Progressive Study on Repetitive Excitation and Demagnetization for Magnetic Refrigeration Using Static Superconducting Coils

Authors *Koichiro Waki[1], Taiki Onji[1], Yamato Kamiyama[1], Keigo Ukita[1], Yoshiki Miyazaki[1], Yasuaki Sakamoto[1], Masaru Tomita[1], Naoki Hirano[2], and Yuta Onodera[2]

[1] *Railway Technical Research Institute, 2-8-38 Hikari-cho, Kokubunji-shi, Tokyo 185-8540, Japan*

[2] *National Institute for Fusion Science, 322-6 Oroshi-cho, Toki-shi, Gifu 509-5292, Japan*

Abstract

Hydrogen is a promising candidate as an alternative to fossil fuels, with an advantage of no emission of carbon dioxide when consumed. Liquefaction of hydrogen is a preferable method to store a large amount of it. It is expected that cooling technologies with high efficiency exist for temperature range especially around 20 K near boiling point of hydrogen. Magnetic refrigeration may be applied to the cooling technologies. Repeated changes of magnetic field (excitation and demagnetization) at magneto caloric materials (MCMs) are required for magnetic refrigeration and obtained by static superconducting coils with trapezoidal wave current[1)].

To easily reduce electric power consumption of the trapezoidal wave current, it was conceived that the trapezoidal wave current was generated approximately by resonance as alternating current if static superconducting coils were combined with capacitors, especially at low frequency for magnetic refrigeration. However, the alternating current will attenuate because of circuit resistance. A method was proposed to adjust the alternating current to the trapezoidal wave current and recover it to the initial value against attenuation[2)]. The method consists of adding 3 switches to a combination of a static superconducting coil and a capacitor and switching on or off as shown in Figure 1.

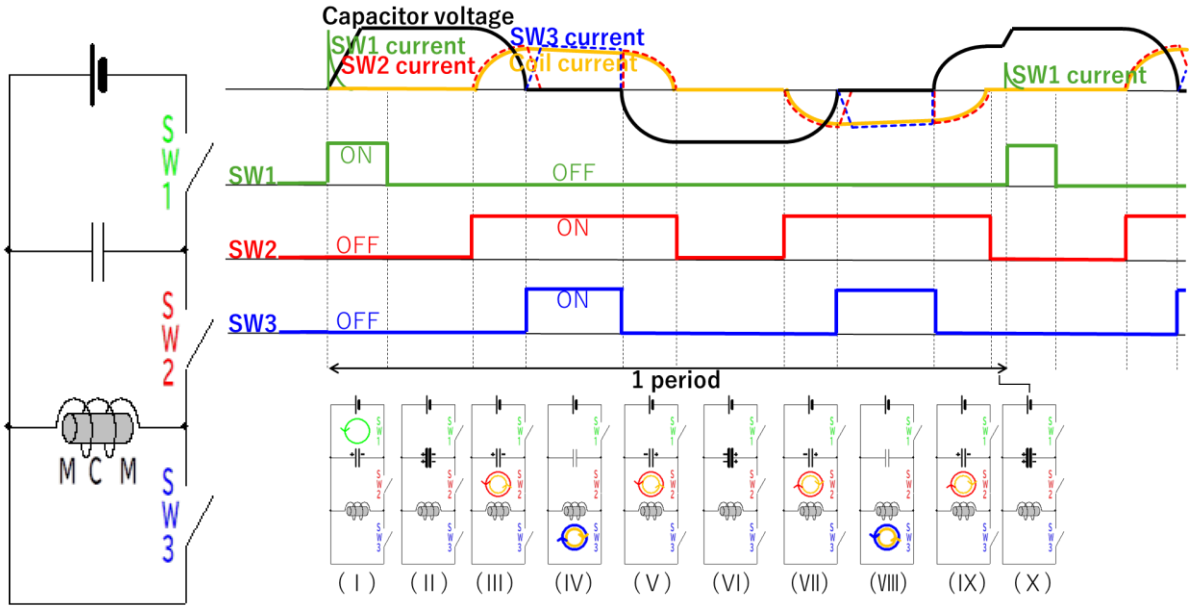

Figure 1 3 switches added to a combination of a static superconducting coil and a capacitor

