UP-GRADATION OF BOOSTER INJECTION KICKER MAGNETS FOR REDUCED BEAM COUPLING IMPEDANCE

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Abstract

Pulsed injection kicker magnets are window frame ferrite magnets were commissioned in the year 1996.Consequent to successful operation in Booster synchrotron , further they were up-graded for reduced coupling impedance. Various schemes for reduction in impedance without distortion of pulse shape and field distribution have been studied. Among three schemes, a kicker with conductor windings around the ferrite showed a significant reduction of impedance without affecting field distribution and pulse shape. This paper focuses on beam coupling impedance reduction techniques, modeling for modified kicker geometry, impedance & magnetic measurements.

INTRODUCTION

20 MeV electrons are injected into the Booster Synchrotron by adopting a multi-turn injection scheme using 1 μs long electron beam pulse from the Microtron at a repetition rate of 1 Hz. A compensated bump producing maximum amplitude near the injection septum is produced using three injection kicker magnets. Injection is carried using the de excitation of the kicker .The field should fall linearly to zero in the duration of 1 μs. During this period about 11 turns are injected using three kickers. [1].

KICKER MAGNETS

The main design criteria for the kicker magnet are to produce half sine wave (13 μs) without any other beam perturbation. Magnet is a ferrite window-frame with copper conductor on each side. In order to get full aperture for e beam, the kicker magnets has been kept inside the vacuum chamber. As magnets have to keep inside vacuum, there are technology challenges of space limitation, vacuum compatible ferrite & electrical connection to purser. Window frame type configuration is chosen on the basis of good field spatial homogeneity, low circuit leakages, and simplicity construction. Electrically lumped type magnet is selected & its layout is shown in figure1.

Window type, electrically lumped kicker magnets are chosen to meet fast response and power supply simplicity. Magnetic design simulations of kicker magnets have been carried out using a FEA package- Flux 2D. The dimensions have been optimized to minimize time dependent reluctance drop in the ferrite yoke, to maximize the flux penetration into the ferrite and kicker operates below the knee of magnetization of B (H) curve (linear region). Each magnet has been constructed in window frame using Ni-Zn ferrite [2].

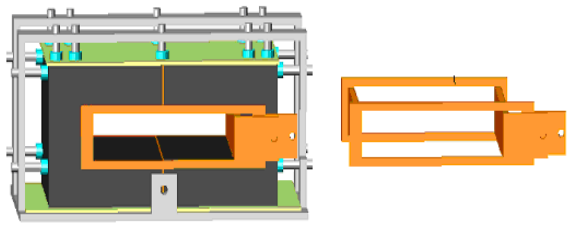

Figure 1: Window frame Kicker magnet

COUPLING IMPEDANCE

Various schemes for reduction in impedance without distortion of pulse shape and field distribution have been studied. Among three schemes, a kicker with conductor windings around the ferrite showed a significant reduction of impedance without affecting field distribution and pulse shape. A copper wire loop (0.5 mm diameter) has been optimized for minimal effect on field distribution but reduction of impedance. Actual three kicker magnets were dismantled; cu wire loop has been inserted around ferrite block in top & bottom poles. Existing kicker magnets have been modified by introducing the copper wire loop around the ferrite block, symmetrically in top and bottom. The longitudinal impedance of the kicker magnet with these schemes has been measured using coaxial wire method in the frequency range 0.3 MHz to 100 MHz.

MEASUREMENTS

A various schemes for reduction in impedance without distortion of pulse shape & field distribution have been studied. To reduce the longitudinal impedance, we investigated a new scheme - a pair of flux breaks in the form of a conducting winding (0.5 mm diameter) around the ferrite symmetrically in the top & bottom poles of magnet along beam path. The conductor winding forms one turn loops around the top & bottom ferrite blocks. This conducting loop does not influence the kicker field but increases the reluctance of the magnetic path, & thus decrease the flux which couples the beam. Inductance from ferrite to beam has been reduced in a great extent is shown in figure 2.

