A DIGITAL CONTROL SYSTEM FOR ACCELERATOR OPERATOR--HOST COMPUTER INTERFACE

Iain Tilbrook

Physics Division, Argonne National Laboratory, Argonne, IL 60439

Abstract

A design for a digital control system for use by an accelerator operator is presented. The system is designed to interface the operator to the host control computer. This is done using panel mount rotary optical shaft encoders. Peripheral hardware processes the shaft encoder signals and allows the operator control over signal parameters such as rate-of-change, etc. A design for a remote terminal for data input and control commands, which is in communication with the host via RS-232, is also presented. The overall design maximizes ease-of-use by the operator while flexibility and expandability are increased over the levels afforded by current systems in use at the Argonne Tandem-Linear Accelerator System (ATLAS). Alternative applications and future improvements are also discussed.

Introduction

ATLAS is a heavy-ion accelerator using a 9-MV tandem electrostatic accelerator to inject into the ATLAS superconducting linac. The positive ion injector (PII) project will replace the tandem with a linac of individually-phased superconducting resonators optimized for low-velocity heavy ions [1]. During the planning stages it was decided to take this opportunity to redesign the hardware of the present control system to optimize operator efficiency while maintaining compatibility with the present software.

Discussion

Design Parameters

A turn of a knob that directly produces a linear response at a selected device is the easiest form of control to understand and gives the operator a feel for the effect that the knob produces. The ideal control system is one that mimicks this response.

The present accelerator control system is divided into two sets of controls: one controlling beam transport, the other controlling beam acceleration. The acceleration controls utilize motors to generate a voltage that is converted into digital pulses. The host computer uses these to adjust the selected device. The number of pulses produced from this system depends on the velocity with which the shaft is turned, not the rotational position of the shaft. This non-positional dependence makes exact device manipulation by knob nearly impossible.

The present beam transport controls are push-button actuated. The button sends a train of pulses to a counter that increases or decreases the value of the selected device. The frequency of the pulse train is user selectable. Without a consistent sense of time, however, the operator has no feel for the rate at which the device value is changing. These are serious drawbacks that can greatly impede an operator's effectiveness. The present system was designed to eliminate these problems.

System Overview

The new control system is comprised of 4 lab-built modules (Fig. 2.1), one CAMAC (Computer Automated Measurement and Control -- IEEE 583) module and a Digital Computer Corporation PDP 11 host computer. The original ATLAS accelerator control system utilizes a PDP 11/34 as the host computer while PII utilizes a PDP 11/73. The differences between the host systems do not affect the performance parameters of the 4 lab-built modules.

