Programmable CENTRONIC 24-LINE INPUT/OUTPUT CARD PART 2

by Dr. Pei An

Dr. Pei An concludes this article, which describes a general-purpose programmable I/O card for computers. Part 1 of this project can be found in Issue 111.

Operation of the Card

The schematic of the card is given in Figure 6A and 6B. The DATA port of the Centronic port sends data from the Centronic port to the I/O card. The STATUS port reads data from the card. The CONTROL port controls reading and writing operations of the 8255 PPI.

Data transfer is facilitated by IC2 and IC3 (74LS241 and 74LS244 tri-state buffers). The control of the 8255 PPI is made by IC4 and IC5 (74LS365 tri-stage buffers and 74LS02 NOR IC). It can be seen from Figure 6 that two lines of the CONTROL port (Pins 31 and 36) are connected to the address lines A0 and A1 of the 8255 PPI via IC4, which is a tri-state Hex buffer IC.

The other two lines of the CONTROL port (Pins 1 and 14) are connected to –RD and –WR of the 8255 via IC4. The two inputs of the 74LS02 NOR gate (Pins 2 and 3) are connected to the two control lines from the Centronic port (Pins 1 and 14) and its output is connected to the ENABLE of IC4 (Pins 1 and 15 of the 74LS365 IC). When the two lines from the Control port are both low, the output of the NOR gate will go high. This will disable all the buffers on the 74LS365 IC and set all the outputs at high impedance state and the two resistors R1 and R2 pull up the –RD and –WR lines high.

To write data to an 8255 register, firstly the required data is written to the Data port and an address to the Control port, then a high-to-low-then-high pulse is issued from -WR line of the Control port. This will enable buffers on IC3 and the data on the inputs of IC3 will be transferred to the 8255 data bus. The –WR low-going pulse will also write the data into the selected register.

Reading data from the 8255 is slightly complicated, since the Centronic port only has five input lines and in order to read an 8-bit data into the computer, the computer has to read at least twice. This is accomplished by IC2 (74LS241). 74LS241 is a tri-state octal buffer IC and its pin-out function is shown in Figure 5(b).

It can be seen that when pin 1 (the 1st enable) is low, the 4 left hand side buffers work (i.e. the outputs follow the inputs). When pin 19 (the 2nd enable) goes high, the 4 right hand

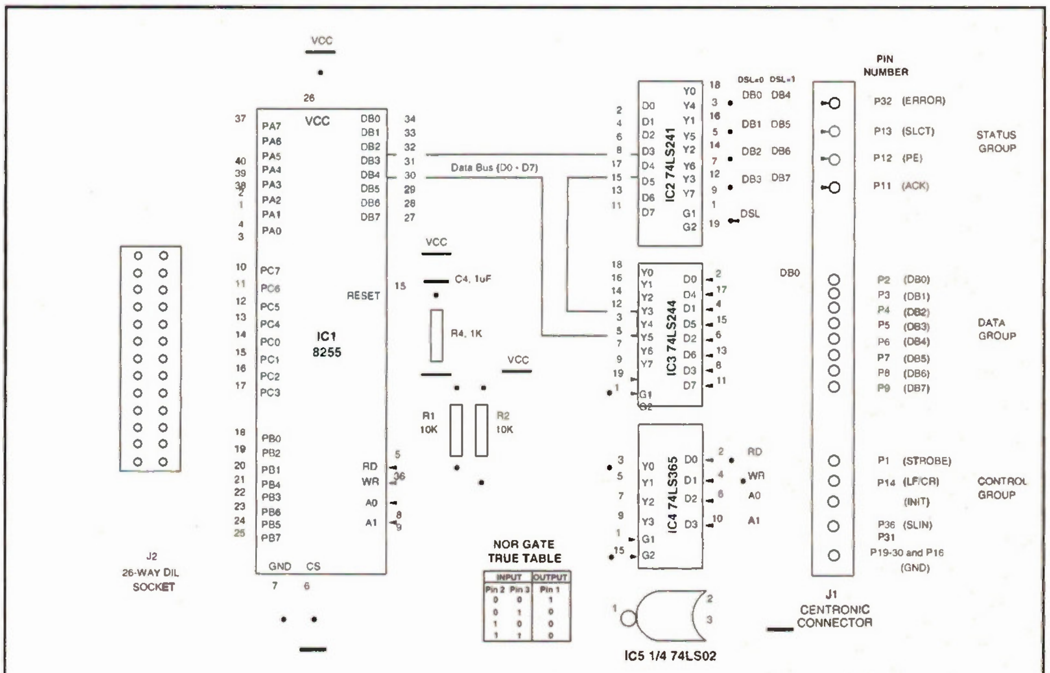
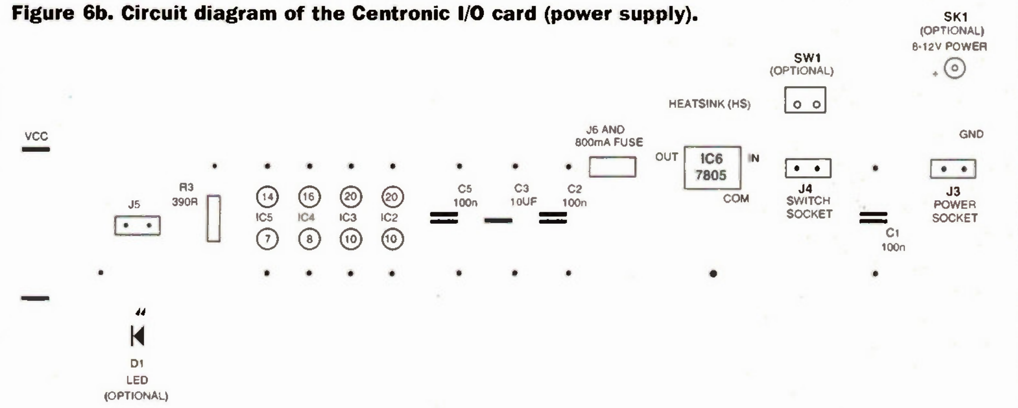


