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# Development of active filter with MOS-FET for 15 MW dc power source

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**Abstract**. A MOS-FET dropper was developed in place of a transformer coupled regulator in the active filter system of the 15 MW DC power supply to reduce the fluctuation to be lower than 10ppm at the Tsukuba Magnet Laboratory, National Institute for Materials Science.

## 1. Introduction

The hybrid magnet at the Tsukuba Magnet Laboratory (TML) producing up to 37.9T consisting of a 15 T superconducting magnet and a resistive magnet energized by 15 MW power source has been mainly used for the evaluation of critical current in superconducting materials and for magnetization measurements since 1996. On the other hand, a solid-state NMR spectrometer was developed with the world highest NMR magnet (21.9 T, 930 MHz) of those days [1], and various kinds of materials have been measured to study the local structure, J-cofupling between the nuclei spins, etc in the last few years, e.c. chemically nonequivalent sites in mesoporous BCN was clearly revealed for the first time [2]. Since the sensitivity and resolution on NMR increases super-linearly with increasing magnetic field, which is pronounced in the quadrupole nuclei, solid-state NMR measurements were tried to use with the TML hybrid magnet system and it became clear that the reduction of the ripple in the power source of 15 MW for the resistive magnet is essential for precise NMR experiments [3]. In the previous system, the fluctuation of the current is about 100 ppm in RMS at the good condition. Then one of the authors (GK) decided to improve the quality of TML 15 MW power source by rewiring with water-cooled interconnection and by introducing a transistor dropper for the active filter part instead of the transformer coupled regulator which had been used since 1994.

## 2. Design of power supply

The schematic diagram of the power supply is indicated in Fig. 1. The output from two 10 MVA transformers (6.6 kV/400V) of Y-Δ and Δ-Δ configurations are rectified by SCR and added in an interphase reactor (IPR) resulting in a 12 phase converter. The output of IPR is connected to a passive filter of inductance capacitance network consisting of a 0.13 F capacitor in parallel with a series connection of a 1F capacitor and a 5 mΩ resistance. The residual main ac component is composition of a fundamental frequency of AC line 50Hz and a 12th harmonic of 600 Hz. For the current regulation, we chose MOS-FET instead of transistors [4] in order to reduce the energy loss at the passive filter part. The MOS-FET bank operates between 1 and 20 volt in control region, and in which whole current flows. The output voltage at the passive filter is controlled to keep the average voltage drop at the passive filter at approximately 8V which is only 2V higher than the voltage drop in the pervious transformer regulator at TML.

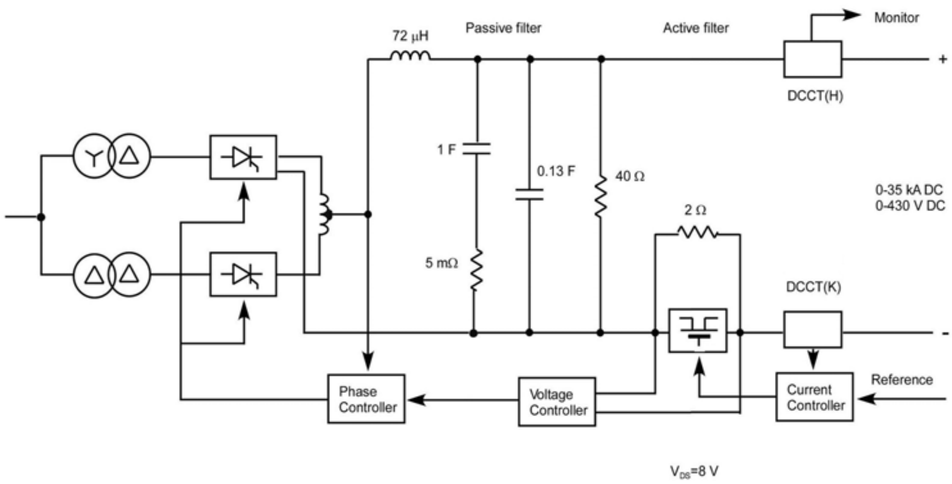


Figure 1. Circuit diagram of 15 MW power supply stabilized with MOS-FET.

