

DATA ACQUISITION SYSTEM

C. D. Cirstea, S.I. Buda, F. Constantin

(Received June 22, 2005)

1. Introduction

A multi parametric data acquisition system was developed around a four input Analog to Digital Converter (AD413A CAMAC Quad 8K) with four independent analogical inputs, working in CAMAC Standard.

This embedded system (software and hardware) consists of the following elements:

- microcontroller PIC 16C745/765;
- hardware interface for multiplexing and generating CAMAC specific signals;
- specific software.

The system emulates the functionalities of a CAMAC controller, collecting data from ADC.

The data transfer is possible by the microcontroller USB interface. The data are transferred to a PC, where is working an emulation program of a multichannel analyzer. The software was developed around the microcontroller that takes and transmits the information.

2. PIC 16C745/765 microcontroller

The PIC16C745/765 devices are low cost, high-performance, CMOS, fully-static, 8-bit microcontrollers in the PIC16CXX mid-range family.

All PIC microcontrollers employ an advanced RISC architecture. The PIC16C745/765 microcontroller family has enhanced core features, eight-level deep stack and multiple internal and external interrupt sources. The separate instruction and data buses of the Harvard architecture allow a 14-bit wide instruction word with the separate 8-bit wide data. The two stage instruction pipeline allows all instructions to execute in a single cycle, except for program branches, which require two cycles. A total of 35 instructions (reduced instruction set) are available. Additionally, a large register set gives some of the architectural innovations used to achieve a very high performance.

The PIC16C745 device has 22 I/O pins. The PIC16C765 device has 33 I/O pins. Each device has 256 bytes of RAM. In addition, several peripheral features are available including: three timer/counters, two Capture/Compare/PWM modules and two serial ports. The Universal Serial Bus (USB 1.1) low speed peripheral provides bus communications. The Universal Synchronous Asynchronous Receiver Transmitter (USART) is also known as the Serial Communications Interface or SCI. Also, a 5-channel high-speed 8-bit A/D is provided on the PIC16C745, while the PIC16C765 offers 8 channels. The 8-bit resolution is ideally suited for applications requiring a low cost analog interface (e.g., thermostat control, pressure sensing etc.).

3. Analog-to-Digital Converter Module

The 8-bit Analog-To-Digital (A/D) converter module has five inputs for the PIC16C745 and eight for the PIC16C765.

The analog digital converters provide a numeric (binary) representation of the analog signal applied at their input. Two of the most important characteristics of an analog digital converter are the resolution and the conversion rate. The conversion rate (sometimes defined by its inverse, the conversion time) expresses how fast the conversion is. The resolution expresses

the closeness degree between the numerical value obtained at the converter exit and the real value corresponding to the analog signal applied at his input.