Figure 6a. Circuit diagram of the Centronic I/O card (main circuit).

Figure 6b. Circuit diagram of the Centronic I/O card (power supply).



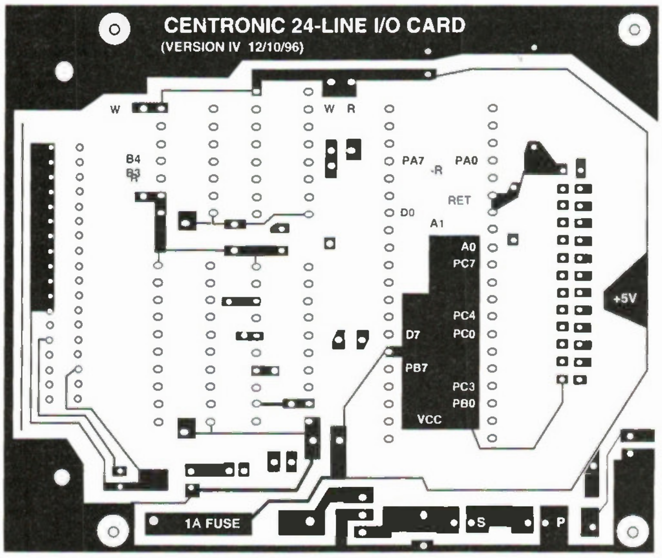


Figure 7. PCB track.

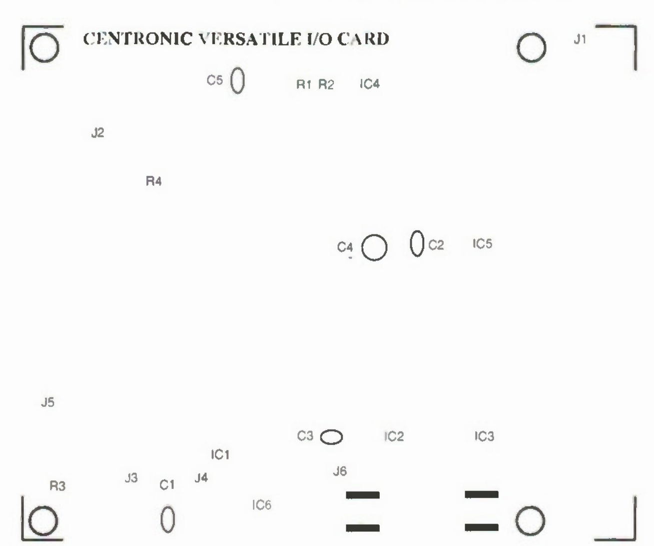


Figure 8. PCB legend.

side buffers will work. If Pin 1 and Pin 19 are connected together to form a Data Selection Line (DSL) and by putting the line low and then high, the Status port can read the 4 bits connected to the left hand buffers and the other 4 bits connected to the right hand buffers, in turn.

These two readings are then bit-manipulated and combined to form a single 8-bit byte. Operating in such a manner, the 8-bit data appearing on the input lines of IC1 can be read into the Centronic port. Referring to Figure 6A, the DSL line is controlled by the first (LSB) bit of the Data port of the Centronic port (DB0). When reading data from an 8255 register, firstly an address (A0 and A1) is written to the Control port and -RD line is held low. This will make the 8255 PPI output data onto its data bus, DB0 to DB7. Then the DSL line is set low and the Status port reads the first reading. The Status port reads the second reading with the DSL line held high. Those two readings are then combined to reproduce the original data.

