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AGS BOOSTER TUNE METER KICKERS[1]

W. Zhang, J. Bunicci, P.R. Cameron, A.V. Soukas, and W. van Asselt

AGS Department, Brookhaven National Laboratory, Upton, NY 11973

ABSTRACT

The AGS Booster tune meter kicker system consists of two identical kickers for horizontal and vertical tune measurements, and a control unit utilizing a programmable logic controller. The kicker modulators are line type pulsers. The pulse energy stored in the PFN is discharged through a set of matched cables to the load magnet and a matching terminating resistor. Some RC compensation networks are used to obtain the fast rising pulse waveforms. The Booster will be used to accelerate protons, as well as many species of heavy ion beams. Thus, it will cover a wide range of revolution frequencies. To cover this wide range, tunes will be measured by kicking the beams with two different pulse lengths. The short pulse duration is about 1 μs, and the long pulse duration is about 3 μs. A switch mode power supply with fast command tracking speed is used for PFN charging and enables the kickers to change pulse amplitudes on a pulse-by-pulse basis. The peak current is 1500 *amperes* at 20 kV. The pulse repetition rate can reach up to a maximum of 200 pulses per second (pps) at 20 kV and 2000 pps at 2.5 kV.

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MODULATOR SYSTEM DESCRIPTION

The AGS Booster tune meter deflectors are located in the E3 section of the Booster ring, which deflect the passing beam by a pulsed magnetic field. There will be four Booster cycles per each AGS proton cycle. Each AGS FEB cycle is about 1.8 s, and 3.3 s in SEB mode. To track the beam energy during acceleration, it is desirable to have a tune measurement every 12 ms for protons, and every 60 ms for heavy ions. Thus the specifications calls for the tune measurement functions as shown in Figure 1 and Figure 2. Since the revolution time of proton varies from 729.2 ns to 1.19 μs, and it ranges from 772.3 ns to 14.08 μs in the heavy ion case, a selection of 1 μs or 3 μs pulse width kicks was specified prior to the modulator design. The acceleration duration for each proton cycle is only about 60 ms. To achieve multiple pulses with different amplitudes requires a fast charging, fast command tracking power source.

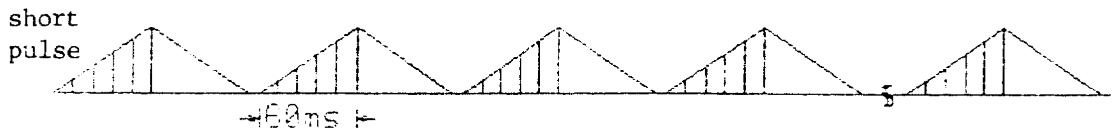

Figure 1. Tune measurement function for proton acceleration.

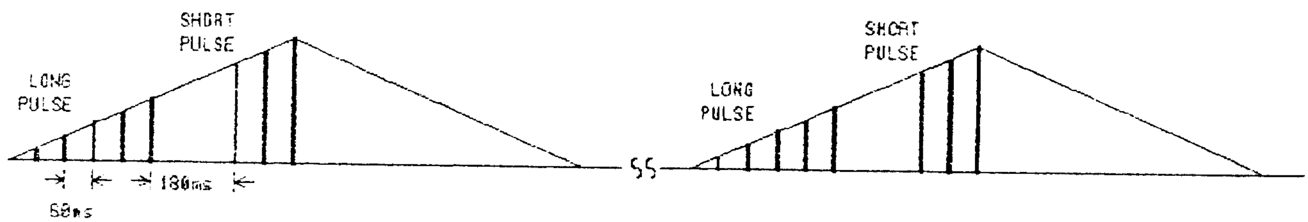

Figure 2. Tune measurement function for heavy ion acceleration.

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Taking advantage of the rapidly developing technology of switch-mode power supplies, the tune operation function can be achieved by adopting it as the modulator power source. A 3 *kWatts* switch mode power supply, ALE-302L, is used for this application. Its fast tracking, fast charging, and fast high voltage output inhibiting features are the main features for our application. Two identical modulators driving horizontal and vertical deflectors are line type pulsers as shown in Figure 3. Each modulator consists of two E-type pulse forming networks. The total capacitance is about $60nF$ for 1 μs PFN, and $220nF$ for 3 μs PFN. In proton operation, a high current discharge rate is required at peak energy. Therefore, we selected the EEV CX1572 thyratron as the discharging switch. The auxiliary grid supply of the thyratron is floating at the PFN high voltage level. A set of cables is used to deliver the current pulse to the magnet load and matching resistor inside the Booster tunnel. The maximum average power dissipation of each tune meter modulator for the above described operation function during the proton FEB mode or heavy ion mode is about 70 *watt*. Solid state diode stacks are used to protect power supply and cables.

At normal operation, the pulse forming network will be charged up right before discharge. To charge up the 1 μs PFN to 20 kV, the time is less than 3.5 ms. The charging time of 3 μs PFN up to peak voltage is less than 12 ms. At a fast pulse repetition rate, the charging supply will be used in a continuous operation mode. The high voltage power supply peak charging current is 500 mA. After each discharge, there is a hundred micro-second high voltage output interruption period, which is an internal function of the power supply. This gives sufficient time to allow thyratron recovery. A new command voltage level can be send to the high voltage power supply for the charging of next pulse, if desirable. During test, we have obtained a maximum pulse repetition rate up to 200 pulses per second (pps) at 20 kV, and 2000 pps at 2.5 kV. Shown in Figure 4 is the PFN charging waveforms at 2000 pps. This fast repetition rate will allow the further functional development of the tune meter kicker. It should be noticed that at this high repetition rate, average power dissipation can reach up to 4 *kWatt*, if used continuously. The system is designed for 70 *watt* average power dissipation. There are four 70 *watt* average power rated resistors used in parallel for the pulse termination, and will be cooled by forced air. Therefore, The high repetition rate operation can only be used periodically of short duration with average power dissipation not exceeding 70 *watt*.

