HARDWARE ASPECTS OF THE IUCF CONTROL SYSTEM+

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Abstract

A variety of standard hardware has been developed to link the Sigma 2 control computer to the Indiana University cyclotron. Monitoring of analog signals is accomplished by using dual ramp, integrating analog to digital converters of the 11 bit or 14 bit variety. Up to 16 channels may be multiplexed to each converter. The control of power supplies is accomplished by using 12 bit or 16 bit digital to analog converters, which may be optically isolated if required, or by motor-driven potentiometers. Movement of probes or slit assemblies is accomplished via stepping motors with feedback obtained from a mechanical counter with electrical readouts or from potentiometers. A standard on/off circuit has been developed which is applicable to power supplies as well as to solenoid operated devices such as beam stops and valves.

1. Introduction

A description of the control system for the Indiana University Cyclotron Facility (IUCF) has been described in detail elsewhere[2]). Essentially, it consists of several hundred cyclotron devices and several operator stations linked to a central computer via a decentralized digital multiplexer system 2). To facilitate the linking of the various cyclotron devices to the digital multiplexer a number of standard analog and digital modules have been developed. These include a 16 channel multiplexer and integrating A/D converter with memory, 12 bit and 16 bit D/A converter modules, a floating A/D and D/A converter module, stepping motor drive modules, and an on/off control module.

2. Hardware

2.1 Analog Data Acquisition

Rather then build an analog data acquisition system featuring one central fast A/D converter with a several hundred channel analog multiplexer, the decision was made early to have many A/D converters, each with a limited number of channels, distributed throughout the facility. This eliminated many long cable runs and their associated noise problems. It also permitted the use of slow integrating type A/D converters, which also helped to minimize noise problems.

A dual ramp integrating type A/D converter with a maximum sampling rate of 200 samples per second was chosen. The maximum number of channels multiplexed to any one converter was limited to 16. This enabled the computer to sample and display all channels of a particular A/D converter at least 10 times per second, which has proven to be more then adequate. The normal scanning rate for updating displayed variables is 2 times per second.

Initially, the system worked on an interrupt basis. After selecting the desired channel of a particular A/D converter, the acquisition program would exit. An interrupt would be generated at the completion of the A/D converter cycle. The acquisition program would then re-enter read the value, and proceed to its next step. To minimize software overhead, this system was eventually modified. The interrupt feature was eliminated and a 16 word, 16 bit memory was added to the A/D converter as shown in figure 1. In this system the A/D converter continuously scans all of its associ-

