01 Dec 1972

System For Data Acquisition From High Voltage Terminals

George W. York

John T. Park
Missouri University of Science and Technology, parkj@mst.edu

James J. Miskinis

David H. Crandall

et. al. For a complete list of authors, see https://scholarsmine.mst.edu/phys_facwork/2410

Recommended Citation

G. W. York et al., "System For Data Acquisition From High Voltage Terminals," *Review of Scientific Instruments*, vol. 43, no. 2, pp. 230 - 232, American Institute of Physics, Dec 1972.
The definitive version is available at https://doi.org/10.1063/1.1685600

RESEARCH ARTICLE | NOVEMBER 04 2003

System for Data Acquisition from High Voltage Terminals

George W. York; John T. Park; James J. Miskinis; David H. Crandall; Victor Pol

Rev Sci Instrum 43, 230–232 (1972)
https://doi.org/10.1063/1.1685600

System for Data Acquisition from High Voltage Terminals*

George W. York, John T. Park, James J. Miskinis, David H. Crandall,† and Victor Pol
Physics Department, University of Missouri–Rolla, Rolla, Missouri 65401
(Received 20 September 1971; and in final form, 18 October 1971)

An inexpensive data acquisition system has been designed to provide high voltage isolation for data acquisition in analog, digital, and pulse modes. The telemetry system uses GaAs light sources, fiber optics, and phototransistors to accomplish the data transmission. Prewired logic boards have been adapted to accomplish the timing and logic functions. Seven decades of digital data are transmitted error free, pulse data can be transmitted at rates up to 1 MHz, and analog data are transmitted with 0.05% full scale accuracy.

INTRODUCTION

The data acquisition system to be described was designed for use in the heavy ion energy loss spectrometer at the University of Missouri–Rolla,[1] but uses techniques which can be of value in other applications involving information retrieval or system control at high voltages. The spectrometer is used to obtain spectra, differential in energy loss, for heavy ions passing through gaseous targets.[2] In order to obtain the high resolution (~0.7 eV) necessary to obtain information about atomic inelastic processes, an acceleration–deceleration technique is used. Both the accelerator and decelerator terminals are maintained at high potential, with a small potential difference ΔV between them, which establishes the energy-loss scale. The transmitted energy-analyzed ion current I is measured at each setting of ΔV. By slowly varying the potential difference between the terminals, an energy-loss spectrum can be obtained.

The technique requires the accurate measurement of ΔV and of the corresponding ion current I, either in the form of a pulse count or as an analog current. The mode of operation, however, places the detectors in the high-voltage (20–200 kV) decelerator terminal. Pairs of data points (ΔV, I) must therefore be transmitted to receivers at ground potential for recording. The data from the detectors are in digital, analog, and pulse modes so that an accurate telemetry system had to be devised to permit transmission in all three modes.

I. APPARATUS

A schematic diagram of the data acquisition system including the telemetry system is shown in Fig. 1. The digital voltage programmer and the ΔV voltage supply as well as the ion current detectors are located in the high voltage terminal, while the counter and high speed paper tape punch are located at ground potential.

The optical telemetry techniques used to obtain the data from the high voltage terminal have been used previously[3] for physical isolation of detection and measurement apparatus. In the present experiment, two types of signals are transmitted. The energy loss scale is established digitally by means of low frequency logic level signals, while the relative current requires the transmission of high frequency (~300 kHz) pulses.

Monsanto ME-7 LED's (light-emitting diode) are used for the low-frequency logic signals. These diodes emit 0.5 mW of power centered upon a wavelength of 0.9 μ. The current transmission uses a Monsanto MV-50 which emits at a peak wavelength of 0.65 μ. Both types have a pulse width of 1 nsec.

The output of these diodes is transmitted to ground potential through 1.6 mm diam×1.22 m noncoherent fiber optics channels. These light rods have successfully maintained a potential difference of >200 kV without breakdown.

The digital signals are detected at ground potential by low-speed silicon phototransistors (LS-400).[4] These transistors have a dark current of 25 nA and a light current of 3 mA for an incident power of 9 mW/cm². Their speed is limited primarily by their slow (15 μsec) fall time. The

