Simple circuit and program to show how to use PC parallel port output capabilities

PC parallel port can be very useful I/O channel for connecting your own circuits to PC. The port is very easy to use when you first understand some basic tricks. This document tries to show those tricks in easy to understand way.

WARNING: PC parallel port can be damaged quite easily if you make mistakes in the circuits you connect to it. If the parallel port is integrated to the motherboard (like in many new computers) repairing damaged parallel port may be expensive (in many cases it it is cheaper to replace the whole motherborard than repair that port). Safest bet is to buy an inexpensive I/O card which has an extra parallel port and use it for your experiment. If you manage to damage the parallel port on that card, replacing it is easy and inexpensive.

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How to connect circuits to parallel port

PC parallel port is 25 pin D-shaped female connector in the back of the computer. It is normally used for connecting computer to printer, but many other types of hardware for that port is available today.

Not all 25 are needed always. Usually you can easily do with only 8 output pins (data lines) and signal ground. I have presented those pins in the table below. Those output pins are adequate for many purposes.

```
pin function
 2   D0
 3   D1
 4   D2
 5   D3
 6   D4
 7   D5
 8   D6
 9   D7
```

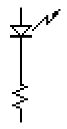
Pins 18,19,20,21,22,23,24 and 25 are all ground pins.

Those datapins are TTL level output pins. This means that they put out ideally 0V when they are in low logic level (0) and +5V when they are in high logic level (1). In real world the voltages can be something different from ideal when the circuit is loaded. The output current capacity of the parallel port is limited to only few milliamperes.

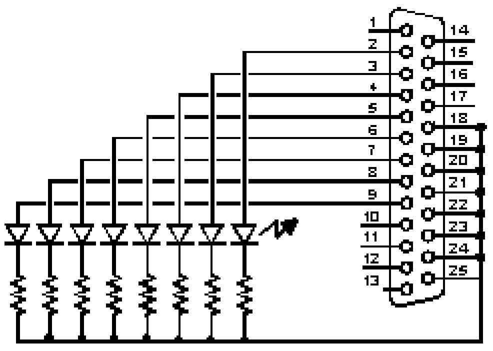
```
        Dn Out ------+
                     |+
  Sourcing         Load (up to 2.6 mA @ 2.4 v)
                     |-
        Ground ------+
```

Simple LED driving circuits

You can make simple circuit for driving a small led through PC parallel port. The only components needed are one LED and one 470 ohm resistors. You simply connect the diode and resistor in series. The resistors is needed to limit the current taken from parallel port to a value which light up acceptably normal LEDs and is still safe value (not overloading the parallel port chip). In practical case the output current will be few milliampres for the LED, which will cause a typical LED to somewhat light up visibly, but not get the full brigtness.



Then you connect the circuit to the parallel port so that one end of the circuit goes to one data pin (that one you with to use for controlling that LED) and another one goes to any of the ground pins. Be sure to fit the circuit so that the LED positive lead (the longer one) goes to the datapin. If you put the led in the wrong way, it will not light in any condition. You can connect one circuit to each of the parallel port data pins. In this way you get eight software controllable LEDs.



The software controlling is easy. When you send out 1 to the datapin where the LED is connected, that LED will light. When you send 0 to that same pin, the LED will no longer light.

Control program

The following program is an example how to control parallel port LPT1 data pins from your software. This example directly controls the parallel port registers, so it does not work under some multitasking operating system which does not allow that. It works nicely under MSDOS. You can look the Borland Pascal 7.0 code (should compile also with earlier versions also) and then download the compiled program LPTOUT.EXE.

```
Program lpt1_output;

Uses Dos;

Var
   addr:word;
   data:byte;
   e:integer;

Begin
   addr:=MemW[$0040:$0008];
   Val(ParamStr(1),data,e);
   Port[addr]:=data;
End.
```

How to use the program

LPTOUT.EXE is very easy to use program. The program takes one parameter, which is the data value to send to the parallel port. That value must be integer in decimal format (for example 255). Hexadecimal numbers can also be used, but they must be preceded by $ mark (for example $FF). The program hoes not have any type of error checking to keep it simple. If your number is not in correct format, the program will send some strange value to the port.

Example how to use the program

LPTOUT 0
Set all datapins to low level.

LPTOUT 255
Set all datapins to high level.

LPTOUT 1
Set datapin D0 to high level and all other datapins to low level.