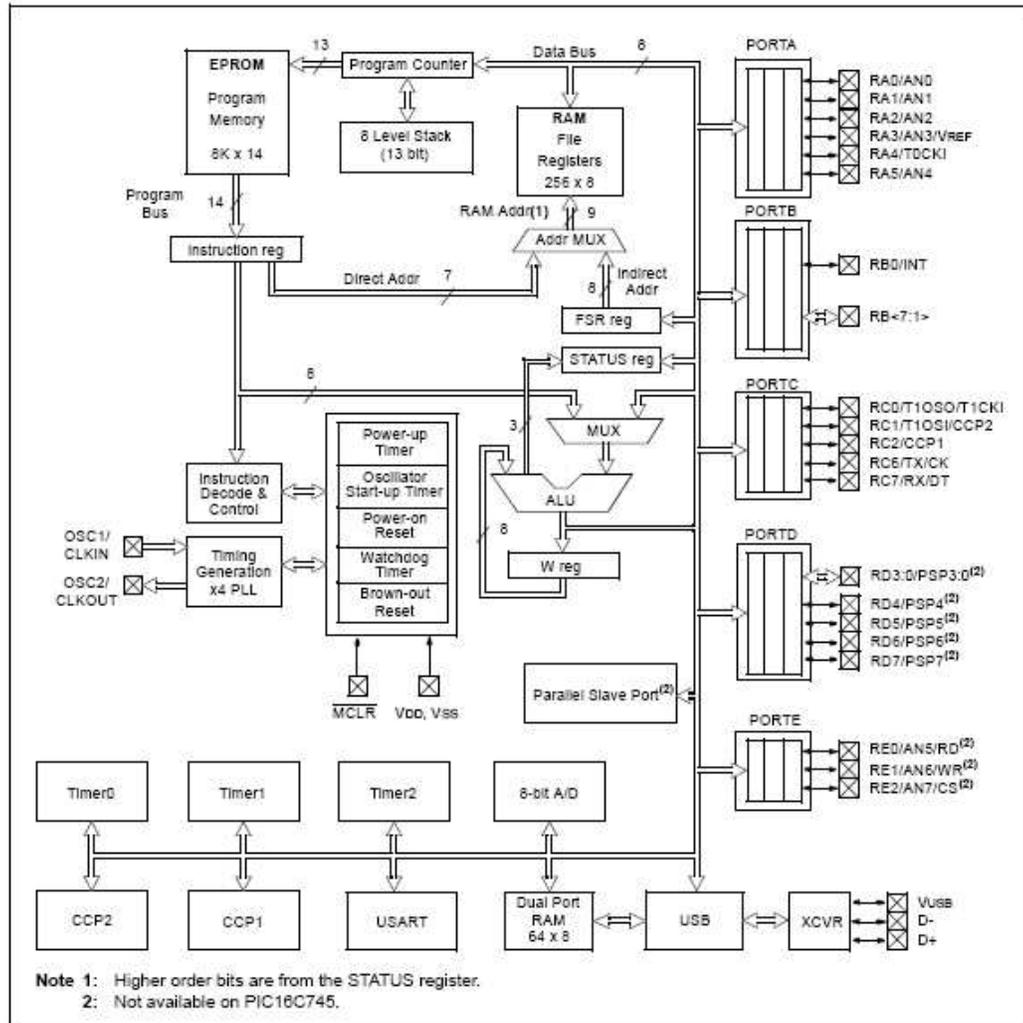


Fig. 1 - PIC16C745/765 Block diagram

The following steps should be followed for doing an A/D conversion:

1. Configure the A/D module:

- Configure analog pins / voltage reference / and digital I/O (ADCON1)
- Select A/D input channel (ADCON0)
- Select A/D conversion clock (ADCON0)
- Turn on A/D module (ADCON0)

2. Configure A/D interrupt (if desired):

3. Wait the required acquisition time.

4. Start conversion:

5. Wait for A/D conversion to complete, by either:

- Waiting for the A/D interrupt

6. Read A/D result register (ADRES)

7. For next conversion, go to step 1 or step 2 as required. The A/D conversion time per bit is defined as TAD. A minimum wait of 2TAD is required before next acquisition starts.

A/D allows conversion of an analog input signal to a corresponding 8-bit digital value. The output of the sample and hold is the input into the converter, which generates the result via successive approximation.

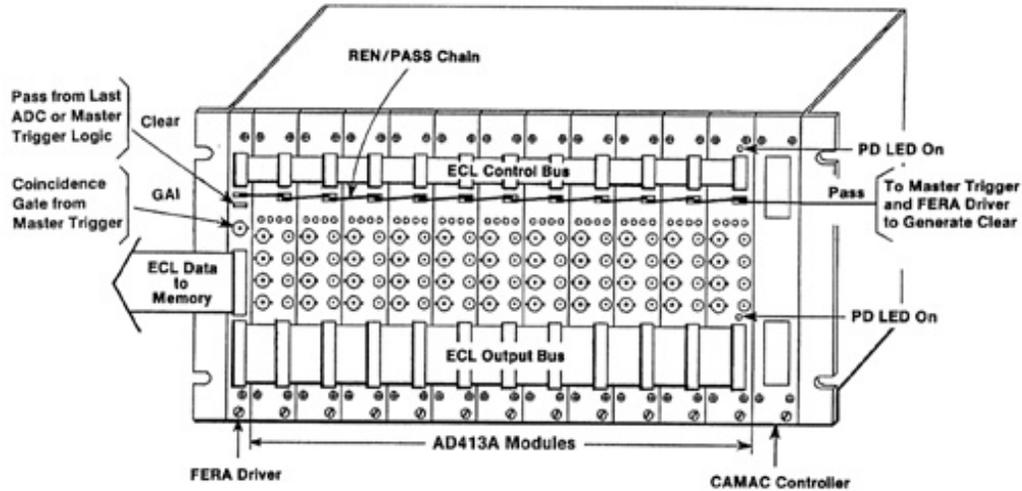


Fig. 2 - Interconnection of multiple AD413As and the LeCroy 4301 FERA Driver for FERAbus Readout