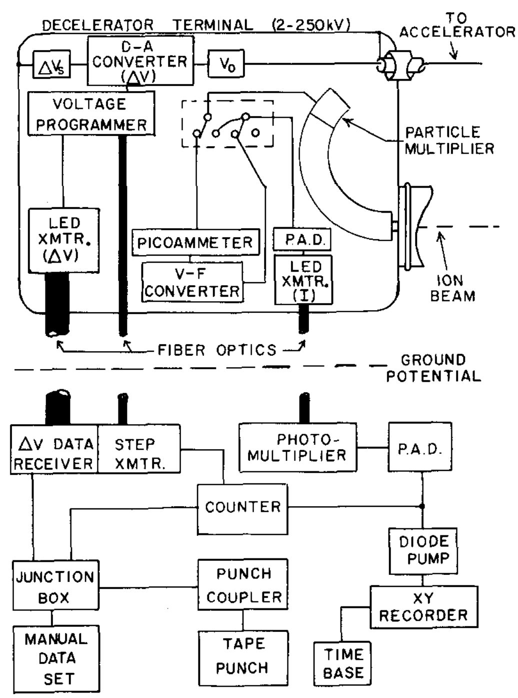

Fig. 1. Schematic diagram of the data acquisition system. The ΔV fiber optics bundle consists of 28 fiber optics channels.

use of these particular devices was dictated by economic considerations. If state of the art phototransistors had been used, this fall time could be considerably reduced with a resultant increase in repetition rate.

The current I is proportional to the ion beam intensity reaching the particle multiplier through the 127° electrostatic analyzer. If the beam intensity is sufficiently low so that counting techniques can be employed, the output of the particle multiplier is applied directly to the pulse amplifier discriminator (PAD). If, however, the beam intensity is high, such that the particle multiplier dead-time prohibits counting, the current is measured by a picoammeter whose analog output is converted by a voltage to frequency (V–F) converter into pulses whose frequency is proportional to the detected current. These pulses then supply the input to the PAD. The discriminated pulses from the PAD are used to drive a LED which converts the data to optical pulses which are transmitted to ground potential.

The optical pulses from the current measurement are detected by means of an inexpensive RCA type 931 photomultiplier. While the quantum efficiency of this tube is low at the peak wavelength of the LED, the light output of the LED is sufficiently high to produce acceptable signals from the photomultiplier. The system has been tested at repetition rates of up to 1 MHz and found to be linear up to that frequency. More sophisticated photomultipliers could be used if higher-frequency transmission were desired. However, in this case, the frequency is limited by the available PAD which is used at ground potential to decrease the inherent noise of the photomultiplier.

The voltage difference between the accelerator and decelerator terminals, ΔV, which establishes the energy loss scale, is set by the output level of a digital–analog (D–A) converter.[5] The output level of the D–A converter is determined by the state of the voltage programmer, which is shown schematically in Fig. 2. The programmer serves

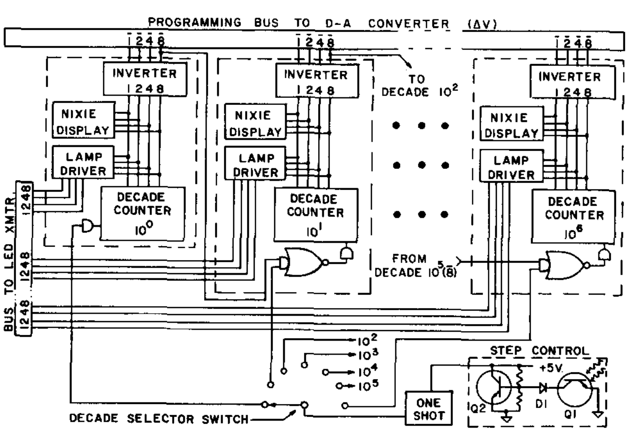

FIG. 2. Schematic diagram of the voltage programmer. All logic modules are of DEC type. Q1 = LS400 phototransistor, Q2 = 2N2219, D1 = 1N483.

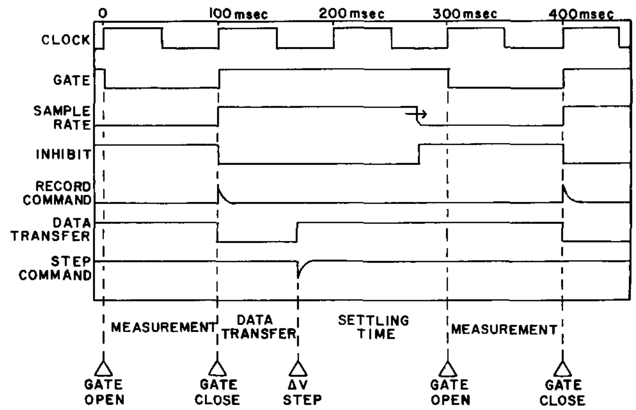

FIG. 3. Timing diagram. Pulse heights are not to actual relative scale.

three basic functions: (1) It provides seven decades of 1248 BCD coding in negative logic levels compatible with the D–A converter; (2) it drives a LED matrix for transmission of the data to ground potential; and (3) it provides a visual readout of the voltage by means of a Nixie display.

