EXPERIMENT OF FAST-ELECTRON EXTRACTION SYSTEM

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Summary

The fast rising magnet system has been tested. The C-type magnet, consists of ferrite-core, has 15mm gap height and 30mm dipole width and is 600 mm long. The current, about 1 kA, was supplied by P.F.N (V_0=80~100 kV, Z =37.5Ω). The magnetic field produced by this current was found to be 0.9 kG. By using this magnet an 1-GeV electron beam, for example, could be deflected by 16 mrad. The typical currnt-rise-time, measured by current transformer, was found to be 30nsec. Fluctuation of magnetic field during the flat top of the current was also found to be less than 2%.

Introduction

When an electron-strage ring with a booster synchrotron for a X-ray lithography is designed, these rings are desired to be as small as possible. Then the electron extraction system, especially for the case of one-turn ejection using a kicker magnet , becomes one of the most important problem. The magnet must satisfy the following conditions.

1) a rapid rise time of magnetic field
2) a large deflection angle
3) a small size.

As for the rise time of field, a lump kicker magnet is slower than a traveling kicker magnet[1], but is considered to be smaller. And here a lump magnet to deflect an 1-Gev electron for 15 mrad was considered and tested and the results are presented in the following section.

Magnet Design

A C-type magnet of ferrite core, and the P.F.N of coaxial cable was used for kicker magnet and pulse generator. The characteristics of the magnet and the P.F.N. were listed below.

Magnet

gap height (h)	10-15 mm
dipole width (a)	30 mm
magnet length (l)	600 mm
inductance (L_K)	1.5 μH

$L_K=\mu_0*a*l/h$
h=15 mm is used

P.F.N

impedance (Z_0)	37.5 Ω
voltage (V_0)	80-100kV

A cross-section of the magnet is shown in Fig. 1. The magnet consisted of three type of ferrite blocks in a stainless holder and was electrically connected to the pulse transmission line, out of the vacuum, by a power feeder of coaxial bellows. The magnet was mounted on a slide table in the vacuum vessel and can be moved in holizontal direction by stepping motor out of the vessel.

When an usual pulsing system is considered, includes a P.F.N., a switch, a transmition line, a terminated resister and a kicker magnet , the kicker current rises above $0.95*V_0/(2*Z_0)$, only after a time of approximatelly $3*L_K/Z_0$. This time is 120 nsec in our magnet and is too slow to one-turn extraction from a small synchrotron. Though there are many methods of pulse shaping, using a ferrite-core load for example,[2] here a capacity connected in series to the kicker magnet was used. The equivalent circuit is represented

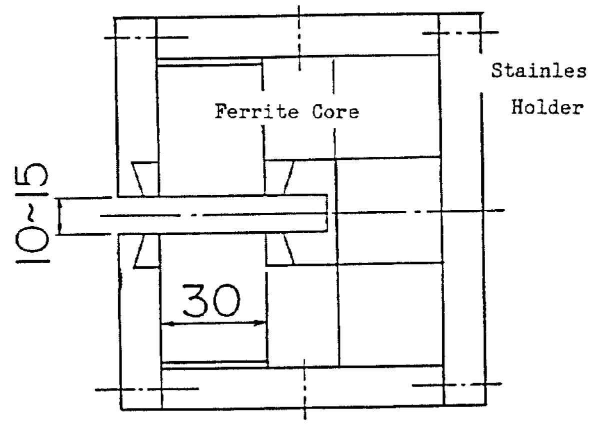

Fig.1 Cross Section of Kicker Magnet

in Fig. 2, C_f , connected parallel to the terminated resister in the figure, meams a floating capacity of the disk-type resister (37.5Ω,40mm$^\phi$,25mm^t) and L_f means a floating inductance. The equation of the magnet current (I_0) is expressed as follows

$$d^2I_0/dt^2+(Z_0/(L_K+L_f)+1/(C_fZ_0))dI_0/dt+(2+C_f/C_0)I+1/(Z_0C_0)\int I_0dt=V_0/Z_0 \quad (1)$$

(after the switch ON)

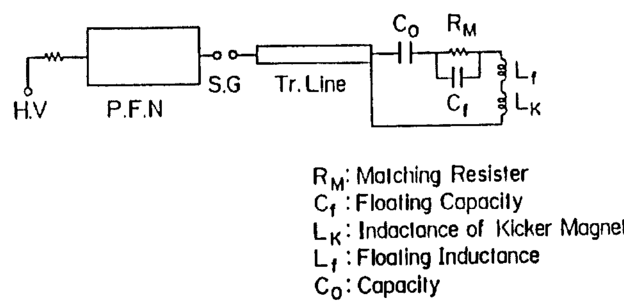

Fig.2 Equivalent Circuit of the System

Results

The magnetic field was measured by a magnetic probe, which was 10 mm square and 10 turns and was placed middle of the magnet dipole. Fig. 3 shows the effects of the serial capacity (C_0) on the magnetic field rise time, in the case of h=15 mm. Here the rise time was defined as the time, the field needs to rise above 95% of its peak value. Though the magnetic field rise time became faster as decreesing the capacitance, flatness of the magnetic field became worse. By considering the rise time and the flat top duration, the capacity of 2500 pF was thought to be the best in our case.