The card consumes about 100mA and incorporates a 7805 1A 5V regulator. An external 8-12V DC supply is required. The regulated 5V power supply is also supplied to the expansion socket which can be used by other external circuits. An 800mA onboard fuse is used to limit the total consumed current. If 74HCT series chips are used, the current consumed by the card can be reduced. The schematic of the power supply circuit is shown in Figure 6B.

Construction

This I/O card is constructed on a single-sided PCB. The artwork of the PCB is given in Figure 7 and the component layout is shown in Figure 8. Components may be mounted on the board in the following order: links, resistors, DIL IC sockets, capacitors, electrolytic capacitors, PCB connectors, voltage regulators, Centronix female connector, fuse holders, 26-way DIL sockets and finally, the ICs. It is suggested that IC sockets are used for all the ICs.

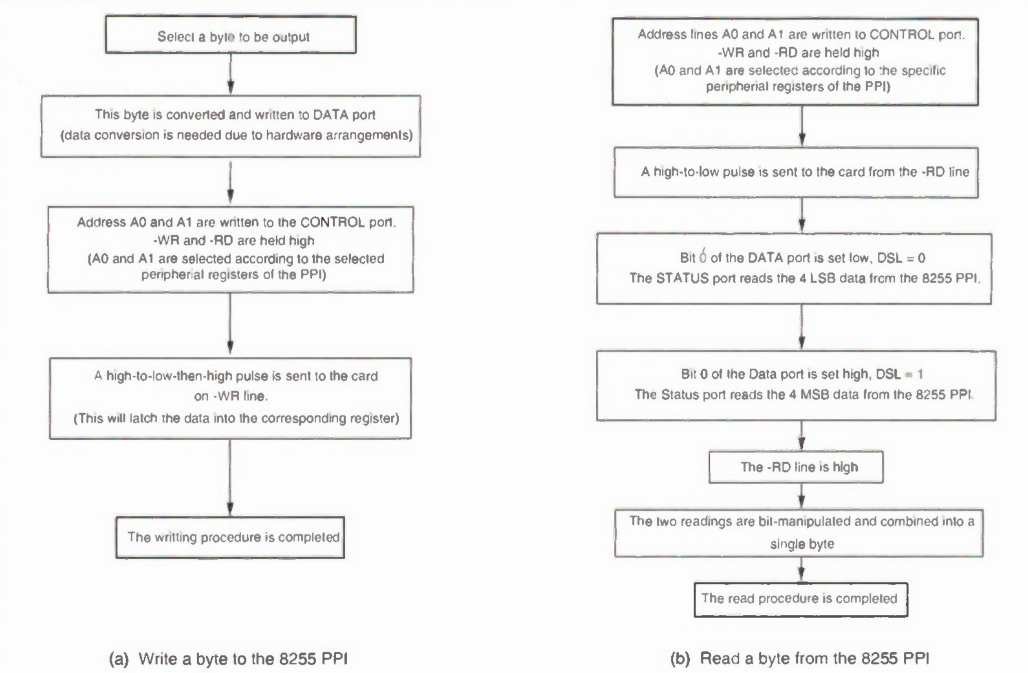
Testing

After soldering, check all the joints and connections to make sure there are no shorts due to excess solder. Only connect the power supply once you have made sure that the board is properly constructed. Since the card is simple to construct and involves no adjustment at all, it should work straight away if all the ICs are OK and properly located in position. To test the output of the ports, connect the card to the Centronic port via the printer cable and run the Demo program (which will configure all the 24 lines as outputs). A logic tester described in Application 5 (Integrated driver ICs) can be used for testing the logic level of the outputs. If a logic generator is at hand, the input function of the ports can be tested as well. However, in this case, the program needs a slight change. When testing the card, readers should be familiar with the pin functions of the 26-way expansion socket (see Figure 1) and know the configuration of the ports. It should be pointed out that connecting a logic output to an output of the 8255 may cause permanent damage to the PPI chip.

Programming

A demonstration program of the card is written in Turbo Pascal 6. The program consists of two operations: writing data and reading data from the card. The flow charts of the two operations are shown in Figures 9(a) and 9(b).

To use the card, first of all, the 8255 PPI should be initialised by writing a suitable control word to the control register. After this, data can be written to or read from peripheral registers. The procedures of writing and reading are discussed in detail below.



(a) Write a byte to the 8255 PPI

(b) Read a byte from the 8255 PPI

Figure 9. Procedures for writing data to and reading data from the I/O card.

