KICKER PREPULSE CANCELER *

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Abstract

The SLC Damping Ring extraction kicker magnets requires that the magnetic field, 58 nsec before extraction, be less than 0.1 % of the extraction field. The kicker thyratrons inherently generate prepulse currents of greater than 2 %. A Kicker Prepulse Canceler system was developed, which generates a 2.5 kV, 40 nsec wide pulse with 8 nsec rise time into 12.5 ohms, in such a manner as to cancel the kicker thyratrons prepulse current. The Prepulse Canceler has a drift of less than 5 nsec and has a jitter of less than 50 psec RMS.

Introduction

The SLAC, SLC project requires the electron damping ring to have two bunch of electrons separated in time by approximately 62 nsec. During extraction the two electron bunches must be extracted from the damping ring within one turn. The specifications require the first bunch to be kicked out with a pulse to pulse and long term stable of 1 part in 10,000 and the second bunch is to be kicked equally and stable to 1 part in 1,000. Figure 1.

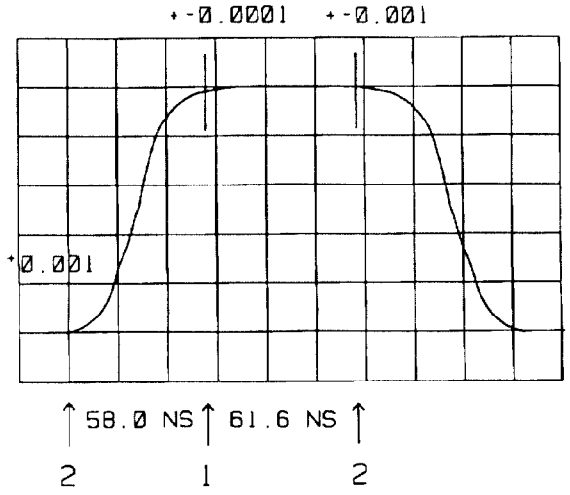

Figure 1.
Extractor Kicker requirements

In addition the second electron bunch cannot be pre-kicked by the rising edge of the kicker pulse by more than 1 parts in 1,000.

Due to the high voltages required by the kicker magnets to accomplish the nominal 58 nsec. rise time of the kicker pulse, multiple gap thyratrons were used in the kicker pulser. The multiple gap thyratrons have an inherent problems in that the individual gaps in the thyratron break down in sequence when the thyratron is triggered. The time delay between gap breakdown is unfortunately greater than 20 nsec and dependant upon the gas pressure in the thyratron. The inherent stray capacitance between thyratron grids generates a small pulse of current from the thyratron when the thyratron gaps break down. *Prepulse* is the name given to these small thyratron pre-breakdown pulses of current. Because the delay between breakdowns are long, dependent on gas presser, and are integrated by the kicker magnet, the result is an noncontrollable kick of the second bunch as it starts its last turn. This magnetic kick is large enough (approximately 1%) to be undesirable for SLC operation. Figure 2

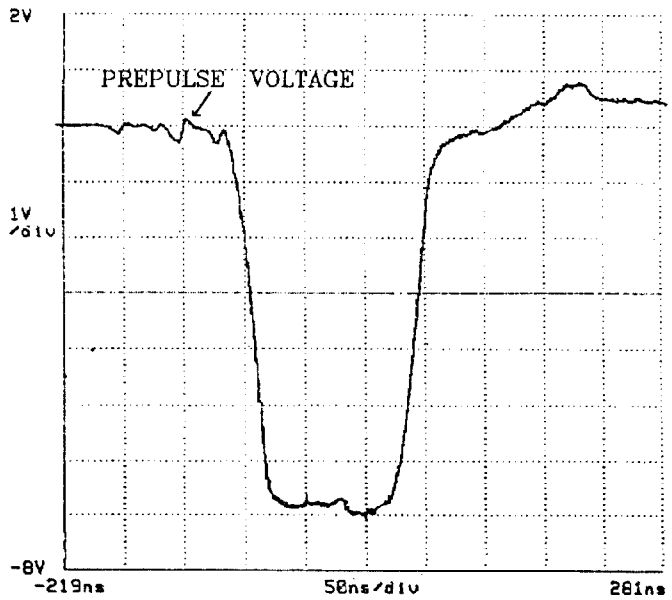

Figure 2.
Example of Thyratron Prepulse

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Design

To eliminate the effect of these prepulses on the second electron bunch a prepulse canceler system was developed. With the main kicker pulse being approximately 2800 amps into 12.5 ohms, it was undesirable to attempt to adjust the main pulse directly. The prepulse canceling system which was adopted was to inject a current pulse from the load side of the kicker magnet system which would start approximately the same time as the main pulse but travailing in the opposite direction toward the magnet. figure 3

