Personal computer-based CAMAC system for data acquisition

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Abstract. A single board auxiliary CAMAC crate controller for a Z80-A based personal computer ZX-spectrum to drive the CAMAC crate housing multiple ADC, TDC, DAC and 16 I/O ports has been developed. The CAMAC crate controller used in this system is of A2 type which supports multiple auxiliary crate controllers. A CAMAC exerciser/training software for the use of CAMAC commands in process control as well as data acquisition has been developed.

Keywords. Personal computer; Z80-A CPU; CAMAC; auxiliary crate controller; CAMAC trainer software.

1. Introduction

Data gathering and analysis in experimental sciences has been undergoing a major revolution in the last quarter of this century due to the appearance of low cost digital computers. It has significantly altered the instrumentation around an accelerator or a nuclear research reactor, which are being increasingly made with built-in micro-processor (μP). These inexpensive μP can very easily and rapidly transform the raw data into elaborate computed results in a user friendly form. We are all aware of the concept of modularity in nuclear electronics equipment. The first internationally accepted standard in nuclear electronics is the well known NIM standard. As digital information began to supplement the analogue instrumentation in nuclear environment a new standard CAMAC (computer automation in measurement, acquisition and control) was designed about a decade ago by ESONE group (EUR 4100e, 1969). It is now being widely used in industrial process control and nuclear instrumentation around a reactor or in an accelerator laboratory. A very large number of CAMAC modules e.g. intelligent crate controllers (CC), analog-to-digital converters (ADC), multichannel digital-to-analog converters (DAC), time-to-digital converters (TDC), scalars, motor controllers, are available off the shelf from a number of competitive vendors. One can easily configure spectrometer, or a multiparameter data acquisition system or an accelerator control panel using these standard CAMAC modules. The use of CAMAC-based systems is being favoured (Satyamurthy and Kataria 1984) since one can easily enhance or reconfigure the system using alternate functional units in the CAMAC crate. Kataria (1984) had earlier developed a pulse height analyzer and data analysis system based on Sinclair ZX-spectrum personal computer. In the present work we report the interfacing of the ZX-spectrum (PC) through a locally designed auxiliary crate controller (ACC). In this way, we can easily use the various standard CAMAC modules without any further hardware interfacing.

2. System configuration

The present CAMAC based data acquisition system consists of a single CAMAC crate with A2 type controller, a 12-channel ADC, an 8-channel TDC and a dataway display module. The A2 type controller supports intelligent modules and auxiliary crate controllers within a single crate for local data processing and control. In the present work, we report an ACC which communicates to the CAMAC dataway on the one hand and to a personal computer Sinclair ZX-spectrum on the other. Figure 1 shows the system configuration.

Personal computer ZX-spectrum is based on Z80-A, 8-bit CPU and has in-built interfaces for use of a standard TV as display unit and for an audio cassette recorder as a program/data storage device. It has its own keyboard and thermal printer. Its basic interpreter is in 16K ROM and 48K RAM is available to the user for his software. For interfacing to user equipment the Z-80 bus (address, data and control lines) is available on a 56 pin connector.

2.1 ACC design fundamentals

The ACC has been designed to fully conform to the standards described in ANSI/IEEE Std. 675-1982. This standard has been defined so that many intelligent ACC can reside in the same crate and process locally the data and control without any conflicts. The ACC functions, in conjunction with A2 type controller residing in CAMAC crate station Nos 24 and 25, on various modules residing in other normal stations, in the crate. Since the

Figure 1. Typical system configuration.

facility to address or to respond to any normal station is given through the crate controller (CC) in order to accommodate ACCs, two features are required: (i) access to the N and L lines at normal stations and (ii) priority arbitration for control of dataway.

Access to the N lines is necessary to allow an ACC to issue a complete addressed command operation. Access to the L-lines is necessary for an ACC to respond to "look at me" (LAM) signals from the modules or controllers or both. Priority arbitration protocol ensures that at any time only one controller is permitted to have control of the crate. It also provides the means for assigning control of the dataway on the basis of preassigned priority. Access to the N and L lines and other signals necessary for priority arbitration protocol is provided through auxiliary controller bus (ACB) as shown in figure 2.

