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AEC RESEARCH AND DEVELOPMENT REPORT

DIGITAL DATA ACQUISITION AND CONTROL FOR A MASS SPECTROMETER

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DIGITAL DATA ACQUISITION AND CONTROL FOR A MASS SPECTROMETER

by

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ABSTRACT

A digital system has been built to automatically punch mass spectrometer data on IBM cards for computer processing and also to control the acceleration potential of the spectrometer. The system can be operated in two scan control modes with the mass spectrometer, and a data logging mode is provided for other laboratory applications.

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INTRODUCTION

An automatic Residual Gas Analyzer System incorporating an MS-10 mass spectrometer is being used for gas diffusion experiments at the Savannah River Laboratory. The spectrometer has been modified to allow remote programming of the acceleration potential, and a programmable electromechanical relay controller has been built to switch analysis samples. Up to seven gas samples can be automatically analyzed for ions in four separate mass regions. Before a digital acquisition system was developed, output data from the spectrometer were recorded on a strip chart recorder and were sorted and punched by hand for computer processing.

CIRCUIT DESCRIPTION

GENERAL

A digital data acquisition system was designed to read up to eight analog inputs, digitize the data with a miniature digital panel meter (DPM), and punch the binary coded decimal (BCD) output data on cards with an IBM 026 card punch unit.

A data logging operating mode is provided for general data collecting from any analog data source. Data from up to eight inputs can be punched out sequentially, either on demand or automatically at 10-, 60-, or 600-second intervals.

The punch card data format consists of a record containing up to eight data fields of five BCD characters each. The data fields include a sign for each input item. The maximum size of each item is 1999. A new card is automatically started when the maximum allowable number of records has been punched on a card.

The input scanning speed ($\sim$3 inputs/second) is limited by the punching rate of the card punch. To read input data faster a high-speed paper tape or magnetic tape could be used in place of punched cards.

MASS SPECTROMETER OPERATION

When operating with the mass spectrometer, the system provides a 10-volt control signal to vary the acceleration potential

of an MS-10 mass spectrometer. The digital system scans each mass region by recording ion current at 128 equal voltage increments through the region. The system can be operated in either of two modes with the mass spectrometer. In the fast scan mode, the acceleration potential is stepped every 0.1 seconds to give scans of 12.8 seconds. A peak-detector circuit initiates the data punch routine when the ion current from the mass spectrometer is at a maximum. The mass region is scanned 128 times sequentially, which, in effect, charts the time-dependent ion current variations at a given mass number. In the slow scan mode, the mass region is scanned only once in 1280 seconds. The digital system steps the acceleration voltage every 10 seconds and begins punching data 5 seconds after each voltage step.

The usual analog data, when the system is used with the mass spectrometer, consist of ion current, acceleration potential, ion current attenuator, and time reference values. Identification data for sample number and mass number are punched on the first card.

DIGITAL TIMING AND CONTROL LOGIC

Timing pulses to operate the digital system are derived from the 60-Hz line voltage (Figure 1). When the data log mode is active, 10-second (T_{10}), 60-second (T_{60}), 600-second (T_{600}), or externally generated timing pulses operate the punch control circuitry. Slow scan and fast scan modes use the T_{10} and $T_{.1}$ (0.1 second) pulse, respectively, to drive a six-bit binary counter (Figure 2). The binary counter output is converted to a 10-volt analog signal to drive the acceleration voltage control of the mass spectrometer. The 128th count ends the scan for slow scan operation; however, for fast scan mode, 128 scans occur before the stop control logic is activated.

