PICee Development System

a PIC16F84-based single-board computer

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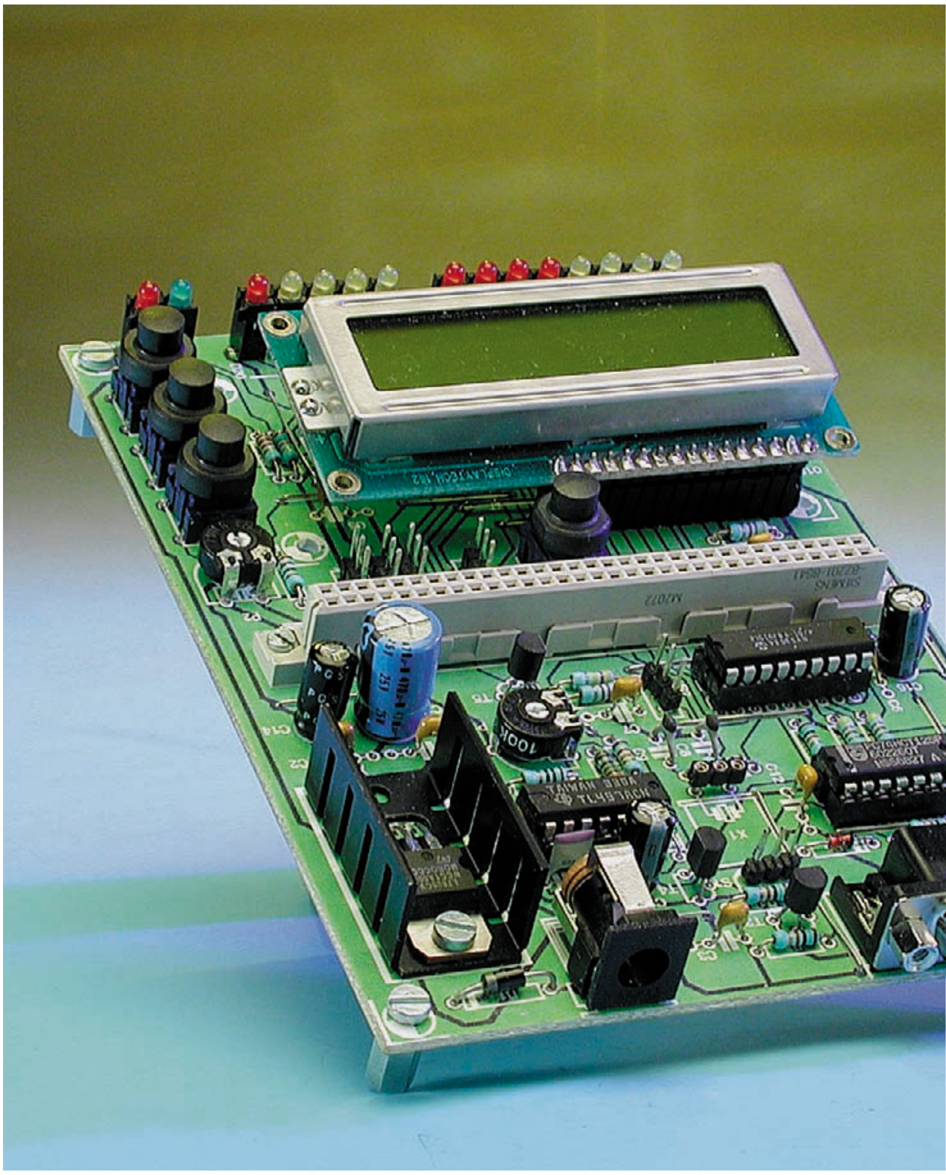
This single-board computer, using the popular low-cost PIC16F84 microcontroller, has been developed with educational applications in mind.



The PICee single-board computer described in this article is a versatile training and development system based on the well-known Microchip PIC16F84 microcontroller. The microcontroller's flash memory is electrically erasable: hence the 'ee' in the title. In contrast to the 89C8252 Flash microcontroller board described in our December 2001 issue, the 16F84 processor used here is a so-called 'RISC' (reduced instruction set computer) microcontroller with only a small number of instructions. The PICee board allows experimentation with all 35 of the processor's instructions without additional hardware. The board encompasses a wide range of applications, from a simple LED flasher to an elegant crystal-controlled clock.

