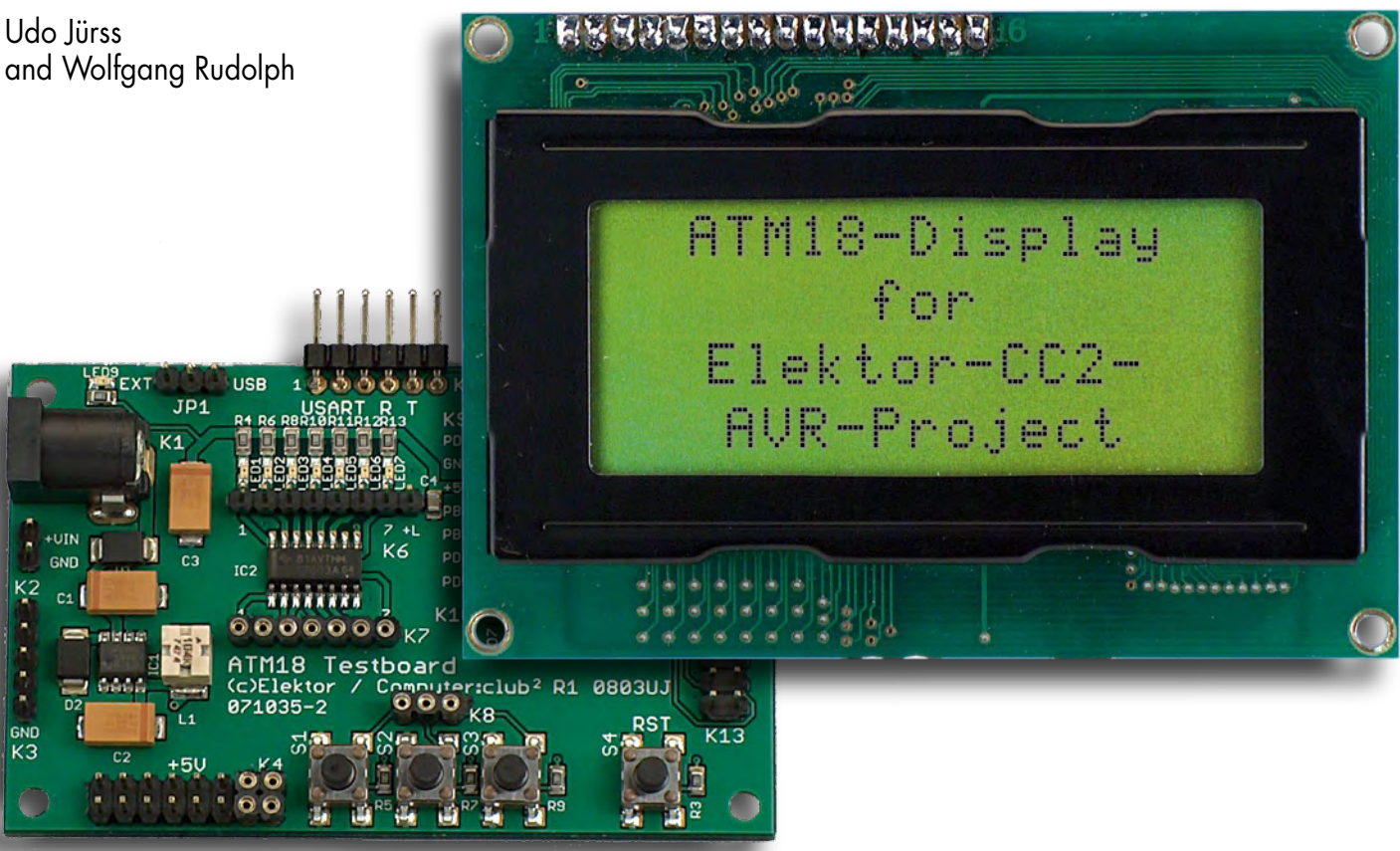


# Two-wire LCD

## ATM18 display for the Elektor AVR project

Udo Jürss and Wolfgang Rudolph



This LCD expansion module for the ATM18 test board opens up a huge range of applications. Although the design might look like a standard interface between microcontroller and LCD panel, there is an elegant technical detail: in order to minimise the number of port pins required, a special two-wire interface has been developed.

An ordinary LCD panel can be driven from a microcontroller using either four or eight data wires. In addition to these, an RS signal is needed to distinguish data from commands, and an E signal

is needed to clock the data into the panel. This large total number of connections is unfortunate in our application because it ties up a number of port pins that could be used for other purposes.

