

# DESIGN OF AN I/O CARD TO DRIVE STEPPER MOTORS FOR COMPUTER AIDED CONTROL OF A ROBOT ARM

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## Abstract

Developments in electronic and computer technology area have increased the importance of computer aided control. The control systems in frequent use are microprocessor control, microcontroller control and the computer aided control. Computer aided control can be implemented by serial port, parallel port or control cards prepared by special purposes. In this paper, a control card to use in computer aided control system to control of the degrees of freedom of a robot arm moving in three dimensional space is designed. For the control, address decoder device, programmable input/output device, four stepper motor driver and stepper motor breaking device are placed on only one control card which is placed in one of the 16 bits ISA slots of computer. On the control card prepared, 48 bits input/output lines are available. 17 of these lines are used as output lines and the rest of the lines are reserved for feedback.

**Key words:** Computer aided control, I/O control card, stepper motor.

## 1. Introduction

Developments in electronic and computer technology area have increased the importance and applications of computer aided control (1). The control systems in frequent use are microprocessor control and the computer aided control (2). Computer aided control can be implemented by serial port, parallel port or control cards prepared by special purposes. Several type of cards in industrial control are developed for stepper motors, servo motors, brushless DC motors, heat and humidity control, etc (3).

In this paper, a special purpose control card to control a number of step motors in a robot arm. The control card designed consists of a decoder unit, programmable input/output

(I/O) unit, stepper motor driver circuits and stepper motor breaking circuits. All the electronic units mentioned are designed to be on a card which can be placed in one of the 16 bits ISA slots of an IBM compatible PC and programmable by using a high level programming language. Figure 1. shows the block diagram of control card in the robot arm system (4).

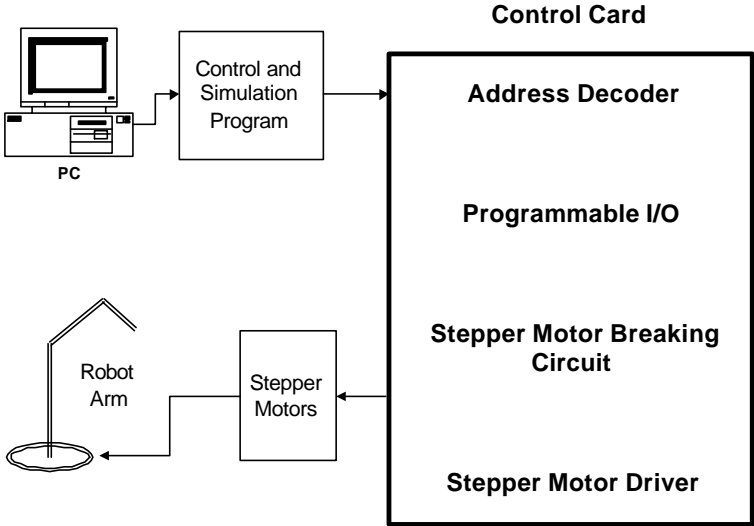


Figure 1. Block diagram of the control card in computer aided control of robot arm.

**2. Address Decoder and Programmable I/O 8255 Unit**

Main parts of the control card are the address decoder and programmable I/O 8255 units. Decoders convert the addresses sent from the program to one output. They are called as many to one decoder, code decoder matrix or simply decoders. If  $n$  the number of inputs for possible  $2^n$  outputs, there is only one output permitted. The circuit in figure 2. uses two 74138 IC. The address sent from CPU is adjusted by address decoder. The second address decoder gives an address choice by using jumpers. The addressing structure in address decoders is shown in table 1. The  $A_1 A_0 = XX$  addresses is used to choose the mods in 8255 IC.

$A_9$	$A_8$	$A_7$	$A_6$	$A_5$	$A_4$	$A_3$	$A_2$	$A_1$	$A_0$
1	0	0	1	1	1	X	X	X	X

Table 1. The addressing structure in the address decoder.