The programming hardware

The socket can accept all varieties of the Microchip PIC16F84, with clock frequencies from 4 to 20 MHz. The clock can be generated using a quartz crystal or an RC oscillator. Switch S2 selects between the two oscillator types. Using the slower RC oscillator is particularly convenient during experimentation or development. The clock

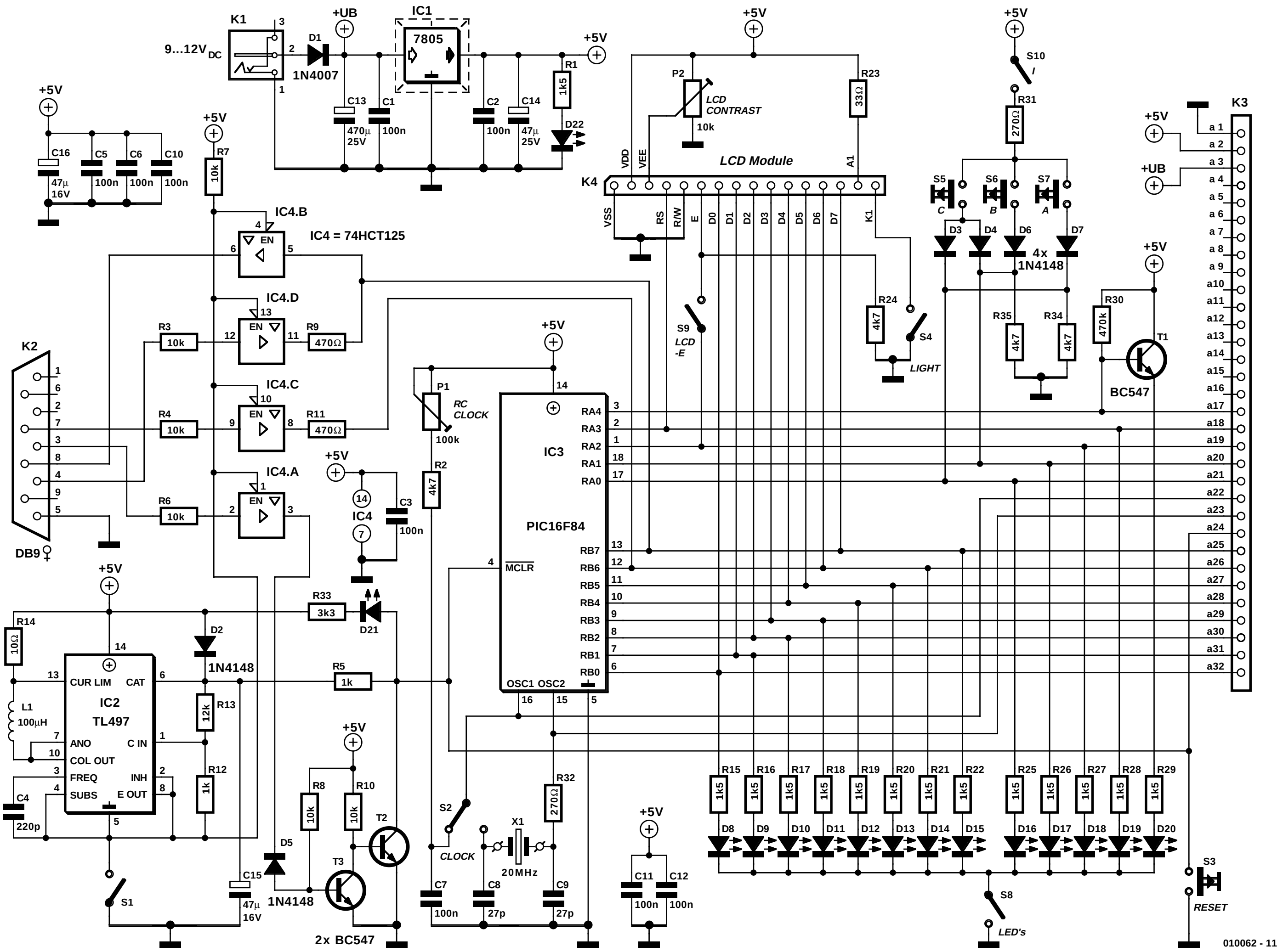


Figure 1. The microcontroller training board includes a wide range of peripherals for experimentation.