4. CAMAC

Computer Automated Measurement And Control, (CAMAC), is a modular data handling system used at almost every nuclear physics research laboratory and many industrial sites all over the world. Its function is to provide a scheme to allow a wide range of modular instruments to be interfaced to a standardized backplane called a DATAWAY. The DATAWAY is then interfaced to a computer. In this way, additions to a data acquisition and control system may be made by plugging in additional modules and making suitable software changes. Thus, CAMAC allows information to be transferred into and out of the instrument modules.

CAMAC modules may be plugged into a CAMAC crate which has 25 STATIONS, numbered 1 - 25. Station 25, the rightmost station, is reserved for a CRATE CONTROLLER, whereas Stations 1 - 24 are NORMAL STATIONS used for CAMAC modules. Usually, Station 24 is also used by the controller in that most controllers are double width (#2 CAMAC). The purpose of the controller is to issue CAMAC COMMANDS to the modules and transfer information between a computer (or other digital device) and the CAMAC modules.

Module power, address bus, control bus and data bus are provided by the DATAWAY. The DATAWAY lines include digital data transfer lines, strobe signal lines, and addressing lines and control lines.

In a typical DATAWAY operation, the crate controller issues a CAMAC COMMAND which includes a station number (N), a subaddress (A), and function code (F). In response, the module will generate valid command accepted (X response) and act on the command. If this command requires data transfer, the (R) or write (W) line will be used. Note that the terms Read and Write apply to the controller, not the module. For example, under a Read command, the controller reads data contained within a module.

When CAMAC readout is selected, data is read from the ADC via CAMAC operations. Three modes exist for reading data from the module via the CAMAC interface: "zero suppression", "addressed" and "sequential".

In addressed readout mode, the various channels can be addressed in a random access fashion by selecting the ADC channel data to be read with CAMAC subaddresses. In this

mode, four data words would have to be read from the module to ensure that all available data are read. Channels that had no pulse arrive during the gating time will report zero. If overflow suppression is enabled, zero will be reported for all overflows. If overflow suppression is disabled, a value greater than 8064 is reported for all overflows. Addressed readout mode is selected by setting bits 9 and 14 of control register 1 to 1.

