8

Interfacing Relays and Transistors

Relays and transistors will be interfaced to your 8255 PC Interface Card in this chapter. The circuits will show how you can turn on and off home appliances such as desk lamps or heavy duty motors.

Introduction and Motivation:

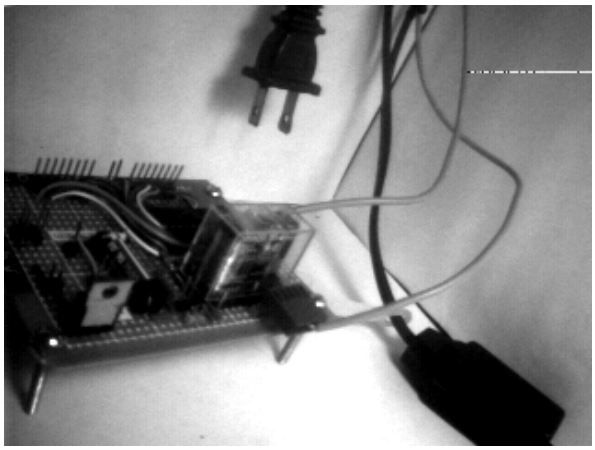

Figure 21: AC powered devices such as desk lamps and home appliances can be plugged into the AC cord (lower right) with this relay interface circuit (left).

Your computer can be programmed to turn on and off home appliances such as desk lamps and TVs. Perhaps you want to design a home security system or automate your home using your PC as a command console. The 82C55 chip can only sink or source about 10 mA, thus you cannot directly perform on/off control on large current devices from its ports. In such cases you can build the relay and transistor circuits in this chapter.

These circuits can control both DC and AC loads. The heart of these circuits is the widely available 74LS374 octal latch. and requires 10 digital I/O lines With a single 74LS374 you can simultaneously control eight devices. Adding another octal latch, you can control another eight devices.

Parts List, Numbers and Sources:

Part Description	Supplier and Number	QTY	Cost($)
74LS374 latch (20-pin DIP)	Jameco 47634	1	0.39
SPDT 5VDC 16 A relay	Digikey Z847-ND	1	3.73
SPST 5 VDC 1 A reed relay	Radio Shack 275-232	1	2.49
12.6 CT 450 mA transformer (opt)	Radio Shack 273-1365	1	4.99
#47 6.3 V 0.15 A lamp bulbs (opt)	Radio Shack 272-1110	1	1.19
Bayonet lamp holders (opt)	Radio Shack 272-355	1	1.29
Heat shrink tubing	Radio Shack 278-1627	1	1.99
AC Extension Cord	Radio Shack 61-2744	1	1.99

Table 10: Parts list for relay and transistor interface circuit. The "opt" designation means that these parts are optional.

Schematic Wiring Diagram:

