PC INTERFACE FOR GAMMA CAMERA REALIZED WITH DIO CARD

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Abstract: In this article we present an original design of an interface between an analog gamma camera and a standard PC. The design is based upon acquisition of the internal digital information of the gamma ray x-y coordinates, directly from the gamma camera (instead from its analog outputs), into the memory of the PC via the inputs of a commercial 24-bit DIO card.

1. Introduction

The gamma camera is rather expensive, but very useful medical diagnostic device which enables various physiological examinations, based on the analysis of the distribution of radioisotopes deliberately injected into the patients for that purpose. Usually, the raw information produced by the examination of patients is organized in a set of sequential diagnostic images which are memorized, either on film or on any other magnetic medium so they could be further analyzed by the physicians. In many cases, the number of raw images can be so high that their "manual analysis" is quite non efficient. Therefore, the rational exploitation of any gamma camera can not be imagined without the use of powerful computers equipped with adequate nuclear medicine diagnostic software.

These days, all new models of gamma cameras are equipped with computers which enable complete automatization of scanning and the diagnostic process. But in the early eighties, the old models of gamma cameras had the computer just as an option, which due to its high price at the time, wasn't always purchased with the equipment. For such an old model of analog gamma camera (maxicamera300) purchased without computer, we have designed our own PC based upgrade system. It's rather unconventional interface is the main topic of this paper.

2. Model of the analog Gamma Camera -MAXICAMERA300"

The model of an analog gamma camera -Maxicamera300, consists of the following main parts: Image Detector, Signal Processor Module, Correction Module, Window Module, Timer-Scaler and Display controller with analog outputs for a photo scope, for a film formatter and for an auxiliary computer.

All this modules are connected as in Fig-1, in order to perform well functioning of the whole system.

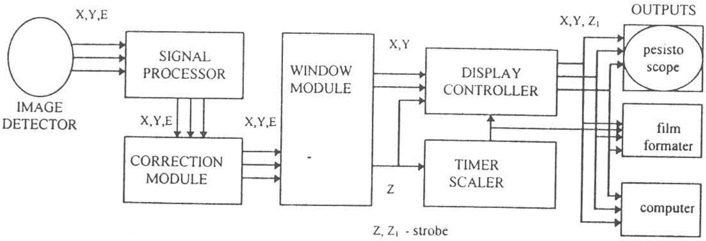

Fig-1 Block Schema of Gamma Camera-MAXICAMERA300

Each gamma ray emitted from the patient strikes the image detector and generates analog pulses X and Y which are proportional to the distance between the center of the image detector and the projections of the detected gamma ray, and pulse E which is proportional to the gamma ray energy. These signals (pulses) have certain spatial and energy distortion and need to be corrected. The correction is achieved by passing the signals through a Signal Processor and through a Correction Module. The corrected signals X, Y and E are led to the Window Module , where the pulses with energy levels outside the desired energy ranges (selected from its front panel) are filtered. As a result, a filtered sequence of pairs of random analog pulses is produced at the output of the Window Module. The pulses have amplitudes which correspond with the X,Y coordinates at the Image Detector where the gamma rays were detected. These pairs of pulses (events) enter into the Display Controller where they can be manipulated (rotated and zoomed) before arriving on the analog outputs of the gamma camera. By accumulation of those pulses for a certain (predefined) period of time, we can obtain images on our output devices.

3. Digital interface for MAXICAMERA300

After detailed analysis of the electrical schemes of the whole gamma camera we found out that the Display Controller of Maxicamera300 was a microprocessor device which had two fast 12 bit AD converters for converting X and Y analog pulses into a digital form. Therefore, we decided to design a digital interface for our gamma camera upgrade system. The interface had to have the following functions:

a) to enable latching of the eight most significant bits of the converted analog pulses X and Y directly from the outputs of the AD converters into the Display Controller, and

b) to enable their synchronized transfer into the memory of the PC without losing any useful information.