### Data transfer

All ordinary LCD panels are connected using 14 wires, plus any connections needed for the backlight. It is here

that models differ, as the manufacturers are not consistent as to whether the backlight supply should be located next to pin 1 or next to pin 14. Our printed circuit board is designed for displays where the backlight connections are on pins 15 and 16, and two pads are provided to which the backlight power supply can be soldered. If a different display is used it is simplest to use just the 14 main connections and leave the backlight unconnected. The display we used has the following pinout:

- Pins 14 down to 7: data bus
- Pin 6:E (enable signal), active high
- Pin 5: R/W, 0 = write, 1 = read
- Pin 4: RS, 0 = command, 1 = data
- Pin 3: VO, contrast adjustment from 0 V to 2 V
- Pin 2: VDD, +5 V
- Pin 1: VSS, 0 V

The direction of data transfer is specified by the level on the R/W signal. Here we only use write mode, and so the pin is connected permanently to ground in the circuit (Figure 1). The internal registers of the display controller are selected using the RS signal, which is used to distinguish between data and commands.

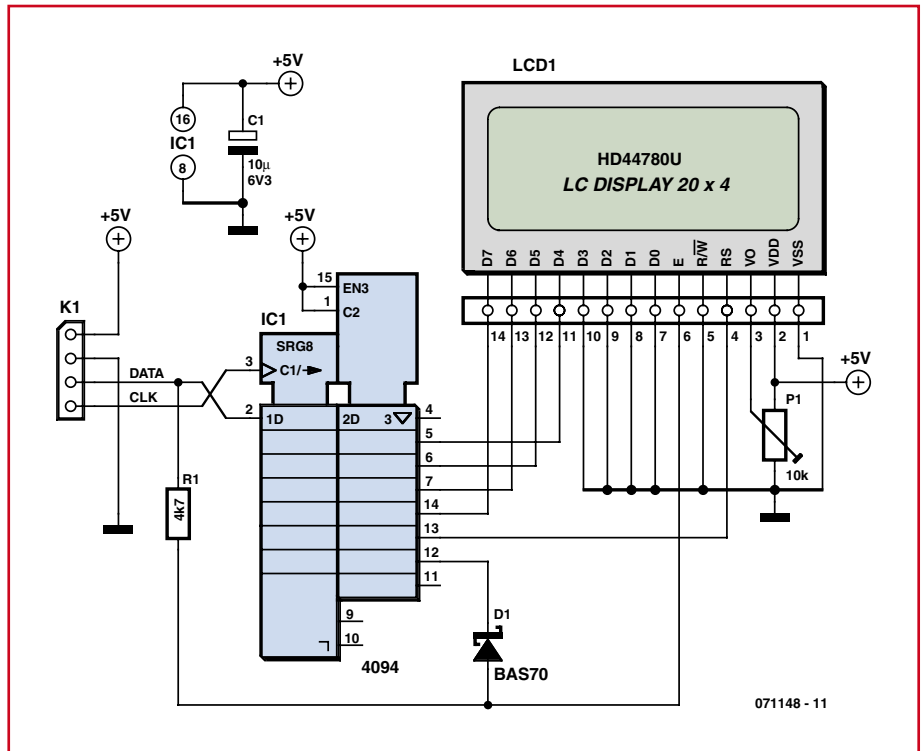


Figure 1. The LCD interface is built around a shift register.

### Two-wire interface

The circuit is based around a port expander that uses two port bits. A natural choice for such a design would be

the I<sup>2</sup>C bus, but we have chosen a faster and cheaper approach. All that we need is a type 4094 shift register (see Figure 1). This allows clock rates of sev-

## C compiler

Advanced C programmers who wish to control an LCD using the expansion module described here can take advantage of two example programs available for download from the Elektor website. One example is for use with WinAVR (GCC) and the other is for use with CodeVision.

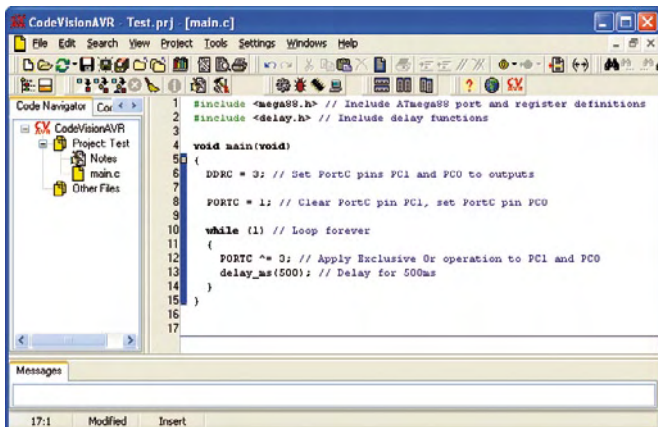
Software house HPIInfoTech has produced a special free-of-charge version of their popular 'CodeVisionAVR' compiler for this Elektor project. The compiler supports the ATmega48, ATmega88, ATmega168 and

ATmega328 with a maximum object code size of 4 kB.