frequency is continuously variable via trimmer P1. Diode D2 and resistor R5 ensure that 5 V is fed to the MCLR input of the microcontroller in normal operation. Pushbutton S3 can be used to reset the processor.

If a DC voltage of around 13.5 V is applied to the MCLR input, the microcontroller switches into programming mode. The programming voltage is generated on the circuit board using a TL497 step-up converter (IC2) and enabled using switch S1, which takes pin 5 of IC2 to ground. LED D21 indicates when programming mode has been activated. The board is connected to a PC over the serial interface via 9-pin sub-D connector K2. Connection can be made using a normal RS232 cable (not a null modem cable) with a 9-pin D-type plug at the PICee end and the usual 9-pin D-type socket at the PC end. **Connection should be made with the unit switched off** — only when the unit is connected should power be applied and the programmer software started up. The two programming signals DATA and CLOCK are taken via drivers IC4.C and IC4.D to microcontroller inputs RB6 and RB7. Driver IC4.B delivers data read from the microcontroller back to the interface. Driver stage IC4.A is used to control the programming voltage and reset the microcontroller.

A microcontroller can become the heart of a microcomputer system with the addition of peripheral components. The circuit board includes three typical applications that allow experimentation with the microcontroller's instruction set. These expansion circuits can also be built into other applications you may develop.

LEDs D8 to D20 indicates the logic values present on the RA and RB ports of the microcontroller. These are very helpful when debugging applications at low speed using the RC oscillator. They can also be used in your first programming exercises: for example, a LED flasher, running light, bar graph display, or LED dimmer. The port LEDs can be enabled or disabled via miniature switch S8.

Switches S5, S6 and S7 form a mini-keyboard. Pressing S6 or S7 produces a logic '1' at port inputs RA1 or RA0, while pressing S7 produces a logic '1' at both inputs, thanks to the wired-OR configuration around D3 and D4. It can be determined in software which button has been pressed. Three buttons can give rise to a wide range of control possibilities if one button is allocated to a 'mode' function to select a value to be changed, while the other two are used to adjust the selected value, up or down. Think of how alarm clocks or time switches are set, or how car radios are controlled.