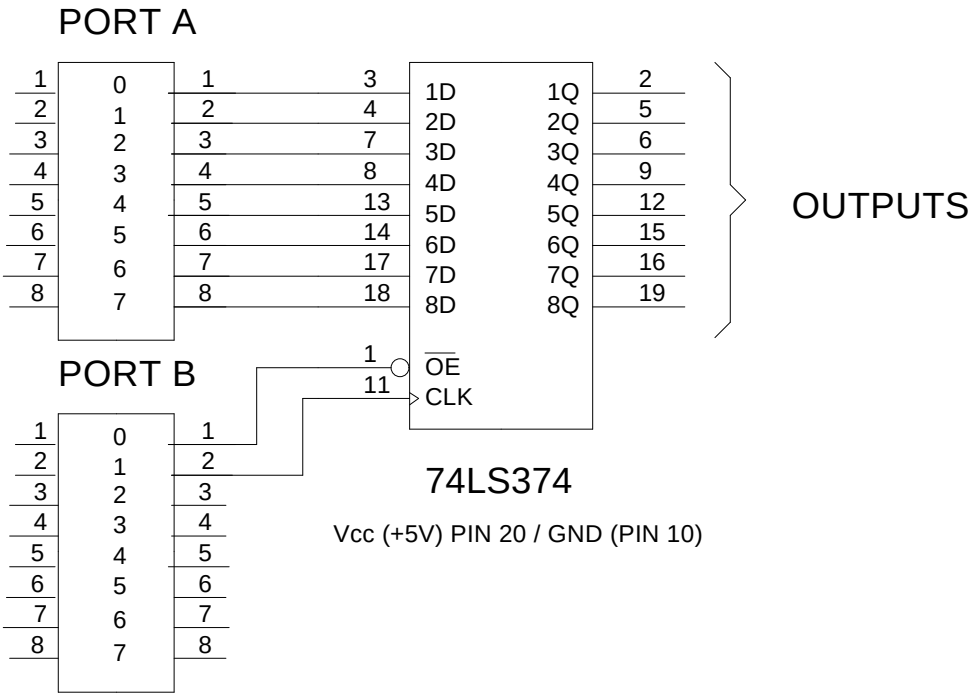

Figure 22: Schematic for interfacing the 74LS374 octal latch. The numbers 0-7 in the boxes labeled Port A and Port B refer to the lines A0-A7 and B0-B7 on the Terminal Expansion Board.

Construction:

The 74LS374 is tristate device with an Output Enable (OE) on pin 1 and a Clock (CLK) on pin 11. The outputs 1Q-8Q are in a high impedance state which will not source or sink current while OE is high. Bringing OE low and CLK high latches the inputs 1D-8D and opens the lines 1Q-8Q. Lines 1D-8D are physically wired to the A0-A7 on the Terminal Expansion Board. The OE and CLK lines are wired to B0 and B1 respectively. When and Q-line (1Q-8Q) is low, the 74LS374 can sink 12 mA which is enough current to drive relays or transistors. The following schematic wiring diagrams will show how various relays and transistors are wired to the Q-lines.

Connecting a SPST reed relay (AC or DC loads):

A reed relay can handle loads up to 1 amp at 125 VAC. A typical toy DC motor (Radio Shack 273-223, 273-255, 273-256) requires voltage supplies from 1.5 to 18 VDC. Depending on the torque on the motor's spindle, about 1 A of current is needed. A reed relay can adequately handle such currents. The same circuit can be used to turn on/off AC

loads that are *less than* 1 amp. Most AC home appliances require more than 1 amp, so the reed relay should not be used. Instead a higher rated relay such as the SPDT will do the job (described in the next section)

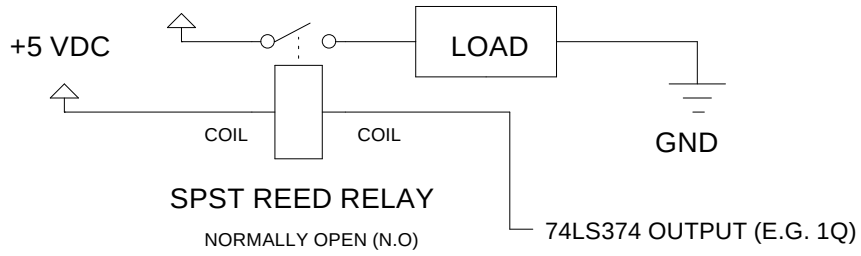

Figure 23: Connecting a reed relay.

Figure 23 shows a reed relay is quickly to the 74LS374 circuit in Figure 22. A motor (or other device) is turned on when the switch is closed. This happens when the relay's coil is energized (that is, current can flow) by setting 1Q and OE low and CLK high You can program this with an `OUT PORTA, 0: OUT PORTB, 1` statement. Turning OE back high, or setting Port A to 1 will turn it off.