When writing data to an 8255 register, the required data is firstly written to the Data port, then the address is written to the Control port to specify a particular register with the other two lines of the Control port set high. Next, a high-to-low-then-high pulse is sent to the 8255 via –WR line of the Control port. This will write the data into the register. It should be noted that we can only write data to the control register and peripheral registers with their corresponding ports configured as output ports. Due to the fact that the data lines of the Centronic port are not connected to that of the 8255 PPI in the same order (Figure 6A), the actual data sent to the 8255 PPI must be converted before output from the Centronic port.

To read data from the card, the following procedure is required (see Figure 9(b)). Firstly, an address (A0 & A1) is written to the Control port with the other two lines of the Control port (–WR and –RD) set high, then a high-to-low pulse is supplied to –RD line. This makes the 8255 to put data to its data bus. Next, the DB0 of the Data port is set low (DSL = 0) and the Status port of the LPT1 reads the first time. Then the DB0 of the Data port is set high (the DSL = 1) and the Status port reads the second time. Finally, the two readings are bit-manipulated and combined into a single 8-bit word and the reading procedure is completed.

Two program tools are supplied with the kit. One is the Turbo Pascal 6 include files, which control the writing and reading operations. When users develop their own Turbo Pascal program, these files can be included in the program. The other tool is the Windows™ DLL files. The DLLs are written in Turbo Pascal for Windows™. When users develop software using Turbo Pascal for Windows™, Visual C or Visual Basic, these DLLs can be called.

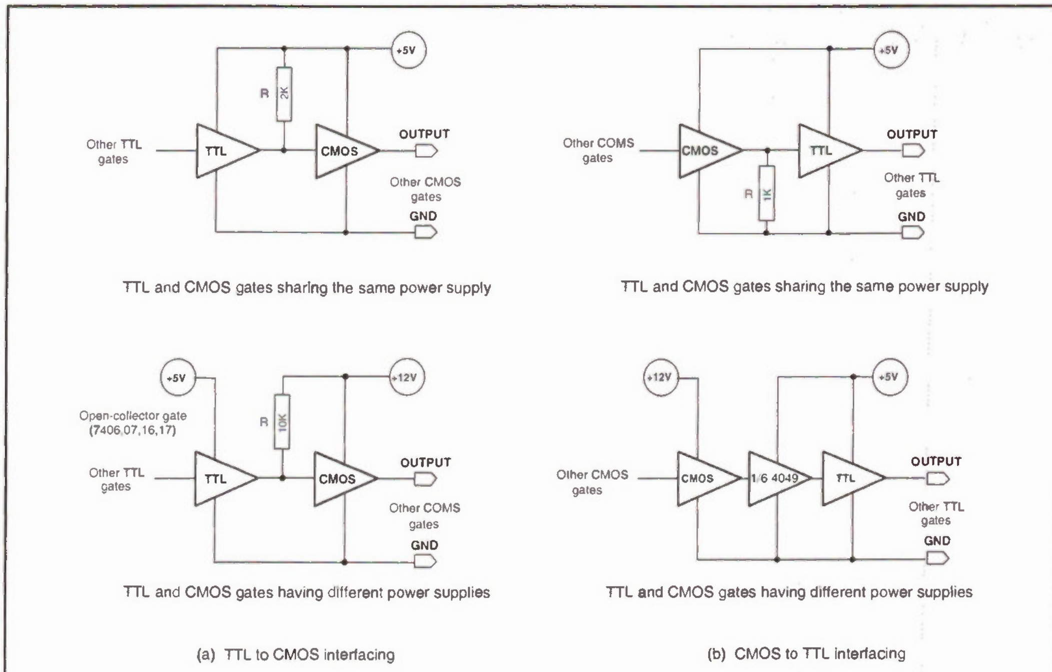


Figure 10. Interfacing between TTL and CMOS gates.