This study progressively reports the method regarding repetitiveness of excitation and demagnetization. Figure 2 shows an experiment of the method as switches are controlled by programmable logic. Because inductance was small such as 4mH of a palm-sized REBCO coil, capacitance was needed to be large such as 340F of an electric double-layer capacitor, for resonance at low frequency such as 0.14Hz. Figure 3 shows a modification of the method to make the capacitor unipolar like an electric double-layer one. Thus, the trapezoidal wave current was continuously generated using a palm-sized REBCO coil and an electric double-layer capacitor under programmable logic control of switches.

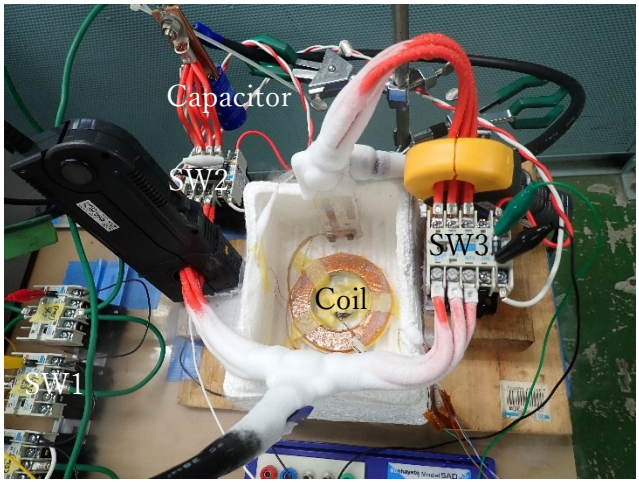

Figure 2 An Experiment of Figure 1

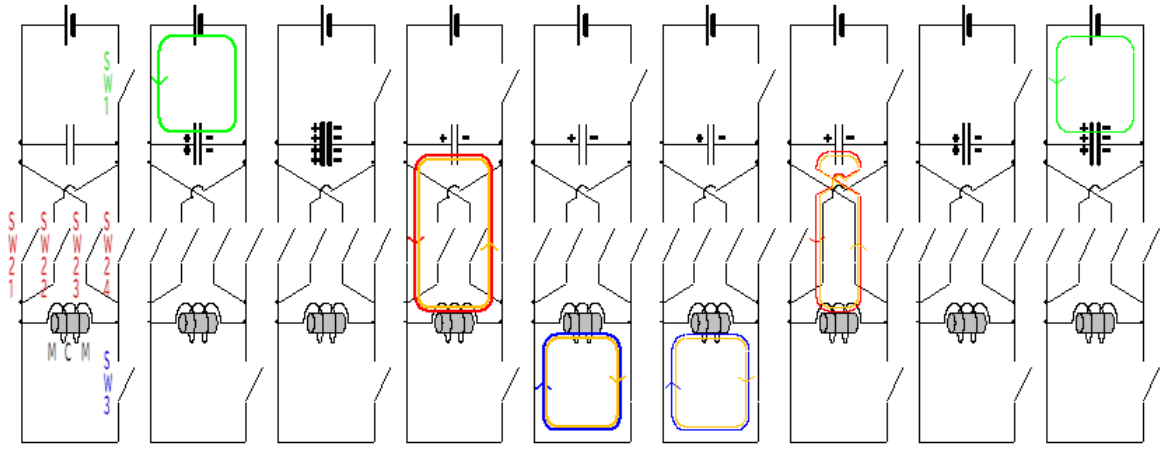

Figure 3 A Modification of Figure 1, Consequently (III) after (IX)

References

1)Y. Kim et al. Cryogenics Vol. 57, pp113-21, 2013

2)K. Waki et al. Cryogenics Vol. 149, 104108, 2025

Keywaords: Magnetic Refrigeration, Static Superconducting Coil, Resonance, Switch