How to calculate your own values to send to program

You have to think the value you give to the program as a binary number. Every bit of the binary number control one output bit. The following table describes the relation of the bits, parallel port output pins and the value of those bits.

```
Pin      2    3    4    5    6    7    8    9
Bit      D0   D1   D2   D3   D4   D5   D6   D7
Value    1    2    4    8    16   32   64   128
```

For example if you want to set pins 2 and 3 to logic 1 (led on) then you have to output value 1+2=3. If you want to set on pins 3,5 and 6 then you need to output value 2+8+16=26. In this way you can calculate the value for any bit combination you want to output.

Making changes to source code

You can easily change te parallel port number int the source code by just changing the memory address where the program read the parallel port address. For more information, check the following table.

```
Format of BIOS Data Segment at segment 40h:
Offset  Size    Description
 08h    WORD    Base I/O address of 1st parallel I/O port, zero if none
 0Ah    WORD    Base I/O address of 2nd parallel I/O port, zero if none
 0Ch    WORD    Base I/O address of 3rd parallel I/O port, zero if none
 0Eh    WORD    [non-PS] Base I/O address of 4th parallel I/O port, zero if
none
```

For example change the line **addr:=MemW[$0040:$0008];** in the source code to **addr:=MemW[$0040:$000A];** if you want to output to LPT2.

Using other languages

The following examples are short code examples how to write to I/O ports using different languages. In the examples I have used I/O address 378h which is one of the addresses where parallel port can be. The following examples are useful in DOS.

Assembler

```
MOV DX,0378H
MOV AL,n
OUT DX,AL
```

Where n is the data you want to output.

BASIC

```
OUT &H378, N
```

Where N is the number you want to output.

C

```
outp(0x378,n);
```

or

```
outportb(0x378,n);
```

Where N is the data you want to output. The actual I/O port controlling command varies from compiler to compiler because it is not part of standardized C libraries.

Here is an example source code for Borland C++ 3.1 compiler:

```
#include <stdio.h>
#include <dos.h>
#include <conio.h>

/********************************************/
/*This program set the parallel port outputs*/
/********************************************/

void main (void)
{
clrscr();             /* clear screen */
outportb(0x378,0xff); /* output the data to parallel port */
getch();              /* wait for keypress before exiting */
}
```

Parallel port controlling in windows programs

Direct parallel port controlling in possible under Windows 3.x and Windows 95 directly from 16 bit application programs and DLL libraries. So you can use the C example above in Windows 3.x and Windows 95 if you make your program 16 bit application. If you want to control parallel port from Visual Basic or Delphi then take a look at the libraries at Parallel Port Central at http://www.lvr.com/parport.htm.

Direct port controlling from application is not possible under Windows NT and to be ale to control the parallel port directly you will need to write some kind of device driver to do this. You can find also this kind of drivers from Parallel Port Central.

Parallel port controlling in Linux

Linux will allow acess to any port using the ioperm syscall. Here is some code parts for Linux to write 255 to printer port:

```
#include <stdio.h>
#include <stdlib.h>
#include <unistd.h>
#include <asm/io.h>

#define base 0x378           /* printer port base address */
#define value 255            /* numeric value to send to printer port */

main(int argc, char **argv)
{
   if (ioperm(base,1,1))
    fprintf(stderr, "Couldn't get the port at %x\n", base), exit(1);

   outb(value, base);
}
```

Save the source code to file lpt_test.c and compile it with command:

```
gcc -O lpt_test.c -o lpt_test
```

The user has to have the previledges to have access to the ports for the program to run, so you have to be root to be able to ron this kind of programs without access problems. If you want to make a program which can be run by anybody then you have to first set the owner of the program to be root (for example do compilation when yhou are root), give the users rights to execute the program and then set the program to be always executed with owner (root) rights instead of the right of the user who runs it. You can set the programn to be run on owner rights by using following command:

```
chmod +s lpt_test
```

If you want a more useful program, then download my lptout.c parallel port controlling program source code. That program works so that you can give the data to send to parallel port as the command line argument (both decimal and hexadecimal numbers supported) to that program and it will then output that value to parallel port. You can compile the source code to **lptout** command using the following line to do the compilation:

```
gcc -O lptout.c -o lptout
```

After you have compiled the program you can run it easily. For example running **./lptout 0xFF** will turn all data pins to 1 and running **./lptout 0x00** will turn all data pins to 0.

Controlling some real life electronics

The idea of the interface shown above can be expanded to control some external electronics by simply adding a buffer circuit to the parallel port. The programming can be done in exactly the same way as told in my examples.

