A PINGER SYSTEM FOR THE LOS ALAMOS PROTON STORAGE RING

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Abstract

Developers at the Proton Storage Ring have long desired a modulator and electrode combination capable of kicking the 800-MeV proton beam enough to conduct tune measurements with full intensity beams. At present this has been accomplished by reducing the voltage on one extraction kicker modulator and turning the other off. This method requires that all of the accumulated beam be lost on the walls of the vacuum chamber. In addition to tune measurements a more recent desire is to sweep out beam that may have leaked into the area between bunches. A four-meter electrode has been designed and constructed for this purpose. The design is flexible in that the electrode may be split in the center and rotated in order to provide vertical and horizontal electrodes each 2 meters long. In addition two solid-state pulse modulators that can provide 10kV in burst mode at up to 700 KHz have been purchased. This hardware and its intended use are described.

1 Introduction

The Los Alamos Proton Storage Ring (PSR) accumulates 800-MeV beam from the LAMPF linear accelerator and compresses macropulses up to 1 msec in length into intense 250 nsec pulses which drive a spallation neutron source. In the past only low-intensity tune measurements were routinely made. To provide tune data at any time throughout the accumulation cycle a pinger system has been developed. In addition to tune data the system described here can provide a series of kicks synchronized with the revolution frequency and timed to sweep beam from the area between bunches. It is believed that electrons trapped by the proton beam are causing an instability [1]. By sweeping beam out from the region between bunches we should be able to verify this theory.

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2 Pinger Uses

Tune Measurements

The most obvious use for our pinger is to kick the beam and observe the resulting betatron motion. From this oscillation one calculates the tune and can measure tune as a function of time into cycle or as a function of beam intensity. We plan to use the pinger in conjunction with wide-bandwidth beam-position-sensing electrodes and very high-speed digitizers to provide a spectral display of beam motion. With a total applied voltage of 20 kV we can provide a 1.1 mrad kick. Folded into the PSR lattice this would provide a maximum deflection of about 11 mm.

Beam Sweeping

A not so obvious use for the pinger is Beam Sweeping. The design of our storage ring allows some beam to leak out of the bunches. This leaves small amounts of beam filling the space between bunches and allows electrons to be trapped. As long as the space between bunches is clean the electrons will hit the beam pipe walls and not be trapped. A small amount of beam leaked into the space between bunches traps the electrons and may cause an instability. We plan to sweep any beam that leaks into the space between bunches out of the ring with the pinger system. We will produce a string of deflecting pulses synchronized to the revolution frequency and kick the beam on every 4th turn. One would prefer every turn but the revolution frequency is 2.8 MHz and the pulsers can only run at 700 KHz.

A preliminary test of beam sweeping was performed during the later part of our 1990 run cycle. Fig. 1 is a comparison of longitudinal beam distribution in the PSR with the sweeping pulse chain on (A) and off (B). During this experiment the minimum available sweeping pulse was 150 nsec while the space between bunches was only 100 nsec. We actually kicked some of the bunch; thus we had more beam loss than anticipated. We did make the beam stable by sweeping beam from between the bunches but we were not able to discern whether this was due to an intensity decrease or from cleaning out the area between bunches.

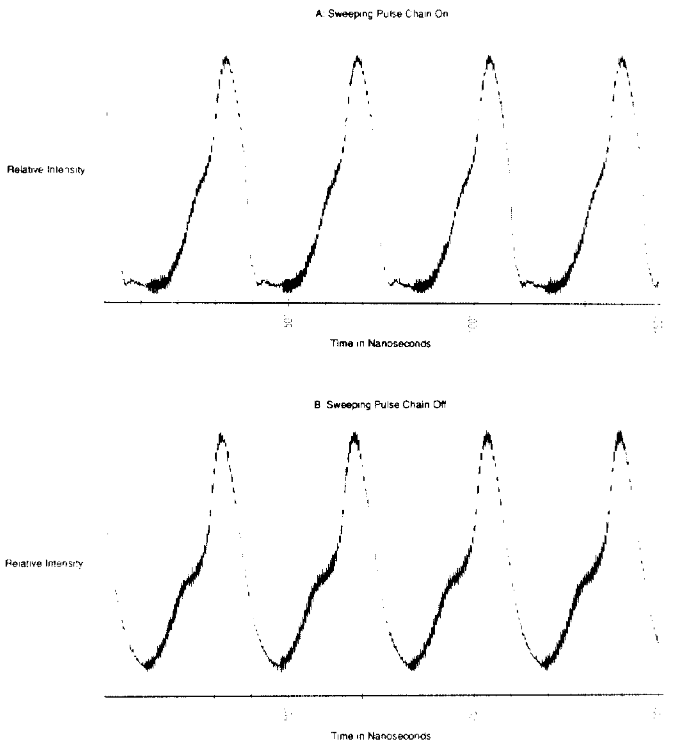

Figure 1: Comparison of longitudinal beam distribution in PSR with the sweeping pulse chain on (A) and off (B).

Beam Shaking

It is also possible to shake electrons out of the proton beam. The technique is utilized to remove trapped ions at Cornell, CERN, and FNAL [2]. We would use the pinger electrode for this purpose by powering it from a broadband RF amplifier. In our case we would drive the electrode in the 50 to 100 MHz range.

Clearing Fields

Another way to remove unwanted electrons is to install clearing electrodes. We have already completed experiments operating our extraction kicker electrodes at several kV with little or no effect. The kicker electrodes are 4 meters in length and there are two sets. The pinger electrode will give us another 4-meter electrode to energize and it is located in a different part of the ring.

