I. Introduction

High-stability flat-top pulsed magnetic field (HFPFM) is a special kind of long pulse magnetic field which is integrated with the advantages of steady high magnetic field and pulsed high magnetic field [1]. The flat-top of HFPFM has the features of high field and low ripple, and has a long duration of flat-top, so the HFPFM is widely used in the scientific experiment to provide the environment for observing the characteristics of materials under magnetic field [2], [3].

II. Magnetic Field System Based on Active Ripple Compensator

The overall topology of the system is shown in Fig.1 and consists of two major parts: 50 T dual-coil magnet system and active ripple compensator. At the WHMFC, a 50 T dual-coil magnet is energized by a 100 MVA generator-rectifier power supply [4]. The 50 T magnet has two coaxially coils and the mutual inductance is 4 mH. The inductance of outer coil and inner coil are 48.5 mH and 5.1 mH, respectively [4].

Active ripple compensator consisting of discharge circuit, control system, touch screen (type MT8050H, made by Weintek) and compensation coil is shown in Fig. 2.

Fig. 1. Topology of the magnetic field system. Fig. 2. Active ripple compensator.

B. Mutual Inductance Coupling

The change of 50 T dual-coil magnet current will cause high induced voltage \( U_{ij} \) on compensation coil which brings difficulties to the control of flat-top. A smoothing inductor \( L_s \) is proposed to eliminate the current coupling and limit the change rate of current in a reasonable range. Fig. 4 shows the voltage of smoothing inductor \( L_s \) and mutual inductive voltage \( U_{ij} \). Because of the large inductance of smoothing inductor \( L_s \), the mutual inductive voltage \( U_{ij} \) is almost equal the voltage of \( L_s \) during the flat-top process.

During the flat-top process, TRIAC \( T \) is in conduction state and \( U_{ij} \) is smaller but still larger than the voltage of \(-C_{av}\). The circuit equation of active ripple compensator is

\[
U_{ij} = L_s \left( \frac{di_j}{dt} + R_i L_s \right) + R_i L_s \left( \frac{di_j}{dt} + R_i L_s \right)
\]

IV. Control System

A. Control System of Generator-rectifier

The generator-rectifier control system has been built and designed at the WHMFC [5]. The outer coil of 50 T dual-coil magnet is powered by 12-pulses rectifier \( R_E \) and the inner coil is powered by 12-pulses rectifier \( R_E \). The coil current is changed by adjusting the trigger angle of rectifiers.

B. Control System of Active Ripple Compensator

The control system of active ripple compensator is designed and built based on FPGA (type EP3C55F484). The coil current is regulated by controlling the turn-on and turn-off of the four MOSFETs.

V. Simulation Results

An integrated model of the magnetic field system is built on MATLAB/Simulink. The models of magnets include the self-inductance, the mutual inductance and the increase of resistance due to the Joule heat. The model of MOSFET include the drain-to-source on-resistance, input capacitance, turn-on delay time, rise time, turn-off delay time, fall time and diode forward voltage.

The output current of full-bridge is shown in Fig. 6. The consumed energy of \( C_{av} \) during discharge process is only about 2 J. As shown in Fig. 7, when the active ripple compensator starts to work, the ripple is quickly suppressed. The red line shows the flat-top accuracy of resultant magnetic field is less than 100 ppm.

VI. CONCLUSION

With the application of active ripple compensator, the ripple of 50 T magnet system is reduced from 1500 ppm to 60 ppm. The experiment platform is under construction and the system is scheduled to be completed in the autumn of 2018. A more effective control strategy for the active ripple compensator is under study. The application of the active ripple compensator for other flat-top magnetic field system, such as the 41 T flat-top magnetic system at the WHMFC, is also under study.