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Computers in Chemistry

A PC Interface for a Single-Ratio Stepper Motor

SCOTT A. RILEY
Department of Chemistry
University of California, Davis
Davis, CA 95616

A. M. NISHIMURA*
Department of Chemistry
Westmont College
Santa Barbara, CA 93108
nishimu@westmont.edu

The stepper-motor-controlled scanning monochromator provides the most reproducible and cost effective method of acquiring spectral data.

A very simple stepper motor controller was designed and built for a scanning monochromator. The circuit design centers around a programmable peripheral interface chip that controls the gate of four power transistors, which in turn activate the coils on the stepper motor. Besides being very inexpensive to build, the interface shows improved performance when compared to the commercially available controller.

Introduction

To maximize the use of our instrumentation, the fluorescence lifetime and spectral acquisition experiments are magnetically clamped on an optics bench. This allows the optical configuration to be easily changed for use in either the analytical or the physical chemistry laboratory. Depending

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upon the experiment, the excitation source can be switched between a mercury lamp and a nitrogen laser. A 0.25-m monochromator (Oriel Instruments, model 77220), equipped with a single-ratio stepper motor drive (Oriel Instruments, model 77228) serves as the dispersive device. Although a stepper motor drive controller can be purchased for this monochromator (Oriel Instruments, model 20040), the availability of wire-wrap prototype cards for the personal computer (PC) makes the development of specialized interfaces convenient and a very inexpensive alternative. The cost of this particular interface is about $60, which is less than one-tenth of the cost of the commercial unit, and most of the cost is in the prototype card. The prototype development card was an 8-bit ISA card (model PCL-750, Advantech Co.), with built-in decode circuitry. In our application, the stepper motor driver section is sufficiently compact such that it occupies less than a third of the card. Another third of the card is taken by a single-channel photon counter interface described elsewhere [1], leaving the rest of the card available for future expansion.

As seen in Figure 1, this interface is exceedingly simple. The heart of the interface circuit is a 8255 programmable peripheral interface (PPI) chip. The PPI is part of the familiar 8000 series of microprocessors and peripherals. Four lines of port A of the PPI are used to power the input of a 74241 line-driver integrated circuit (IC). The driver is connected to four general purpose power transistors, which in turn switch each of the four windings of the stepper motor to ground. The other ends of the coils are held in common to the +12V lead, which is conveniently available from the PC power supply.

In contrast, for the commercial unit, the common lead to the windings of the stepper motor is held at ground potential. Then the controller sends +12 V pulses to activate the coils of the stepper motor. Our circuit design results in a significant improvement in the performance of the stepper motor. The main differences are that the motor runs noticeably quieter, due to the more efficient pulse shaping, and faster, because the pulse timing can be tightly controlled by software. Finally, this interface circuit is extremely durable, and has been in use by students for the past year without a single failure.

As mentioned above, the compactness of the interface leaves much of the circuit board free for expansion. An example of a needed expansion might be the capability to digitize an analog signal from a photodetector while the monochromator is being scanned. We recently had just such a need. Because the PPI has ports B and C open,

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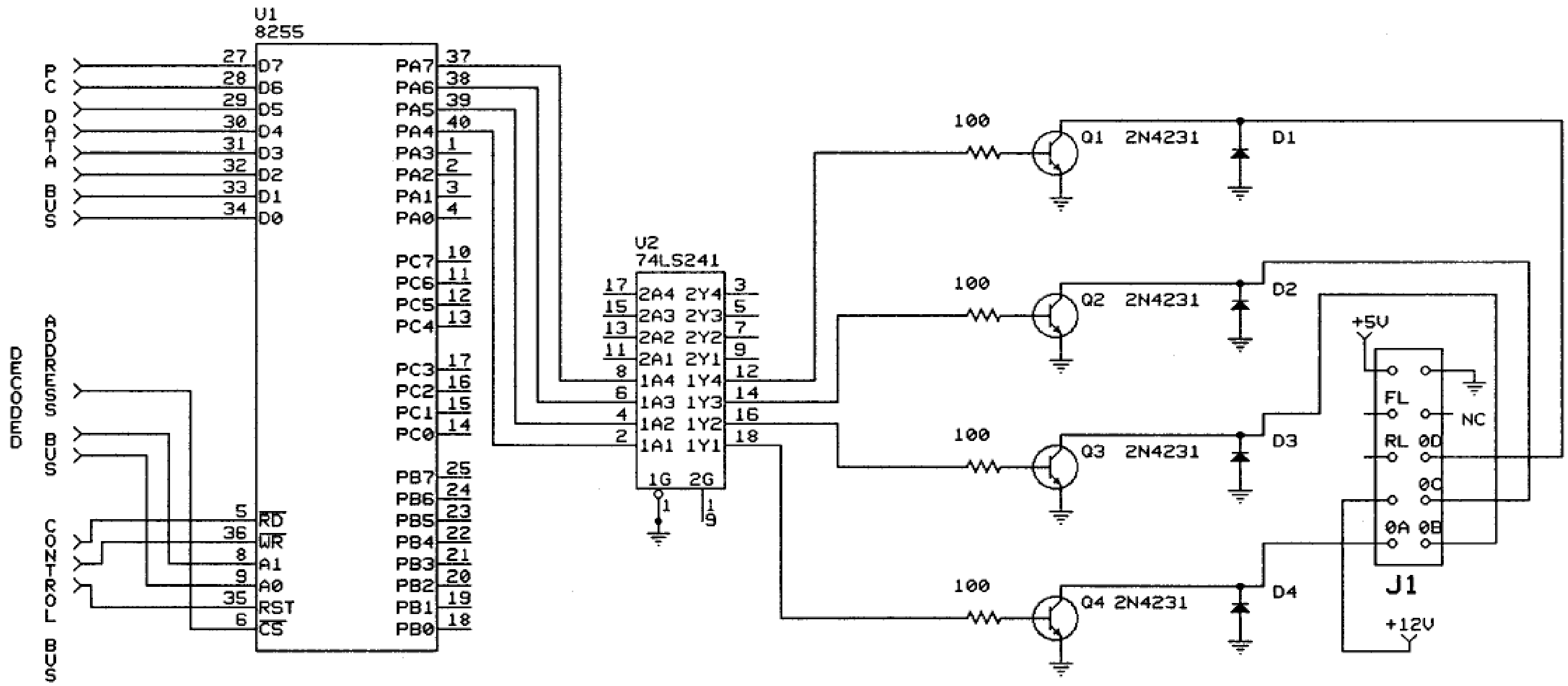