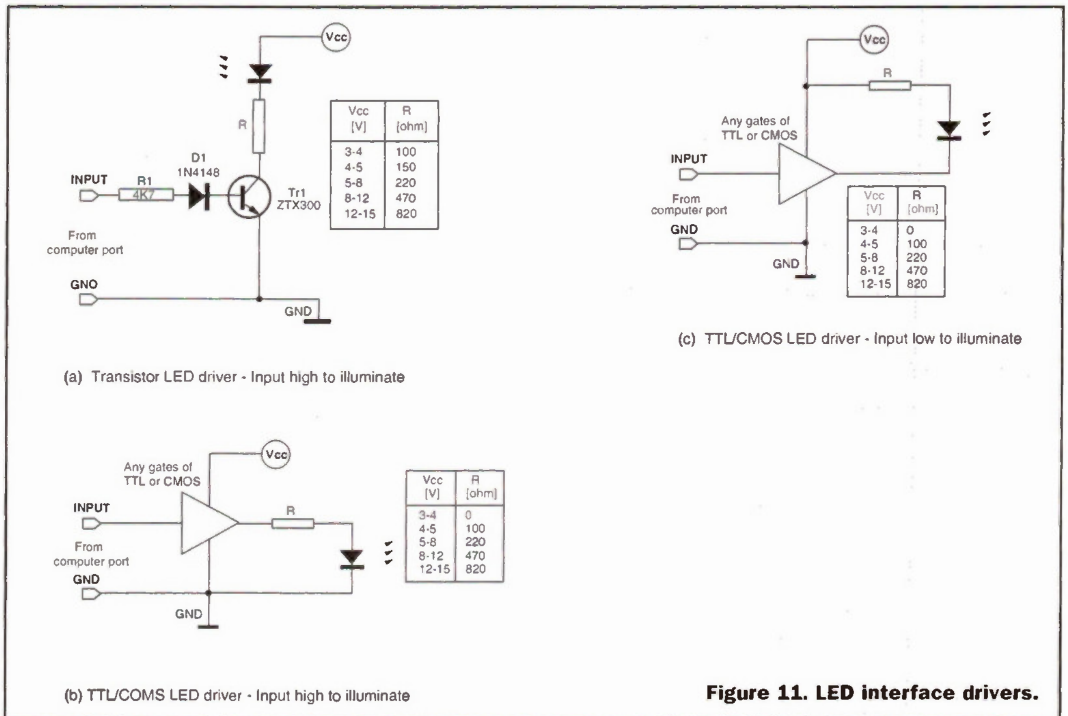


Figure 11. LED interface drivers.

Applications

Building this I/O card is only half of the story of computer interfacing. The other half is to do the actual interfacing with external devices. There are mainly two interfacing schemes. The first is to use the I/O card as an output device to control external devices. The other is to use it as an input device to obtain information from the external world. In this section, various ways in which external devices can be interfaced to the I/O card are discussed.

Before this, a brief description is given to show the relationship between logic levels (0 or 1) and voltage levels of a TTL output and input. A TTL output has two status, Logic 0 and Logic 1. At logic 0 state, the output voltage will be any voltage between 0-0·8V. At logic 1, the voltage will be between 2-5V. A TTL input will interpret any incoming voltage between 0-0·8V as 'Logic 0' and interprets any incoming voltage between 2-5V as 'Logic 1'.

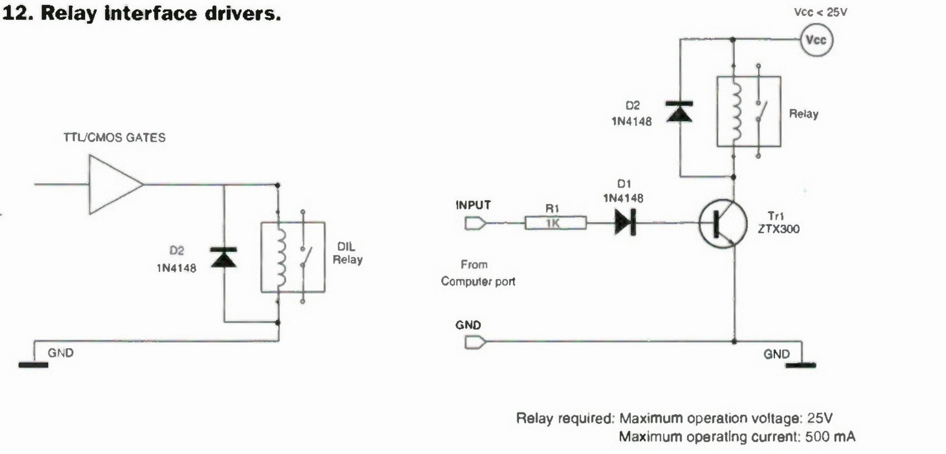
Interfacing between TTL and CMOS

Often, a TTL gate and a CMOS gate have to be connected together. Figure 10(a) shows how this is achieved. The upper figure is the case where the two gates share the same power supply and the lower one is where the two gates have different power supplies. Figures 10(b) shows how a CMOS gate is connected to a TTL gate.

