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DUAL POWER SUPPLIES FOR PEP-II INJECTION KICKERS*

J. Olszewski, F.-J. Decker, R.H. Iverson, A. Kulikov, C. Pappas,
SLAC, Menlo Park, CA 94025, U.S.A.

Abstract

Originally the PEP-II injection kickers where powered by one power supply. Since the kicker magnets where not perfectly matched, the stored beam got excited by about 7% of the maximum kicker amplitude. This led to luminosity losses which were especially obvious for trickle injection when the detector is on for data taking. Therefore two independent power supplies with thyratrons in the tunnel next to the kicker magnet were installed. This also reduces the necessary power by about a factor of four since there are no long cables that have to be charged. The kickers are now independently adjustable to eliminate any non-closure of the kicker system and therefore excitation of the stored beam. Setup, commissioning and fine tuning of this system are discussed.

INTRODUCTION

The approach for two power supplies for the two injection kickers in each PEP-II ring addresses the following problems of the single pulser approach [1]:

1. Kicker amplitudes not matched
2. Kicker timing not matched
3. Kicker reflection too big, not canceling
4. Big beam excitation might cause aborts

First we describe the design, implementation and testing of the new system, then the fine tuning with beam is discussed.

TWO POWER SUPPLY DESIGN

A schematic of the new PEP injection kicker system is shown in Figure 1. The modulators are installed in the PEP tunnel directly on top of the magnets, with all associated power supplies and electronics located in the support buildings. A drawing of the modulator is shown in Figure 2. Operation of the modulators is as follows. Each modulator has a dedicated capacitor charging supply to independently charge the capacitors. A single grid driver is used to trigger both modulators, the difference in the beam time of flight between kickers is compensated for by differing lengths of cable from the grid driver to the two modulators. Fine adjustment of the kicker timing is controlled by adjusting the thyratron reservoir voltage. For the CX1135 tube used it was found that the timing could be adjusted by approximately 20 ns by varying the reservoir voltage. Measurements of the anode delay versus reservoir voltage for an anode voltage of 2500 V and 3500 V are shown in Figure 3. Trim capacitors in parallel with the main capacitor are used for precision matching of the magnet current pulse shapes. In this fashion, it is possible to independently control the amplitude, shape, and timing of the kicker pulses. Figure 4 shows the magnet current in each of the kicker magnets for the PEP high energy ring kicker magnet system.

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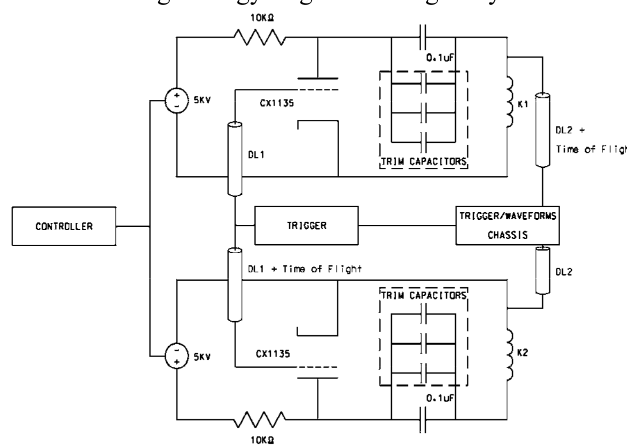

Figure 1: Schematic of the new PEP injection kicker system.

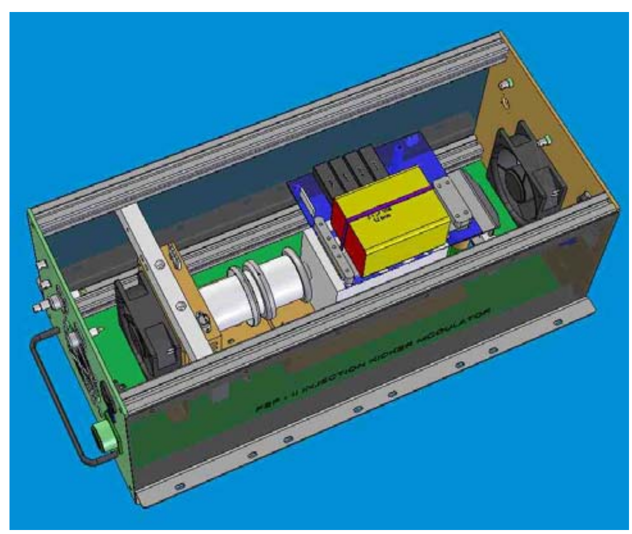

Figure 2: New PEP injection kicker modulator.