2.2 Hardware developments

Figure 2 shows a general block diagram of the ACC developed in-house. Data transfers over Z-80 bus is 8-bit wide and on CAMAC dataway it is 24-bit wide. As shown in the block diagram, ACC first assembles the CAMAC commands from the information received from personal computer properly in accordance with the CAMAC dataway protocol, then it raises request flag (Req) for taking command of dataway. After getting grant-in, ACC starts its dataway cycles operation. During the dataway operation, the status of X, Q and B signals are latched. During CAMAC read operation, it latches the information from R-lines, so that one can transfer the 24-bit data to personal computer byte by byte later on. Wired OR (VECTOR) interrupt facility is provided for L lines, so that the personal computer can respond to the request from the modules for servicing. In the present system, the data are being acquired in interrupt mode.

In the present design, two modes of priority arbitration protocol have been provided (i) request/grant (R/G) and (ii) auxiliary controller lockout (ACL); the preferred mode is the R/G protocol. In this mode, when a request is raised, it checks for grant-in signal. If grant-in is present, busy and request inhibit signals are generated and the sequence of timing signals for dataway operation is started. If grant-in is not present i.e. dataway is already in command of some other controller, the auxiliary controller requesting dataway, waits for that operation to be completed. In R/G protocol, this type of delay is to be accounted for. In ACL mode, where a controller cannot wait for this delay, the dataway operation of lower priority controller will be aborted and dataway will be given to higher priority controller. The lower priority controller will resume its operation subsequently.

3. Functional description

ACC receives the CAMAC commands operation to be performed on CAMAC modules from personal computer. During addressed command operation, it generates the 5-bit binary code (EN) for the station number associated with the command and then transmits it via the EN lines of the ACB. The CC receives this station number code (EN) decodes it and then addresses the appropriate normal station. AC also establishes other necessary signals on the B, AN, FN, S1 and S2 lines appropriate for the command operation to be performed and to define the timing of the operation. During addressed command operations involving data, the ACC transmits or receives data via W or R lines. The

Figure 2. Block diagram of auxiliary crate controller.

unaddressed operations, e.g. dataway initialize Z and dataway clear C, do not require use of EN-signals of the ACB. But ACC still establishes the necessary signals B, S1 and S2 and Z or C lines. Figure 3 shows the sequence of signals for an ACC to gain control of dataway for an addressed command operation.

3.1 Software developments

A general purpose software for training in the use of various CAMAC commands has been developed. In the help mode (H), the software displays at a glance all the CAMAC commands e.g. common control commands Z, C, I and dataway commands. In debug-mode (D), one can execute each CAMAC command one by one, using friendly mnemonic symbols (R for read, W for write) and thus debug the CAMAC modules and the associated software. In one session with the training software, one achieves remarkable familiarity with CAMAC system. In the extended mode (X), one can easily write CAMAC subroutines for data acquisition from multiple units in CAMAC crate and debug them extensively from both the software and hardware aspects. This software is written in BASIC language, and can therefore be easily transported to other personal computers.

A dedicated software package for multiparameter data acquisition using a 12-channel nuclear ADC and a 8 channel TDC and display and test module has also been written. In order to achieve faster rate of data acquisition, parts of the software are in machine code e.g. the interrupt service routines, real time one and two parameter data display routines etc. The main program controlling the data acquisition, and setting up the various initial conditions e.g. (choosing the no. of ADC, TDC) is in BASIC language, and has been planned carefully keeping in view the needs of the experimentalists. After defining the parameters of an experiment, the data acquisition is carried out using

Figure 3. Sequence of signals for an ACC to gain control of dataway for an addressed command operation.

interrupt facilities; and data display and control is carried out in the background. A number of BASIC routines for spectrum analysis are also available and further they are easy to modify to suit the individual requirements of the experimentalists. At present, the acquired data can be stored only on audio cassette tape at a speed of 1100 baud rate.

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