# Inductive De-fluxing of Superconducting Quantum Interference Devices

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***Abstract*— Magnetic flux trapping is a serious problem in both low-temperature (LTS) and high-temperature (HTS) thin-film superconductive quantum interference devices (SQUIDs) and Josephson junction circuits. Trapped vortices in Josephson junctions can significantly degrade SQUID properties or even make them completely non-functional. Vortices can be trapped in superconducting films during the cooling process or can be caused by transient currents during current switching, electrostatic discharges through cable connections, etc. Unavoidable flux trapping happens in SQUIDs when a strong external field is applied. It can be a magnetization field in the case of superparamagnetic relaxation measurements (SPMR) or a pre-polarization field in the case of ultra-low field magnetic resonance imaging (ULF MRI), when an unshielded thin-film SQUID-based gradiometer is used. SQUID sensors stop working after being exposed to magnetic fields of only a few Gauss in strength. The most common way to remove frozen vortices is heating up a SQUID chip above its critical temperature which removes trapped fluxes and returns a SQUID to a normal operation. However, heating up a whole chip is usually too slow, is not reliably repeatable and dissipates too much energy. Earlier, we proposed a new alternative method for fast removal of trapped vortices in superconducting thin films by applying sinusoidal decaying magnetic field in an orthogonal direction. We called this method an alternating current or AC de-fluxing technique. In this paper we compile results obtained using planar thin-film LTS SQUID gradiometers and thin-film HTS SQUID magnetometers with bi-crystal Josephson junctions. This new inductive AC de-fluxing technique is much faster than a conventional thermal cycling and dissipates significantly less energy. The technique was successfully tested with multiple LTS and HTS SQUID sensors. Finally, we discuss a possible mechanism to explain the observed inductive de-fluxing effects. We propose vortex-antivortex annihilation as a plausible mechanism explaining the observed inductive de-fluxing effects.**

***Keywords (Index Terms)*– Magnetic flux, flux trapping, de-fluxing, thin film, Josephson junction, superconducting quantum interference device, SQUID, vortex, antivortex.**

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This paper extends the validity of results presented in *IEEE Trans. Appl. Supercond.*,
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