Connecting a Transistor (DC loads only):

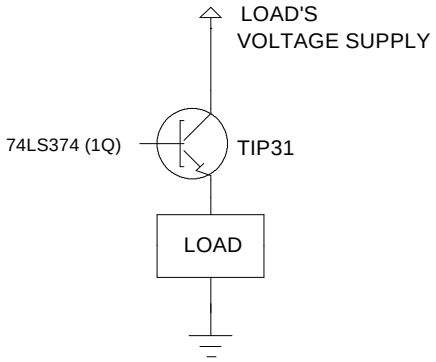

Figure 24: Interfacing a TIP31 NPN transistor to the 74LS374

The schematic in Figure 24 shows a transistor connected to the 74LS374 circuit in Figure 22. The TIP31 is an NPN solid-state transistor. Transistors are usually cheaper, last longer and switch faster than relays. Transistors can handle higher currents if proper heat sinks are used. The TIP31 can handle up to 3 amps at 40 VDC. This device can thus be used instead of a reed relay to turn a motor on or off. In Figure 22 a high on 1Q and CLK, and a low on OE will enable the TIP31's gate and allow current to flow from its collector to emitter. For example, you can use `OUT PORTA, 1: OUT PORTB, 1` to turn on the motor. Writing a 0 to Port A, or setting OE back high will turn it off.

Connecting a SPDT Relay (Heavy DC or AC loads)

A SPDT relay typically can handle heavy current loads. You can turn on a big AC or DC load (such as a home appliance running on 120 VAC or big DC motor), by energizing the coil in the same manner as the reed relay. You set 1Q and OE low and CLK high. This flips the switch so that the current can flow from the load's voltage supply. The cited SPDT relay can handle up to 16 Amps. Thus it can be used to handle most home appliances. The schematic to control DC loads is shown in Figure 25:

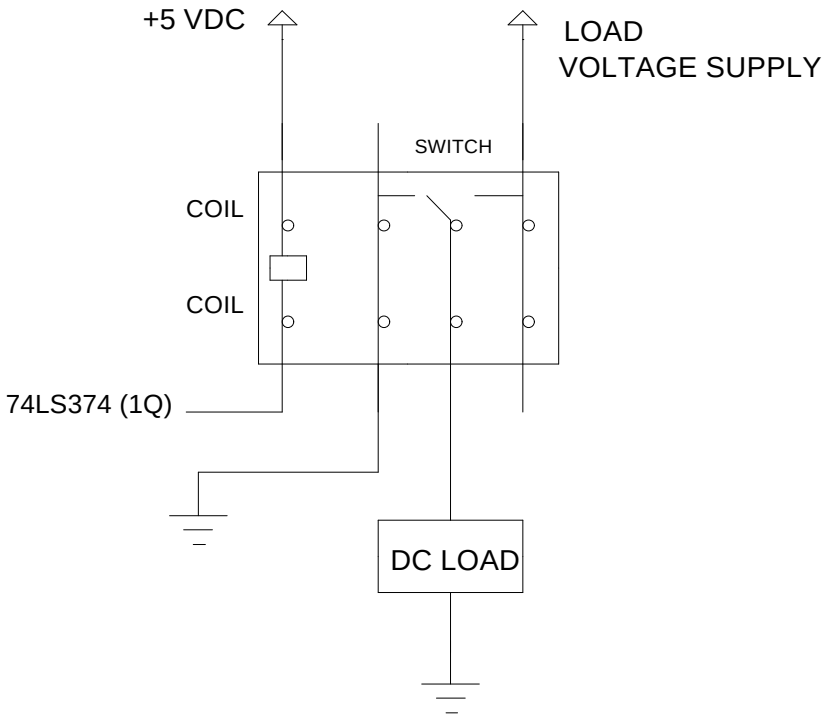

Figure 25: Schematic to connect a SPDT relay to the 74LS374 to drive DC loads

To run AC loads, you need to use the schematic in Figure 26. AC loads can be dangerous. It is suggested that you first use a circuit with a transformer to ensure that you understand the principles behind SPDT enabling and disabling of AC current. For example, the cited transformer steps your household 125 VAC down to 6.5 VAC. The #47 lamp can be attached to the transformer's secondary coils and to the SPDT relay. You can then write a program to turn on or off the #47 lamp. The schematic is shown in Figure 26.

