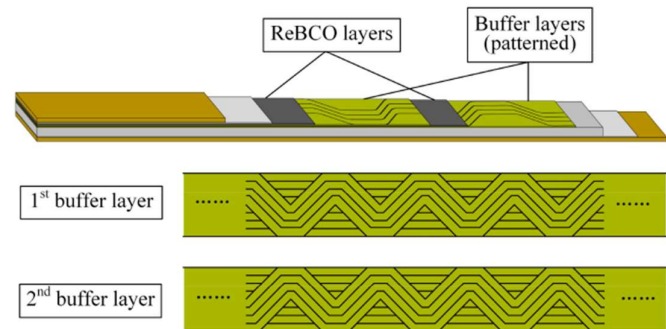


Reduction of AC losses in a novel superconducting cable : the Roebel tape

Superconductors are considered the next generation of materials that have the potential to meet the growing need for energy efficiency in societies. This is why the race to develop the most efficient superconductors has been underway for several decades. One of the challenges faced by researchers is the power loss that occurs in superconductors when carrying an AC current or when exposed to an external AC magnetic field. These losses represent a key element to be understood and controlled in order to develop efficient superconductors. This is because AC loss places a burden on the cryogenic cooling system of the superconductors. Thus, the use of High Temperature Superconductors (HTS) in electric systems is closely related to the development of innovative low-AC-loss cables.

In 2022, the concept of a new HTS Roebel cable was developed and designed at the University of Cambridge. More specifically, it is a Roebel tape called Patterned Superconductors for AC Loss Minimization (PSALM), whose manufacturing process is simpler and more resource-efficient compared to traditional Roebel cables. The design includes several features that contribute to lowering the losses. In particular, the field-canceling effect allowed by the specific complementary meander-shaped pattern of the tapes significantly reduces AC transport losses.



Double layer Roebel tape, with meander shape patterns for each layer in opposite directions

To understand how the field-canceling effect occurs, one can use Norris's theory on type-II superconducting strips. In an HTS strip carrying a current or exposed to an external magnetic field, current vortices appear in the material and rearrange themselves such that the current equals the strip's critical current density in the outer regions. The magnetic field penetrates the strip through these outer regions and is expelled from the inner region. As a consequence, AC losses occur only in the outer regions. This is why understanding the motion of these outer regions is a key element in reducing AC losses.

The idea of the PSALM is to share the current between several superconducting layers. Thus, for a PSALM made of N layers and carrying a current I , each layer should ideally carry a current I/N . Each one of the N tapes is patterned in a meander shape such that the intrinsic magnetic field of each one is partially canceled by the field created by other layers. Thus, the total magnetic field seen by each tape (layer) is reduced, the outer regions' width of each tape decreases, and

the AC losses decrease. This effect, called the field-canceling effect, significantly reduces the AC transport losses (by up to 60%).