Building your own relay controlling circuit

The following circuit is the simples interface you can use to control relay from parallel port:

```
                             Vcc
                              |
                              +------+
                              |    __|__
                            Relay   /^\  Diode 1N4002
                             Coil  /---\
                              |      |
                              +------+
                              |
                           | /
                 4.7K    B |/  C
parallel port >-\/\/\/\/---|        NPN Transistor: BC547A or 2N2222A
data pi                    |\  E
                           | V
                             |
parallel port >--------------+
ground pin                   |
                          Ground
```

The circuit can handle relays which take currents up to 100 mA and operate at 24V or less. The circuit need external power supply which has the output voltage which is right for controlling the relay (5..24V depending on relay). The transistor does the switching of current and the diode prevent spikes from the relay coil form damaging your computer (if you leave the diode out, then the transistor and your computer can be damaged).

Since coils (solenoids and relay coils) have a large amount of inductance, when they are released (when the current is cut off) they generate a very large voltage spike. Most designs have a diode or crowbar circuit designed to block that voltage spike from hitting the rest of the circuit. If that diode is bad, then the voltage spike might be destroying your "sink" transistor or even your I/O card over a period of time. The mode of failure for the sink transistor might be short circuit, and consequently you would have the solenoid tap shorted to ground indefinitely.

The circuit can be also used for controlling other small loads like powerful LEDS, lamps and small DC motors. Keep in mind that those devices you plan to control directly from the transistor must take less than 100 mA current.

WARNING: Check and double check the circuit before connecting it to your PC. Using wrong type or damaged components can cause you paralllel port get damaged. Mistakes in making the circuit can result that you damage your parallel port and need to buy a new multi-io card. The 1N4002 diode in parallel with the relay is an essential protection component and it should not be left out in acu case, or a damage of the parallel port can occur because of high voltage inductive kickback from the relay coil (that diode stops that spike from occuring),

Safer new design

The circuit example above works well and when transistor is of correct type and working properly. If for some reason B and C sould be shorted together and you are suing more than +5V in the relay side, the circuit can push that higher voltage to the parallel port to damage it. The following circuit uses two 1N4148 diodes to protect parallel port against higher than +5V signals and also against wrong polarity signals (power on the circuit is accidentally at wrong polarity.

```
                             Vcc
                              |
                              +------+
                              |    __|__
                            Relay   /^\  Diode 1N4002
                             Coil  /---\
                              |      |
                              +------+
                              |
          Diode             | /
          1N4148  4.7K   B |/  C
parallel  >-|>|-+--\/\/\/--|        NPN Transistor: BC547A or 2N2222A
port data       |          |\  E
pin             +-|<|-+      | V
            1N4148    |      |
parallel  >-----------+------+
port ground                  |
                          Ground
```

Adding even more safety idea: Repalce the 1N4148 diode connected to ground with 5.1V zener diode. That diode will then protect against overvoltage spikes and negative voltage at the same time.

Bad circuit example

I don't know WHY I see newbies who don't THINK electronics very well yet always putting the relay "AFTER" the transistor, as if that was something important. Well it's NOT, and in fact its a BAD PRACTICE if you want the parallel port to work well! This type of bad circuit designs have been posted to the usenet electronics newsgroups very often. The following circuit is example of this type of bad circuit design (do not try to build it):

```
                             Vcc
                              |
                           | /
                 4.7K    B |/  C
parallel port---\/\/\/\/---|        NPN Transistor: BC547A or 2N2222A
                           |\  E
                           | V
                             |
                             +------+
                             |    __|__
                           Relay   /^\  Diode 1N4002
                           Coil   /---\
                             |      |
                             +------+
                             |
                           Ground
```

NOTE: This is a bad design. Do not build or use this circuit.

The problem of the circuit is that the voltage which goes to the relay is always limited to less than 4.5V even if you use higher Vcc supply. The circuit acts like an emitter follower, which causes that the voltage on the emitter is always at value base voltage - base to emitter voltage (0.6..0.7V). This means that with maximum of 5.1V control voltage you will get maximum of 4.5V out no matter what is the supply voltage (when it higher than 5V and below transistor breakdown voltage).

Other problem is that in some cases this type of circuit can start to oscillate if the base resistor is right on the edge.