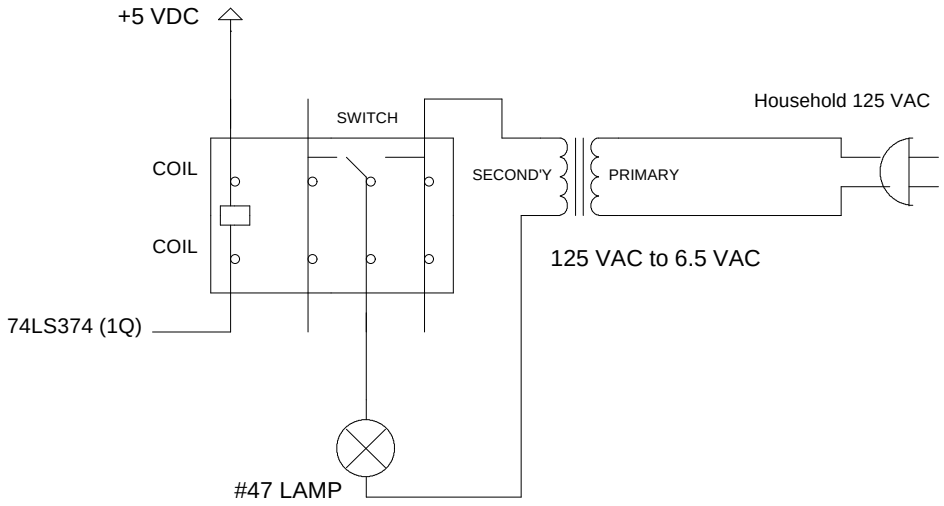

Figure 26: Playing it safe, this AC relay circuit uses a 6.5 VAC transformer to turn on and off a small current #47 lamp

Once you are confident of SPDT principles for turning AC on and off, you can control the switching of 110 VAC household current.

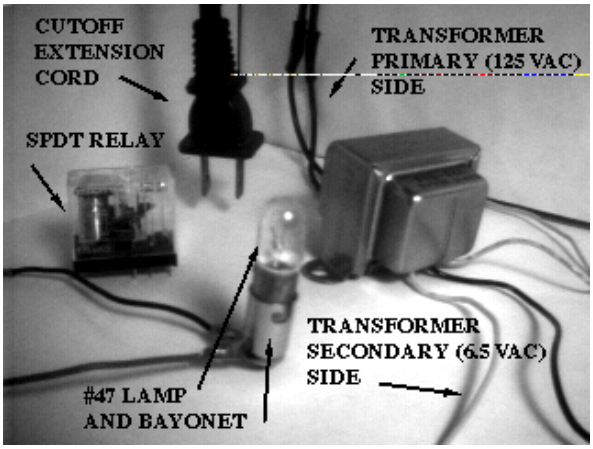

Figure 27: Transformer, #47 lamp, SPDT relay and an regular 6 foot AC extension cord.

A regular 6 foot AC extension cord's female end was cut off and soldered to the transformer's primary. Heat shrink, or electrical tape should be used to ensure that there is no short. The cited transformer is center-tapped. This means that it can provide either 6.5 VAC (if the center and adjacent wires are used) or 13 VAC (if the left and right wires are used).

The #47 lamp is shown installed in the bayonet holder. The circuit is then wired up as shown in the schematic (Figure 26). Setting 1Q and OE low and CLK high flips the relay's switch enabling the transformer's secondary 6.5 VAC to flow through the lamp and turn it on. This is accomplished with an `OUT PORTA, 0: OUT PORTB, 1` statement. Setting Port B to 2 will turn the lamp off.

Once you are confident in using AC power you can turn on household appliances in a similar manner. A regular 6 foot extension cord is shown in Figure 29. The female and male

ends are left intact. Only one wire is spliced. Two 20 gage wires are soldered to each end of the spliced wire and protected with heat shrink to prevent shorts.

