# A PC based System for the Control of an Object Manipulator Movements in an X-Ray Tomograph

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*Abstract*— **In this paper, a PC based system for controlling an object manipulator and CCD detector movements of an X-Ray tomograph is presented. The system replaces the old manual keyboard which was not able to perform movements with high precision. It uses the new and advanced capabilities that modern PC's offer to perform the movements with a click of a mouse. The new system offers more flexibility and especially more precision when performing the movements compared to the old manual keyboard.**

*Index Terms*— **Object manipulator, X-Ray tomograph, DAQ board, CCD detector.**

## I. INTRODUCTION

The tomograph *fxs* 160.50 from Fein-focus is a microfocus X-ray system that contains an objet manipulator which operates in 5 different directions, together with the movements of the CCD detector which operates in another direction. These movements are governed via a keyboard that can only be operated manually. The goal of this project is to automate these movements to be able to manipulate them directly from a Personal Computer (PC) without recourse to the manual keyboard. In this case, the movements will be performed with additional precision compared to those performed using the manual keyboard, and sequential movements can be achieved using appropriate programming. This project uses a DAQ interface card together with a small circuit designed to enable communication between the PC and the control unit of the tomograph. In the next section, details of these parts are explained, starting with the PC-DAQ interface.

## II. THE PC-DAQ INTERFACE

To allow the PC to send orders (direction of movements) to the tomograph's control unit, a mean of communication has to be established between them. This is achieved using a DAQ interface card together with a small circuit designed to imitate the operations of the switches and joysticks of the manual keyboard (Fig.1). In this section, the first part that contains the DAQ interface card is explained.

The DAQ interface card used is a 24 bits digital input/output USB board (PMD 1024-LS from Measurement Computing). This means that the PC communicates with the

Manuscript received March 21, 2008.
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card using a USB cable. The 24 digital I/O (take logical 0 or 1 only) are organised in three ports (port A, B and C) and can be programmed individually as Inputs or Outputs. The outputs of the digital ports are directly connected to the intermediary circuit via wires.
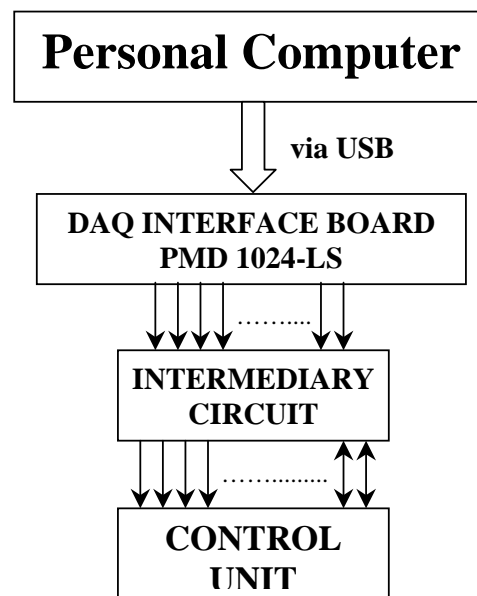


Figure 1. Architecture of the new PC based system

The movements of the object manipulator and the CCD detector to be automated are to be operated following these axes:

(X -, X+):   Movement to the (left, right) inside the tomograph
(Y -, Y+):   Movement (down, up) inside the tomograph
(ZR -, ZR+):   Movement to the (back, front) inside the tomograph
(ROT -, ROT+): Rotation to the (left, right) inside the tomograph
(TILT -, TILT+): Tilt to the (left, right) inside the tomograph
(ZII -, ZII+):   Movement to the (back, front) inside the tomograph of the CCD detector.

Each of these movements has a special wire associated to it and is connected to the control unit inside the tomograph via a 37 pin D type connector. In addition to the above twelve movements, there are four wires connected to a knob in the manual keyboard for speed changes.