3 Electrodes

Our pinger electrodes are configured as a balanced 100-ohm transmission line. We drive the electrodes from two separate sources of opposing polarity such that each pulser looks into a 50-ohm terminated line. Each electrode is back-terminated in 50 ohms through cables long enough to prevent any reflections from arriving back at the electrodes during the flat top portion of the pulse. Terminating resistors are simple carborundum resistors 2 inches in diameter, 12 inches long supplied with integral corona ring end caps. The resistors are immersed in oil and cooled by immersing a water-cooled coil of copper tubing into the oil.

Fig. 2 gives the end view of our pinger electrode showing the Macor support insulators, corona rings that shield the triple junction where the stainless steel end piece contacts the Macor insulator, and the adjusting hardware at the rear of the insulator. The drawing shows the electrodes in their horizontal deflecting orientation, but we will actually install the electrodes in their vertical deflection orientation with the electrodes at the top and bottom. The ears at the

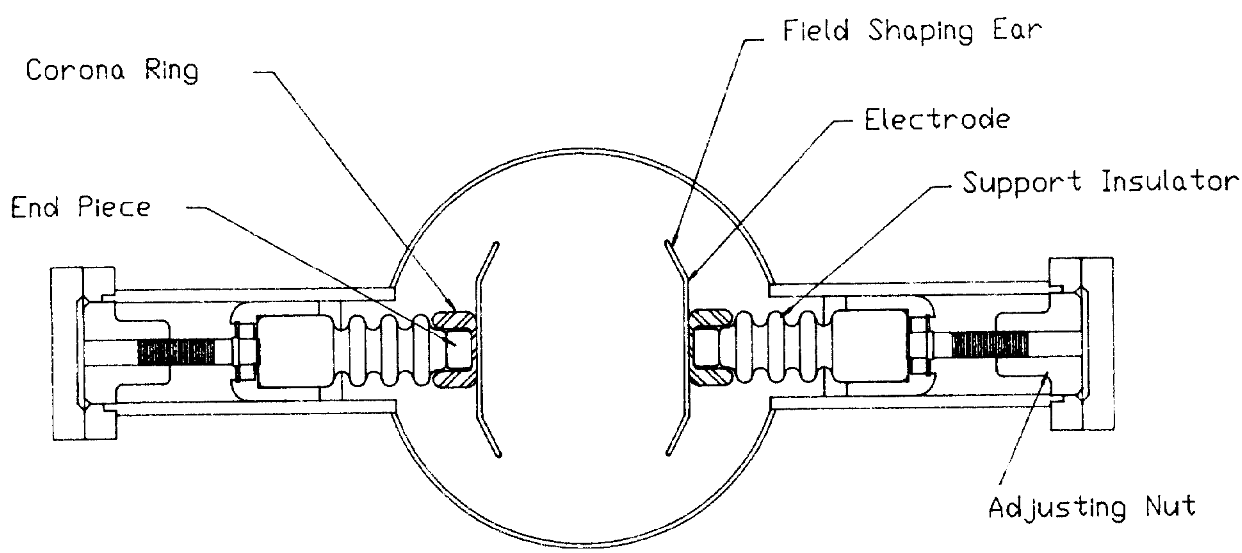

Figure 2: End view of pinger electrode.

edges of the plates were adjusted for best field uniformity [3]. In this design the field is uniform to one percent over an area of 9 cm horizontally (± 4.5 cm) 4 cm vertically (± 2.0 cm) and uniform to 6 percent out to ± 3 cm vertically. We have split the housing and the electrodes at the center to allow for their use as independent vertical and horizontal electrodes of half their present 4-meter length. The support insulator design was borrowed from the PSR Extraction Kicker electrodes to save design time and minimize the number of spare parts required.

We have set 4 inches as the minimum allowable aperture anywhere within the PSR beam pipe. The pinger electrodes are set to this 4-inch spacing to maximize the available kick.

Power is supplied to the electrodes through-off-the-shelf vacuum feedthroughs that present a fairly uniform 50-ohm impedance. The long ports on the housings were included to allow the eventual replacement of the lower-voltage stock feedthroughs with the higher-voltage feedthroughs used in our extraction kickers.

4 Pulse Modulators

We supply pulses at the downstream end of each electrode thus taking advantage of both the magnetic and the electric fields. We pulse one electrode with a positive 10-kV pulse and the other electrode with a negative pulse. Since they are produced by separate units that drive a balanced line it is desirable to have the pulses well matched and to have them arrive at the electrode at the same time. In our application we are not very sensitive to pertubations on the top of the pulse that mismatches would cause, but still wish to minimize these pertubations. We do not yet have enough experience with these units to know how well matched the pulsers will remain over time.

Table I gives the specifications for the pulse modulators we are using. The modulators are commercial products and are all solid-state. The unique feature of these units is that they can produce a string of pulses at up to 700-kHz repetition rate. Our units have been modified to allow up to a millisecond long burst of 700-kHz 90-nsec-long pulses.

Table I: Pulse Modulator Electrical Specifications

Minimum Output Voltage	1kV
Maximum Output Voltage	10kV
Maximum Output Current	200 Amperes
Minimum Pulse Width	90 nsec
Maximum Pulse Width	270 nsec
Rise Time	40 nsec
Fall Time	40 nsec
Pulse Recurrence Frequency	50 Hz 700 KHz Burst

5 Acknowledgements

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