A major advantage of the old kicker system was that both magnets were driven from the same modulator. There was one capacitor charging supply, one trigger generator, and the beam time of flight was compensated by differing lengths of cable to connect the magnets [2]. This design insured that both magnets would have reasonably similar pulses with the correct timing, unless there was a failure in the modulator output cables or the magnets themselves. The major disadvantage of this design was that of matching the current pulses in each magnet. The long cables from the modulator to the magnet gave a fixed output impedance of the modulator. The design attempted to match the cable impedance at the

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magnet by using a complimentary circuit in parallel with the magnet. This match was imperfect for several reasons. First the magnet itself is a distributed network, and the complimentary components were all lumped elements. Second, the complimentary circuit only has a finite number of components of discrete values, so even matching to a fixed inductance is not always possible. And finally, there is no way to compensate for cable attenuation for the differing lengths of cable. The result of these mismatches meant that there were unavoidable reflections from one magnet which eventually propagate to the other magnet. An attempt was made to reduce these reflections by adding damping resistors at the output of the modulator, but this reduction was marginal for trickle charging of PEP.

While the new modulator design provides much better matching of the two current pulses, there is a possibility of powering only one magnet if a thyraton self triggers or in other fault conditions, thus steering the beam into BaBar. For this reason the controls of the new modulator are much more complicated than for the old system. The new design employs a single PLC to set the power supply voltages, adjust timing by setting the reservoir voltages, monitor the modulator status and communicate with the PEP control system. In addition to the slow PLC, a fast system was needed that could monitor the magnet current pulses to insure they are well matched, and appropriately timed.

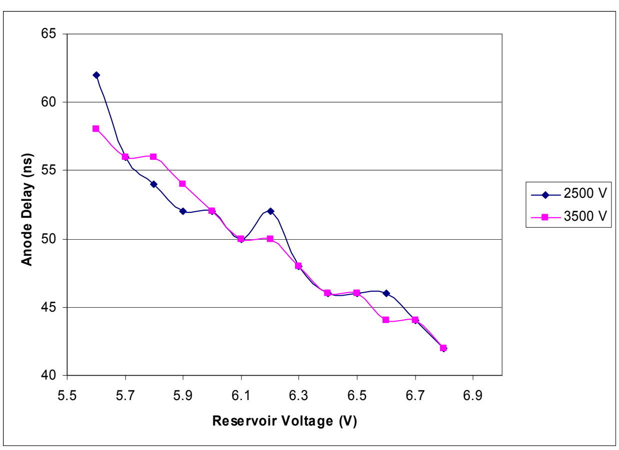

Figure 3: Anode delay time vs reservoir voltage.

A waveform monitoring chassis was designed and built that creates a window in which both current pulses must lie. If either pulse is outside of this window, or if only one current pulse exist inside the window, the chassis returns a fault to the PEP control system, while the PLC inhibits the further injection of beam. In addition the chassis takes the difference in the two waveforms for diagnostic purposes.

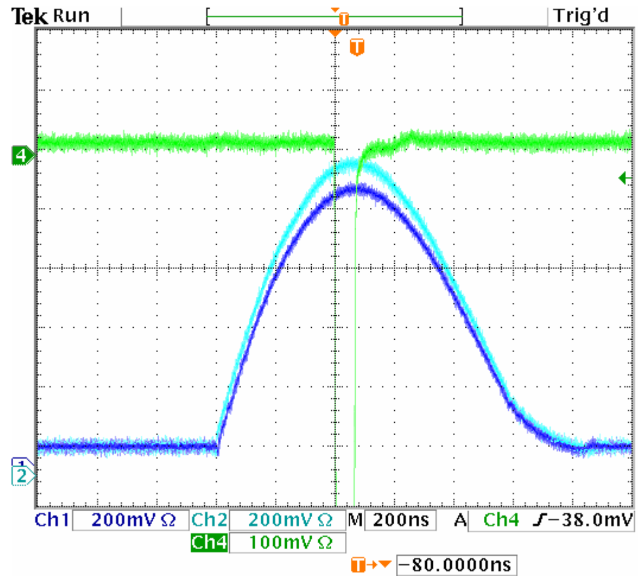

Figure 4: Trigger and the two kicker pulses.

KICKER EFFECTS ON THE BEAM

The kicker closure was checked and tuned with the beam by looking at the stored beam and pretending to inject, firing the kickers and moving the trigger time. Figure 5 compares the old (top) and new (bottom) results. The dashed, blue curve shows the y-position, measured by a BPM (beam position monitor) inside the kicker bump. It is directly obvious, that the new setup doesn't show any long tails (to the left!) from pulse reflections. The pulse is also a little wider (450 → 650 ns FWHM), which means that next pulse getting injected at high rate (30 Hz) should be further away.