The waveform of magnetic field is shown in Fig. 4, in the case of C_0=2500 pF. The fluctuation of the magnetic filed is shown to be less than 2.0% and the flat top duration was found to be more than 60 nsec.

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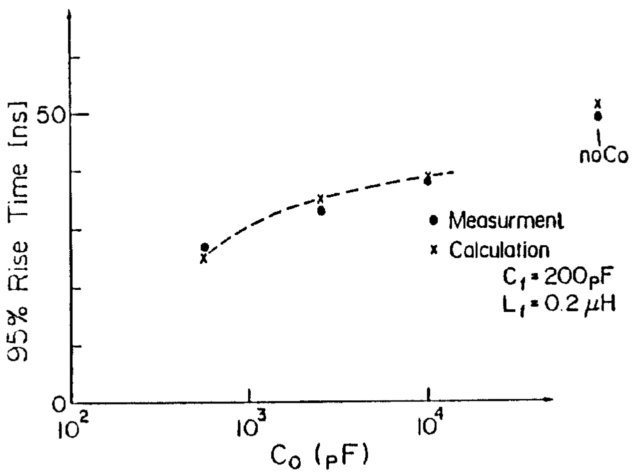

Fig.3 95% Field Rise Time v.s. C_0

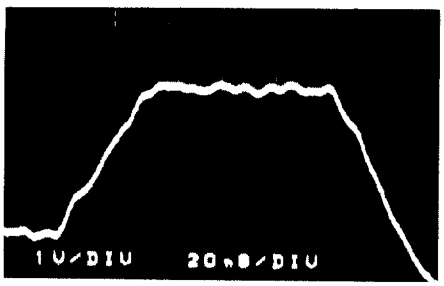

Fig.4 Magnetic Field Wave Form

The current wave form is also shown in Fig.5. The fluctuation of the wave form is thought to be a noise of switching gap. The current rise time is found to be less than 30 nsec from the photograph.

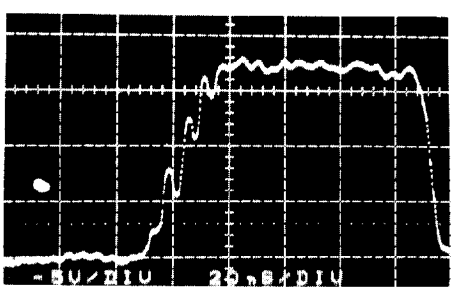

Fig.5 Current Wave Form

Fig. 6 shows the magnetic field profile in holizontal direction, in the case of h=10 mm V_0=80 kV. Though the fine profile of the magnetic field can't be measured by using the magnetic probe of large aperture (10mm□), the size of the good field region was found to be more than 10 mm and this may be enough to extract a synchrotron-damped electron.

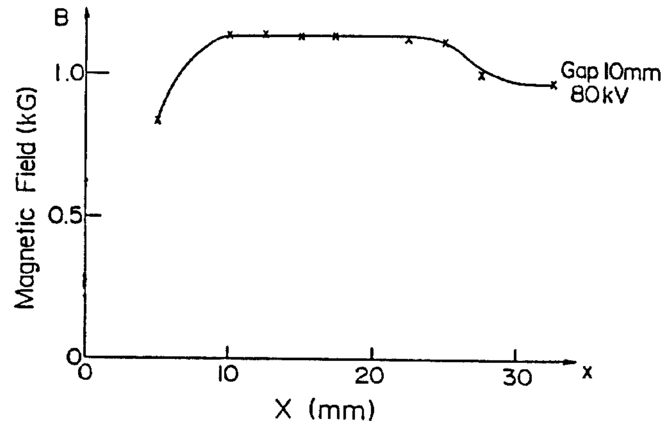

Fig.6 Holizontal Magnetic Field Profile

Conclusion

The rise time of the current and the magnetic field is substantially improved by using the capacity serial to the kicker magnet. As a result the kicker magnet, which has a 95% rise time of 33 nsec, a flat top duration with small fluctuation less than 2%, and a good field region more than 10 mm, was obtained.

Acknowledgements

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2. A. Brunger, A non-linear step pulse steepening dely line, CERN 68-25 (1968).