A version limited to 16 kB code size costs around fifty pounds and a 32 kB version is around sixty pounds, within the reach of many hobbyists.

The compiler produces very efficient code and includes a so-called 'smart linker' that only includes in the final object file functions that are actually called. It is therefore possible to use comprehensive libraries without having to tailor them to each application.

CodeVision makes setting up a project very straightforward. The integrated 'CodeWizard' automatic program generator generates a complete skeleton for your program. Beginners in particular will find it helpful to use this as a model for their programs in the same way as they can learn from our example programs. Automatic generation of libraries and selection between application and bootloader code, as well as code templates for frequently wanted program functions, make it easier to get started. Built-in drivers for all current programming adaptors allow devices to be programmed directly from within CodeVision. Internal EEPROM and fuse bits can also be programmed, and there is a built-in terminal with file transfer and hexadecimal debugging output. The compiler offers powerful optimisation features for advanced users including global register allocation and freely-programmable ISR entry and exit code, comprehensive help (also available on-line) and a debugging interface to AVR Studio.



CodeVisionAVR in use

eral MHz rather than the 400 kHz maximum that can be achieved using I<sup>2</sup>C. At first sight things might look a little complicated. First we have to send the data bits D4 to D7 and RS, and then we have to generate an enable pulse on the E wire. To achieve this, the data input to the shift register is logically ANDed with output Q7 using a resistor and a diode. Only when Q7 is high will a pulse on

the data input be transmitted to the LCD as a pulse on its E input. To make sure that no spurious E pulses are generated, the following sequence must be observed.

1. Clock eight zero bits into the shift register by setting the data signal low and generating eight clock pulses. The bits are clocked in on each rising clock edge. Now all the Q outputs of the shift

register are low, and in particular no E signal can be generated.

2. Now send seven data bits. The first bit must be high and will ultimately appear on Q7, where it will allow an E pulse to be generated. The second bit is destined for the RS signal on Q6; the next four bits are data. The final bit is zero, ensuring that the data signal is left low. After a total of seven clock pulses the data bits will appear as required on the Q outputs, and in particular Q7 will be high.

3. Now we emit a pulse on the data signal, which in turn generates a pulse on the E line because Q7 is high.

The above procedure must be carried out twice, once for the high data nibble (bits D4 to D7) and once for the low data nibble (bits D0 to D3). **Listing 1** shows an excerpt from the BASCOM example program that can be downloaded from the *Elektor* website. Data can be written to the LCD (with RS being set high) using `Lcd_write_data`, while commands can be sent (RS low) using `Lcd_write_ctrl`, for example when initialising the display controller.

## Initialisation

The display recognises a large number of commands, all of which are sent with RS set low. The commands are grouped into families according to the number of zeros that appear in the high-order bits of the command byte (see **Table 1**). The display also includes an internal cursor register that points to an individual character position on the display. In the case of a two-by-sixteen display we have:

Row 1: addresses 00h to 0Fh  
Row 2: addresses 40h to 4Fh

while for a four-line display with 20 characters per line we have:

Row 1: addresses 00h to 13h  
Row 2: addresses 40h to 53h  
Row 3: addresses 14h to 27h  
Row 4: addresses 54h to 67h

The cursor advances automatically as each character is written, or the address can be set directly in order to write to any desired position. On power-up a number of initialisation commands must be written to the command register. **Listing 2** shows an example of how an LCD can be initialised

