AN ISOLATED GRID ELECTRON GUN AND PULSER SYSTEM FOR LONG/SHORT PULSE OPERATION*

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Summary

The new NPI gun at SLAC serves the dual functions of producing long pulse (up to 5 μsec, 180 pps) electron bursts for nuclear physics experiments, and also short (1 nsec) pulses for filling Stanford Synchrotron Radiation Laboratory (SSRL). This is accomplished by means of a newly designed, isolated grid gun, cathode pulsed with a solid state long pulse pulser, and grid pulsed with a fast recharging avalanche type short pulse (1 nsec) grid pulser. The grid pulser is bipolar so that a fast blackout notch can be placed in the long cathode pulse. This fast notch can be seen by Stanford Linear Collider (SLC) instrumentation and allows the long pulse beam to be computer controlled by SLC intensity and beam position monitors.

Introduction

A series of guns for accelerators has been designed at SLAC over the last twenty years. Both long pulse and short pulse guns from 100 mA to 20 A have been included in this family. The latest design, designated our Model 7-1, is similar to our Model 5 gun which uses a replaceable EIMAC Y646B cathode-grid assembly and is capable of peak currents in excess of 1 A at cathode voltages of up to 100 kV. Two features of the Model 7-1 gun are a new replaceable cathode-grid assembly from EIMAC (Y845) which is mounted on a 2-3/4 inch Conflat flange, and an isolated grid design that allows low capacity access to the grid structure independent of the grid focus electrode. This latter feature allows independent pulsing of the grid and cathode electrodes which permits both long and short pulse beam generation from the same gun. A photograph of this new gun is shown in fig. 1, and the gun cross section is shown in fig. 2. Block diagrams of both the long and short pulsers are shown in figs. 3 and 4.

Gun Optics

Beam optics for the Model 7-1 gun were modeled using Herrmannsfeldt code, and the results are shown in figs. 5 and 6 for high current and low current operation. General design goals for the gun were:

Operating voltage:	50 to 100 kV DC cathode voltage
Peak current:	1.5 A maximum over two year operating life
Beam Emittance:	less than 3π cm-mrad over all current operating conditions, optimum emittance at maximum current.
Cathode-grid transconductance:	Better than 10 mS over useful operating life
Fast pulse capability:	1 nsec FWHM pulses, or long pulses to 5 μsec

Gun optics design was modeled with a perveance limited beam of 2.9 A at an accelerating potential of 100 kV. Electrode shapes were optimized to produce a minimum emittance beam at this operating point.

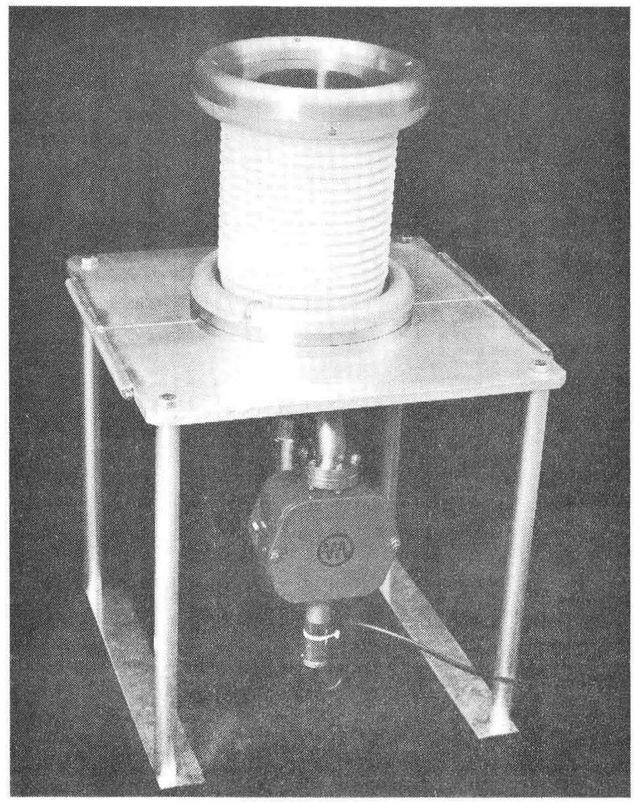

Fig. 1. Model 7-1 gun.