Our MOS-FET bank consists of 120 modules connected in parallel, and the module consists of 20 parallel 300 V, 86 A, 600 W MOS-FETs as indicated in Fig. 2. Each FET has source resistance to equalize current sharing, and each module has feed back circuit to equalize electric characteristic of every module. One module is designed to control average current of 300 A between 1 and 20 V and assuming the mean power consumption up to 3 kW. A Zener diode is built in to cramp the voltage at 25 V. A 20 bit digital to analog converter is used for generating the current reference voltage, and a 40kA DCCT (Kudo) with Hall-effect sensor is taken in the current feedback control. The fundamental ripple component in current is taken out from the voltage across the load and used for the fine regulation the current. The output current is monitored by two methods of DCCTs (Hitec) and a 50 μΩ resistance (Sumitomo).

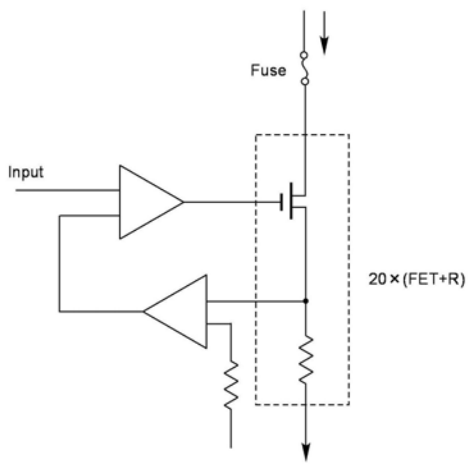


Figure 2. Diagram of active filter module.

## 3. Assemble and Tests

All of the electric parts such as transformer, interphase reactor, active filter DCCT etc. were remodeled to insulate from earth potential through floor or water cooling line and one point earthed in order to reduce the effect of AC line and SCR rectifier, and a water cooled buss bar system was introduced for the interconnection of these parts. The inner connections in passive filter were also rewired to minimize the stray inductance.

To test the new system, an AC component of magnetic field was measured by an induction method with a pick up coil placed in the center of a magnet. A multi-Bitter type of magnet whose inductance and resistance are approximately 12 mH and 10 mΩ were used for the field generation. Figure 3 shows the AC ripple in the 25 T field without the fine regulation. It is seen that the main ripple frequencies are 50 Hz and 600 Hz and fluctuation is about $2\times10^{-4}$ T (2 Gauss) in RMS, which means that the ripple and noise components are suppressed less than 10 ppm in RMS at 25 T. After the final adjustments of fine regulation circuit, the precision better than 3ppm will be achieved before the end of 2006.

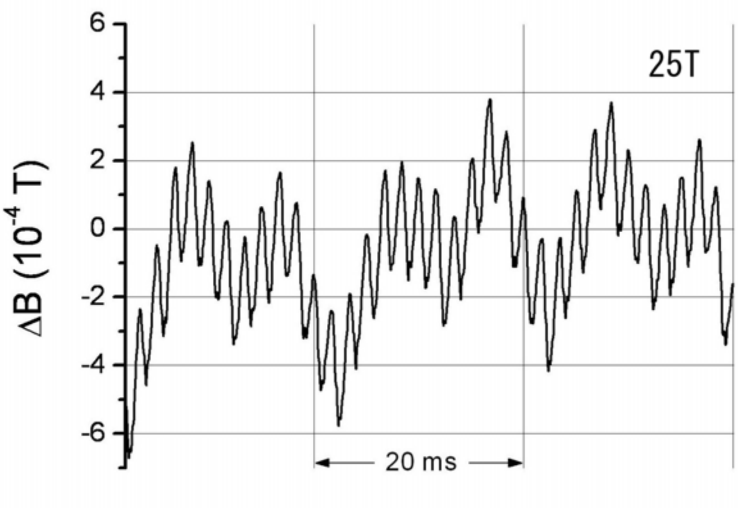


Figure 3. AC component of magnetic field at 25 T in a restive magnet without the fine regulation. The ripple level is less than 10 ppm in RMS.

## 4. Conclusion

We developed an active filter using MOS-FET and remodeled the TML 15 MW power supply. Highly stable magnetic field with low noise and low ripple of less than 10 ppm in RMS has been achieved at 25 T.

## References


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