

Introduction

This application note contains basic information about interfacing external circuitry to computer I/O cards. Much of the information here is general purpose and can be applied to any I/O card, while some is more specific to cards which use the 82C55 interface chip (such as the CRD155B).

The information presented here is basic in nature, and it is useful to beginners and those who are unfamiliar with interfacing to real-world devices.

Output Circuits

By using the proper circuitry, it is possible to use a logic-level output to control just about anything. Transistors and relays enable us to switch very large loads. In this section, we will look at a couple simple techniques that let us control real-world devices with a computer I/O card.

The first circuit is illustrated in Figure 1. We have a small-signal NPN transistor switching an LED. When the output pin of the I/O card goes high (turns on), then the transistor is forward-biased, and it conducts current between its emitter and collector. You can think of the transistor as a switch. When it is forward-biased, the switch is closed and conducts current; otherwise, the switch is open and does not conduct. Like anything in the real world, however, the transistor is not ideal; in other words, it is not a perfect switch. When it turns on and conducts current, it only *approximates* a switch. There is a voltage drop across the transistor, and this energy is dissipated as heat. This is why heat sinks are used whenever transistors switch large currents.

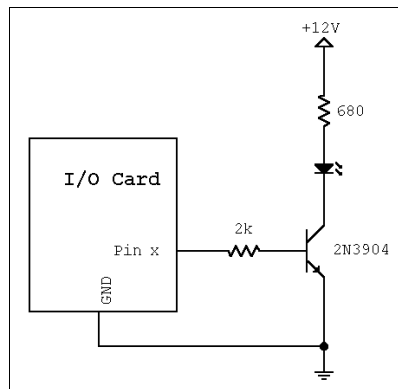


Figure 1: Basic transistor switch

There are several things to note about the circuit in Figure 1. Let's start at the output pin. The 2k Ω resistor is used to limit the current which flows from the output pin into the transistor. When the output pin is high, the base-emitter junction of the transistor is really a forward-biased diode capable of drawing a lot of current. The output pin is not capable of supplying much current, and fortunately we don't need very much to turn on the transistor. The resistor limits the current to an acceptable level. The CRD155B can supply a minimum of 2.5 mA of current from an output pin. It is actually capable of supplying more, but the 82C55 chip data sheet specifies that it can supply at least this much. Doing the math on the circuit in Figure 1, we can calculate the current draw on the output pin. Assuming that the pin is at 5 volts when it is high and that we have a .7 volt drop across the base-emitter junction of the transistor, we have:

$$\begin{aligned} \text{current} &= \text{voltage} / \text{resistance} \\ &= (5 - .7) / 2000 \\ &= 4.3 / 2000 \\ &= 2.15 \text{ mA} \end{aligned}$$

This is well within the capabilities of the card.

Also note the 680 Ω resistor in series with the LED. It is common practice to put a current-limiting resistor in series with an LED to keep it from burning out. Finally, note that the ground of the I/O card is

connected to the ground of the external power supply used to power the LED. This is necessary in order to establish proper voltage references. In order for the transistor to turn on, its base must be positive with respect to its emitter. We know that the output pin is positive with respect to the I/O card ground when the output pin is turned on. If we connect this ground to the ground of the external power supply, then both circuits have a common reference. When the output pin goes high, it is now positive with respect to the ground of the external power supply and thus positive with respect to the emitter. The transistor will turn on, and the LED will light.

By using several transistor stages, it is possible to increase the gain of the circuit and thereby switch very large currents. A convenient way to increase gain and still use just a single transistor package is to use a Darlington-pair transistor. This looks like a normal transistor and it is connected the same way, but it is actually two transistors in one package. They are internally connected to yield a high gain.

The next circuit we will examine uses a transistor to drive a mechanical relay. A mechanical relay has several advantages over solid-state switching devices, but there are always trade-offs in engineering. Relays have disadvantages as well, and the application determines the correct choice to use. The main advantage of mechanical relays is that they can switch very large currents with no appreciable heat build-up (unlike transistors). They can switch AC or DC, whereas simple transistor circuits like Figure 1 can only handle DC. The main disadvantages of relays are switching time and contact life. A relay takes time to turn on and turn off. It may be only a fraction of a second, but compared to transistors it is an eternity. Transistors are capable of switching millions of times every second, and thus they can be used for high-speed switching applications like PWM control of motors. Relays are used for much slower applications such as lights, uncontrolled motors, etc. Contact life is a measure of how many switching operations the relay can perform before the mechanical contacts wear out. While relays can last a long time, the transistor is still superior in this area since there are no mechanical parts to wear out.

Figure 2 shows a basic circuit which uses an NPN Darlington transistor to drive a relay. Note the similarity to Figure 1. Here the load is a relay instead of an LED. When the output pin goes high, the transistor turns on, allowing current to flow through the relay coil. This causes the relay to switch its contacts.

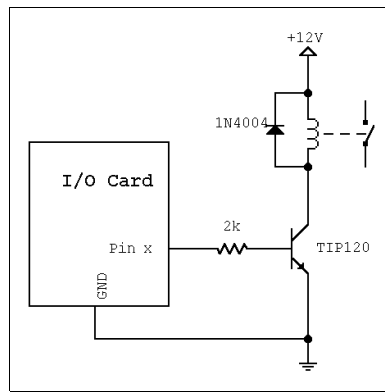


Figure 2: Driving a relay

Note that we use a current-limiting resistor at the base of the transistor. This was discussed above in the circuit for Figure 1. The diode in parallel with the relay coil is important. This clamps the inductive spikes caused by the switching of the relay coil. Without this diode, the coil will generate voltage spikes which could harm some components in your circuit. Be sure to install the diode with the correct polarity. If you install it backwards, it will always be forward-biased and will approximate a short across the relay coil. Your circuit will not work correctly and could be damaged.