## Listing 1

### Data transfer using the shift register

```
Sub Lcd_write_data(byval D As Byte )
  Rs = 1
  Low_nibble = D And 15
  High_nibble = D / 16
  Lcd_write_nibble High_nibble
  Lcd_write_nibble Low_nibble
End Sub

Sub Lcd_write_ctrl(byval D As Byte )
  Rs = 0
  Low_nibble = D And 15
  High_nibble = D / 16
  Lcd_write_nibble High_nibble
  Lcd_write_nibble Low_nibble
End Sub

Sub Lcd_write_nibble(byval D As Byte )
  Pe_clock = 0
  Pe_data = 0
  'Clear all stages of shift register
  For N = 1 To 8
    Pe_clock = 1
    Pe_clock = 0
  Next N
  'Set E level at Q7
  Pe_data = 1
  Pe_clock = 1
  Pe_clock = 0
  'Set level for RS at Q6
  Pe_data = Rs
  Pe_clock = 1
  Pe_clock = 0
  'Shift in 4 bits
  Mask = 8
  For N = 1 To 4
    State = D And Mask
    If State = 0 Then
      Pe_data = 0
    Else
      Pe_data = 1
    End If
    'Clock in data with rising edge
    Pe_clock = 1
    Pe_clock = 0
    Shift Mask , Right
  Next N
  'Shift in zero bit
  Pe_data = 0
  Pe_clock = 1
  Pe_clock = 0
  'Set E
  Pe_data = 1
  Pe_data = 0
End Sub
```

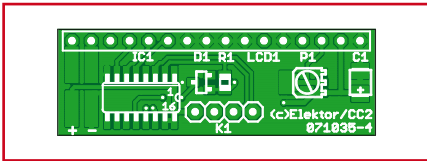


Figure 2. Printed circuit board for the LCD expansion module.

## COMPONENTS LIST

### Resistors

R1 = 10k $\Omega$  (SMD 805)  
P1 = 10k $\Omega$  preset (SMD)

### Capacitors

C1 = 10 $\mu$ F 6.3V (SMD)

### Semiconductors

D1 = BAS70 (SMD)  
IC1 = 4094 (SMD SO16)

### Miscellaneous

K1 = 4-way SIL pinheader  
LCD1 = LC Display 4x20 characters  
(HD44780 compatible)  
14-way SIL pinheader  
PCB with SMDs premounted, incl. all  
parts and 4x20 LCD; Elektor Shop #  
**071035-93**

Table 1. Display commands

Function	7	6	5	4	3	2	1	0
Clear display	0	0	0	0	0	0	0	1
Cursor home	0	0	0	0	0	0	1	x
Entry mode	0	0	0	0	0	1	ID	S
(ID=1/0: right/left, S=1/0: without/with scroll)								
Display, Cursor	0	0	0	0	1	D	C	B
(D,C,B=1/0: display, cursor, blink on/off)								
Scroll	0	0	0	1	SC	RL	x	x
(SC=1/0: scroll/cursor moves to RL=1/0: right/left)								
Initialisation	0	0	1	DL	N	x	x	x
(DL=1/0: 8-/4-bit bus, N=1/0: two lines/one line)								
User-defined character memory	0	1	Character			Column		
Display memory	1	Memory address						

over its four-bit data bus.

### Text output

In order to display text at a defined po-

sition we must first set the cursor address. It is convenient to express the position in terms of the column (x-coordinate) and row (y-coordinate). Then a call to `Lcd_pos` will move the cursor as

## Listing 2

### Initialisation

```
Sub Lcd_init
  Waitms 50
  Lcd_write_ctrl &H20
  Waitms 50
  Lcd_write_ctrl &H20
  Waitms 50
  Lcd_write_ctrl &H28
  Waitms 50
  Lcd_write_ctrl &H0C
  Waitms 50
  Lcd_write_ctrl &H01
  Waitms 50
End Sub
```

## Listing 3

### Text output

```
Sub Lcd_pos (byval X As Byte , Byval Y As Byte )
  D = 127 + X
  If Y = 2 Then D = D + 64
  Lcd_write_ctrl D
End Sub

Sub Lcd_text (byval Text As String )
  J = Len(text)
  For I = 1 To J
    Char = Mid(text , I , 1 )
    D = Asc(char)
    Lcd_write_data D
  Next I
End Sub
```

Advertisement



Die-cast aluminium,  
metal and plastic  
enclosures.

sales@hammond-  
electronics.co.uk



[www.hammondmfg.com/uk](http://www.hammondmfg.com/uk)

required. For example, Lcd\_pos 1,1 will move the cursor to the leftmost column of the first row. Then Lcd\_text can be used to write a string of characters, as illustrated in **Listing 3**.

**Printed circuit board**

The interface circuit can be constructed on the compact printed circuit board shown in **Figure 2**, which uses SMD components. Those wary of soldering SMDs can purchase ready-populated boards from the Elektor shop, with just the external connections left to be soldered by hand. The four-way connection to the ATM18 test board is best fitted with a header socket so that temporary connections can be made for test purposes using lengths of solid-core wire.