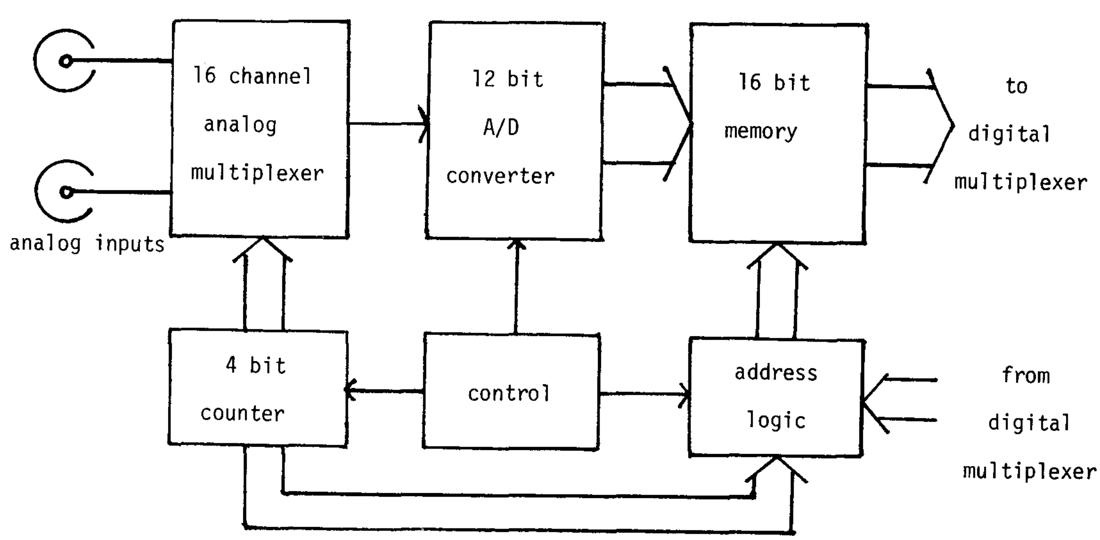

Figure 1. Block diagram of self-circulating analog multiplexer and A/D converter system

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ated channels sequentially and stores the result in its memory. When the acquisition program desires data, it must only generate the proper address and read the value immediately.

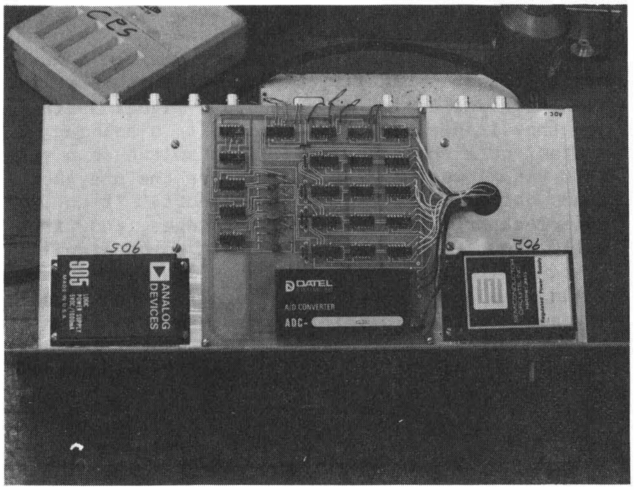

Figure 2. Self-circulating A/D system. Converter in center, flanked by power supplies and logic. Not shown (underneath) is analog multiplexer. Inputs are at rear.

2.2 D/A Converters

Two standard D/A converter modules for controlling power supplies have been developed. One type contains a 12 bit D/A and a storage register; the other uses external storage and has only a 16 bit converter (shown below). Full scale output may be either ± 5 V or 0-10 V.

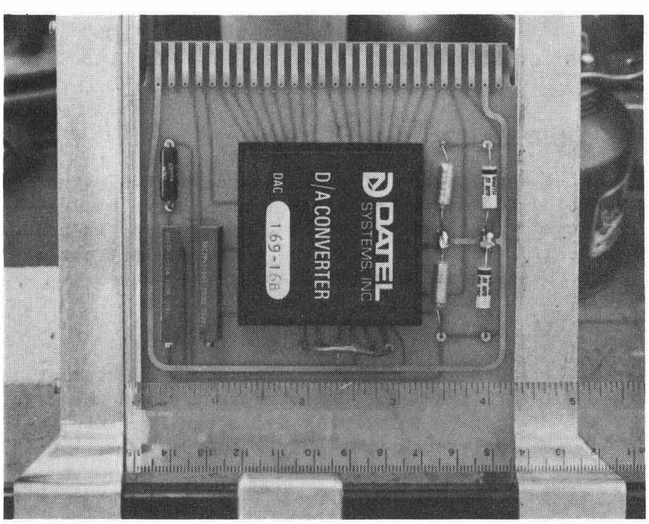

Figure 3. 16 bit D/A converter mounted on standard 52-pin card.

2.3 Floating A/D and D/A module.

The remote programming and monitoring provisions of some power supplies require devices that are not referenced to ground, but to some point tens or hundreds of volts above ground. To meet these requirements a module containing an optically isolated D/A converter and a transformer coupled A/D converter was developed. A block diagram of the module is shown in figure 4 and a photograph of a typical module in figure 5. Full scale output of the D/A converter can be $\pm$ 5 V or + 10 V. and the full scale input of the A/D converter can be $\pm$ 200 mv. or $\pm$ 2 V, depending on the particular model chosen.