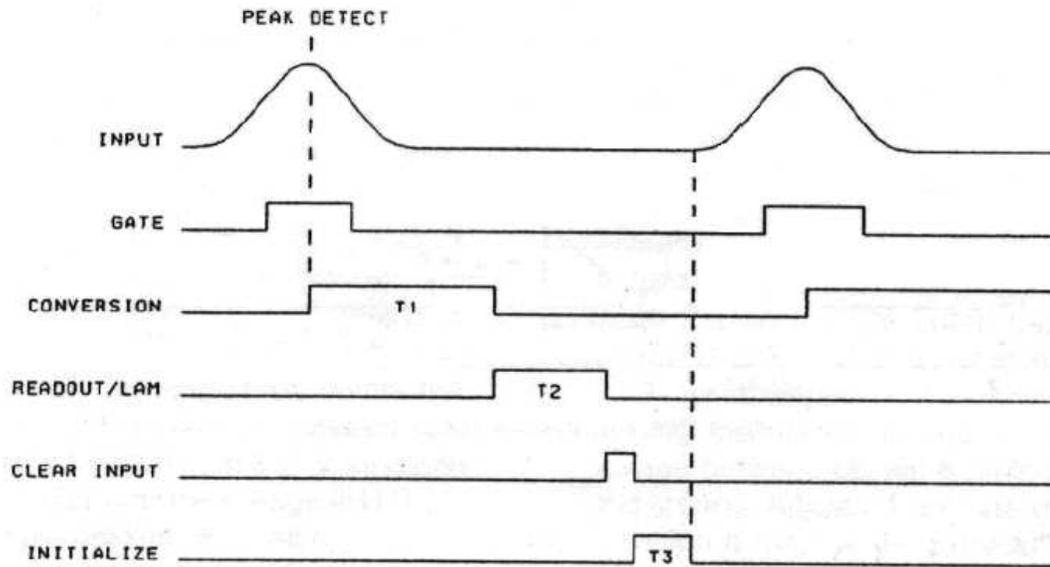


Fig. 3 - Conversion timing diagram

- T1: - 6 μ s per input which is above the lower-level and below the upper level;
 - 1 μ s per input which is above the lower-level and above the upper level;
 - 0 μ s per input rejected by PUR or GATE or lower-level discriminator;
- T2: - 2 to 5 words at > 100 ns per word for zero-suppressed ECL readout;
 - 4 words at > 100 ns per word for sequential ECL readout;
 - 2 to 5 words at > 1 μ s per word for zero-suppressed CAMAC readout;
 - 4 words at > 1 μ s per word for sequential CAMAC readout;
- T3: - 0,8 μ s if zero-suppression is not used;
 - 0 μ s if zero-suppression is used.

5. Software

USB simplify the connecting procedure for peripheral devices to a PC

Transfers take place at one of two speeds. Full Speed is 12 Mb/s and Low Speed is 1.5 Mb/s. Full Speed covers the middle ground of data intensive audio and compressed video applications, while low speed supports less data intensive applications.

Full speed supports four transfer types: Isochronous, Bulk, Interrupt and Control. Low speed supports two transfer types: Interrupt and Control. For data transfer we use the Full Speed, Interrupt transfer.

Interrupt Transfers are designed to communicate with devices which have a moderate data rate requirement. Human Interface Devices like keyboards are but one example. For Interrupt Transfers, the key is the desire to transfer data at regular intervals. USB periodically polls these devices at a fixed rate to see if there is data to transfer.

This system of analyzes is used in association with detectors which measure gamma rays or alpha particle energies emissive by sources. The system contain a number of same width cells, named channels, which, usually, have a maximum number of 8192. The width of

cell correspond to a very well specified energetic interval and can be set by user. The signals which came from ADC are sorted in different channels, according to their high. After the end of measuring, data may be expose on the screen or may be printed.

The complete result consist of enumerated channels, from one to maximum number, alongside the points accumulated in each channel. The energy of gamma ray can be identified by searching the photo-peak centered in a channel correspond to a specified energy. An ideal system has an linear response, existing a direct adequacy between number of channel and gamma ray energy.

In absence of information from detector, we made a simulation for background, with 400 channels. The results, for a random distribution, are processed in fig. 4 and fig. 5.