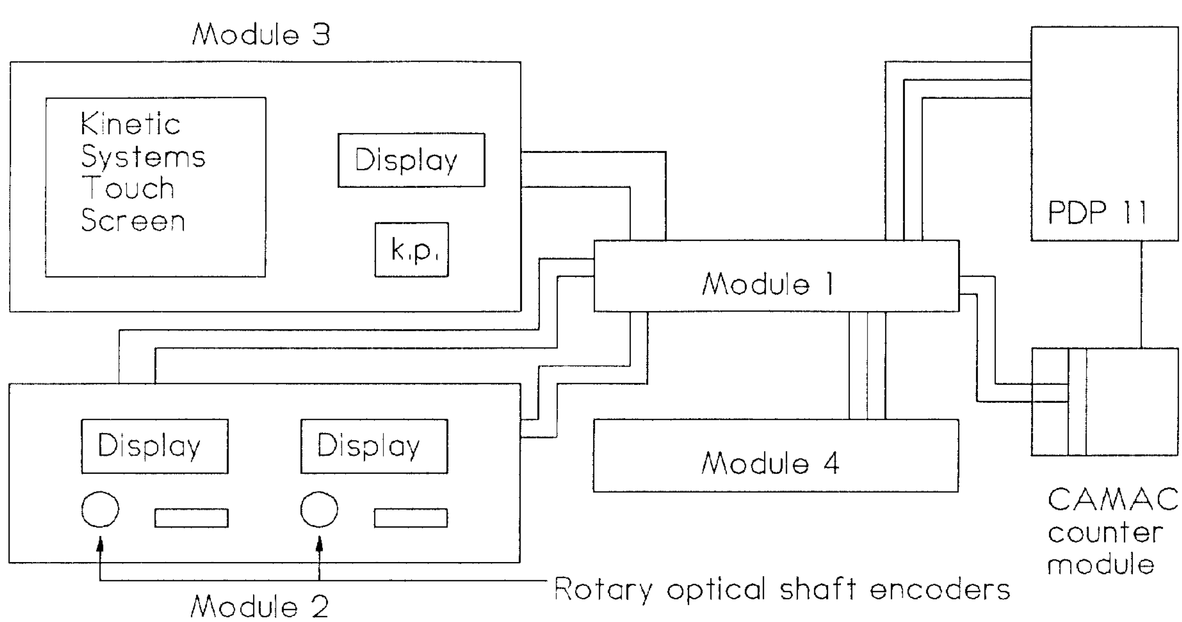

Figure 2.1. Block diagram of new ATLAS control system.

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The one CAMAC module used by the system is the Kinetic Systems 3640 Quad 16-bit Up/Down Counter [2]. This module receives counting pulses from the controls. The net count is read out by the host computer which adjusts the selected device accordingly.

Module 1: The Interpreter: Module 1 in Fig. 2.1 is the command interpreter. This is the heart of the control system. It serves many functions:

1. It encodes the terminal characters from the keypad, the Channel A command buttons, and the Channel B command buttons;

2. it jumpers the data signals received from the host to the appropriate pins for the three vacuum fluorescent displays;

3. it processes the control pulses for the CAMAC counter;

4. it regulates the rate of the control pulses and performs the lock-out function; and

5. it generates the indicator signals for the knobs panel.

The module itself has no externally mounted controls, except for a "Reset" button that resets the data terminal's transmitter.

Module 2: The Control Knobs: This is the primary improvement over the present system. Module 2 consists of two sets of control knobs with displays and control buttons. These are Channel A and Channel B. The control knobs themselves are panel mount rotary optical shaft encoders. The shaft encoder signals are sent to Module 1 for processing and then sent out to the CAMAC counter.

The displays are vacuum fluorescent, 2 lines by 20 characters per line, and they are RS-232 compatible (DECO #DE222A-1) [3] driven by separate RS-232 ports on the PDP 11. The signals are jumpered in Module 1.

The five control buttons serve two functions. Two buttons adjust the count rate and lock out further counts to prevent accidental changes. The three remaining buttons, the command buttons, send commands to the host computer through the terminal port. The preliminary designations for the functions initiated by these buttons are "Save", "Recall", and "Shift". "Save" allows an operator to store the present value of the device. "Recall" allows an operator to load the previously saved value, and "Shift" changes the functions of the two former buttons to as yet undetermined functions.

The panel mount shaft encoders (BEI Motion Systems #PMS3-256) produce two TTL-level pulse trains that are approximately 90 degrees out of phase. Each train produces one pulse for every 1.4 degree of rotation or 256 counts per revolution [4]. Pulse B will lead or lag Pulse A depending on whether the shaft is rotated clockwise or counterclockwise, respectively. The pulse trains are fed into a type "D" flip-flop to encode a "Direction" signal (Fig. 2.2). The pulse trains are also run into an exclusive OR gate to produce the Very Fast signal (512 counts/rev), while Pulse A is fed into a series of binary counters to produce the Fast (128 counts/rev), Medium (32 counts/rev), and Slow signals (8 counts/rev). The "Rate" button controls the data multiplexers that select which pulse rate is passed out.

The processed pulses are mixed with the "Lock" and "Direction" signals. The drivers for the CAMAC counter are mono-stable multivibrators. This is so the drive signals return to a known state when not in use. This avoids unstable hardware interactions while the system is in a waiting state.