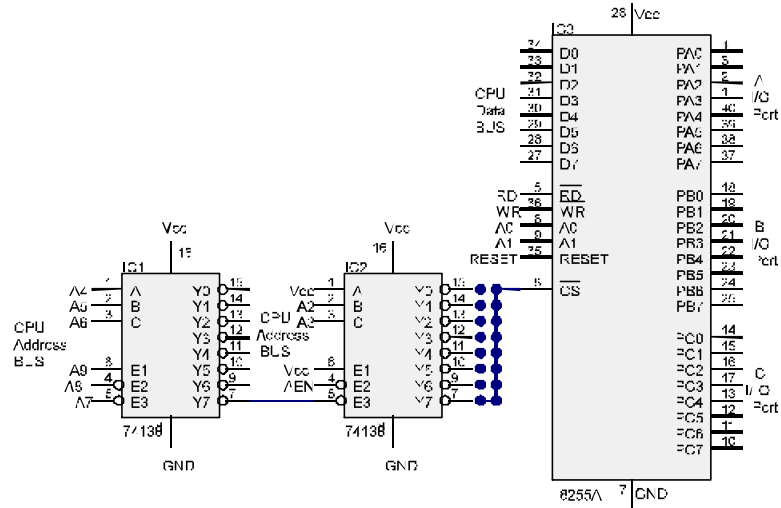


Figure 2. Address decoders and the connections to 8255 I/O.

The 8255 chip is present in the PC/XT to establish a connection between CPU and various other components, such as the keyboard, the DIP switches for the configuration settings, and the NMI mask register. The 8255 has 24 pin in all, divided into three groups of eight pins each. The groups are denoted by port A, port B, and port C, respectively. Figure 2. shows the pin assignment scheme of the 8255 with address decoders 74138 connected. 8255 is programmable in three different modes (5):

- Mode 0: simple unidirectional input/output without handshake; depending upon the programming for input or output, the data is simply read from or written to the port concerned. Thus, the 8255 has two 8-bit and two 4-bit ports in this mode. In the PC/XT all three ports are operated in mode 0.
- Mode 1: unidirectional input/output with handshake via a nibble of port C;
- Mode 2: bi-directional input/output via port A with handshake via the high order nibble of port C.

Thus a very flexible chip for I/O purposes is available for computer designers. Figure 3(a) shows a diagram of its internal structure and 3(b) shows basic mod descriptions.