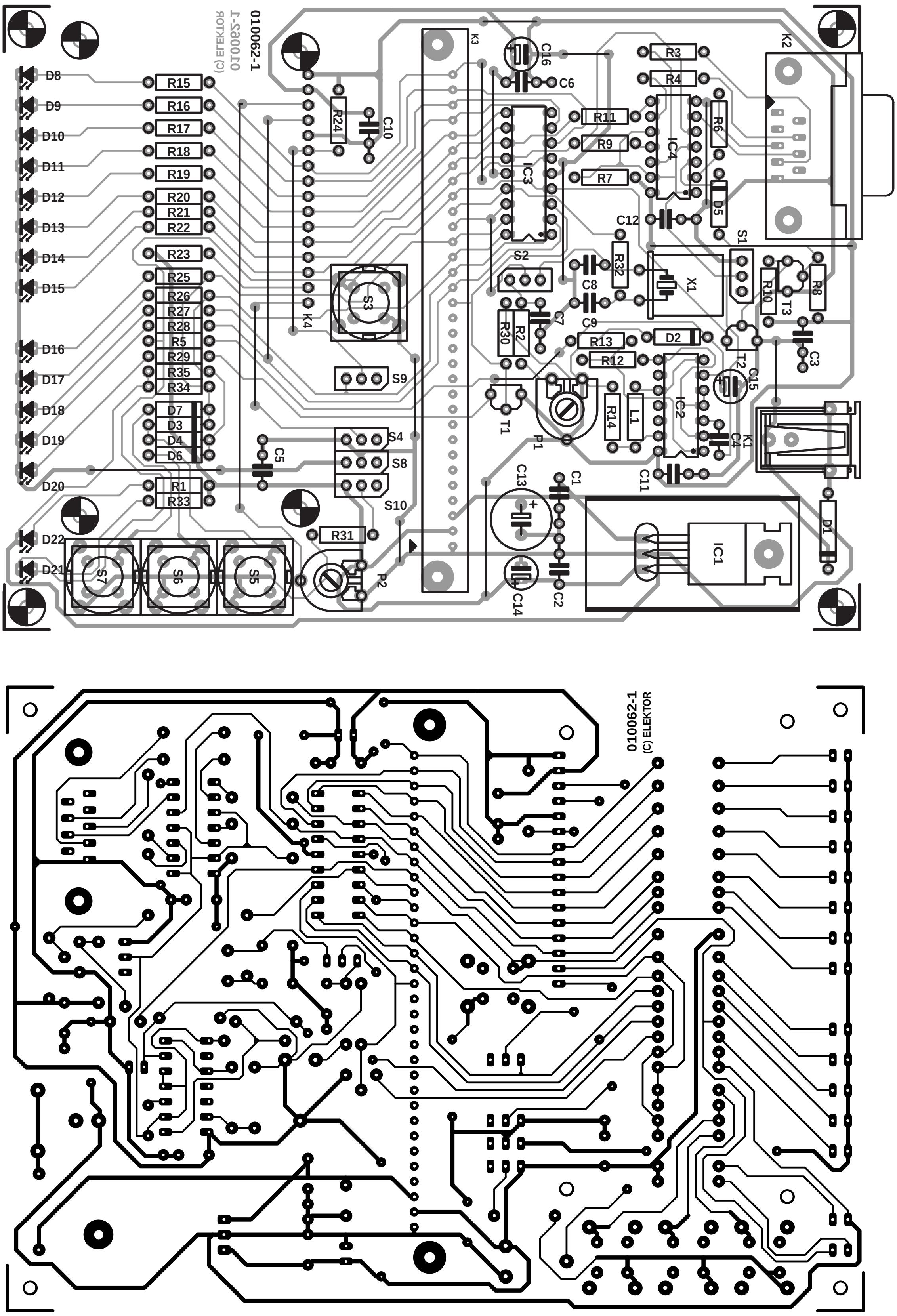
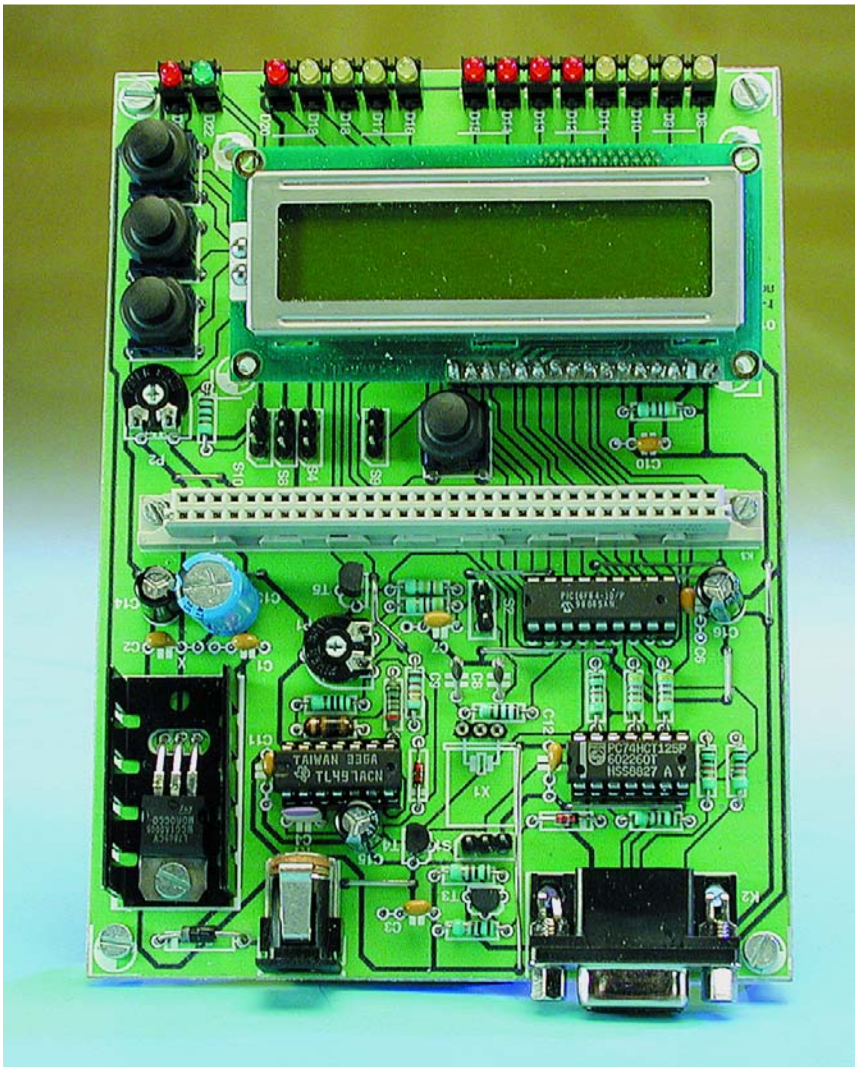