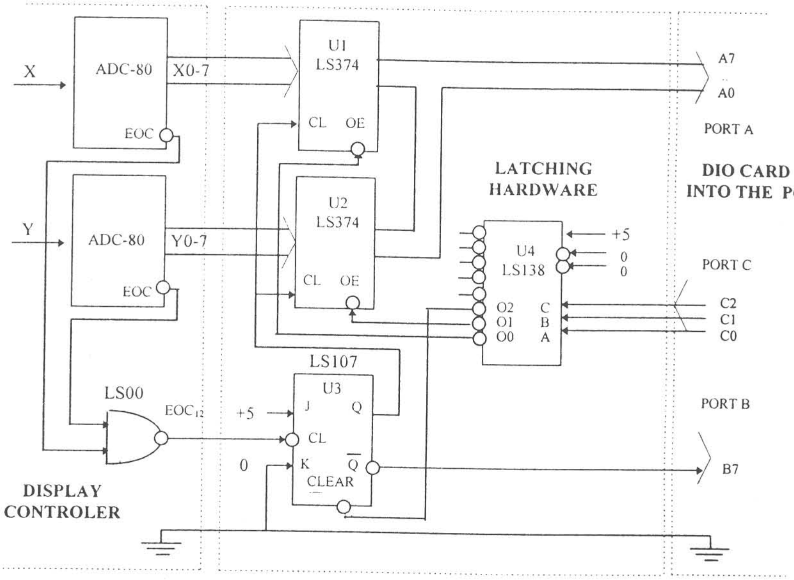

Fig-2 Hardware of the digital interface for gamma camera

3.1 Structure of the interface

In order to fulfill the stated requests we designed a special hardware, shown in Fig-2. It consists of two latches U_1 and U_2, one JK flip flop U_3, and one 1 of 8 decoder U_4. This design enables latching of the digital coordinates X and Y immediately after the end of the conversion in both AD converters and their sequential transfer to the memory of the PC through the I/O ports of a commercial 24 bit DIO card installed in the PC. The inputs of the latching hardware can be divided in two groups according to the direction from which they are entering the latching hardware:

1) Inputs from the Display Controller
   - eight bits from the first AD converter - X_{0-7}
   - eight bits from the second AD converter - Y_{0-7}, and
   - strobe EOC_{12} which signalizes the end of the conversion (in both converters).
2) Inputs from the DIO card
   - Only the 3 least significant bits c_2, c_1 and c_0, of port C (c_2,c_1,c_0)

The outputs of the latching hardware have connections only to the DIO card. These outputs are:

- the inverted $\overline{Q}$ output of the status FF on the latching board, and
- 8 bit bus from the outputs of U_1 and U_2 latches.

The inverted output $\overline{Q}$ is connected to the most significant bit of port B, while the other eight outputs are connected to port A of the DIO card in the PC.

3.2 Theory of operation

When the conversion of both pulses in the inherent AD converters of the Display Controller is finished, the signal EOC_{12} is generated. It sets the Q output of the JK flip flop which enables latching of X_{0-7} and Y_{0-7} signals into the latches U_1 and U_2, respectively. From that moment on, the transfer of latched data into the PC memory can start. This moment is detected by a software "polling" loop which checks the status of the $\overline{Q}$ output of U_3 (through the MSB of port B). Since the "output enable" pins of the latches are connected to the outputs of the decoder U_4, we start the reading of the latched data by sending appropriate logical levels on the three least significant bits c_2, c_1 and c_0 of port C.

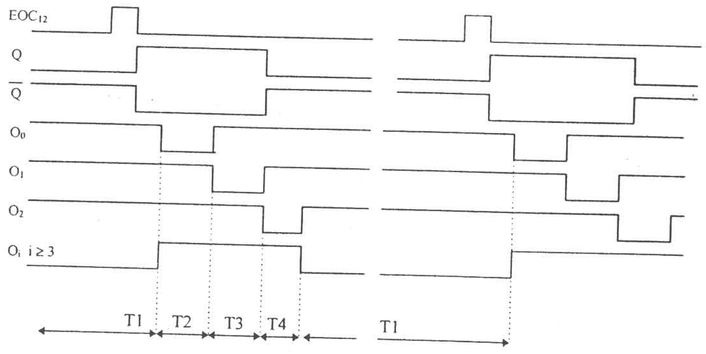

Fig-3 Timing diagram

In order to read the latch U_1, output O_0 of the decoder U_4 is selected by sending 00H on port C. While O_0 is low, the latched data in U_1 is read through port A. Similarly, the latched data from U_2 is read after selecting output O_1 of the decoder U_4. The selection of O_1 is obtained by sending 01H to port C.

