

# STUDY ON THE PLS INJECTION KICKER MAGNET AND MODULATOR

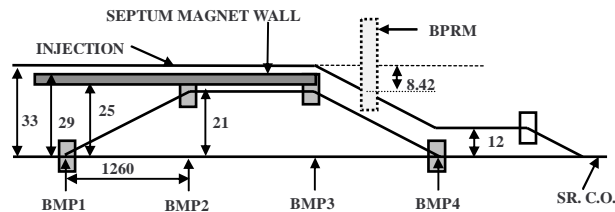
S. H. Nam, S. H. Jeong, and J. H. Suh  
 PAL/POSTECH, Pohang 790-784, Kyung-Buk, S. Korea

## Abstract

The PLS injects 2.0 GeV electron beams from Linac to storage ring (SR). After storing the current to 170 mA, the beam energy is ramped up to 2.5 GeV in the PLS SR before providing the beam to users. In the PLS SR injection section, there are four kicker magnets and one kicker modulator. Peak current for each magnet is about 12 kA for 2.0 GeV injection that corresponds to 21 mm bump. Analytical, simulation, experimental studies of the kicker magnet show good field uniformity. An usable peak current range of the kicker system is also studied for future upgrade. The kicker magnet and modulator has been operated for 35,800 hours as of August 2001 since its installation..

## 1 INTRODUCTION

The 2 GeV full energy electron beam from the linac is transported through a beam transfer line (BTL) to the storage ring. The injector linac is located under ground and the storage ring is positioned on ground. A septum magnet deflects the electron beam on the same level as the stored beam in the SR. The injected beam from the BTL into the storage ring is then placed within the storage ring beam dynamic aperture by kicker magnets. In Fig. 1, a concept of the bumped beam orbit is presented. A thin septum magnet wall separates the injected beam. Total four kicker magnets are used to disturb the normal storage ring beam orbit, to move the orbit closer to the septum magnet wall and also bring the injected beam within the storage ring beam dynamic



aperture [1].

Fig. 1. Bumped beam orbit. Units are in mm.

INJECTION: Injected beam path, SR C.O.: Storage ring center orbit, BPRM: Beam profile screen monitor (During injection, the screen is removed.), BMP1, BMP2, BMP3, BMP4: Kicker magnets (1.324 kG peak field), SEPTUM MAGNET: Indicates septum magnet wall (11 kG peak field)

## 2 KICKER MAGNET

Table 1. Specification of the kicker magnet

Parameter	Specification
Beam Energy	2.0 GeV
Bending Field (@ 8.4 kA per magnet)	0.1324 T
Max. Relative Field Deviation	0.5 %
Max. Time Jitter between Magnets	6 ns
Number of Turns per Pole	1 turn
Resistance of Magnet @40 °C	8.28 mΩ
Inductance of Magnet	0.867 μ H

Major parameters of the kicker magnet at 2 GeV SR operation are given in the table 1 [2]. Only one kicker magnet modulator is used to drive the four kicker magnets, to give balanced current for all four magnets and also have precise timing between magnet currents. Specification of the kicker magnet modulator is ~6 μs pulse width, 30 kV maximum voltage, ~24.06 kA peak current, 266 MW maximum power and 10 Hz repetition rate. It can bump 2.0 GeV electron beam to the maximum of 21 mm [1].

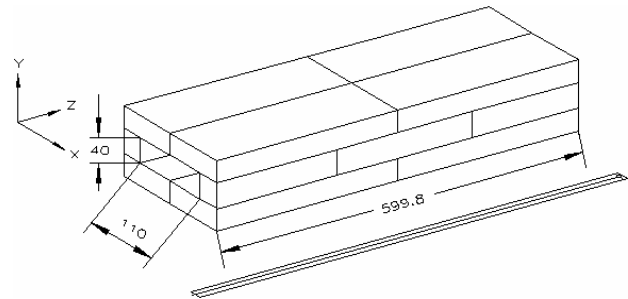


Fig. 2. Ferrite structure of kicker magnet

Table 2. Specification of MN80C ferrite core

Parameter	Specification
Initial Permeability	2400
Maximum Permeability	6000 typ.
Maximum Flux Density	4800 gauss min.
Remanent Flux Density	2000 gauss max.
Coercive Force	0.23 oersted max.
Cure Temperature @40	230 °C typ.
DC Volume Resistivity	200 Ω -cm typ.

Core material of the kicker magnet is ferrite MN80C that is provided from Ceramic Magnetics, and the structure is appeared in Fig. 2. As shown in the figure, upper and lower

cores are consisted of 4 blocks each. The size of each block is 80x30x299.9 mm. Left and right side cores are consisted of 3 blocks each, and the each block size is 30x40x299.9 mm. Main specifications of the core material are given in Table 2 [3].