LED drivers

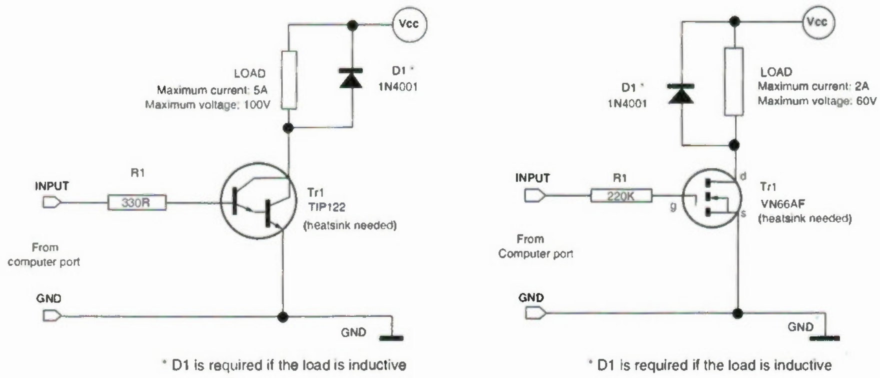
Using computers to control LEDs is very common in interfacing projects. LEDs are low-power light-emitting devices which require only about 5mA at 2V potential to illuminate. Several LED drivers are shown in Figure 11. Figure 11(a) shows a LED driver using a transistor, ZTX300. In this circuit, a resistor R has to be used in series with the LED and its value should be chosen according to the voltage applied. LEDs can also be driven by TTL or CMOS gates directly, as shown in Figures 11(b) and 11(c). In Figure 11(b), a logic 1 at the gate output will illuminate the LED. In Figure 11(c), a logic 0 will make the LED to illuminate. For TTL gates, the voltage of the power supply is 5V, the serial resistor R is thus about 100Ω. For CMOS gates, R should be chosen according to the voltage of the power supply.

Figure 12. Relay interface drivers.



(a) Relays driven directly by the TTL gates

(b) Relay driver using a transistor



(a) Darlington transistor high power driver

(b) VMOS transistor high power driver

Figure 13. Darlington and VMOS transistor high power drivers.

Relay drivers

Low power reed relays, some of which are housed in tall DIL plastic packages, will operate with a coil voltage of about 3·7V and a current of 7·4mA. These can be driven directly from TTL gates. A suppressor diode must be used to protect the TTL output against the reverse voltage generated as the relay switches off. However convenient, the contact rating of this type of relay is rather low. The maximum voltage is usually below 100V and the maximum power is in the range from 3 to 10W. This only enables loads such as low voltage filament bulbs and small electric motors to be controlled, but is inadequate for the majority of applications.

Medium and high power relays require higher coil voltage and current, hence, relay drivers have to be used. Figure 12 shows a relay driver using a transistor ZTX300. The driver will operate for a maximum supply voltage of 25V and a maximum current of 0·5A. This is adequate for most relay applications. The actual voltage of the power supply should be chosen according to the specification of the relay applied. In all cases, the suppressor diode must be used. Other medium power transistors such as BC108C and BC548 can also be used for such an application.

Drivers for high-current loads

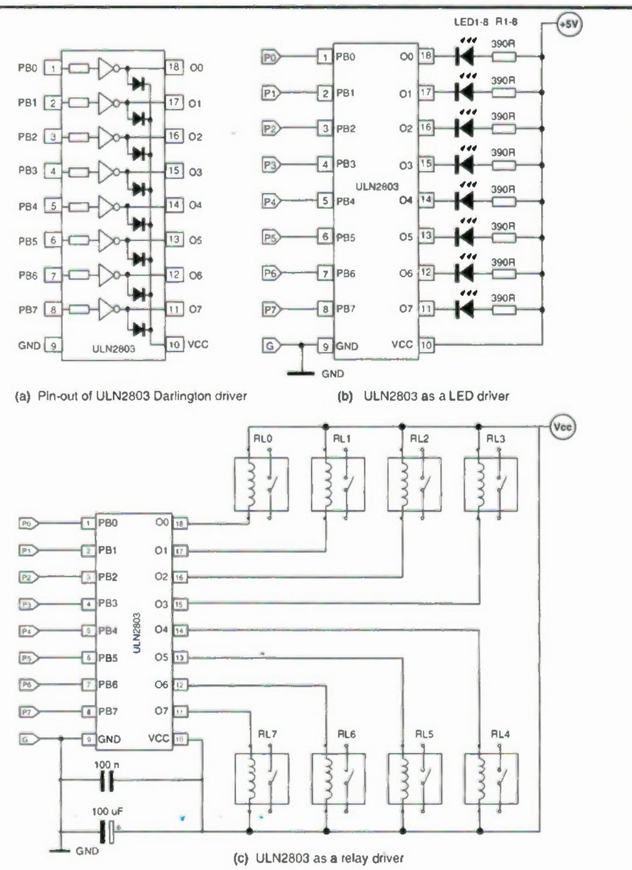
Figure 13 shows two driver circuits. The first one uses a Darlington power transistor, TIP122, which can be used with a maximum supply potential of 100V and a maximum current of 5A. Darlington transistors start to conduct for a base voltage of 1·2V and have a typical current gain of 5,000, therefore, a base voltage slightly higher than 1·2V will cause the transistor to saturate in conduction. It can, therefore, be interfaced directly to TTL gates. The second one uses a VMOS transistor, VN66AF, which can handle a maximum voltage of 60V and a current of 2A. A VMOS transistor requires an input voltage between 0·8 to 2V to conduct, thus it is possible to directly drive a VMOS transistor from a TTL output. In both cases, the suppressor diode must be used for highly inductive loads such as relays or electric motors and is not necessary if the load is non-inductive such as bulbs or electronic circuits.