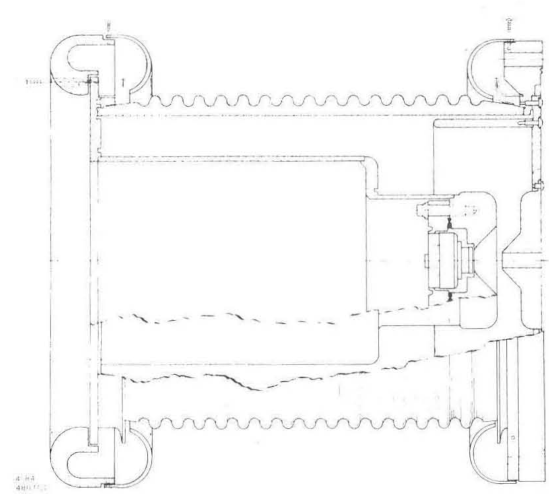

Fig. 2. Gun cross-section.

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The modeled beam profile for this case is shown in fig. 5, and the phase space is a very low 0.17 π cm-mrad. Under grid control, a series of lower current profiles were modeled, and the lowest current profile is shown in fig. 6. Beam current is 100 mA, but the phase space has grown to 2.5 π cm-mrad due to over-focusing caused by the lack of beam space charge. All current levels of this design can be comfortably transported in the accelerator admittance, and the beam quality is best at high currents where beam loss is most critical.

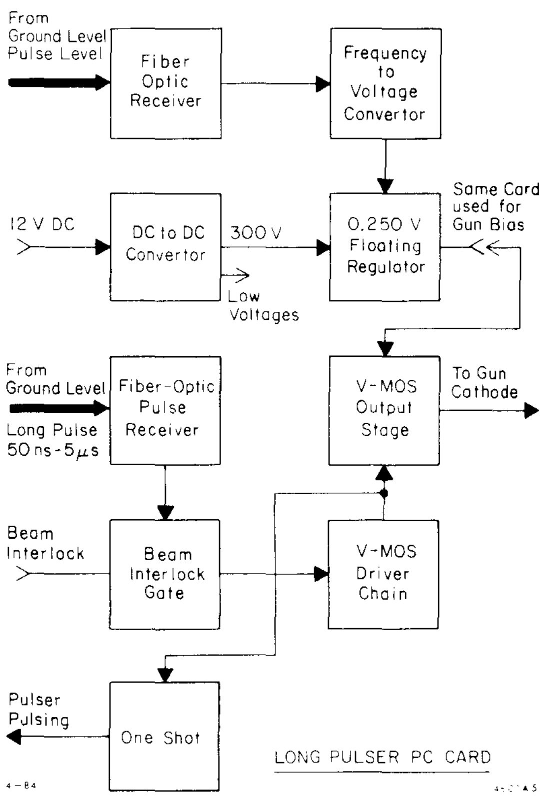

Fig. 3. Long-pulse system.

Pulsing Systems

Along with the new gun design, new solid state pulsers were developed to provide long pulse capability for nuclear physics experiments, and short (1 nsec) pulses for electron injection into SSRL. The new long pulser is shown in block diagram form in fig. 3. The whole pulser and programmable power supply system is contained on a single 4-inch by 6-inch PC card. The output stage of the pulser is a high voltage, high current V-MOS transistor that can deliver a 50 nanosecond to 5 μsec pulse of up to 300 V into a 50 Ω load. Rise and fall times of this output stage are less than 20 nsec. The driver chain consists of two lower power V-MOS transistors, some TTL interlock logic, and a fiber-optic fast pulse link that brings the pulse up to the gun high voltage deck. Level programming is done by controling the voltage to the output V-MOS transistor via a fiber-optic controlled programmable power supply. The whole system operates from a single 12 V DC source on the high voltage deck. The same card with the pulser disabled is used to supply the variable bias for the gun grid.

The short pulse pulser uses avalanche transistor technology, and two very fast avalanche photodiode type fiber optic links for triggering. An rf switching type high voltage supply, photodiode fiber-optic receivers, and some ECL processing and interlock circuitry are laid out on another 4-inch by 6-inch PC card operating from the common 12 V DC source. The actual fast avalanche pulsers are contained on a small PC card and socket that connects directly to the gun cathode-grid assembly.