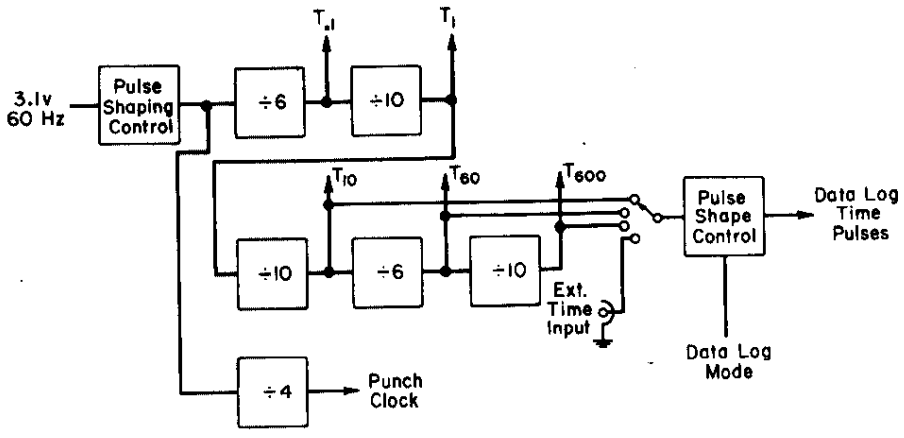

FIGURE 1. Timing Block Diagram

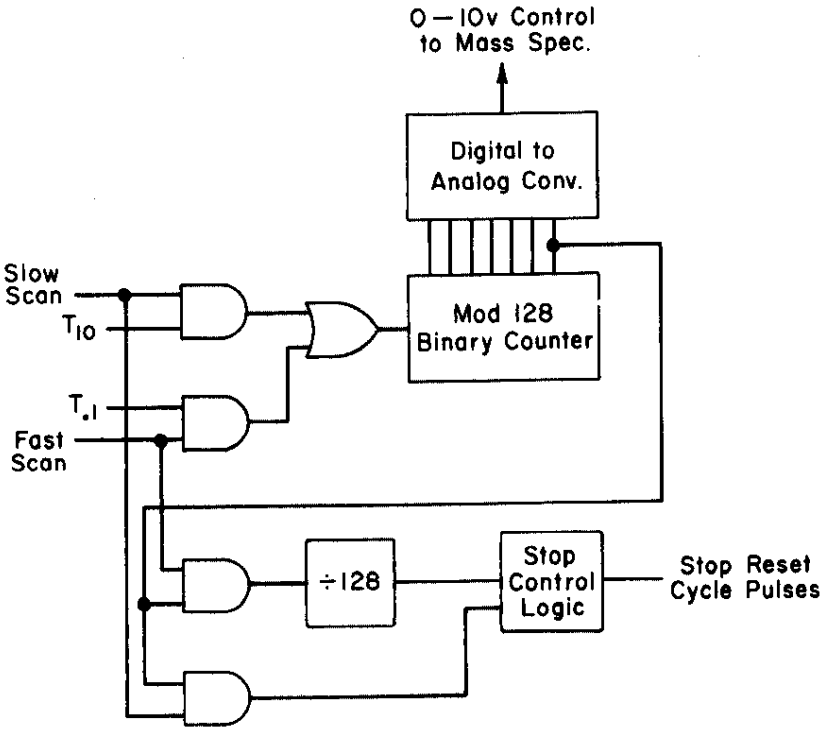

FIGURE 2. Functional Diagram of Scan Control

ANALOG INPUT

Input data of ±5 volts drive eight operational amplifiers connected as noninverting amplifiers to give high input impedance (Figure 3). Gain of the amplifiers can be changed with trimpots. Amplifier 1 is connected to a peak detector circuit that starts the punch cycle in fast scan mode. Outputs of the operational amplifiers are connected to field effect transistor (FET) switches, each of whose output is bussed to provide the ±1 volt analog input to a digital panel meter. The FET switches are sequentially activated by a special Mod 8 circuit. BCD output from the panel meter is connected to the punch decoders.

