DESIGN CONSIDERATIONS ON THE ACTIVE FILTER FOR THE BENDING MAGNET POWER SUPPLY OF TRISTAN ACCUMULATION RING

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The bending magnet power supply of TRISTAN accumulation ring is 24 pulse SCR rectifier. This power supply theoretically has a fundamental ripple conponent at 1200 Hz. However, due to the three phase unbalance of the power line and the fluctuation of the firing angle of the SCR rectifier, lower frequency ripples are produced. Assuming that the three phase unbalance is 3% and that the fluctuation of the firing angle is 1°, typical voltage ripples can be calculated and are shown in Table 1. The powers of the ripples after passing through the passive filter are also given. Though the higher frequency ripple conponents can be reduced considerably with the passive filter, the lower ones, especially 50 and 100 Hz, can not.

To attenuate the lower frequency ripples, the active filter is used as shown in Fig. 1. The voltage ripple detected by the ripple detecter is amplified and then applied to the primary winding of the reactor transformer (R.T.) whose secondary winding is connected to the bending magnet bus. So as to cancel the ripples on the magnet, the output voltage has inversed phase to the ripples. Then following relations are obtained,

Output power of the amplifier[1)] $$P = (1+M)\, P_\ell = (1+M)\, L_\ell\, \omega\, I_\ell^2,$$

Primary voltage across the R.T. $$V_p = -a\, L_\ell\, \omega\, I_\ell,$$

Primary current on the R.T. $$I_p = -\frac{1}{a}(1+M)\, I_\ell$$

and

Cross section of the core of the R.T. $$S = \frac{L_\ell}{M}\cdot\frac{1}{N_s^2}\cdot\left(\frac{\ell}{\mu} + \frac{\delta}{\mu_0}\right),$$

where

$$M = \frac{\text{Total inductance of the magnet}}{\text{Secondary inductance of the R.T.}} = \frac{L_\ell}{L_s}$$

and

$$a = \frac{\text{Number of the primary turns of the R.T.}}{\text{Number of the secondary turns of the R.T.}} = \frac{N_p}{N_s}.$$

I_ℓ is the ripple current on the R.T.. P_ℓ and ω are the power and the frequency of the ripple, respectively. ℓ is the average length of the core and δ is the gap of the core which is determined so that the iron of the core does not saturate. μ and μ_0 are magnetic permeabilities in the core and vaccum, repectively. N_s is limited to several turns, since the secondary winding of the R.T. must have the large current capacity. Therefore the basic parameters of the active filter is determined mainly by M and a. M is settled by optimizing the power of the amplifier P and the cross section of the core S. Once M is determined, a is adjusted so that V_p and I_p do not exceed the maximum operating range of the amplifier.

According to Table 1, total ripple power is 1.99 W. Fig. 2 shows the P's and S's as the function of M's, assuming that $N_s = 3$, $\ell = 1.2$ m, $\delta = 10.1$ mm and $\mu = 0.0063$ H/m. From this figure, M is determined to 2000. If we select a to 4, following parameters are finally obtained, $N_s = 3$, $N_p = 12$, $S = 0.48\ m^2$, $\delta = 10.1$ mm, $L_s = 525\ \mu H$, $L_p = 8.4$ mH and $P = 3.98$ kW.

Reference

1) H.Baba et. al.,IEEE Trans. Nucl. Sci. NS-28,June,1981,3068

Frequency of of the ripple	Voltage ripple	Attenuation by the passive filter	Power of the ripple
50 Hz	2.9×10^{-3}	- 6 dB	1.110 W
100	1.5×10^{-2}	-15	0.855
150	5.8×10^{-3}	-22	0.016
200	6.8×10^{-3}	-26	0.005
250	5.8×10^{-3}	-30	0.002
300	5.8×10^{-3}	-33	0.002

Table 1. Uncharacteristic ripples

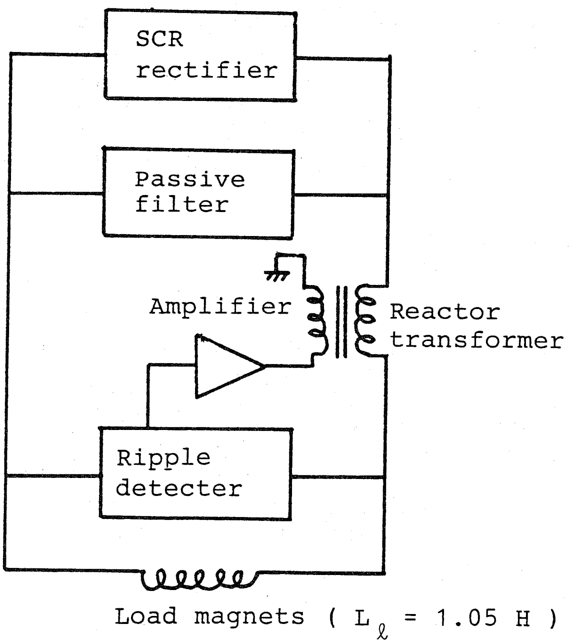

Fig. 1. Schematic diagram of the active filter

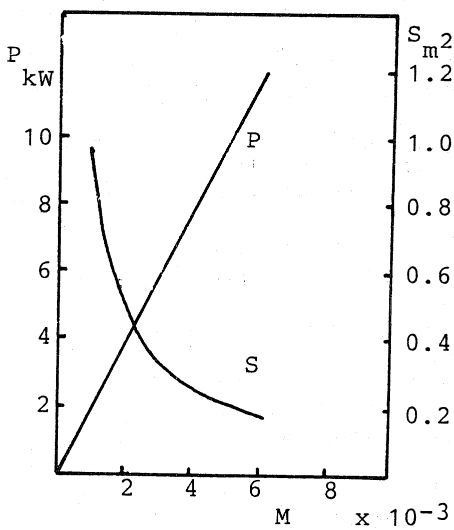

Fig. 2. M dependence of P (the powe of the amplifier) and S (the cross section of the iron core)