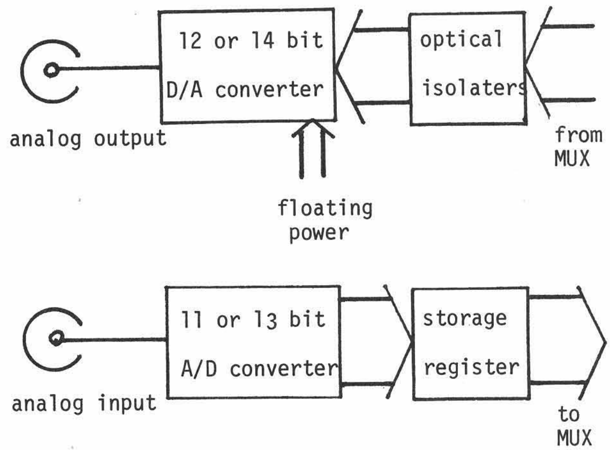

Figure 4. Block diagram of floating power supply control module

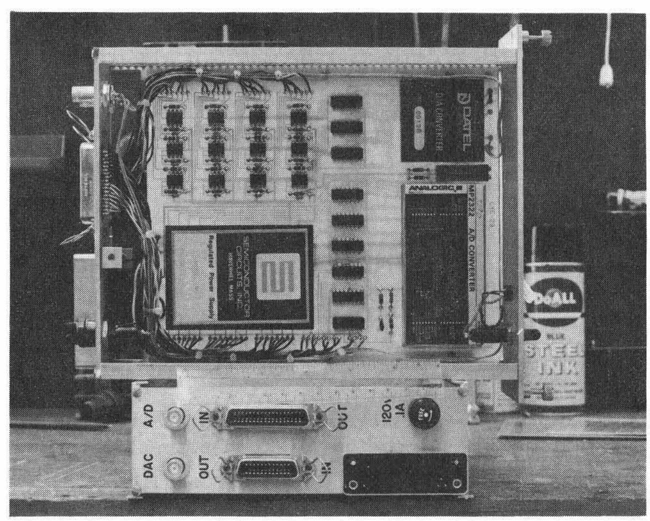

Figure 5. Floating power supply control module. Top view (upper module) shows all components. Rear view (lower module) shows digital and analog inputs and outputs, connector to power buss.

2.4 Stepping Motor Drive Modules

Many motor-driven devices such as probes, slit assemblies, and tuning capacitors are required in the operation of the cyclotron. "Slo-Syn" type SS and type M stepping motors and translator modules were chosen for this purpose. Four SS translators or two M units are housed in a single chassis, and linked to the computer as shown below. One 16 bit word controls up to 4 motors. 8 bits select which motors are to move, and the direction (s) of rotation. One bit selects a common high or low speed, and the remaining 7 bits are loaded into a preset down counter. When the counter has reached zero the motions cease and interrupt is returned to the computer, allowing a dormant program to restart.