Module 3: The Terminal: Module 3 is the data terminal. It consists of a 2 line by 20 characters-per-line vacuum fluorescent display (DECO #DE222A-1) [3] and a 5 x 4 matrix keypad. It is mounted on the same panel as the Kinetic Systems touch screen. Several programs initiated by the touch screen require keypad input. The terminal logic elements are located in the interpreter module.

The logic paths for the terminal are presented in Fig. 2.3. Data from the matrix keypad is encoded into an address by the 74C923 [5]. The encoded address is

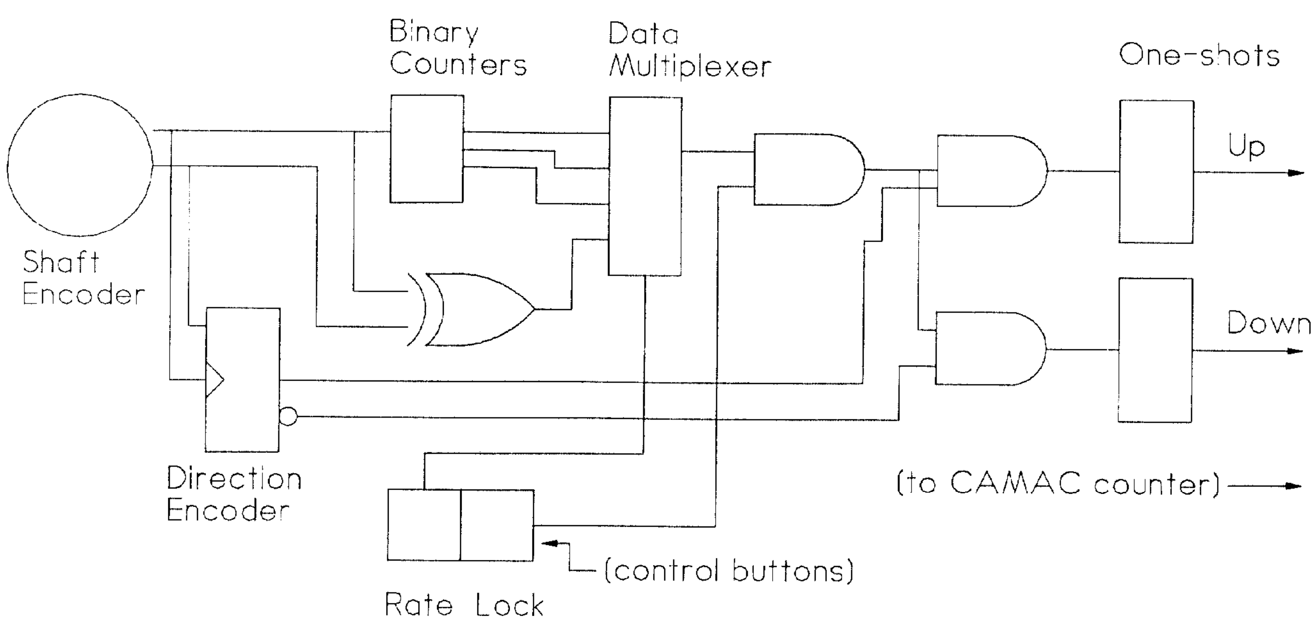

Figure 2.2. Logic diagram for control knobs.

held by the internal latch until the Enable Decoder Logic enables the internal buffer. The PROM (Programmable Read Only Memory), 74S288 [6], presents the ASCII value of the encoded key to the transmitter latch of the UART (Universal Asynchronous Receiver Transmitter), IM6402 [7]. The UART changes the parallel data to RS-232 format serial data which is sent to the host computer by the driver, MC1488 [8].

The terminal also receives data from the command buttons in Module 2. The signals for "Save" and "Recall" are encoded by the 74HC148. The address is latched along with the "Shift" signal and data is passed through the rest of the logic as described previously.