Input Circuits

Input ports allow us to access real-world data. It could be something as simple as monitoring a switch or something as complicated as establishing a communication link to another computer. We will examine a couple basic concepts to keep in mind when you are trying to read data.

Figure 3 shows a simple setup which allows us to read the state of a switch. When the switch closes, we might want to display something on the computer screen or perhaps turn on an external device. This is the beauty of combining hardware and software; the same switch can be used for different purposes with just a simple software change. The flexibility and possibilities are endless. But, back to Figure 3. We need a way to pull the input low when the switch is in one position and pull the input high when the switch is in the other position. This could be accomplished very easily with a SPDT switch; however, this is not always practical. They are more expensive and less common than SPST switches. Fortunately, we can use SPST switches very easily, as shown in the figure. The key is the pull-up resistor. When the switch is open, the resistor pulls up the input pin and we read a logic '1'. The pull-up is weak because of the resistor, but it is strong enough to register a definite '1' on the input. When the switch is closed, the direct connection to ground easily overpowers the weak pull-up, and we read a '0' on the input.

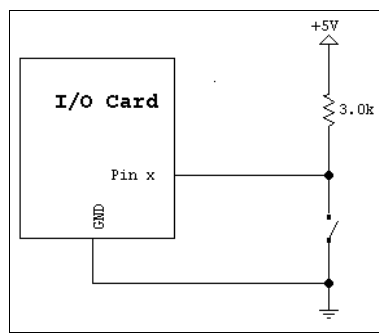
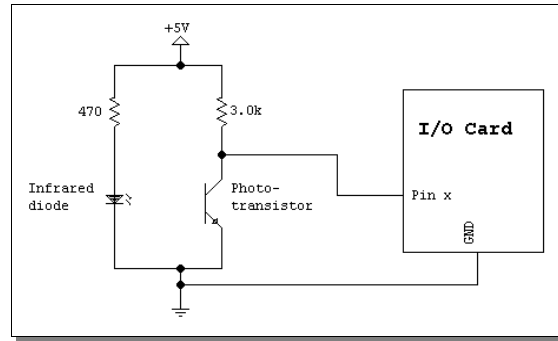


Figure 3: Reading a switch

The following note applies specifically to the 82C55 chip and therefore to the CRD155B I/O card. As noted in the CRD155B product manual, the 82C55 employs internal port-hold circuitry to maintain the state of its I/O pins. What this means is that a very weak pull is applied to the pins. We must be able to overpower this with our pull-up resistor in order to properly read the state of our switch. To do this, simply use pull-up and pull-down resistors no larger than 3.3k Ω ; and of course, connect your pull-up resistors to a +5 volt supply.

Some devices which you want to read may employ what is referred to as an 'open-collector' output. This type of device will actively pull its output to ground when in the 'low' state and let its output 'float' when in the 'high' state. To properly connect to such a device, we again need a pull-up resistor. It is really the same setup as in Figure 1, but the device uses a transistor as a switch instead of the mechanical SPST switch shown in the figure. Many infrared devices are built in this manner. For example, suppose you want to read the output of an infrared interrupter device to sense if a machine has returned to its home position. When the machine is home, a metal tab interrupts an infrared beam; when the machine is not at home, the beam shines onto a phototransistor. You need to read the output of this phototransistor.

This is a typical open-collector arrangement, and it is shown in Figure 4. Note that when nothing separates the infrared diode and the phototransistor, the light turns on the transistor and the input pin of the I/O card is pulled to ground. When something interrupts the infrared beam, the transistor turns off, and the pull-up resistor causes the input pin to be pulled high. Without this pull-up resistor, the output of the transistor would float and the state of the input pin would be questionable.



Opto-Isolation

Depending upon your application, you may want to electrically separate your I/O card from the circuitry it interfaces to. This provides a level of protection for your card in the event that something goes wrong in the external circuitry. In this arrangement, the only link is infrared light. It is very similar to the arrangement in Figure 4, except that the power supplies are isolated from each other. A small supply is needed on the I/O card side in order to provide a pull-up to the phototransistor. The grounds are also separated. A typical setup is shown in Figure 5.

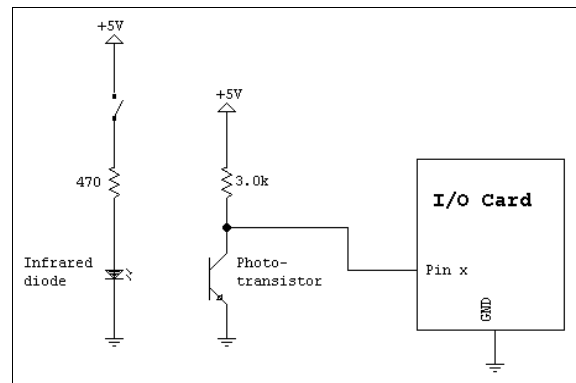


Figure 5: Optical isolation

As you can see, the only link between the external circuitry and the I/O card is infrared light. In a real-world situation, the infrared diode would be switched by a logic gate instead of a mechanical SPST switch. Note that a similar arrangement could be used for the I/O card *output* lines. In this situation, the output line would drive the infrared diode, and the phototransistor would connect to the external circuit.

There are a number of opto-isolators available in convenient DIP packages.

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Winford Engineering
4169 Four Mile Road
Bay City, MI 48706

Ph: 1-877-634-2673
FAX: 1-989-671-2941

E-mail: sales@winfordeng.com
Web: www.winfordeng.com