The voltage step size is determined by the decade selector switch and the voltage range switch (the latter is not shown). A stepping pulse produced by the counter at ground potential drives a LED which sends an optical pulse through a fiber optics channel to the step control located in the decelerator. The pulse is detected by a phototransistor and transformed into a logic level pulse. This pulse drives the one-shot module which is used basically as a pulse stretcher–inverter in this application. The output from the one-shot is directed to the appropriate decade counter module which simultaneously drives the Nixie display, diode drivers, and inverters. The decade counter modules are set by a high logic level and count when the input steps to low level. Overflow occurs through the use of the NAND gates. When the inverted "8" bit of the preceding decade goes low, the NAND gate output provides a high level to set the decade counter module. When the "8" bit then goes high on overflow, the output of the NAND gate goes low, initiating the count. All of the modules are of the DEC[6] type.

Control of the system is achieved through the use of the internal timing of the counter, which is located at ground potential. A typical timing diagram is illustrated in Fig. 3 for a sample time of 0.1 sec.

Measurement occurs during the period when the counter gate is open, the duration of which is determined by 1 cycle of its internal clock. Upon termination of the measurement, a record command is generated and the coupler transfers the (ΔV, I) data pair to paper tape. After 70 msec has been allowed for data transfer, a step command is generated. This command drives the stepping diode, which transmits an optical pulse to the step control on the voltage programmer, which advances the ΔV power supply one unit.

The system is then ready for another measurement when the counter sample rate multivibrator returns to low level after its preset time. This multivibrator is initiated upon gate closure and inhibits the gate until the multivibrator returns to its stable state. The tape punch coupler also generates an inhibit pulse to prevent data acquisition during the time the punch is in operation. The inhibit gates from both the coupler and the multivibrator must be open before a new measurement can begin. In practice, the multivibrator has the longest duration and hence determines the measurement repetition rate. The duration of the multivibrator pulse is variable from 170 msec to infinity. The D–A converter is thus allowed a minimum of 100 msec to settle to its newly programmed value. After the end of the multivibrator pulse, the gate is free to open again on the first positive going clock pulse and the cycle is repeated.

The digital data for the voltage ΔV and the current I, together with pertinent manual data (graph number, electrometer range, etc.), are then transmitted to the punch coupler, which formats the data and transmits it serially to a paper tape punch for recording.

An analog signal is derived, at ground potential, from the current measurement by a simple diode pump for use as the Y axis of an X–Y recorder. This signal is then plotted against time as a visual aid for the operators.

II. DISCUSSION

The transmission of the seven BCD decades of digital data appears to be error free. Elaborate tests have been employed and to date no transmission error has been detected. The accuracy of the energy loss scale is therefore limited only by the accuracy of the D–A converter itself.

Pulse data can be transmitted at frequencies up to 1 MHz essentially error free. The frequency limit is imposed by the available PAD rather than the telemetry system. It would appear to be relatively easy to push this frequency limit to over 100 MHz.

The accuracy of the analog current measurement is limited by the accuracy of the picoammeter and the V–F converter. The V–F converter is specified from the manufacturer to be linear to within 0.025% from 0–1 MHz. Tests of the linearity of the entire analog transmission system, including the PAD and light optics, yield a value of 0.022% linearity over the entire full scale range. No detectable differences were evident between checks of the system and of the V–F converter alone. A more sophisticated V–F converter could be purchased to further improve the transmission accuracy. However, in our case, the over-all accuracy is limited by the picoammeter, making this additional expense unjustified.

The system has proven to be a very efficient, accurate, and reliable data acquisition device. To date no difficulties have arisen in the telemetry system and the only problems have come from normal wear in the high speed paper tape punch resulting from hundreds of hours of use.

ACKNOWLEDGMENTS

The authors would like to express their thanks to Tom Guilford and Harris Ageno for their assistance in the wiring of the voltage programmer. Technical discussions with B. L. Sterbenz concerning the applications of the DEC flip chips were also much appreciated.

* Work supported by a grant from the National Science Foundation.

† Present adress: J.I.L.A., University of Colorado, Boulder, Colo. 80302.

[1] J. T. Park and F. D. Schowengerdt, Rev. Sci. Instrum. **40**, 753 (1969).

[2] Recent studies of proton impact on various gases include (He) J. T. Park and F. D. Schowengerdt, Phys. Rev. **185**, 152 (1969); (N_2) F. D. Schowengerdt and J. T. Park, Phys. Rev. A **1**, 848 (1970); (CO) J. T. Park, D. R. Schoonover, and G. W. York, *ibid.* **2**, 2304 (1970); and (O_2) J. T. Park, F. D. Schowengerdt, and D. R. Schoonover, *ibid.* **3**, 679 (1971).

[3] R. E. Dannenberg and H. Katzman, Rev. Sci. Instrum. **40**, 640 (1969).

[4] Texas Instruments Corp., Dallas, Tex. 75222.

[5] Model 3330A, John Fluke Corp., Seattle, Wash. 98133.

[6] Digital Equipment Corp., Maynard, Mass. 01754.