Module 4: The Power Supply: Module 4 supplies power to the three previously mentioned modules. Specifications are as follows:

a) +5 Vdc, 3A;

b) +15 Vdc, 0.1 A; and

c) -15 Vdc, 0.1 A.

Although the terminal and control cards utilize CMOS or high-speed CMOS technology that draws very little current, the three vacuum fluorescent displays draw a great deal of current from the +5 V supply.

Summary

By using panel mount rotary optical shaft encoders, the ATLAS operator is given position-dependent controls that allow him/her to more effectively manipulate devices by removing the need for a consistent sense of time or velocity. The digital nature of the encoder signals greatly simplifies interface to the host computer. This improvement over previous systems in use at ATLAS is further enhanced by control buttons that adjust the sensitivity of the shaft encoder and allow the operator to send commands to the host through the data terminal.

This system, while designed for a PDP 11 computer, will operate with any host using CAMAC and having three RS-232 ports. For power-limited applications the vacuum fluorescent displays may be replaced with liquid crystal displays (LCD's). Future improvements will make use of the unused command inputs (Fig. 2.3) to add functions such as automatic zeroing and automatic scaling of values.

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References

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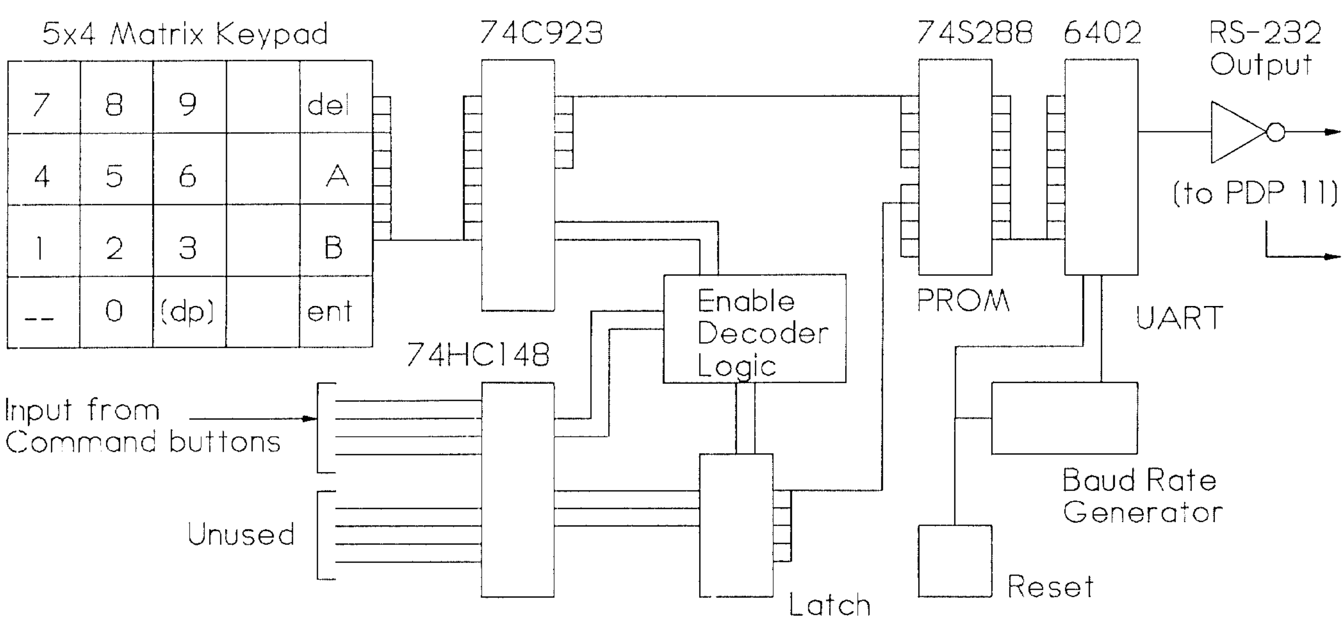

Figure 2.3. Logic diagram for data terminal.