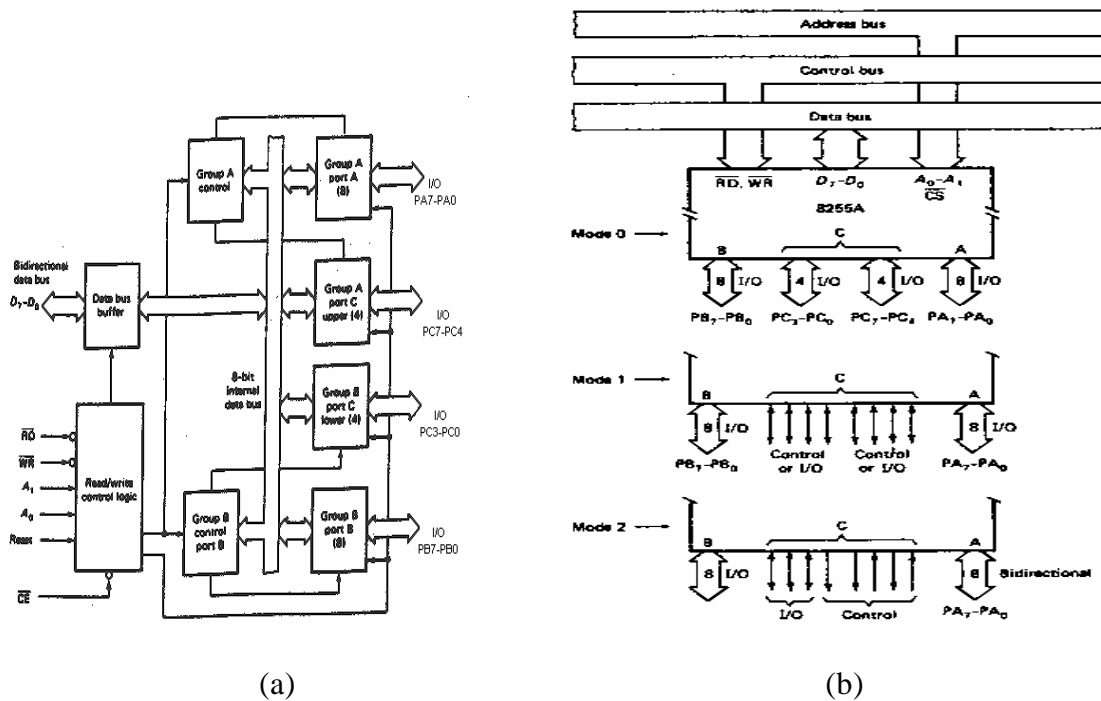


Figure 3. (a) 8255 internal structure, the ports A to C can be programmed individually, (b) basic mod descriptions.

Mode programming of the individual ports is carried out with a control word. The control word register is accessed in the PC/XT at the port address 63h, and the three ports A, B and C with the port addresses 60h, 61h and 62h, respectively. The ports programmed for output may be written by a simple OUT or read by an IN instruction. All ports programmed for input can only be read, not written. Figure 4. shows the structure of the control word.

A mode control word for setting the operation modes of ports A, B and C comprises a set bit 7 (D7) to distinguish this control word from a set or reset command for a single pin of port C. The three low order bits D2-D0 refer to the mode of group B, which consists of port B and the low order nibble of port C. Port B and pins PC3-PC0 can be programmed separately for input or output. As for port B, only modes = and 1 are available – the single bit D2 is sufficient for defining the mode.

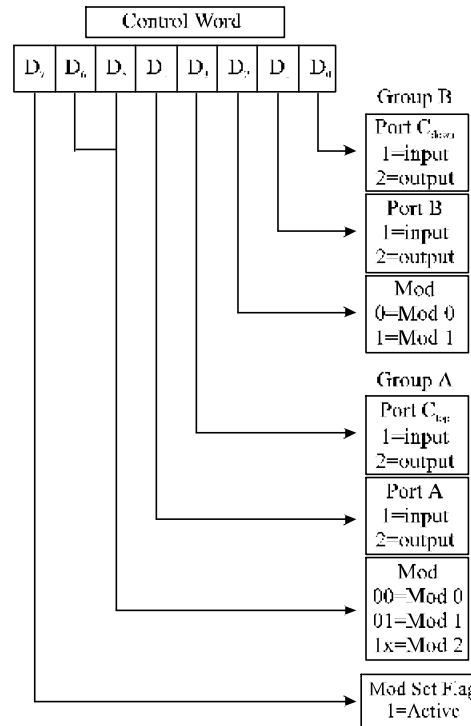


Figure 4. Structure of the control word.

### 3. Stepper Motor Driver Circuit

Figure 5. shows block diagram of a stepper motor control system. The system consists of a DC power supply, square wave input signal, driver circuit and stepper motor. In the prototype system, power supply of PC is used as DC power supply and the input signal is generated in motherboard of PC and formed by control program (6). The driver circuit is a form of bipolar structure (7). Since the stepper motors has two poles, each stepper motor uses two circuits as shown in figure 6. Block diagram of control circuit from CPU to stepper motors is shown in figure 7.

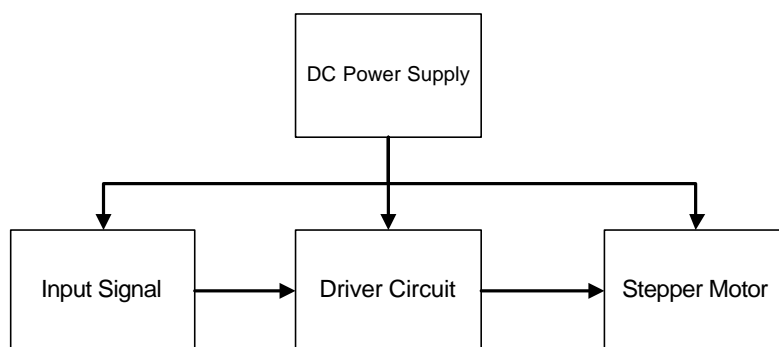


Figure 5. Block diagram of the stepper motor control system.