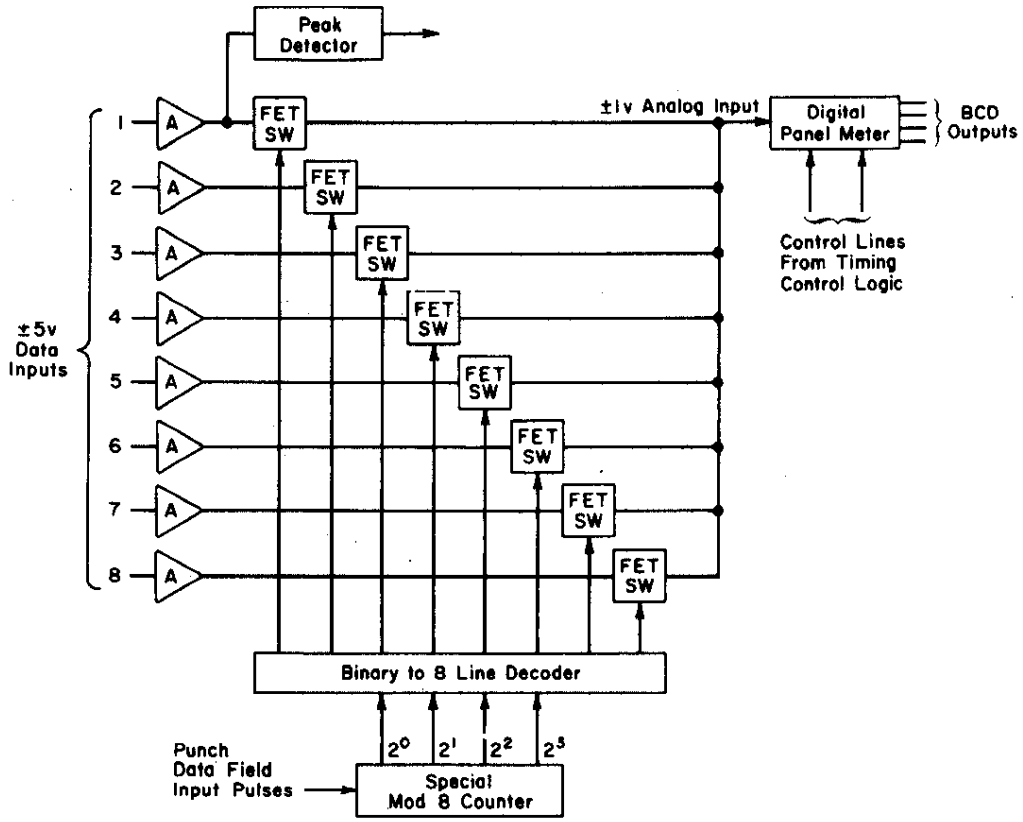

FIGURE 3. Block Diagram of Analog Inputs

PUNCH CONTROL LOGIC

Punch control logic generates a train of six pulses, P1-P6, to control card punch operations (Figure 4). The sign and magnitude of digitized data are decoded with a binary-to-decimal decoder and are punched by P1-P5 pulses. The P6 pulse signals the DPM to digitize the next number. The Special Mod 8 Counter (Figure 5) stops the punch sequence after the number of inputs corresponding to one record has been punched. The first card is released after the identification data and one data record are punched, and all others are released after being punched with as many records as possible.