FIGURE 1. SCHEMATIC DIAGRAM OF THE STEPPER MOTOR INTERFACE.

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one of these 8-bit ports was wired to an analog-to-digital converter, ADC-0804, which is available through electronic distributors, such as JDR Microdevices and Jameco for about $2. In this way, the analog output from a photomultiplier at the exit of the monochromator can be digitized, giving rise to an absorption or emission spectrum [2].

Circuit Description

In Figure 1, the input lines on the left which includes 8 bits of data lines (D0–D7), two address lines (A0, A1) , read/write (RD/WR), reset (RST), and chip select (CS) come directly from the buffered signals, which are available on the prototype card. Therefore, only what is shown in the schematic diagram, Figure 1, must be built on the card. In our application, all ICs were socketed and connections made using wire wraps. Referring to Figure 1, the 8255 PPI, designated as U1, is a programmable peripheral interface IC commonly used in PC interface circuits. The 74241, U2, is a line driver IC whose output is held in the low impedance mode, always active (pin 1 low). The 100-Ω resistors current-limit the drain from the 74241 to the base of Q1–04, which are 4-A 200-V NPN general purpose, audio-frequency power transistors. One end of the windings of the stepper motor is kept at +12V by tapping the PC's power supply. If the stepper motor requires other voltages, such as +15V or +24V, these can simply be applied to the motor using an external power supply via J1 instead of the +12V without modification to the rest of the circuit. The other end of the winding is driven low to ground when a particular power transistor conducts. The resistance of the individual coils of the stepper motor is 41 Ω, and although the windings are made active in an overlapping sequence, no more than 0.6 A is drawn from the power supply at any given time. This is far below the maximum output capability of most PC power supplies. During its operation, no loading effects to the power supply was noticed. Because of the inductive load, D1–D4 are in the circuit to serve as protective diodes. The forward and reverse limits from the microswitches on the monochromator, which appear on most monochromators, can be fed to the PPI for monitoring purposes by using pull-up resistors and +5V from the PC. The input–output connections to the monochromator can be made via 10-pin headers which are on 0.1" centers. The interconnection can be made using sockets that crimp to ribbon cables of sufficient length to cover the distance between the monochromator and the computer.

The components including the power transistors remain cool during operation and therefore are not driven beyond their rated current drain capabilities. In our

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application, heat-sinking of the power transistors was found to be unnecessary, although it is recommended.

The program shown in Appendix I (33an1897.pdf) was written in Microsoft Visual Basic, and simply rotates a bit through the four outputs of port A. A delay between the rotate instruction is a simple nested FOR routine in which the limits are adjustable parameters to accommodate the maximum stepping speed of the motor and the CPU clock. In order to minimize the waiting time for the monochromator to reset, the reverse crank routine should have the smallest possible FOR instruction limits. The program keeps track of the revolutions of the stepper motor for control purposes.

Conclusion

The stepper-motor-controlled scanning monochromator provides the most reproducible and cost effective method of acquiring spectral data. If the cost of the controller is prohibitive, then this simple inexpensive circuit is definitely worth the attempt. The result is a comparable, if not an improved, controller for the scanning monochromator.

In summary, a comparison of this circuit and the commercially available stepper motor driver shows several advantages of this circuit design: a) the motor runs much quieter; b) the motor can be driven at a much faster scan rate, which is especially significant when reversing; c) the circuit requires a minimum of components and can be constructed at a fraction of the cost; d) no external power supply is required beyond the PCs; and e) if a PC is part of an existing experimental setup, then the integration of this driver interface into the PC is extremely simple.

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2. A modified schematic diagram showing the ADC will be provided upon request.