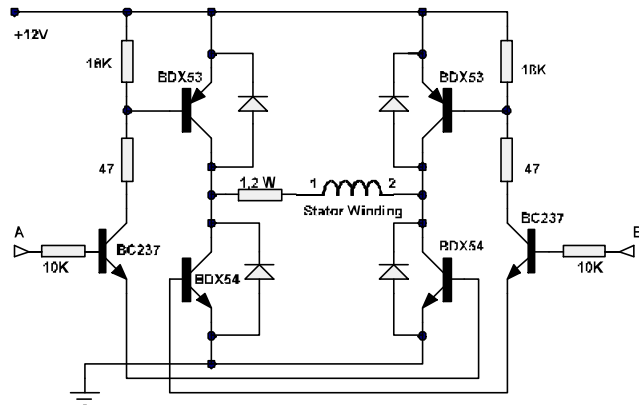


Figure 6. Stepper motor driver circuit.

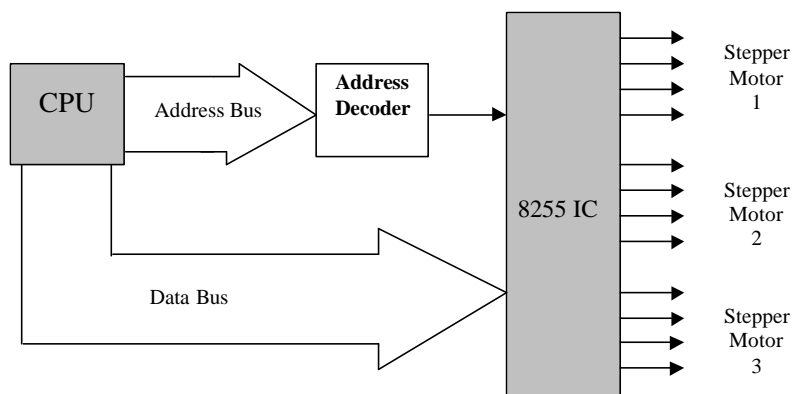


Figure 7. Block diagram of control circuit from CPU to stepper motors.

#### 4. Stepper Motor Breaking Circuit

Responses and stops of stepper motors are synchronous to input signal without load. When the motor is run with load, then there may be a slip in the mechanical position of the motor. Solution to this problem is to design a breaking circuit as shown in figure 8. The type of breaking is a kind of electrical breaking with constant voltage applied to stator windings of the stepper motor (8). Although the working voltage of the motor is 12 volts, 5 volts from the DC power supply of PC is used for breaking. Any voltage applied continuously exceeding 5 volts causes overheating of the motor. The interchange between 5 and 12 volts is performed by using a relay.

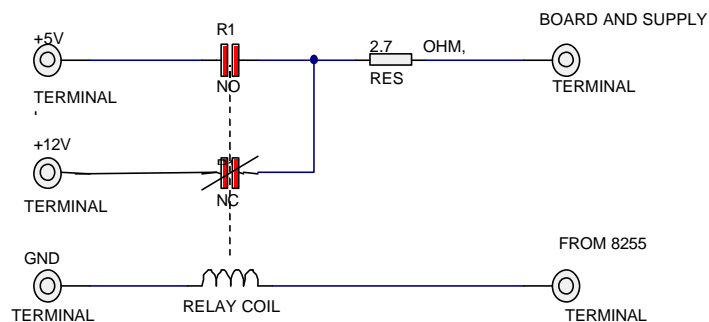


Figure 8. Stepper motor breaking circuit.

## 5. Conclusions

In this paper, a low cost control card to use in computer aided control system to control of the degrees of freedom of a robot arm moving in three dimensional space is designed. Address decoder device, programmable input/output device, four stepper motor driver circuit and 2 poles stepper motor breaking device are placed on only one control card which is placed in one of the 16 bits ISA slots of computer. On the control card prepared, 48 bits input/output lines are available. 17 of these lines are used as output lines and the rest of the lines are reserved for feedback. The card features a full I/O address decoder, employing two 74138 decoders.

However the control card prepared is for controlling the stepper motor, it can also be used for general purposes like controlling servo motors, brushless DC motors, heat and humidity control, etc. For the large stepper motors, an external DC power supply must be used instead of computer's power supply.

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