New three-structure repetitive pulse magnetic field power supply system

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A new topology has been proposed to realize the required current waveform. A low energy feedback full bridge structure was designed to extract the residual magnet energy to recharge the capacitor instead of being dissipated as heat. Use the battery to approximately compensate the voltage drop of the current resistance. A serial inductor L₁ and a high frequency voltage adjusting structure was added to achieve the flat-top current.

In Fig. 2, the C₂ is used to quickly charge the magnet. The magnet, illustrated as inductor L₁ and resistor R₂ connected in series, has an increasing resistance because of the quickly rising temperature. The battery in Structure 2 along with the structure 3 is used to provide a flat-top duration, which is a high frequency current injecting structure with an isolated transformer. The topology has several merits as follows:

1. Feed back the magnet energy, decrease the recharging power and reduce the heat of the magnet;
2. Maintaining the magnetic field with lower voltage and reducing the flat-top magnet field ripple by high frequency smaller current;
3. Simple and reliable electric isolation between different voltage grades of main circuit and flat-top turning structure.

The repetitive flat-top (RTPHF) as a special field has been considered in some scientific researches such as neutron diffraction, NMR and so on.

In order to have an RTPHF waveform, several characteristics are in need: can build-up the magnetic field rapidly; have a high stability flat-top; can demagnetize the field steadily; and have a short intervals time between the repetitive magnetic field pulses.

Hence the required waveform would have the corresponding stages: the current rising stage, the flat-top stage, the current fall stage, and the cooling stage.

Step 1: Determine the battery voltage U₁ and the resistance R₁ of the serial inductor; Choose U₁ that can provide the average non-changed part of the voltage of the magnet needs. Choose R₁ to help the actual battery voltage U₂ match the flat-top current.

Step 2: Determine the transformer (L₀ and ratio): Use the possible biggest L₀ to decrease the H-bridge operating current. Choose the ratio slightly bigger than the discharging voltage: structure 3 Withstand Voltage

Step 3: Determine the inductors L₁, L₂, and M: Choose the proper L₁ that can satisfy the limits of the Discharging Voltage, the Rising Time, and the range of the duty ratio.

Step 4: Determine the DC bus voltage of structure 3: Choose the voltage slightly bigger than the subdivision voltage of U₁ to prevent inrush current.

Step 5: Determine the L₁: Choose the proper L₁ with the limit of H-bridge operating current (with certain duty ratio).

Step 6: Choose the C₁ and U₁: Determine the C₁ to satisfy the limits of discharging voltage and the max rising time. Determine the U₁ to ensure the flat-top current was the setting value.

### III Designing Procedure

The topology starts to operate in charging mode. The magnet is charged by C₁ and the magnetic field is built quickly.

### IV Experiment & Conclusion

In rising stage, the C₁ of the structure 1 discharge the magnet, providing a steep rising stage. The magnet current boosts to 30A in 1.5ms. In flat-top stage, the battery of the structure 2 provide a steady current for 4ms and the structure 3 operate to provide the magnet the shortage of the voltage. In feedback stage the current falls rapidly and feeds back to the capacitor. In cooling stage the outer circuit charges the C₁, C₂ to the setting voltage before next pulse.

### Conclusion

In this paper, a new three-structure topology has been proposed to generate RTPHF. All of the three structure can work properly at their stage to generate high discharging current, to stabilize the flat-top, and to realize the energy feedback. The experiment result shows this topology is feasible.