The red curve in the old setup was the non-closure (N-C) as found originally with +0.7, -0.5 mm excursions. A lengthy resistance change finally resulted in the green curve, which still gave 10-15% luminosity dips in the old setup. These were still bothersome, especially with trickle injection [3].

The new setup after one amplitude and one timing change, shows directly that the kicker bump is closed a factor of two better, which should give barely visible luminosity dips of 2.5 to 4%. A finer tuned setup is possible whenever it might become necessary.

Detector Backgrounds

The BaBar background from HER injection seems to have a new mode this run, compared to previous run [4]. After the first few turns the backgrounds are clean for a long time after injection, but then a big spike occurs at around 15 ms (Fig. 6). There is no good explanation for this, except that the time scale is of the order of the damping time (30 ms), and part of the injected beam might be in some non-linear regime. The injection bump amplitude is about the same as last year (compare Fig. 5), making it hard to be the cause. A slightly bigger bump (5%) can put the stored beam far enough away from the septum that particles eventually drifting outwards in y could not end up on the septum, but the detector.

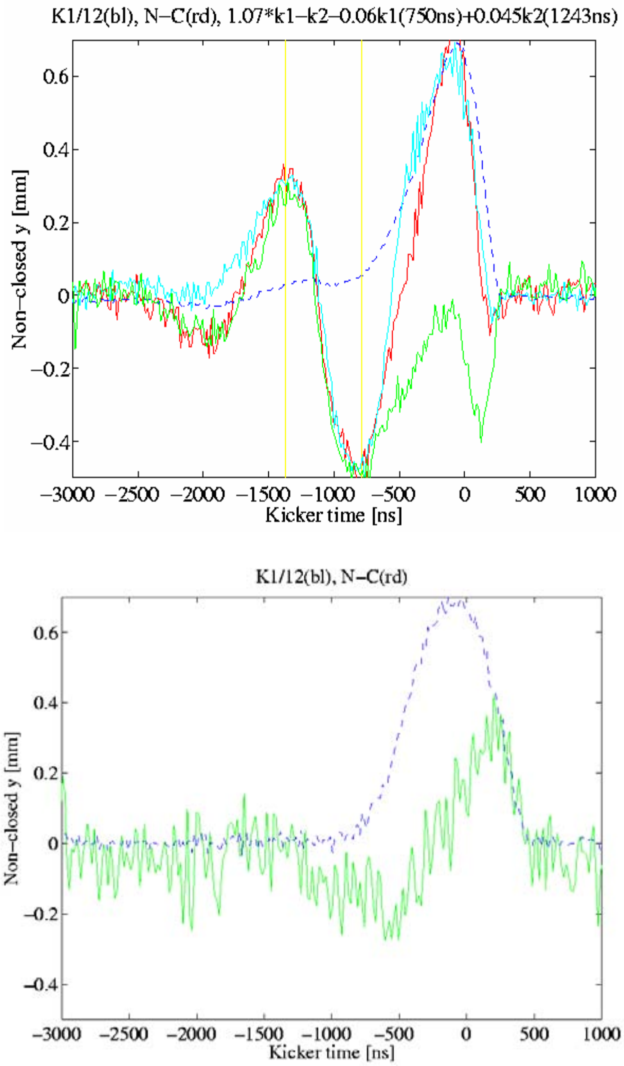

Figure 5: Old (top) and new (bottom) beam response due to injection kickers. The blue, dashed line is the main kick from kicker 1 (K1) divided by 12. The green is the closure of the two pulses.

SUMMARY

The new injection kicker systems, with each of the two kickers having their own power supply, were commissioned quite successful. The old pulse reflections are gone, and the closure is a factor of two better after a first, fast adjustment. This will already reduce the luminosity dips by a factor of four.

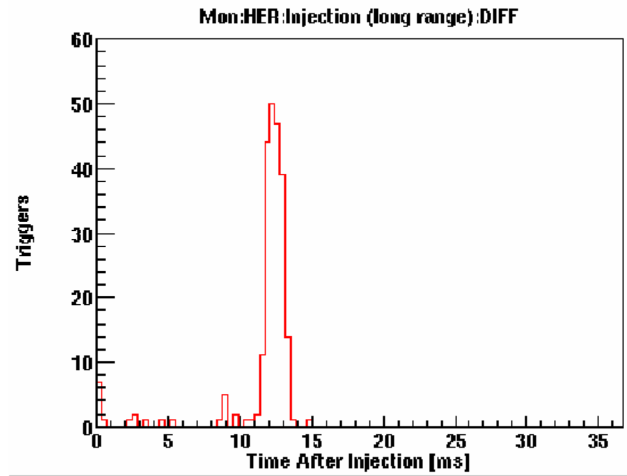

Figure 6: Background signal, showing a strange 15±2 ms peak after injection.

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