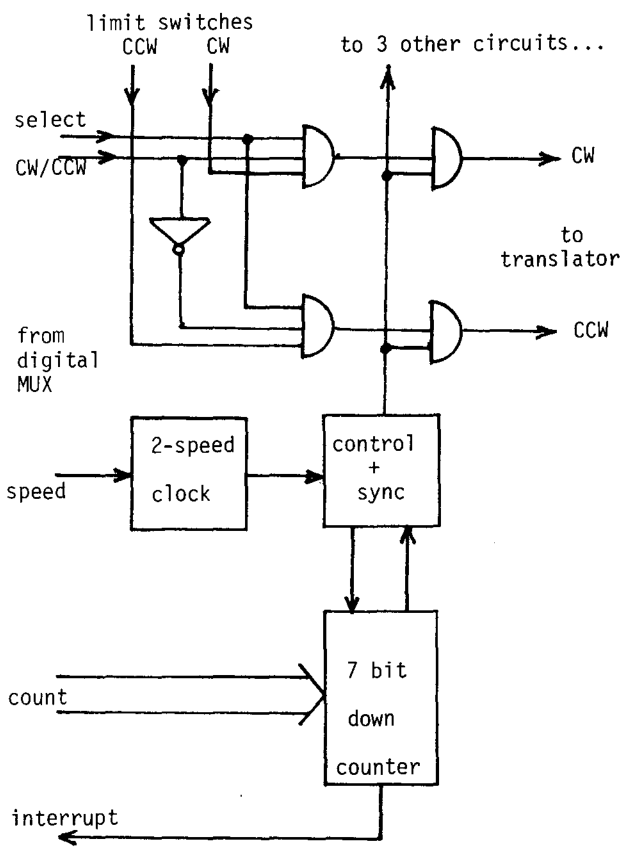

Figure 6. Simplified block diagram of stepping motor drive control circuitry.

To provide feedback to the computer from the actual mechanical motion, 10-turn potentiometers are used where accuracies less then .5% are adequate. For higher accuracies, mechanical counters with BCD electrical readouts, such as those made by Veeder-Root, are used.

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2.5 On/off Control Modules

A standard module for on/off control of power supplies, valves, beam stops, and other devices requiring two position control was developed. The module accepts four interlock signals and a local remote select bit. A 1 to 0 transition at the selected input triggers a one-shot which enables a drive transistor to energize the selected device via an optically coupled solid state relay. The energized device must return a signal indicating that it has been energized (i.e. a holding contact on a contactor or a limit switch on a valve). This signal must be returned before the one-shot times out or the device will shut off. If an interlock trips while a device is energized, it will turn off and remain off until an on signal is re-generated. The module provides four status signals to the computer: a "local/remote" signal, a "ready" signal (all interlocks satisfied), an "on" signal, and a fault" signal (interlock tripped). Signals for energizing local lamps are also provided.

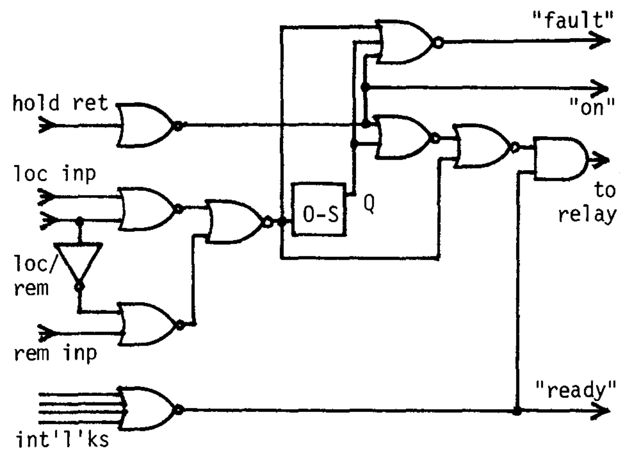

Figure 7. Logic diagram of ON/OFF circuit. Lamp and relay drivers omitted. "Low" is true for all inputs; "high" is true for outputs.

3. Conclusion

The development of a few standard modules has enabled the rapid interfacing of a large variety of cyclotron devices to the computer. As an added benefit, the required software development could also be reduced to a few standard segments.

4. References

1. B. M. Bardin, S. A. Lewis, D. J. Plummer, T. E. Zinneman, "Computer Control of the Indiana University Cyclotron Facility," AIP Conference Proceedings No. 9, 1972, 490-497.

2. T. E. Zinneman, B. M. Bardin, "I.U. Accelerator Control System Digital Multiplexer", IEEE Transaction on Nuclear Science, NS-20 616 (1973).