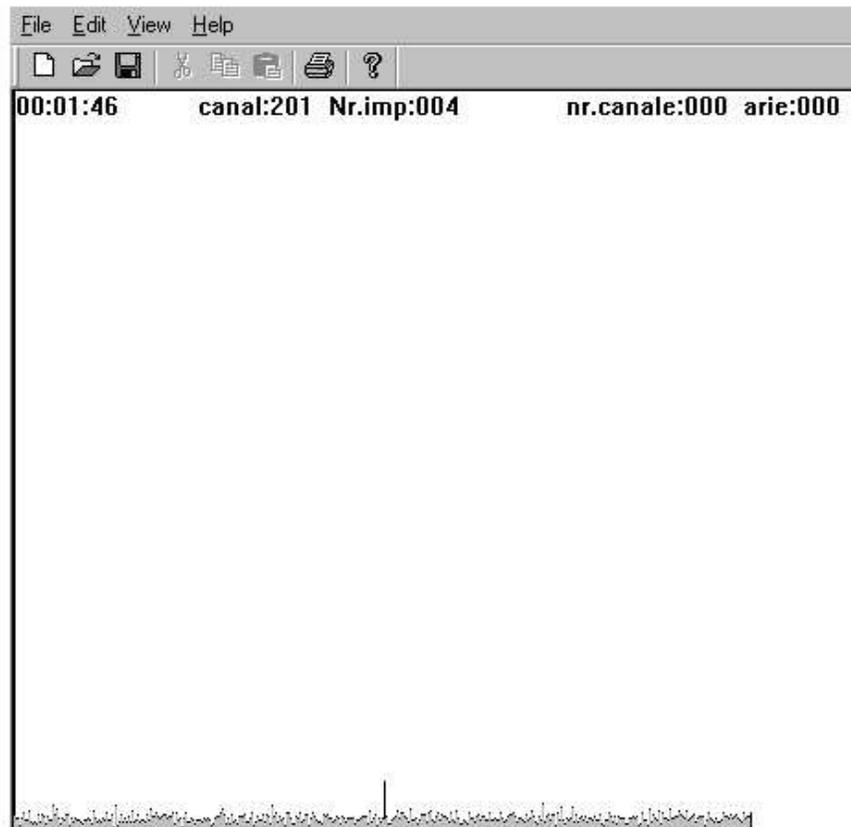


Fig. 4 - Positioning cursor on channel 201 with the registering of 4 pulses

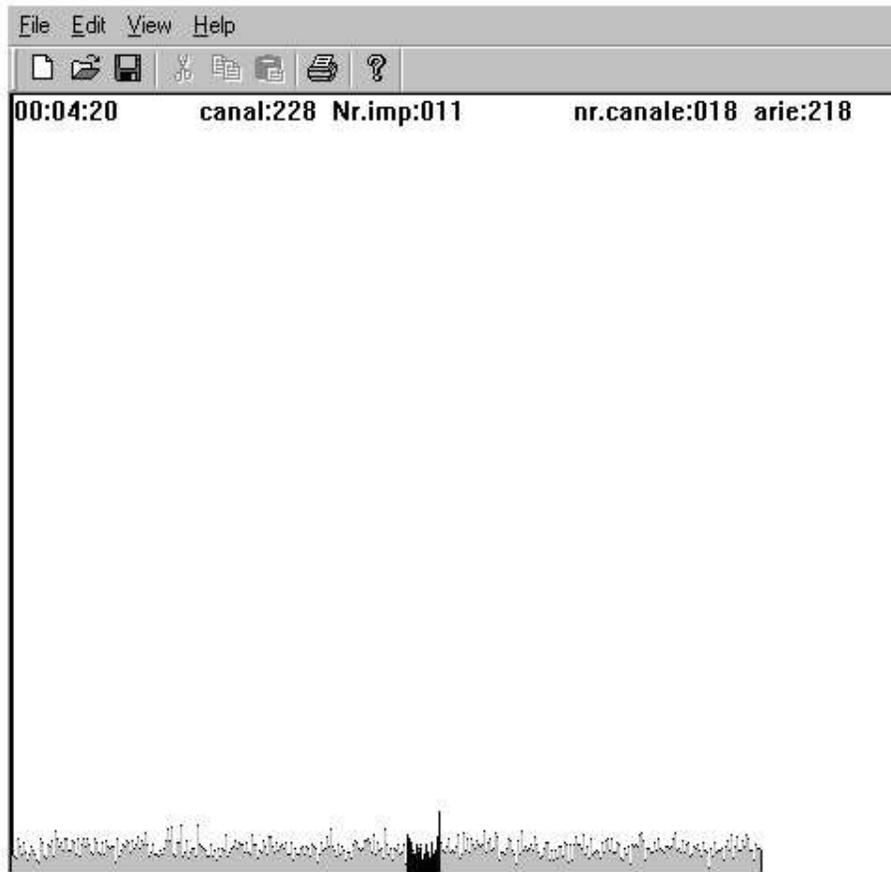


Fig. 5 - Selecting a region with 18 channels

6. Conclusions

- The analyze system is used in association with detectors that measure energies of gamma radiations or alfa particles emitted by a source.
- The multichannel analyzer is used to measure gamma radiations with various energies.
- The multichannel analyzer implemented function allows:
 - The dynamic visualization of the spectrum;
 - The movement of cursor on the spectrum indicates the position and the content of each channel
 - The identification of the spectrum zones with the integral calculation of the intensified zone.

REFERENCES

1. PIC16C745/765 8-Bit CMOS Microcontrollers with USB, 2000 Microchip Tehnology Inc.;
2. Gh. Toacse, Introducere in microprocesoare, Ed.Stiintifica si Enciclopedica Bucuresti,1986;
3. Model AD413A CAMAC Quad 8K ADC, Operanting and service manual;
4. An introduction to Camac;
5. Costin Stefanescu, Nicolae Cupcea, Electronica Aplicata – Sisteme inteligente hardware – software de masurare si control, Bucuresti 2000.