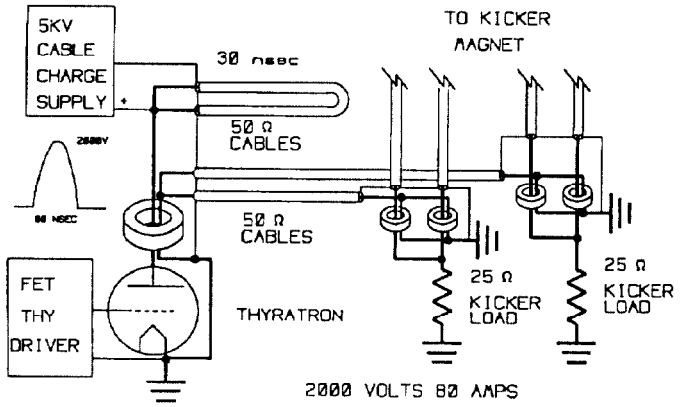

Figure 3.
Simplified Canceler Schematic

The injected current pulse is timed to reach the kicker magnet just prier to the main pulse coming from the other direction and thereby interferes or canceling the thyratron induced prepulses. Because the small prepulse was injected by way of a saturable core at the load which saturates quickly with the main pulse which then arrives much later at the load (approximately 400 nsec.) the main pulse has little effect on the prepulse canceler pulse or its pulser. Refections from the saturable core occures after extraction is over and as a result do not effect the extraction.

Saturable core transformer.

The saturable core transformer was built into the kicker loads and consists of a one turn 1" ID x 2" OD x 1" th CMD-5005 ferrite with a one turn primary coming from the prepulse canceler pulser. The resulting transformer will support a 2.5 kv 40 nsec wide prepulse canceler pulse without saturation. The cores will then saturate quickly under the present of the main pulse transmitting only a small amount of energy to the prepulse canceler pulser. The kicker loads use four cable or 12.5 ohms requiring the use of a core for each cable. figure 4

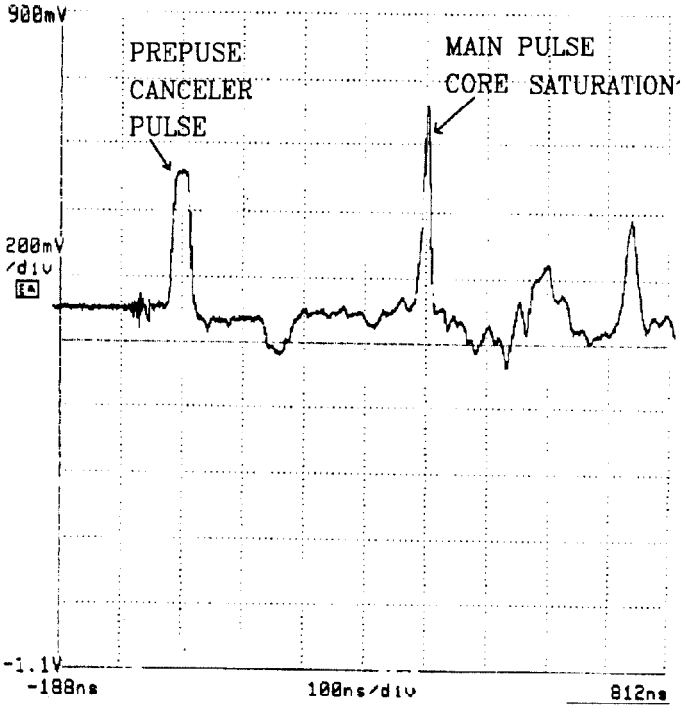

Figure 4.
Canceler Pulse & Core Saturation

Pulser design

The prepulse canceler pulser was designed to using a fast thyratron. A thyratron was chosen to reduce the possibility of problems when the main pulse reflected back to it before the saturation of the transformer core.
The thyratron chosen was a EEV CX-1588 because of it small size, high voltage capability and most of all its fast rise time. With the Thyratron being driven from a fast thyratron FET driver the rise time of the pulse is less than 5 nsec with a jitter of less than 50 psec RMS. Figure 5