Integrated driver ICs

In cases where a number of LEDs, relays or loads are needed, an integrated driver IC such as ULN2803 (or ULN2003) is recommended. This IC has 8 Darlington pair transistor drivers (ULN2003 has 7 pairs) and the pinout is shown in Figure 14(a). In use, pin 9 is connected to the GND and pin 10 is connected to the positive power supply. The maximum voltage is 50V and each driver can handle up to 0·5mA current. For currents above 0·1A, heatsinks should be used. Figures 14(b) and 14(c) give the circuit diagrams in which 8 LEDs and 8 relays are controlled by the IC, respectively. The former can be used as a simple logic level indicator for checking the operation of the present I/O card (see section 'Testing').

Opto-isolator

Opto-isolators are used to electrically isolate the computer from the external devices. This is useful to ensure that any fault or mistake in the device side will not lead to the damage to the computer. A typical opto-isolator consists of an infra-red LED and a photo-transistor (see Figure 15). In use, the LED is driven from a TTL



(a) Pin-out of ULN2803 Darlington driver

(b) ULN2803 as a LED driver

(c) ULN2803 as a relay driver

Figure 14. ULN2803 Darlington driver IC and its applications; (a) Pinout, (b) LED driver, (c) Relay driver.

gate in the normal way. For the photo-transistor, there are two configurations, i.e., inverting and non-inverting. In the first case, a logic 1 at the input will result in the output going low (Figure 15(a)). In the second one, a logic 1 at the input will make the output high (Figure 15(b)).

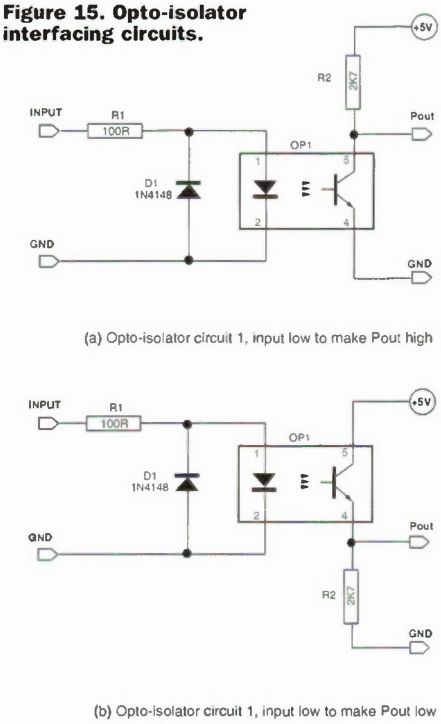
Opto zero-crossing Triac isolator

This device (e.g. MOC3041) is mainly used for controlling the mains (see Figure 16). It incorporates an infra-red LED a zero-crossing unit and a Triac. The Triac has a 400V rating and can handle a maximum current of 100mA. Sometimes, this is inadequate and more powerful opto triacs are used. **When dealing with the mains supply, extreme care must be taken.**

Input conditioning interface for TTL gates.

In some applications, the signals from certain sensors to be sensed by a TTL input are not TTL compatible. It is necessary to incorporate additional interfacing circuitry between the sensor and the input port. Figure 17(a) shows how a switch is interfaced to the TTL input. This circuit is known as the 'debounced' switch. Figure 17(b) shows how temperature can be sensed using a temperature sensor. The arrangement generates a logic 0 input whenever the temperature level exceeds the threshold setting and vice-versa. Figure 17(c) shows how light level is sensed using a photodiode sensor. This circuit generates a logic 0 input whenever the light level exceeds the threshold setting and vice-versa. Figure 17(d) shows how sound can be sensed using a crystal microphone. In the absence of sound, the output from the amplifier is about 2·5V. When sound is detected, the output oscillates above and below this level and the low-going voltage change can be detected. ELECTRONICS

Figure 15. Opto-isolator interfacing circuits.



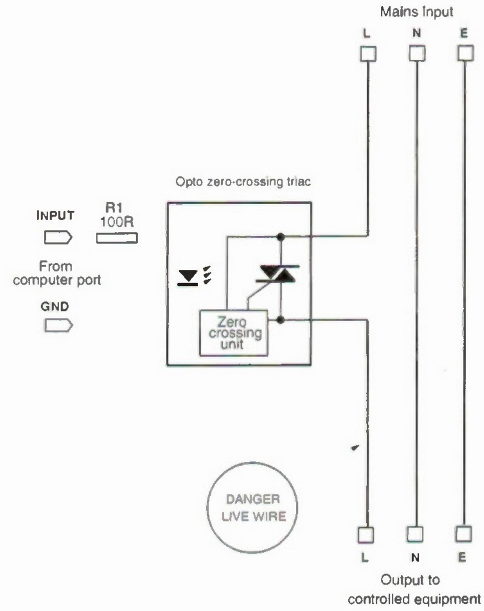


Figure 16. Opto zero-crossing triac for mains control applications.