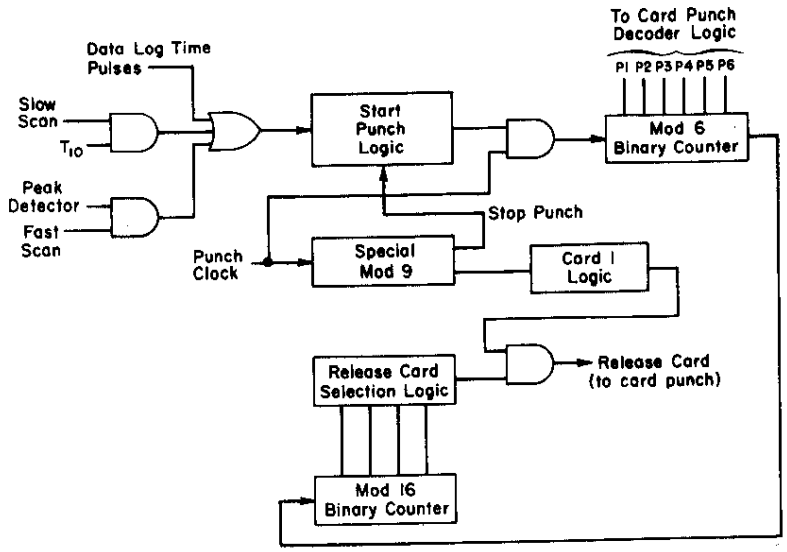

FIGURE 4. Functional Diagram of Punch Control

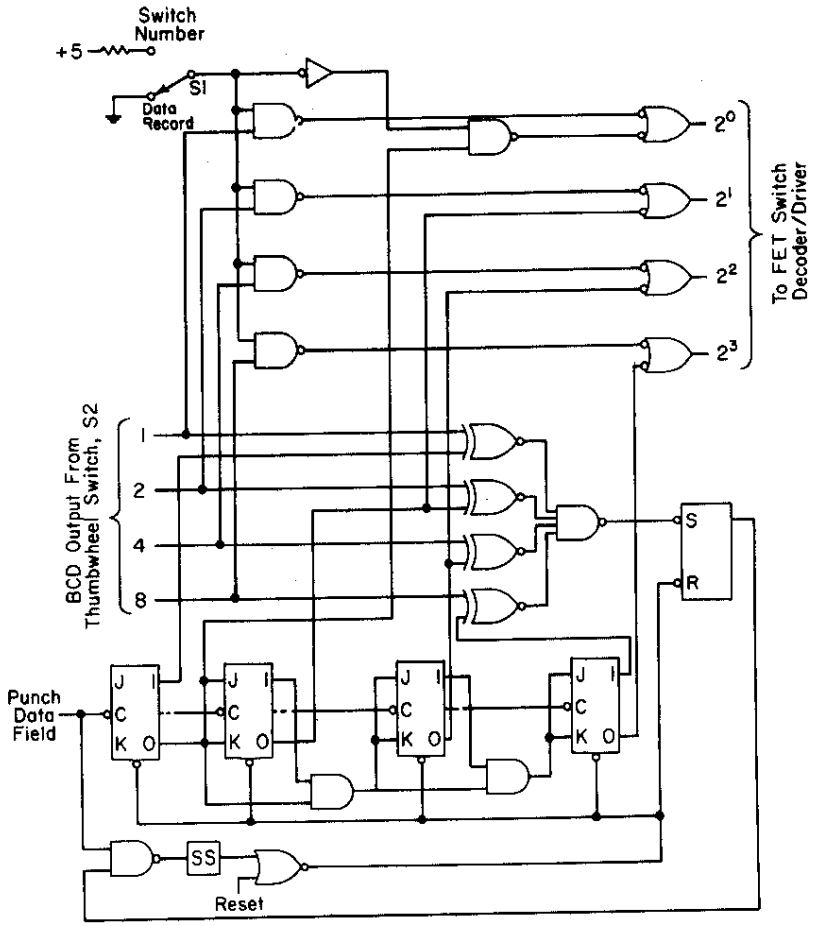

FIGURE 5. Logic Diagram for Special Mod 8 Counter

SPECIAL MOD 8 CIRCUIT

A unique part of the logic circuitry is the Special Mod 8 Counter (Figure 5). A panel selector switch, S1, and a thumbwheel switch, S2, are set to turn on one of the eight FET switches for testing an input or to set data record size at one to eight inputs for scanning. The thumbwheel switch has a BCD output. The four binary output lines from the Special Mod 8 circuitry, 2^0-2^3, turn on the FET switches (Figure 4) through a binary-to-decimal converter.

FABRICATION

The system was built with integrated circuit DIP (dual in-line package) modules, wire-wrapped, and mounted in a drawer (Figures 6 and 7).