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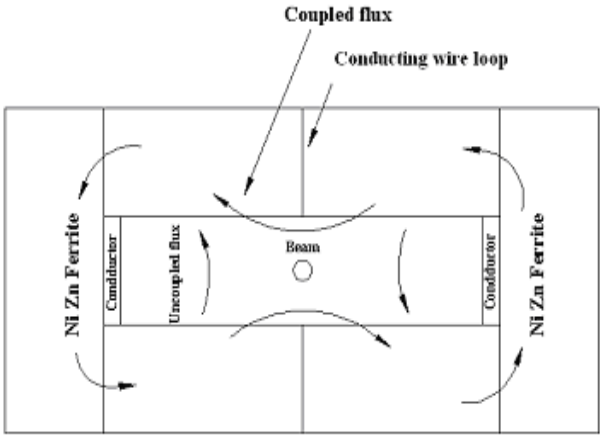

Figure 2: Cross section of kicker magnet

For the longitudinal coupling impedance measurement, a thin metal wire is installed on the axis of the REF/DUT, which forms a coaxial transmission line with characteristics impedance of about 370 ohm. Matching 50 ohm of the network analyzer to 370 ohm of the reference line is achieved by adding resistive networks. The longitudinal impedance of kicker magnet with & without conducting loop has been measured from 0.3 to 50 MHz using RF Network Analyzer. We performed longitudinal impedance measurements by transforming the kicker magnet under test into a coaxial line by putting a central thin metallic wire in order to measure the transmission parameters S21 through the line. The central conductor emulates the charged particle beam. From coaxial line theory we calculated the longitudinal impedance from the S21.We have determined the longitudinal impedance of a kicker magnet with 0.5 mm copper wire loop .The real part of the impedance has a peak value of about 6-7 ohms around 10 MHz. The imaginary part of the impedance is inductive within the test frequency .Experimentally observed results were compared with values obtained from New Resonance model. A close agreement has been observed. Measured pulsed magnetic field homogeneity (~ 10^{-3}) and waveforms are shown in 3 & 4 respectively.

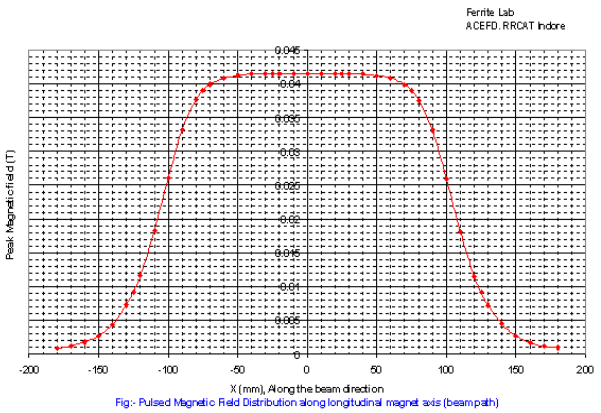

Figure 3: Pulsed magnetic field distribution along longitudinal axis (beam path)

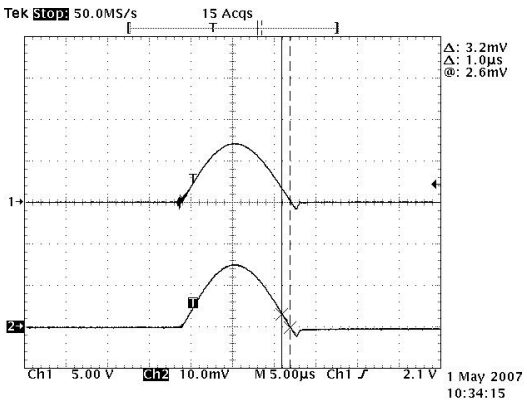

Figure 4: Pulsed waveforms of Current & Kicker field Pulse at 1 µs (Top trace- I & Bottom trace-B)

MODIFIED KICKER MAGNET

Modified kicker magnet is installed in the vacuum tank as shown in figure5.

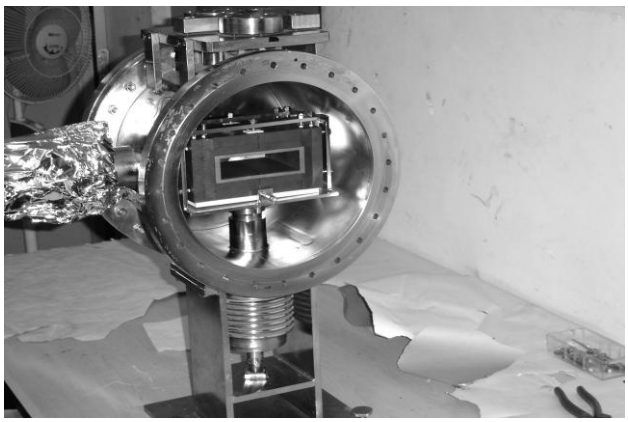

Figure 5: Assembled kicker magnet in Vacuum tank

CONCLUSIONS

Modified Pulsed kicker magnets are working satisfactorily in the injection of 20 MeV electrons into Booster Synchrotron during accelerator operations. They are found to work efficiently and reliably.

ACKNOWLEDGEMENT

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2. R.S.Shinde "Technical Note – Pulsed injection kicker Magnets for Booster Synchrotron", March 2008.