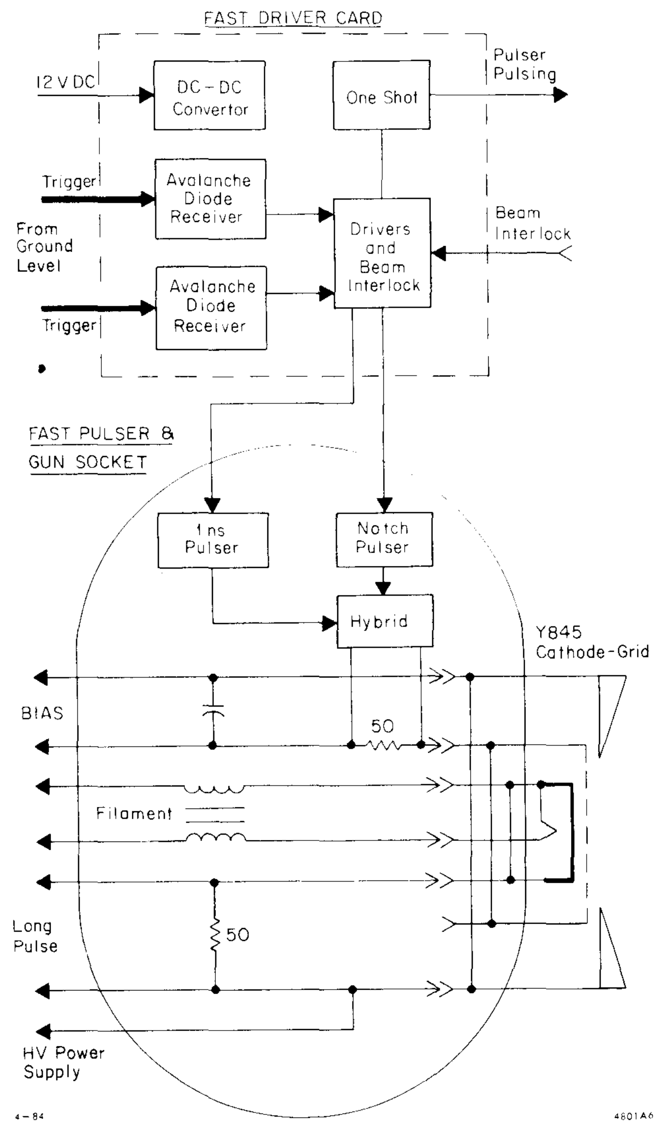

Fig. 4. Short-pulse system.

A 1 nanosecond FWHM positive avalanche pulser that is retriggerable at a 2 MHz rate delivers from 2 to 6 SSRL fill pulses per macro-accelerator pulse when required for Ring filling. A second fast pulser delivers a doublet pulse to the grid when triggered. This produces a notch in a long pulse beam and a fast beam spike that can be detected on the single bunch SLC beam position monitoring system, and thus lets the SLC instrumentation monitor the NPI beam. Since this pulser is separately triggerable, the beam monitor feature can be used only on monitor beams if the notch or spike affects physics data taking on experimental beams.

First usage of the new gun and pulser system will be in the Fall of 1984 when the Nuclear Physics Injector becomes operational. When the new system is proven out, similar gun and pulser systems will be installed in the two sockets of the SLAC main injector.

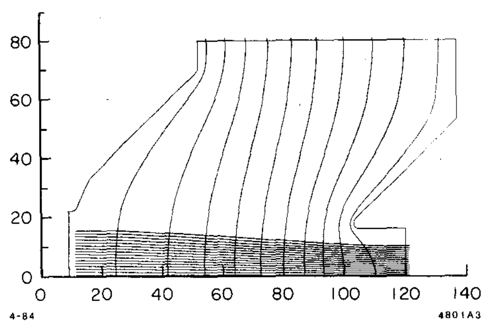

Fig. 5. Perveance limited electron trajectory.

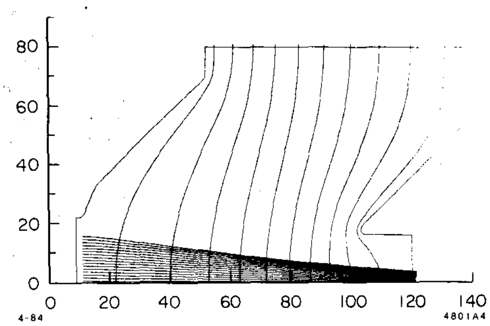

Fig. 6. Grid controlled electron trajectory.