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A HIGH-VOLTAGE PULSE MONITOR SYSTEM FOR NEUTRINO ELECTRON ELASTIC SCATTERING

by

Charlie Dalton

ABSTRACT

The Neutrino Electron Elastic Scattering Experiment will use 40 high-voltage pulser and 40 flash-chamber detector modules. This report describes the proposed microprocessor controlled monitor system to ensure the safe and efficient operation of the high-voltage pulsers and flash chambers.

I. INTRODUCTION

This report describes the proposed monitor system to ensure the safe operation of the flash-chamber detectors for the Neutrino Electron Scattering Experiment at the Los Alamos Scientific Laboratory. The detector will be located at the LAMPF beam dump neutrino cave. The detector consists of 40 modules for a total thickness of 4.5 m. Each module has a cross section of 3.0 x 3.0 m and contains a 2.5-cm-thick scintillator and 10 flash chambers. Figure 1 shows a sketch of the neutrino cave including the drift tube veto counters and additional shielding which surround the detector.

A separate high-voltage pulser¹ will be used to trigger each module of 10 flash chambers.² The monitor system will check that the pulse-chamber combination is working within its design criteria. These criteria have been established to ensure that the chambers and the data collection system operate with high efficiency and without extra cell firings. In addition, a malfunctioning system would be a safety hazard,

Fig. 1. Sketch of the neutrino cave.

the radiated noise could increase which would cause serious problems to adjacent equipment, and the energy levels are sufficiently high to destroy components of the system.

II. PULSER-CHAMBER REQUIREMENTS

The flash chambers (Fig. 2) consist of extruded polypropylene plastic confined between two conducting plates. Aluminum foil (0.025-mm thick) is used to form the plates. One will be pulsed to high voltage, the other will be at ground. A noble gas mixture (typically neon and helium) fills the cells in the polypropylene. When a particle passes through the chamber, it ionizes some of the gas. If the passage of this particle, as sensed by scintillation counters meets the trigger requirements, a voltage pulse of 5 kV and 500-ns long will be applied to the flash chambers. This causes an avalanche near the track which propagates down the chamber as a plasma that can be detected electronically.

Fig. 2. Flash chamber construction.

Ten flash chambers will be sandwiched together to form one module. Figure 3 shows the physical hookup and termination of one module to a pulser. The complete system will require 40 pulsers operated in parallel. The pulser output must develop 5 kV across a load of 0.5Ω with a pulse width of 500 ns, and for proper formation of the plasma, a di/dt greater than 1 MA is needed. Figure 4 shows the schematic of the pulser that will be used. It is comprised of a HY1313B grounded grid thyatron and 10 pulse-forming networks

Fig. 3. Physical layout of pulser and load.

(PFN). The PFNs will be charged to a dc voltage. When an event is detected, the HY1313B will be triggered connecting the PFNs to the flash-chamber load which will discharge the PFNs forming the high-voltage pulser.

In the plastic flash chamber described above, the efficiency is typically 90% and usually only one cell yields a signal. If the applied voltage pulse is too large or the pulse width too wide, the chamber will suffer flash-over problems, a condition in which photons and/or electric field disturbances cause an adjacent cell to discharge spontaneously. If the pulse height is too low, the plasma arising from the presence of a nuclear particle will not form and no data will be present. If the pulse width is too narrow, the plasma will not propagate down the cell and will not be detected.

If one of the chambers or interface cables develops a short, two events will occur: The first, most important, would be the potential shock for personnel; the second would be the destruction of the pulser due to high current reversals in the storage capacitors of the pulse-forming networks.

Fig. 4. High-voltage pulser.

III. MONITOR SYSTEM

The monitor must be able to detect the high-voltage pulse and its width for all 40 high-voltage pulsers with a precision of $\pm 5\%$. This level will ensure that the chambers will be working within a few percent of maximum efficiency, optimum resolution, and that the chambers and interface cables are being operated at a safe level. Figure 5 shows the overall block diagrams of the monitor which will convert the signals and be controlled by a microprocessor.

Fig. 5. Monitor system.

Each pulser will have a 1000:1 voltage divider network to reduce the high-voltage pulse height to ≈ 5 V. All 40 pulsers will develop their pulse at the same time dictating the use of a sample-and-hold circuit. The sampled signals must be held until the microprocessor is ready to read the signals. By using an integrating sample-and-hold, the sampled signal is proportional to the total charge in the pulse. The high-voltage pulse is from a low impedance source so the pulse will be gated through a FET switch to the integrator. The sample circuit has a high impedance input so the accuracy of the integrator will not be degraded by a low load impedance. The integrated pulse is held in the sample-and-hold gate until the microprocessor is ready to read it out. When the microprocessor detects an event pulse from an input port, it will issue a read pulse to an 8-bit ADC, then wait 25 μ s for conversion of the sampled signal. After conversion, the 8 bits from the ADC are read into the microprocessor and compared with an upper and lower limit.

Figure 6 shows the flow diagram of the software needed for the system. If the charge is outside the tolerance

Fig. 6. Flowchart.

limits for five consecutive samples, a warning will be issued to the experimenter. If the experimenter has not issued a reset by the time the pulse is outside the limits for 20 consecutive times, that pulser will be shut off. All the signals will be multiplexed into one input port.

The filament, bias, auxiliary grid, and high-voltage supply voltages of each pulser will be monitored to $\pm 10\%$ to ensure the tube has the proper operating parameters. This information will also be available to aid in troubleshooting a defective pulser.

The filament, bias, auxiliary grid, and high-voltage supply are all dc voltages. Divider networks will lower the voltages to the proper levels. The voltages will be multiplexed into one 8-bit ADC and read into the microprocessor after the high-voltage pulse has been processed. This is done after the processing of the high-voltage pulse. If one of the voltages is outside its limits, a warning will be issued to the experimenter. If a pulser is disabled due to the high-voltage pulse being

incorrect, the experimenter will be told which pulser and the voltage readings.

IV. PERFORMANCE AND CONCLUSION

The basic design of the system has been tested. The circuit output data was read into an Intel 8085 microprocessor to evaluate the system accuracy and linearity. The width of the pulse could be resolved to within $\pm 1.2\%$ and voltage to within $\pm 2\%$. Linearity was within ± 3 channels over the full range (Fig. 7). The filament, bias, auxiliary grid, and high-voltage supply could be monitored to $\pm 1\%$.

Fig. 7. Input pulse (relative charge).

The performance of the circuit is well within the design limits necessary to achieve safe, reliable operation of the pulser-chamber system. It will assure the experimenter that the data being received are within the defined system operating limits. This system could also be used to monitor photomultiplier tube high voltage, multiwire proportional counter high voltage, and high-voltage pulse power applications.

REFERENCES

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