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Fabrication of power supply with IEGT for TFC of a small fusion device
IEGTを用いた小型核融合装置のTFC電源の製作

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Our laboratory are making a small fusion tokamak device. This devise need stable toroidal magnetic field for stady of controll disruption. I achieve stable field using capacitor bank and IEGT. In this session, the ways and means to this power supply and the result of power sistribution.

1. Introduction

Our laboratory are making a small fusion tokamak device. This devise need stable toroidal magnetic field for stady of controll disruption.

Many somall fusion device have problem for flat-top current. Especially, our device is desirable to generate flat-top current of toroidal magnetic field coil to confine nearly steady state plasma.

2. Method

The purpose of this study achieves flattop current with longer than existing capacitor discharge by using IEGT which is switching device of high-power.

IEGT developed by TOSHIBA stands for Injection Enhanced Gate Transistor. IEGT has higher operation voltage and current than IGBT and higher switching frequency than GTO. Chart 1 is performance of ST1500GXH21 that is we using IEGT.

Chart 1 performance of ST1500GXH21

V_{CES}	4500V
I_{CP}	3000A
V_{GES}	±20V
V_{GE}(off)	Min:3.7V,Max:5.7V
V_{CE}(sat)	5.0V
C_{ies}	200nF
t_{ON}	1.3μs
t_{OFF}	11.5μs

Fig 1 is circuit figure. The circuit is added in IEGT with existing method of discharge of capacitor, and added in reflux diode in parallel with TFC.

In the state ON of IEGT, the capacitor is discharge through the IEGT, and current is flowing the TFC. On the other hand, in the state of OFF of IEGT, inductance of TFC drives the current through a diode. In the state ON of IEGT, the current follows eq1.In the state OFF, the current follows eq2. i means a current of TFC. V_C means capacitor voltage. L is inductance of TFC. R is resistance of TFC. I_0 is initial value of current of TFC. This circuit makes flat-top current repeating two states.

The timing of IEGT turn ON/OFF is calculated in advance on PC, after that calculated timing is programmed to a micro controller. The micro controller control IEGT.

We can control the current of TFC by feed back with monitoring the current of TFC. But I adopt programming in advance because this is simpler control than feed back.

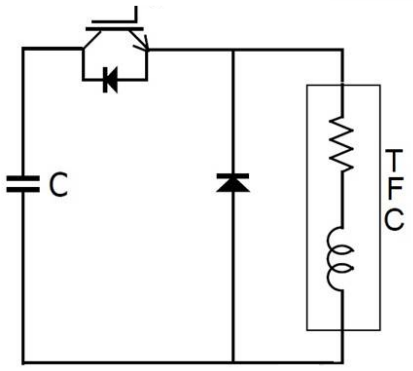

Fig1 circuit of power supply

$$i = \frac{V_c}{L\omega_d} e^{-\alpha t} sin\omega_d t \qquad (1)$$

$$\begin{cases} \alpha = \frac{R}{2L} \\ \omega_d = \sqrt{\frac{1}{LC} - (\frac{R}{2L})^2} \end{cases}$$

$$i = I_0 e^{-\frac{t}{\tau}}, \tau = \frac{L}{R} \qquad (2)$$

Fig2 Photo IEGT

3. Computer simulation

We simulated by PC this circuit with parameter of a capacitor capacity, a resistance and inductance of TFC that is planned to make. These parameters are chart2, and the result of simulation is fig 3.

Chart2 parameter of simulation

C	4mF
V_C	4000V
R_{TFC}	1.1orm
L_{TFC}	42.7mH

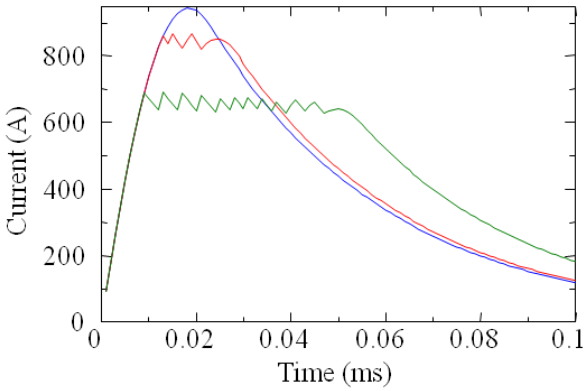

Fig3 Result of simulation

Blue curve is usually capacitor discharge. Red curve is large current and short flat-top. Green is small current and long flat-top. This circuit makes longer flat-top than usually capacitor discharge. In addition, changing timing of IEGT ON/OFF make difference flat-top current.

4. Test circuit

In the poster, we'll show the result of power supply with IEGT. Before that, we check up planned system with test circuit. Test circuit is using IGBT instead of IEGT, and capacitor voltage is 20V.

Fig4 is result of test circuit. Red curve is current of experiment. Blue curve is current of numerical simulation. You can see that both waveforms are similar. This shows that the way is enough to control.

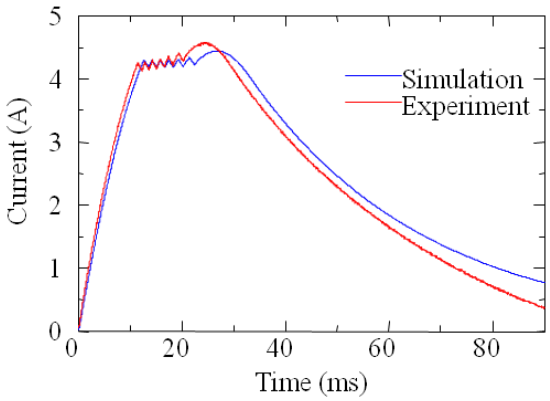

Fig4 Result of test circuit

5. Features of this power supply

We wrote in computer simulation, this system is possible changing flat-top time with changing timing of IEGT ON/OFF. This feature make a various operate patterns.

And this system can apply to many coils to calculate timing following these equations. But this can't apply with a small inductance of coils. Because of current down and up quickly.

References

[1] TOSIBA Revew Vol.63 No.11 (2008)