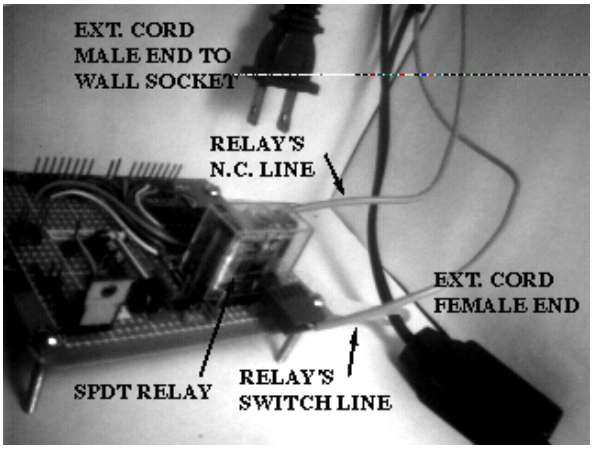

Figure 28: A 6 foot AC cord is spliced. Two wires are soldered to the spliced ends and run to the SPDT relay.

One 20 gage wire hooks up to the relay's normally closed (N.C) pin, while the other hooks up to the relay's switch pin. This is shown in more detail in Figure 28. You can then plug a desk lamp or other appliance into the extension cord's female end and plug the AC cord's male end into a 125 VAC wall socket. You can turn on an appliance by issuing a low on 1Q and OE and a high on CLK as follows: `OUT PORTA, 0: OUT PORTB, 1.`

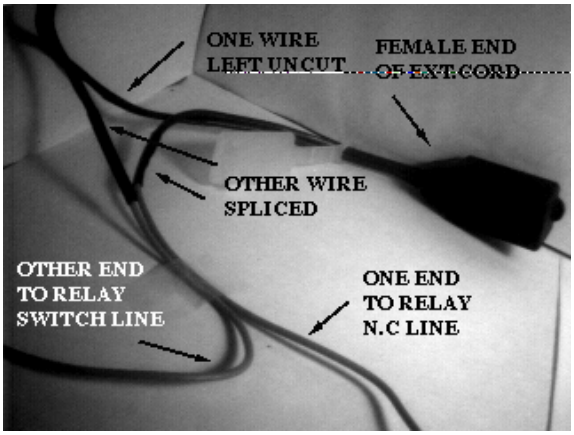

Figure 29: A closer view of the spliced AC extension cord.

The relay circuit is quick to build and an economic and efficient way to have on/off control with your PC. You can control up to 8 relays and/or transistors by wiring each device to an output line (1Q to 8Q). If you wire up two 74LS374 on Ports A and B, and use 4 digital lines (2 for each OE and 2 for each CLK) on Port C, then you can then control 16 relays and transistors. The 74LS374's latching capabilities allows you to turn on or off relays individually or simultaneously.

Some manufacturers sell digital input/output cards with relays and a buffer (like the 74LS374) selling them for over $100. The listed parts, show that such an interface can be made for less than $30, with the SPDT relay being the bulk of the cost. As shown, a TIP31 may be more than enough for your DC needs and is much cheaper than using mechanical relays. The QBasic and Turbo C program listings follow

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QBasic Program Listing for Relay Interface:

```
'   FILE: RELAY.BAS
'   DESC: Uses the 74374 latch to turn on a relay linked with port A.0
'         Port B:  B.0 = OE AND B.1 = CLK
```

```
    CLS : LOCATE 2, 1: PRINT "ENTER BASE ADDRESS (DECIMAL) E.G. 608 :"
    INPUT BASEADDR: PORTA = BASEADDR
    PORTB = BASEADDR + 1: PORTC = BASEADDR + 2: CNTRL = BASEADDR + 3
    OUT CNTRL, 128: ' All ports configured for output
    OUT PORTB, 2: ' B.0 (CLK) and B.1 (OE) both disabled

    DO
        LOCATE 4, 1: PRINT "Port A.1 has normally open relay"
        LOCATE 5, 1: PRINT "Enter (1) to turn on"
        LOCATE 6, 1: PRINT "Enter (2) to turn off"
        LOCATE 7, 1: PRINT "Enter (3) to turn off and quit"
        LOCATE 8, 1: PRINT "Selection => "
        LOCATE 8, 14: INPUT SGNAL
        IF SGNAL = 1 THEN GOSUB TURNON
        IF SGNAL = 2 THEN GOSUB TURNOFF
        IF SGNAL < 1 OR SGNAL > 3 THEN GOSUB REDO
    LOOP WHILE (SGNAL <> 3)
    OUT PORTB, 2: ' OE IS NOW HIGH
    LOCATE 20, 1: PRINT "EXITING"
    END

TURNON:
        OUT PORTA, 0: ' A.0 is low thus relay enabled
        OUT PORTB, 1: ' CLK high and OE low
        LOCATE 10, 1: PRINT "Load (Motor) is on "
        RETURN

TURNOFF:
        OUT PORTA, 1: ' A.0 is high thus relay off
        OUT PORTB, 2: ' CLK low and OE high
        LOCATE 10, 1: PRINT "Load (Motor) is off"
        RETURN

REDO:
        LOCATE 15, 1: PRINT "Enter 1, 2 or 3"
        RETURN
```