The speed can be changed from minimum (0) to maximum (position 9) following a 4 bit BCD counter as shown in the table below:

Table 1. The four bit BCD counter and the appropriate wire voltages

| Speed position | Bit 3 | Bit 2 | Bit 1 | Bit 0 | Voltage of the common wire (V) |
|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0.435 |
| 1 | 0 | 0 | 0 | 1 | 0.525 |
| 2 | 0 | 0 | 1 | 0 | 0.625 |
| 3 | 0 | 0 | 1 | 1 | 0.895 |
| 4 | 0 | 1 | 0 | 0 | 1.355 |
| 5 | 0 | 1 | 0 | 1 | 1.925 |
| 6 | 0 | 1 | 1 | 0 | 2.975 |
| 7 | 0 | 1 | 1 | 1 | 4.355 |
| 8 | 1 | 0 | 0 | 0 | 6.205 |
| 9 | 1 | 0 | 0 | 1 | 8.855 |

Added to the above, the manual keyboard possesses a stop button used in case of emergency. This button when pressed causes the little window in the tomograph to open, stops generation of X-rays and operating the movements of the object manipulator and the CCD detector is no longer available.

Therefore, in order to automatically control the movements of the objet manipulator, the CCD detector and the stop button, the DAQ card must connect to the circuit with 12+4+1 wires, each with a specific function. These are explained in the table shown below:

Table 2. Wires connections and their function

| Port | Bit | Function |
|---|---|---|
| Port A | A7 | X - |
| | A6 | X+ |
| | A5 | Y - |
| | A4 | Y+ |
| | A3 | ZR - |
| | A2 | ZR+ |
| | A1 | ZII- |
| | A0 | ZII+ |
| Port B | B7 | ROT - |
| | B6 | ROT+ |
| | B5 | TILT - |
| | B4 | TILT+ |
| | B3 | SPEED BIT 3 |
| | B2 | SPEED BIT 2 |
| | B1 | SPEED BIT 1 |
| | B0 | SPEED BIT 0 |
| Port C | C7 | STOP BUTTON |
| | C6 | NC |
| | C5 | NC |
| | C4 | NC |
| | C3 | NC |
| | C2 | NC |
| | C1 | NC |
| | C0 | NC |

III. INTERMEDIARY CIRCUIT

This circuit which contains only transistors and relays is used to imitate the operations performed by the switch buttons and joysticks of the manual keyboard (Fig.2).

When the bipolar transistor 2N2222 receives a logical 1 (+5V) from the DAQ card in its base, it becomes saturated, hence joining the emitter and collector to the same voltage (+5V). The relay receives the +5V in its input (as it is directly connected to the transistor's emitter), switches state to allow the current to flow from the common wire (with its appropriate voltage as shown in table 1) to a designated wire in the tomograph's control unit (through the 37 pin D-type Connector), hence triggering the appropriate movement of the objet manipulator, the CCD detector or causing the window to open.

For example, if we want to move the objet manipulator to the right (X– movement), we must send the order from the PC to the DAQ card to output a digital +5V from bit 7 of port A (A7). As this bit is connected to the base of a transistor, this latter saturates sending the emitter voltage to the collector's (connected to +5V from the DAQ card). The emitter in turn is linked to the input of the relay, which when subjected to a digital +5V switches state allowing the current to flow from the common wire to the appropriate wire responsible for moving the object manipulator to the right in the control unit of the *fxs* 160.50. This procedure is similar for all movements and speed changes. The programming language used to build the application software for communicating between the PC and the tomograph thorough the DAQ interface card is Visual Basic 6 (VB6). This application software is explained in the next section.

IV. APPLICATION SOFTWARE

This application software was built using Visual Basic 6 to enable the PC to communicate (send orders) with the tomograph through the DAQ interface card.

Visual Basic is a high level programming language developed by Microsoft. Based on the BASIC language, it provides a graphical programming environment and a paint metaphor for developing user interfaces. In Visual Basic, a programmer can add a substantial amount of code simply by dragging and dropping controls, such as buttons and dialog boxes, and then defining their appearance and behavior.

The application uses buttons on the main form to perform all the required 12 movements. With the aid of the object's event handlers, a proper code for outputting a logical one '1' to the appropriate bit in the corresponding port on the DAQ board can be added. In this case, when the button is pressed, the movement associated to this button is performed for a given period of time controlled using a timer on the main form. A slider is used to choose and display the speed of the movement. This is done via incrementing or decrementing the BCD counter (as explained in section II). The application also allows automatic movements to be programmed using timers, which was not available using the manual keyboard.