The 16-way connection can also be fitted with a socket or plug to mate with a connector on the LCD, or direct connection can be made using header pins or a ribbon cable. The four connections to the microcontroller are V<sub>CC</sub>, GND, data and clock. Data and clock can be

connected to any two port pins: the example software uses port B.1 for clock and port B.2 for data.

**In use**

Using the display module is very easy. **Listing 4** shows a simple example program that displays a measured voltage

on analogue input ADC(0). The analogue-to-digital converter is configured to use the external 5 V reference, and the 10-bit conversion result, in the range 0 to 1023, is written to the display. The complete example program is available for free download from the *Elektor* website at [www.elektor.com](http://www.elektor.com).

(071148-1)

**Listing 4**

**Outputting a measured value**

```

Config Adc = Single , Prescaler = 64 , Reference = Off
Start Adc

Lcd_init

Lcd_pos 2 , 1
Lcd_text „adc(0) = “

Do
  Lcd_pos 2 , 2
  Value = Getadc(0)
  Text = Str(value)
  Lcd_text Text
  Waitms 500
Loop
    
```

Advertisement

# PCB-Soldering.co.uk

Suppliers of PCB Soldering Equipment & Rework Stations

NEW IN STOCK

328 Working Platform

<p style="writing-mode: vertical-rl; transform: rotate(180deg); font-weight: bold; font-size: 0.8em;">850A+ SMD Rework Station</p> <p style="text-align: center; font-weight: bold; font-size: 0.8em;">Online Price £44.95</p>	<p style="writing-mode: vertical-rl; transform: rotate(180deg); font-weight: bold; font-size: 0.8em;">932 Vacuum Pick Up Station</p> <p style="text-align: center; font-weight: bold; font-size: 0.8em;">Online Price £29.95</p>	<p style="writing-mode: vertical-rl; transform: rotate(180deg); font-weight: bold; font-size: 0.8em;">937+ 45W Soldering Station</p> <p style="text-align: center; font-weight: bold; font-size: 0.8em;">Online Price £37.95</p>	<p style="writing-mode: vertical-rl; transform: rotate(180deg); font-weight: bold; font-size: 0.8em;">Range Of Tools &amp; Accessories</p>
<p style="writing-mode: vertical-rl; transform: rotate(180deg); font-weight: bold; font-size: 0.8em;">2738 CPU Controlled PCB Work Station</p> <p style="text-align: center; font-weight: bold; font-size: 0.8em;">Online Price £139.95</p>	<p style="writing-mode: vertical-rl; transform: rotate(180deg); font-weight: bold; font-size: 0.8em;">2900 70W Soldering Station</p> <p style="text-align: center; font-weight: bold; font-size: 0.8em;">Online Price £74.95</p>	<p style="writing-mode: vertical-rl; transform: rotate(180deg); font-weight: bold; font-size: 0.8em;">Soldering Iron Tips &amp; Air Nozzles</p> <p style="text-align: center; font-weight: bold; font-size: 0.8em;">Wide Selection Available</p>	
<p style="writing-mode: vertical-rl; transform: rotate(180deg); font-weight: bold; font-size: 0.8em;">853A Quartz Infrared Preheater</p> <p style="text-align: center; font-weight: bold; font-size: 0.8em;">Online Price £69.95</p>	<p style="writing-mode: vertical-rl; transform: rotate(180deg); font-weight: bold; font-size: 0.8em;">950 SMD Hot Tweezers &amp; Station</p> <p style="text-align: center; font-weight: bold; font-size: 0.8em;">Online Price £44.95</p>	<p style="writing-mode: vertical-rl; transform: rotate(180deg); font-weight: bold; font-size: 0.8em;">710 Infrared Welding Station</p> <p style="text-align: center; font-weight: bold; font-size: 0.8em;">Online Price £750.00</p>	<div style="text-align: center;"> <p style="font-size: 0.7em;">Suppliers of Test-pins, Receptacles &amp; Probes...</p> <p style="font-size: 0.7em;">For Test-pins &amp; Probes Visit <a href="http://www.test-pins.co.uk">www.test-pins.co.uk</a> Above discount code also applies</p> </div>

www.pcb-soldering.co.uk

Allendale Electronics Ltd, 43 Hoddesdon Industrial Centre,  
Pindar Road, Hoddesdon, Hertfordshire. EN11 0FF.

T: +44 (0)1992 450780 W: [www.pcb-soldering.co.uk](http://www.pcb-soldering.co.uk)  
F: +44 (0)1992 450781 E: [sales@pcb-soldering.co.uk](mailto:sales@pcb-soldering.co.uk)