Program Description:

The program begins by prompting the user for the card's base address and assigns addresses to `PORTA`, `PORTB`, `PORTC` and `CNTRL`. For this program, Port A's digital I/O lines are connected to the 74LS374's 1D-8D inputs. Port B's B0 and B1 connect to CLK and OE respectively. Also assumed is that an normally open relay is attached to 1Q.

After the address assignments, the program prompts the user to enter (1) to turn on the relay, (2) to turn off the relay and (3) to turn off the relay and exit. If the user types a 1 and ENTER the subroutine `TURNON` is executed. A 2 goes to the `TURNOFF` subroutine. Recall that the relay is turned on by having a 1Q and OE low and CLK high. This is done with a `OUT PORTA, 0` and `OUT PORTB, 1` statements in the `TURNON` subroutine.

Turning off the motor requires a high on 1Q and OE and a low on CLK. This is accomplished with `OUT PORTA, 1` and `OUT PORTB, 2`, which is in the `TURNOFF` subroutine. The Turbo C program operates in the same manner and follows.

Turbo C Program Listing for Relay Interface:

```
/*
    FILE: RELAY.C
    DESC: Uses the 74374 latch to turn on a relay linked with port A.0
*/

#include<stdio.h>
#include<stdlib.h>
#include<dos.h>          /* outportb, inportb defined here        */
#include<conio.h>        /* formatted text functions defined here */

void main(void) {

   int Sgnal;
   int BASEADDR, PORTA, PORTB, PORTC,CNTRL;

   clrscr();            /* clear screen */
   window(5,5,75,30);   /* set up text window */
   gotoxy(1,1);
   cprintf("Enter Base Address (decimal) e.g. 608\n");
   gotoxy(1,2); scanf("%d", &BASEADDR);
   PORTA = BASEADDR;
   PORTB = BASEADDR + 1;
   PORTC = BASEADDR + 2;
   CNTRL = BASEADDR + 3;

   outportb(CNTRL, 128);   /* configure all ports for output */
   outportb(PORTB, 2);     /* (B.0) CLK low and (B.1) OE is high */
   while(1) {
       gotoxy(1,4); cprintf("Port A.1 has normally open relay\n");
       gotoxy(1,5); cprintf("Enter (1) to turn on\n");
       gotoxy(1,6); cprintf("Enter (2) to turn off\n");
       gotoxy(1,7); cprintf("Enter (3) to turn off and quit\n");
       gotoxy(1,8); cprintf("Selection => ");
       scanf("%d", &Sgnal);
       switch (Sgnal) {
       case 1 : outportb(PORTA, 0); /* A.0 is low thus relay enabled */
                outportb(PORTB, 1); /* CLK high and OE low */
                gotoxy(1,10); cprintf("Load (Motor) is on \n");
                break;
        case 2 : outportb(PORTA, 1); /* A.0 is high thus relay off */
                outportb(PORTB, 2); /* CLK low and OE high */
                gotoxy(1,10); cprintf("Load (Motor) is off\n");
                break;
        case 3 : outportb(PORTB, 2); /* OE is now high */
                gotoxy(1,20); cprintf("Exiting\n");
                exit(0);
                break;
       }; /* end of select */
       if(Sgnal<1 || Sgnal>3) {
           gotoxy(1,15); cprintf("Enter 1, 2 or 3\n");
       };
   }; /* end of while */
}; /* end of main */
```