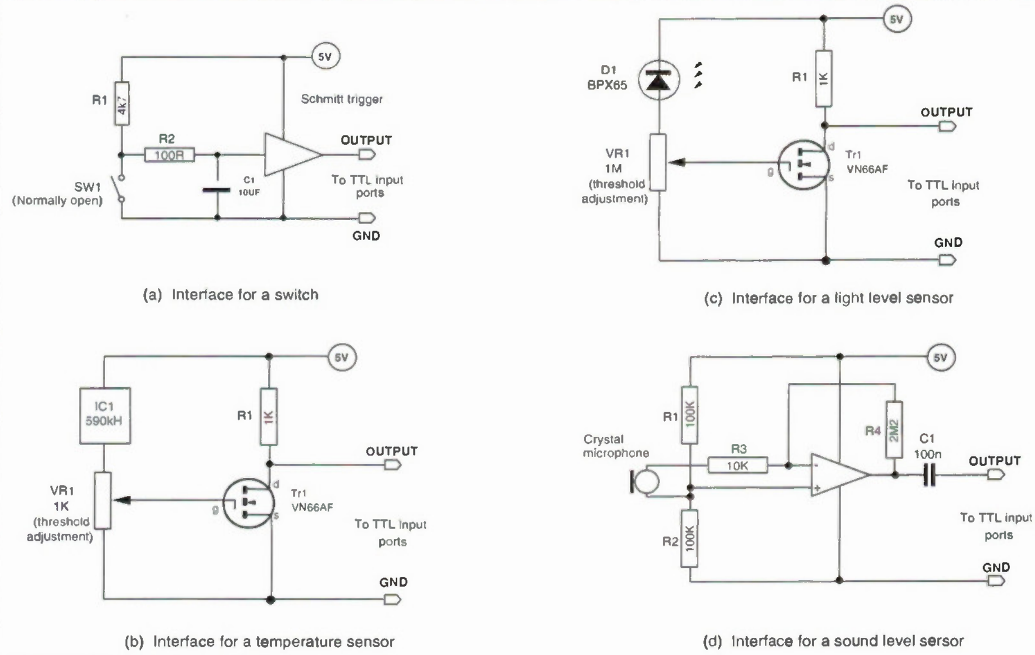


Figure 17. Interface circuits for various sensors.

PROJECT PARTS LIST

RESISTORS: All 0·6W 1% Metal Film

R1,R2	20k	2	(M20K)
R3	390Ω	1	(M390R)
R4	1k	1	(M1K)

CAPACITORS

C1,2,5	100nF Ceramic disc	3	(YR75S)
C3	10µF 63V Radial Electrolytic	1	(AT77J)
C4	1µF 63V Radial Electrolytic	1	(AT74R)

SEMICONDUCTORS

IC1	8255 PPI	1	(YH50E)
IC2	74LS241 Octal Tri-state Buffer (or 74HCT241)	1	
IC3	74LS244 Octal Tri-state Buffer (or 74HCT244)	1	(QQ56L)
IC4	74LS365 Hex Tri-state Buffer (or 74HCT365)	1	(YH11M)
IC5	74LS02 NOR Gates (or 74HCT02)	1	(YF02C)
IC6	7805 5V Regulator (1A rating)	1	(CH35Q)

MISCELLANEOUS

J1	36-pin Female Centronix-type Connector	1	
J2	26-way DIL Male Socket	1	
J3-5	2-way PCB Connectors	3	
J6	Fuse Holder	1	
F1	800mA Fuse	1	
LK1-10	0·6mm Diameter Copper Wire	As Req.	
	6BA Spacers for PCB Mounting	4	
	Heatsinks for 7805 Power Regulator	1	

OPTIONAL

SK1	2·5mm Power Socket	1	
SW1	Toggle Switch	1	
D1	5mm LED	1	(WL27E)

The Maplin 'Get-You-Working' Service is not available for this project. The CEN8255 Kit is available from the author at a price of £37.00. They include all the components for the board. Windows Visual Basic and Turbo Pascal 6 software drivers (both EXE files and source codes) are provided with the kit. Assembled and tested cards are also available at £45.00. Please add £3.50 for postage and packing and send your order and cheque to Pei An, 11 Sandpiper Drive, Stockport, Cheshire SK3 8UL, United Kingdom.