Circuit with optoisolation

If you want to have a very good protection of the parallel port you might consider optoisolation using the following type of circuit:

```
                                                V+   (12V)
                                                 |
                                    +------------+
                                    |            +------+
Parallel                            |            |      |
Port                                |    D1     ---     |
                                    |   1N4001  / \    Relay coil
          R1    1  ----------- 5    |          /---\    |
 D(x) ----1k------| Opto-      |-----+            |      |
                  | Isolator  |                  +------+
 GND -------------|           |-+                |
                2  ----------- 4|                |
                   CNY 17 or    |   R2        | /
                   4N25         |   4.7K    B |/  C    T1
                                +--\/\/\/\/---|       BC547A or 2N2222A
                                              |\  E
                                              | V
                                                |
                                          external circuit ground
```

Typical optoisolator pinout (CNY 17 and 4N25):

```
    -----------------------------
 1--|----          |------------|--6
    |   |          |            |
    | \---/ \      |    ------  |
    |  \ /  \     | | / C    |  |
    |  --- \  \|   | |/     |  |
    |   |   \ --   --|       ---|--5
    |   |    \|    B |\         |
 2--|----    --      | V E      |
    |                   ---------|--4
 3--|--NC                      |
    -----------------------------
```

The opto-isolator is there to protect the port. Note that there are no connections between the port's electrical contacts. The circuit is powered from external power supply which is not connected to PC if there is no need for that. This arrangement prevents any currents on the external circuits from damaging the parallel port.

The opto-isolator's input is a light emitting diode.R1 is used to limit the current when the output from the port is on. That 1kohm resistor limits the current to around 3 mA, which is well sufficent for that output transitor driving.

The output side of the opto-isolator is just like a transistor, with the collector at the top of the circuit and the emitter at the bottom. When the output is turned on (by the input light from the internal LED in the opto-coupler), current flows through the resistor and into the transistor, turning it on. This allows current to flow into the relay.

Turning the input on the parallel port off causes the output of the opto-isolator to turn off, so no current flows through it into the transistor and the transistor turns off. When transistor is off no current flows into the relay, so it switches off. The diode provides an outlet for the energy stored in the coil, preventing the relay from backfeeding the circuit in an undesired manner.

The circuit can be used for controlling output loads to maximum of around 100 mA (depends somewhat on components and operation voltage used). The external power supply can be in 5V to 24V range.

Optoisolated higher power circuit

Here is a higher power version of the circuit described above:

```
                                                 V+  (12V)
                                                  |
                                     +------------+-----+------+
                                     |                  |      |
                                     |                  |      |
Parallel                             |                  |      |
Port                                 |         D1      ---     |
                                     |        1N4001   / \    Relay coil
          R1     1 ----------- 5     |                /---\    |
 D(x) ----1k------| Opto-     |-----+                  |      |
                  | Isolator  |                  +-----+------+
 GND -------------|           |-+                |            |
                 2 ------------ 4|                |            |
                   CNY 17 or     |  R2         | /             |
                   4N25          |  4.7K    B |/  C T1         |
                                 +--\/\/\/\/---|     BC547A    |
                                 |             |\  E           |
                                 |             | V          | /
                                 /               |        B |/C  T2
                                 \ R3            +----------|    power
                                 / 10 kohm                  |\E  transistor
                                 \                          | v
                                 |                            |
                                 +----------------------------+
                                                              |
                                                 external circuit ground
```

In this circuit Q1 is used for controlling the base current of Q2 which controls the actual current. You can select almost any general purpose power transistor for this circuit which matches your current and voltage controlling needs. Some example alternatives are for example TIP41C (6A 100V) or 2N3055 (100V 15A). Depending your amplification facter inherint to the transitor Q2 you might not hough be able to use the full current capability of the output device T2 before there will be excessive losses (heating) in that transistor.

This circuit is basically very simple modification of the original optoisolator circuit with one transistor. The difference in this circuit is that here T2 controls the load current and Q1 acts as a current amplifier for T2 base control current. Optoisolator, R1, R2, Q1, D1 work exactly in the same way as in one transistor circuit described eariler in this documents. R3 acts like an extra resistor which guarantees that T2 does not conduct when there is no signal fed to the optoisolator (small possible current leaking on optosiolator output does not make T1 and T2 to conduct).

Reading the input pins in parallel port

PC parallel port has 5 input pins. The input pins can be read from the I/O address LPT port base address + 1.

The meaning of the buts in byte you read from that I/O port:

- D0: state not specified
- D1: state not specified
- D2: state not specified
- D3: state of pin 15 (ERROR) inverted
- D4: state of pin 13 (SELECTED)
- D5: state of pin 12 (PAPER OUT)
- D6: state of pin 10 (ACK)
- D7: state of pin 11 (BUSY) inverted

Here are some code snipplets to read LPT port:

Assembler

```
MOV DX,0379H
IN AL,DX
```

You get the result fo read from AL register

BASIC

```
N = INP(&H379);
```

Where N is the numerical value you read.

C

```
in = inportb(0x379);
```

or

```
in = inp(0x379);
```

Where N is the data you want to output. The actual I/O port controlling command varies from compiler to compiler because it is not part of standardized C libraries.