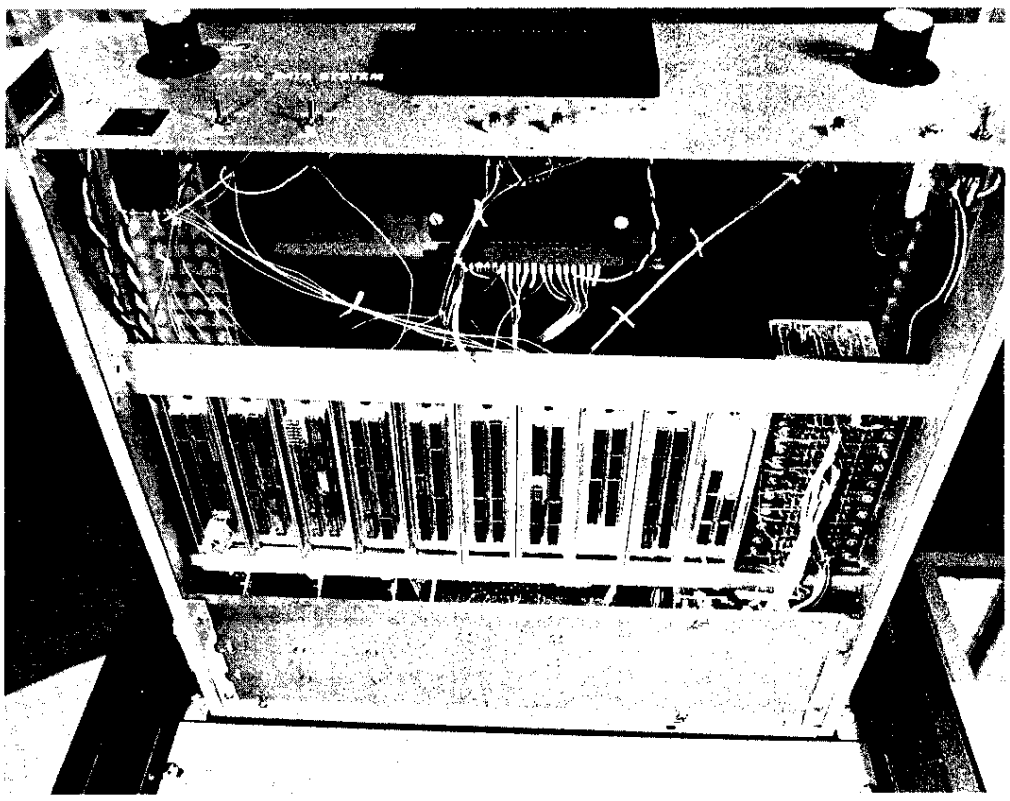

FIGURE 6. Bottom View of Logic Drawer

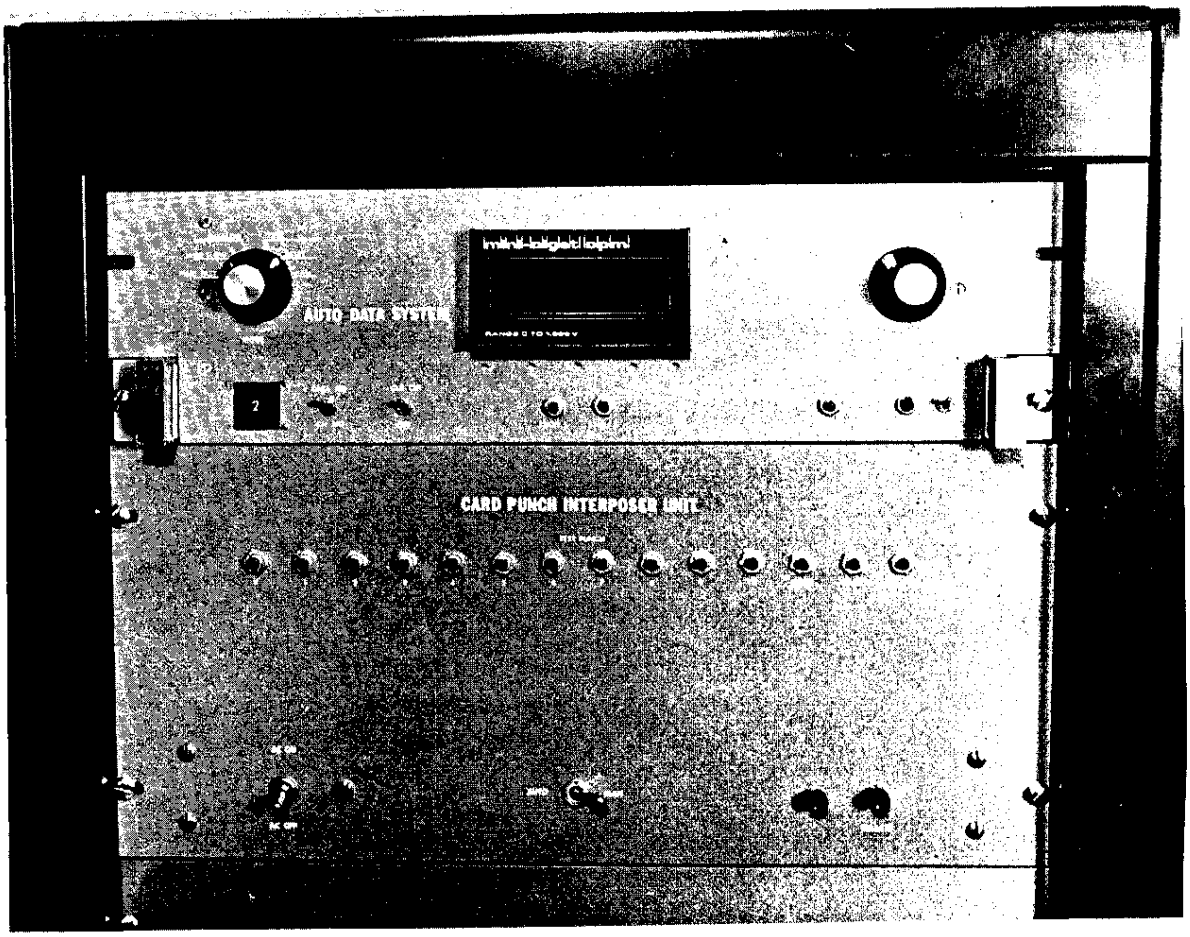

FIGURE 7. Front View of Data Acquisition System