BI-RESONANT CIRCUIT FOR EXCITATION OF SYNCHROTRON MAGNET

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1. Introduction

The rapid cycling synchrotron with an energy range from several hundreds MeV to 1 GeV is a fascinating tool as a very intense pulsed neutron and meson source. At KEK the design studies of a high intensity proton synchrotron, GEMINI[1)], is in progress. Construction of the model of bi-resonant circuit is one of the outcomes of these design studies.

The repetition frequency of GEMINI is 50 Hz and the intensity is several times 10^{13} protons per pulse with a maximum energy of 800 MeV. The beam power is 400 kW, the RF frequency range is 1.51 to 2.98 MHz, and the required RF voltage is around 250 kV. In order to reduce such a large RF power, we investigate the possibility of adopting bi-resonant circuit as the exciting device for the magnet system, which produces a resonant frequency of 33 Hz during acceleration and 100 Hz in the reset period of the magnet. This circuit was originally proposed by M. Foss and W. Praeg[2)], and ours is an improved modification of their circuit. In the original circuit, the resonant frequency is switched with thyristors by adding or separating a part of the resonant capacitors, whereas in our circuit thyristors are replaced by GTO (Gate Turn Off) thyristors which are capable of self-turing off. This would eliminate turn off circuit and substantially simplify the original circuit. In the following we will describe how the circuit works.

2. Circuit description

Figure 1 illustrates the block diagram of the resonant circuit and Fig. 2 shows the waveforms of the circuit. The reference of time ($t = t_0$) is taken at the end of the acceleration where the magnet current starts to reset. Capacitor C_1 and magnet inductance L constitutes a 100 Hz resonant circuit ($t_0<t<t_2$), and C_1, C_2 and L constitute 33 Hz ($t_2<t<t_3$) circuit.

At $t = t_0$ --- The magnet current is at its peak and the voltage on capacitors C_1 and C_2 are zero.

At $t_0<t\leqq t_1$ --- The capacitor C_1 is charged and reaches peak voltage at $t = t_1$.

At $t_1\leqq t\leqq t_2$ --- The capacitor C_1 is discharged through the inductance L waiting for the GTO to be switched on.

At $t_2<t<t_3$ --- The GTO is turned on at $t = t_2$ when the capacitor C_1 current is at its peak. The capacitors C_1 and C_2 are now charged in the opposite direction.

At $t = t_3$ --- The capacitor voltage on C_1 and C_2 have their maximum in the accleration regime. The GTO1 is spontaneously turned off at $t = t_3$.

At $t_3<t<t_4$ --- The GTO2 is now turned on at $t = t_3$ to maintain 33 Hz oscillation. The capaciors C_1 and C_2 are charged. Their current is

at its peak at $t = t_4$. The GTO2 is turned off at this moment, and the circuit comes back to the initial state.

3. Model magnet

The parameters of the model circuit are, L = 10 mH, C_1 = 0.25 mF, C_2 = 2.56 mF, $\hat{i}_1$ = 22 A, $\hat{i}_2$ = 90 A, where $\hat{i}_1$ and $\hat{i}_2$ are maximum current through the capacitors C_1 and C_2. Details of other parameters will be presented in the talk.

We have presented the principle of the bi-resonant circuit, of which model is now under construction. Although the purpose of this work is to confirm the behaviour using the GTO thyristors of the bi-resonant circuit, many details remain to be clarified in the application of the full scale circuit for GEMINI. These are now under investigation.

References

1) H. Sasaki, et al., "Very Intense Proton Synchrotron GEMINI" (in Japanese), KEK Internal 82-6 (1982) 71, "Proton Synchrotron for Intense Neutron and Meson Beam", (Proceedings of this conference).

2) M. Foss and W. Praeg, "Shaped Excitation Current for Synchrotron Magnets", Proceedings of IEEE Transactions on Nuclear Science, NS-28 (1981) 2856.

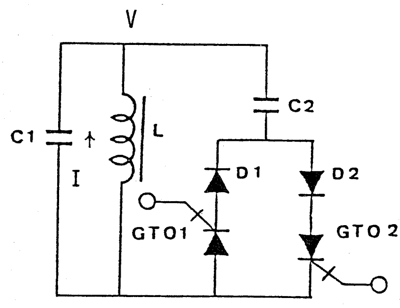

Fig. 1 Block diagram of bi-resonant circuit

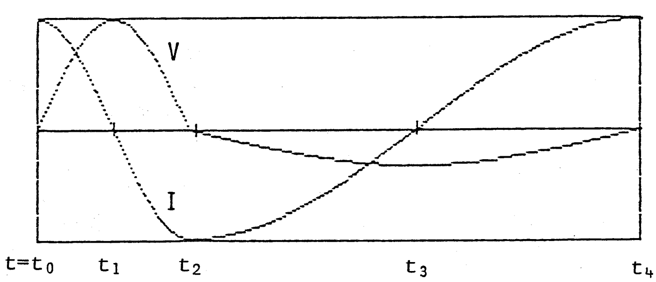

Fig. 2 Waveform of the bi-resonant circuit