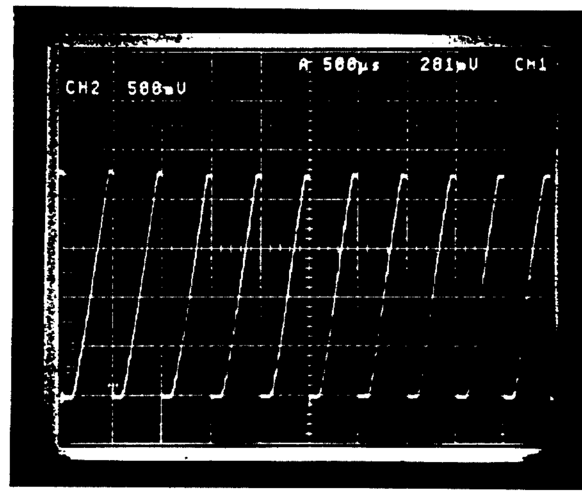

Figure 4. PFN charging wave form at 2.5 kV, 2000 pps rate.

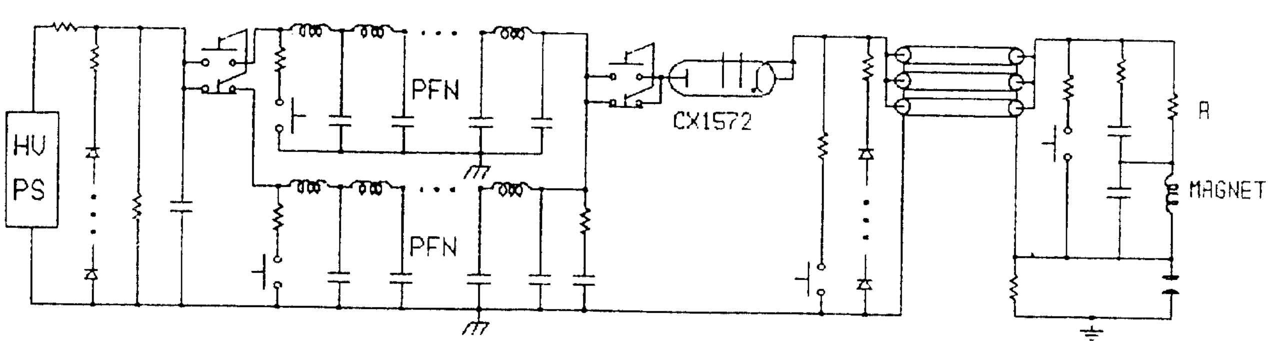

Figure 3. Tune meter modulator schematic diagram.

Two modulators can be synchronized or can be operated asynchronously. During asynchronous operation the pulse signal and noise isolation has to be controlled, to avoid false triggering. Shown in Figure 5 are the PFN charging waveforms of the horizontal and vertical modulators triggered 32 ms apart, at 20 kV in continuous charging mode.

The tune meter deflectors are the picture frame lumped ferrite magnets, located inside the same vacuum chamber. The inductance of the horizontal magnet is 1.8 μH, and the vertical magnet is 1.6 μH. Some R-C networks are used for pulse front compensation. The pulse rise time from 10% to 90% is about 140 ns for short pulse and 250 ns for long pulse. The pulse flat top at 90% lever is >600 ns for short pulse, and about 3 μs for long pulse.

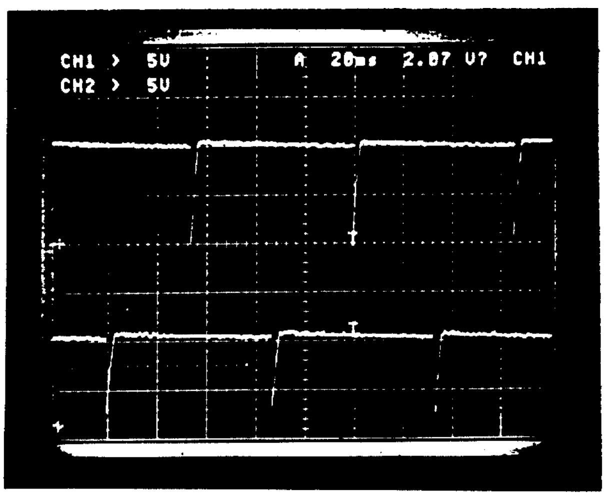

Figure 5. PFN charging waveforms at 20 kV, asynchronous operation mode.

A programmable logic controller controls both modulators, high voltage power supplies, interlock systems, and serves as a local remote station between main control and modulators. Based on the standardized AGS power supply control scheme, we use TTL input and output modules for remote control and readback; 10–60 V dc input and output modules for high voltage power supply, modulator, and interlock system control and readback; 115 V ac output module for fast 20 kV high voltage relay control. The different response times of low voltage and high voltage devices and possible pulsed noise problems have been put into consideration of the PLC software program design. The horizontal and vertical tune deflectors are usually pulsed at different times. However, the pulse interaction has not shown to be a problem for two synchronized/asynchronous high power modulators sharing the same PLC input/output modules.

The tune meter modulators have been tested with the Booster central control, and powered up to their maximum ratings with dummy coil loads. The installation and system testing are in progress.

REFERENCES

[1] "Booster Design Manual," AGS Booster Project, Brookhaven National Laboratory, 1988.

[2] A.V. Soukas, "AGS Booster Standardized Power Supply Control," AGS Booster tech. note #165, BNL, 1990.