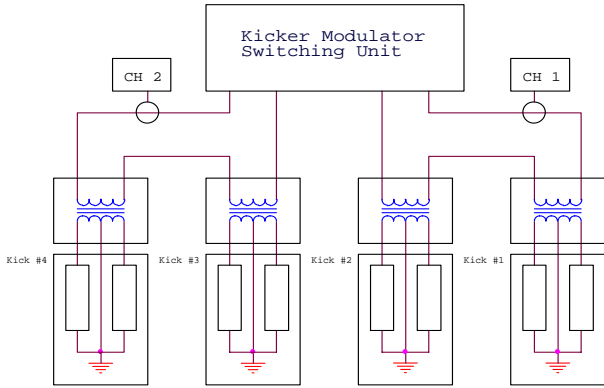


Fig. 3. Cable connection diagram of the kicker system. CH1 and CH2 indicate current transformers.

The cable connection diagram of the kicker magnets is shown in Fig. 3. Kicker magnets 1 and 2 and magnets 3 and 4 are connected in series. These two serially connected magnets are connected in parallel at the kicker modulator. The kicker magnets 1 and 2 are positioned at the up-stream side and the kicker magnets 3 and 4 are positioned at the down-stream side. There is a pulse transformer between the modulator and the magnet as shown in Fig. 3. The pulse transformer turn ratio is 1:2, and the secondary has a center tap so that equal but apposite direction current can flow for each side of the magnet conductors. Peak currents of each channel (CH1 and CH2 in Fig. 3) are in greater than 95 % balance.

### 3 MEASUREMENT AND ANALYSIS RESULTS OF THE KICKER MAGNETIC FIELD

Peak current of the kicker magnet has the following relationship with the peak magnetic field:

$$I = \oint H \cdot dl \approx \frac{B_o g}{\mu_0} + \frac{B_{fe} L_{fe}}{\mu_0 \mu_r} \quad (1)$$

where  $B_o$  is the peak field,  $g$  is the air gap height of the kicker magnet ( $g=40$  mm),  $B_{fe}$  is the magnetic flux density in the core,  $L_{fe}$  is the average pass length through the core, and  $\mu_r$  is the relative permeability of the core. Since the magnet is designed such that no significant saturation effects occur, implying that

$$B_o g \gg \frac{B_{fe} L_{fe}}{\mu_r} \quad (2)$$

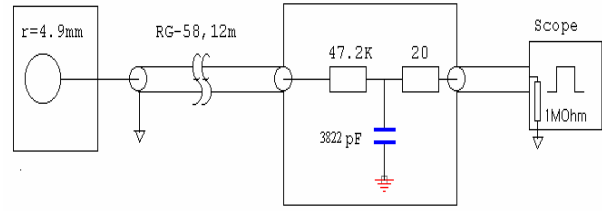


Fig. 4. A B-dot probe with an integrator  
Therefore, the second term of Eq. (1) can be neglected, and the peak current can be approximated as

$$I = \frac{B_o g}{\mu_o} \quad (3)$$

Fig. 4 shows a B-dot probe setup that is used to measure the magnetic field in the kicker magnet air gap. The probe sensor is an one-turn loop with 9.8-mm diameter, made with 0.6-mm thick enamel wire. The output voltage of the probe,  $V_o$ , has the following relationship with the peak field of the kicker magnet:

$$V_o = \frac{A B_o}{T_I} \quad (4)$$

where  $A$  is the area of the probe sensor, and  $T_I$  is the RC time constant of the integrator. The sensitivity of the probe is calculated as 0.042 mV/Gauss from Eq. (4). The measured sensitivity is 0.035 mV/Gauss. The difference is mainly from the position angle and the uniformity of the one-turn loop.

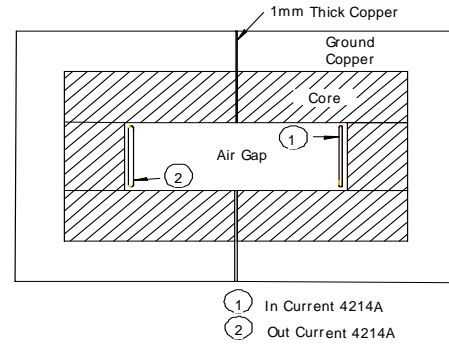


Fig. 5(a). Setup for ANSYS simulation

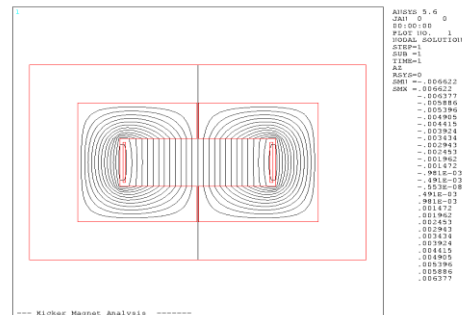


Fig. 5(b). Simulation result: 2-dimension flux line plot