In addition to the current movements, a MATROX image grabber board is available and can be used to visualise in real time images of objects obtained from inside the tomograph.
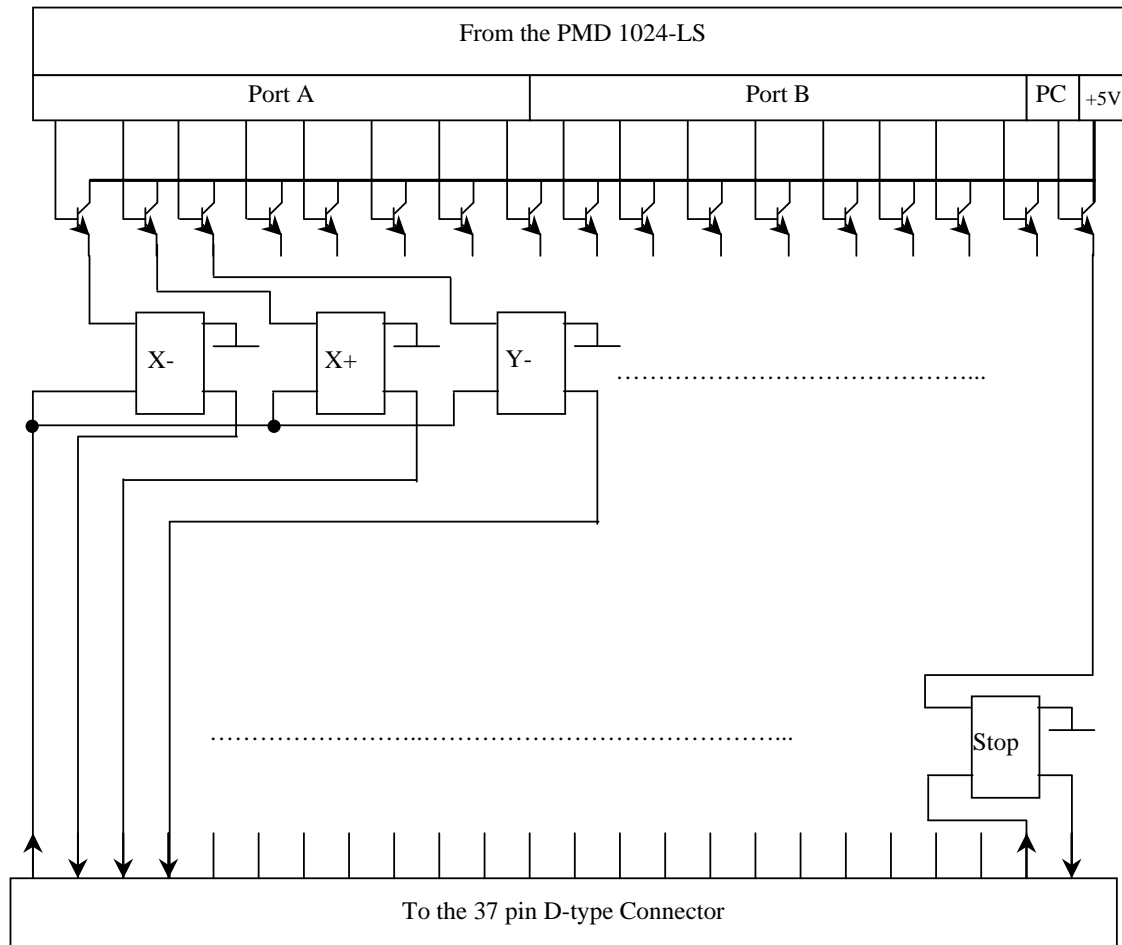
Figure 2. Schematic diagram of the intermediary circuit

## V.   CONCLUSION

In this paper, a PC based system for controlling the movements of an object manipulator in an X-Ray tomograph was presented. The new system uses the capabilities that modern PC's offer to perform the movements with a click of a mouse and is to replace the old keyboard that could only be manipulated manually. The advantages gained by using this system are numerous. To mention, the movements can now be done with more precision as they are controlled by PC. Also, there is a capability of turning the object manipulator automatically to take image projections with the aid of the CCD detector at different angles. The application software allows taking these images via the MATROX image grabber board. Incorporating 2D and 3D image reconstruction techniques within the current system application to build a fully automated system for reconstructing X-Ray images of objects is an area of future work.