

§29. Design of a 1.5kA Transformer-type Persistent Current Switch

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On the basis of satisfactory results in experiments of a 100A transformer-type persistent current switch (PCS) in the last year, a 1.5kA transformer-type PCS has been designed. This PCS has a structure of a current transformer [1] with two secondary coils T_2 , T_3 and four tertiary coils B_1 , B_2 , B_3 , B_4 in the secondary circuit as shown in Fig.1. The former coils are inversely wound so as to suppress magnetic saturation of a Si-steel core due to direct currents flowing through an energy storage coil, the latter coils are wound non-inductively and located out of the Si-steel core of the transformer.

Especially B_3 and B_4 coils function as a load for alternating currents of a transformer. To shorten switch-on time and enhance stability, the vertical and horizontal cooling channels are set every turn and layer in all the winding coils .

The switch-off time delay in this type of a PCS should, in principle, be shorter than a quarter period of frequency of control current in the primary coil. Superconducting ac wires with

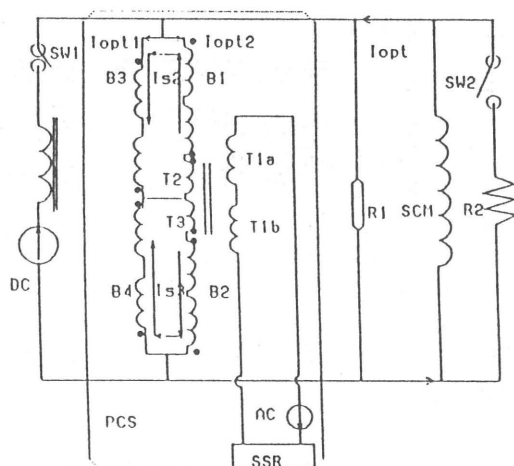


Fig. 1. Conceptual circuit of a 1.5kA transformer-type PCS.

copper matrix were chosen for the primary coil, in view of stable excitation as a trigger, and superconducting ac cables without copper matrix were chosen for the secondary and tertiary coils because high resistance is required in the switch-off mode. The total losses of this PCS are roughly given by the sum of superconductor loss estimated to be 6.7w, core loss calculated to be 39.4w and Joule heat during switch-off mode estimated to be 34.7w. Although these heats are seemed to be large, those result in very small value except for the latter because quench of the secondary circuit takes place in a very short time.

The main parameters of this PCS are listed in Table 1.

In conclusion, by adding bifilar winding coils to the secondary circuit, the transformer-type 1.5kA PCS with the switch-off time shorter than 100ms, the switch-off resistance larger than 100Ω and the size smaller than $\phi 300\text{mm} \times h500\text{mm}$ has been designed.

Table 1. Main parameters of a 1.5kA transformer-type PCS.

Maximum current capacity	3.3 kA
Operational current	1.5 kA
Normal resistance	>100 Ω
Response time	<100 ms
Working margin	46 %
Transformer-shape	shell-type
capacity	84.87 kVA
turn ratio	10
leakage impedance	0.048 Ω
percent impedance	1.13 %
leakage magnetic field	0.39 Tesla
Coil shape	thin wall solenoid
height	1.92 cm
thickness	1 mm, 1.3 mm
gap	2 mm
Primary coil : voltage	600 V
maximum current	200 A
number of turns	300
cooling channel	2 mm \times 4 mm (H), 3.2 mm \times 0.65 mm (V)
Secondary coils : voltage	60 V
number of turns	30
cooling channel	2 mm \times 4 mm (H), 6.3 mm \times 0.65 mm (V)
core area	72.34 cm ²
Bifilar winding coils : voltage	0
number of turns	4 \times 1080
normal state resistivity	0.4 Ω /m
cooling channel	1 mm \times 4 mm (H), 1 mm \times 0.35 mm (V)

H : Horizontal, V : Vertical

References

- 1) Takeo, M., Sato, S., Funaki, K., Kuroda, K., Cryogenics 32 (1992) ICEC Supplement 459.