After reading both latches, the hardware must be prepared for latching the next event. Therefore we reset the JK FF by sending sequentially 02H and 03H to port C, Fig-3. From that time on, our hardware is ready to latch the coordinates of the next event. Meanwhile, our software uses the starting part of T1 for registration of the detected event into the memory and for testing the criteria for stopping the acquisition process. The registration of the events can be either in a "list", or in a "frame" mode. In the first case, the coordinates of the events are recorded in a sequential file while in the second case frames (two-dimensional arrays) with a predefined dimension up to 256x256 bytes(words) are used.

After a registration of one event, the acquisition program continues to check the $\overline{Q}$ output of the Flip Flop for as long as it is high. When the program detects low level on $\overline{Q}$, the coordinates of a new event have already been latched and they are ready to be transferred into the PC memory.

4. Discussions about the design

The presented interface was realized with a commercial 24 bit DIO card from which we use only 9 inputs and 3 outputs. This solution was chosen as a compromise between the speed of acquisition and the number of signals going through the cable which connects the latching hardware to the DIO card in the PC. Otherwise, we could have designed various modifications of the presented solutions where, either we could have used more DIO inputs to obtain faster (non multiplexed) acquisition of the events, or we could have avoided the DIO card and use the printer port for multiplexed acquiring the latched information in nibbles.

Our investigation has shown that the highest count rate with this interface is limited by the speed of the PC's local bus. With 66Mhz PC-486, we have managed to obtain rates of up to 70000 counts/sec which is quite satisfactory for the diagnostic performances of the whole upgraded system.

Although we had no chance to compare our solution with any commercial one based on the use of analog acquisition card, we have concluded that our solution has few advantages:

a) The price of our solution is much cheaper then the analog one. (The price of a professional ADC card exceeds few thousand $USA).

b) The noise immunity of digital signals led from the gamma camera to the DIO card is higher than the immunity of analog signals which are to be brought to the inputs of the AD card in the PC.

c) The acquisition software can be easily optimized for speed for various modes of acquisition.

The only disadvantage of our design is the technical difficulty in fitting the latching circuit and connecting it with the Display Controller.

With the presented interface we can obtain very good diagnostic images, which do not use expensive film, but plain paper as shown in Fig-4.

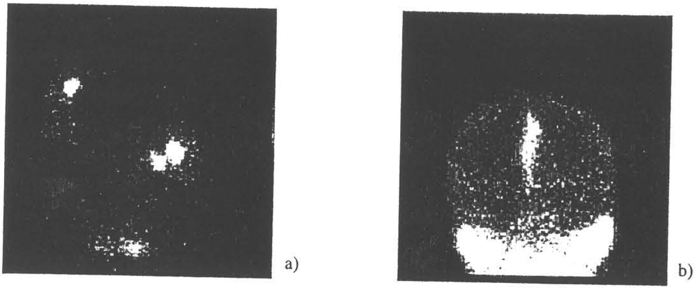

Fig-4 Diagnostic Images a) Kidneys, 45 minutes after injection of radioisotope, b) head-60 minutes after injection of radioisotope

5. Conclusion

In this paper we have presented a digital interface between an old model of a gamma camera and a standard PC, which has already been realized at the department of nuclear medicine in Bitola. With the presented interface and the whole upgraded system, we have increased the diagnostic potential of our old gamma camera and reduced its exploitation expenses for diagnostic images.

The presented solution is very cheap and it is rather simple to realize. In spite of its low price, it enables high count rates and high noise immunity for the signals which arrive to the PC via the DIO ports.

Although we were unable to practically compare the performance of our interface with any commercial analog acquisition system, we believe that our solution has better price-performance rate.

6. Literature

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