§19. Conceptual Design of dc Power Supply for FFHR Superconducting Coils

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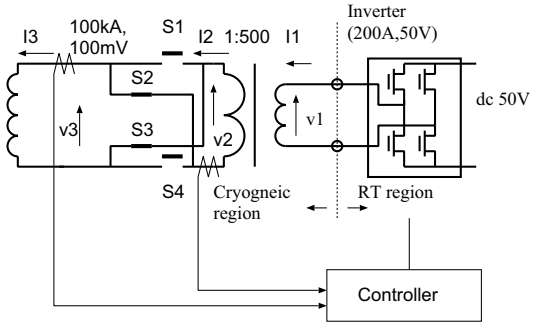
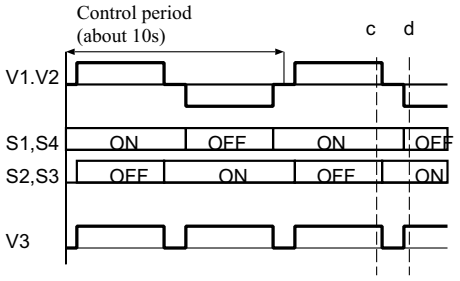
The FFHR uses a large scale super conducting coils which operating current is around 100kA. To excite these coils in steady state operation, a low voltage but large current dc power supply is necessary. A rectifier using mechanical conductor was designed for this purpose. The circuit diagram is shown in Figure 1. As shown in the figure, the frequency converter generate very low frequency rectangular wave and it is step down with a superconducting transformer and converted to dc current using a rectifier.

This configuration has following merit, the power converter works in low current then the loss in the converter becomes lower, the current through the current lead is also low then the small current lead is enough. The operation frequency of the rectifier is much lower than the usual rectifier. In this case the size of the transformer may become the bottle neck. When we assume the second voltage $v2$ is 0.1 V and the turn number $N2$ is 1, the the required magnetic flux $\Psi = V2T/N2$ becomes 0.5 Wb. If the maximum magnetic flux density B_{max} is $\pm$ 1.0 T then the cross section of the core becomes 0.25 m^2 and the core size becomes approximately 0.5 m * 1.2 m *1.2 m. When we select turn-numbers of secondary winding as 4, then the core size and volume becomes half and 1/8 of the above values. This size is not too large and reasonable as a component of the power supply.



(a) Configuration of the power supply



(b) Commutating operation for ZVZC switching

Fig. 1: Extra low voltage and high current power supply.

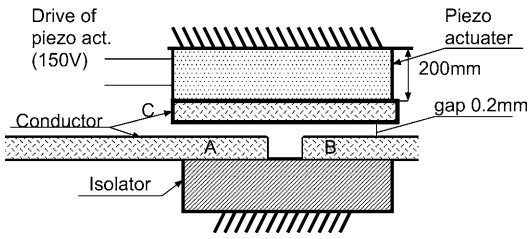


Fig. 2: Mechanical switchgear using piezoelectric device.

Table I: Specification of the extra low voltage DC power supply

Output	0.1V, 100 kA
Inductance of Load	25 H
Driving inverter	
Voltage	50V
current	200A
capacity	10 kVA
Transformer	
Primary?@winding	200A, 500 turns
Secondary winding	100 kA 1 turn
Core cross section	0.25 m^2
Size	0.5 m * 1.2 m * 1.2 m
Weight	5t?@
Switching device	mechanical contact
Driver	,piezoelectric (150 V)

The load of this power supply has large inductance and the over lapped switching is necessary to keep the current path. With this sequence, the switching are performed under zero voltage and zero current (ZVZC), and the damage of the conductor can be small enough.

The switching device is also one of key components of the power supply. For this power supply, the mechanical contact is selected as a switching device. Because the secondary voltage is very low such as 0.1 V, the narrow gap between conductors such as 0.2 mm, is allowable. To drive the conductor, piezoelectric device is suitable because the required stroke is very small, its quick response, it can generate high pressure, and low driving current as shown in Fig. 2. The stroke of the piezoelectric device is about 0.1 % of its length so the 200 mm length piezoelectric device is enough to drive the conductor. In the small current applications, similar conductor is utilized as Lead Switch. The lead switch has large life cycles such as 10^7 or 10^8 when they operated under the ZVZC situation. These operating cycles are equivalent to 3 or 30 years when the switching period is 10 seconds, and is enough long to use in the power supply.

The specification of presented power supply is shown in Table I.