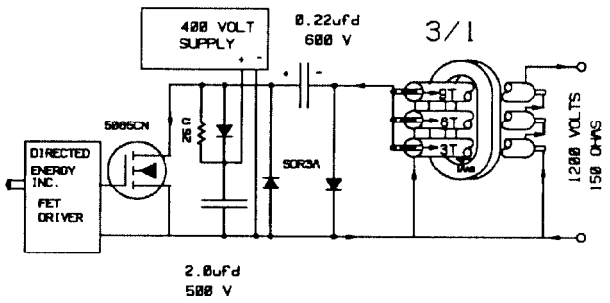

Figure 5.
Thyratron driver Schematic

The total delay of the driver and thyratron was less than 60 nsec with drift of less than 5 nsec so that no trigger time compensation was needed. The output pulse from the prepulse canceler pulser must be positive to match the canceling requirements. therefore an inverting saturable transformer consisting of two ferrite core (same material as the load transformer) provide the inversion and support the output pulse of 2.5 kv 40 nsec into 25 ohms with a 5 nsec rise time. The line for the pulser is a standard coax cable. The cable is resistance charged from a remotely controllable 5 kv power supply.

Results

The prepulse canceler pulser was fabricated and installed in the north damping ring extraction kicker system. Figure 6 & 7

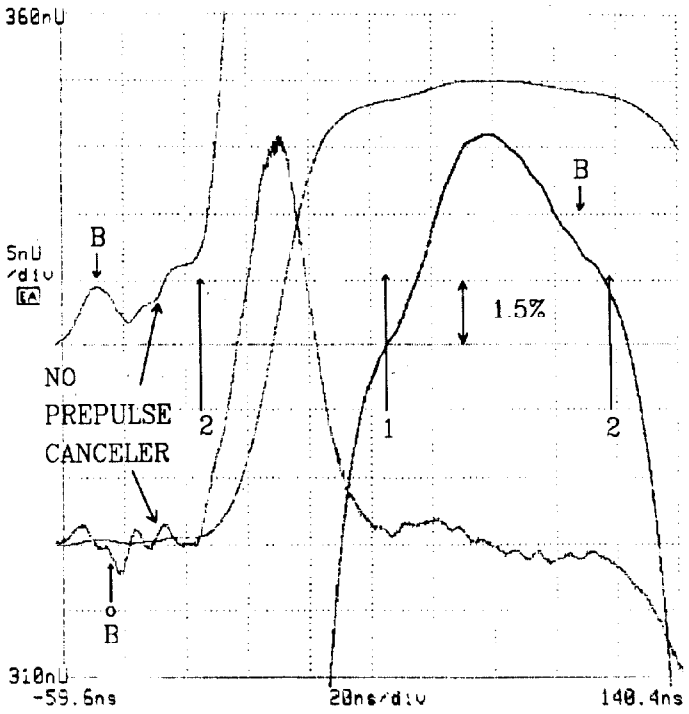

Figure 6.
Kicker Pulse without canceler

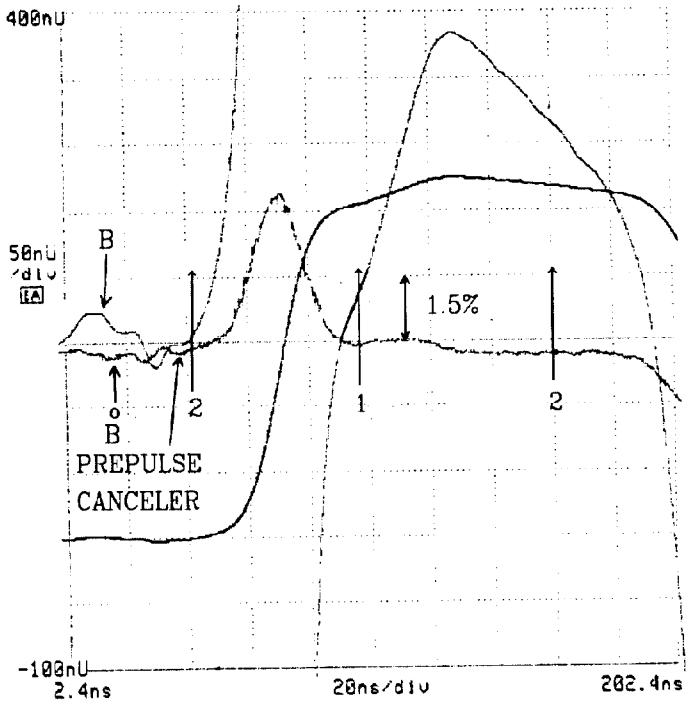

Figure 7
Kicker Pulse with canceler

References

[1] F. Bulos, et al.,"Some Fast Beam Kicker Magnet Systems at SLAC", Proceedings of the 1987 IEEE Particle Accelerator Conference, p. 1884.