Figure 2. The layout of the single-sided printed circuit board for the PICee single-board computer.

When bright light falls on the LEDs, a voltage can be developed at the high-impedance inputs to the microcontroller that can lead to false readings: for this reason R34 and R35 are fitted across monitor LEDs D16 and D17 to pull the input signals down to ground, avoiding this unwanted effect.

A 2-line by 16-character alphanu-



COMPONENTS LIST

Resistors:
R1,R15-R22,R25-R29 = 1kΩ5
R2,R24,R34,R35 = 4kΩ7
R3,R4,R6...R8,R10 = 10kΩ
R5,R12 = 1kΩ
R9,R11 = 470Ω
R13 = 12kΩ
R14 = 10Ω
R23 = 33 Ω
R30 = 470kΩ
R31,R32 = 270Ω
R33 = 3kΩ3
P1 = 100kΩ preset
P2 = 10kΩ preset

Capacitors:
C1,C2,C3,C5,C6,C7,C10,C11,C12 = 100nF
C4 = 220pF
C8,C9 = 27pF
C13 = 470µF 25V radial
C14,C15,C16 = 47µF 16V radial

Semiconductors:
D1 = 1N4007
D2-D7 = 1N4148
D8-D11,D16-D19 = LED, 3mm, yellow, low current
D12-D18,D20,D21 = LED 3 mm, red, low current
D22 = LED, 3 mm, green, low current
T1,T2,T3 = BC547
IC1 = 7805
IC2 = TL497AC
IC3 = PIC16F84
IC4 = 74HCT125

Miscellaneous:
K1 = mains adaptor socket, PCB mount
K2 = 9-way sub-D socket (female), angled pins, PCB mount
K3 = DIN41612 connector, model B (Conrad Electronics # 741582)
K4 = 16-way SIL connector*
L1 = 100µH
S1,S2,S4,S8,S9,S10 = toggle switch, 1 c/o contact, or 3-way pinheader with jumper
S3,S5,S6,S7 = pushbutton, e.g., ITT/Schadow type D6
X1 = quartz crystal socket with crystal*
Heatsink for IC1, e.g. type ICK35 (Fischer) (Dau Components)
PCB, order code **010062-1**
Disk, contains example programs, order code **010062-11**

meric LCD dot matrix module can be fitted to allow the system to display more complex information. This module is based around the Hitachi HD44780 controller, which has become something of an industry standard. The display is driven using the E (enable) and RS (register select) signals, which are connected to port pins RA2 and RA3. The read/write (R/W) input of the module is tied permanently to ground (GND), since it is only rarely that read mode is wanted. Trimmer P2 allows the display contrast to be set, and the backlight can be turned on and off via switch S4. The LCD controller can be enabled and disabled via switch S9.

All the microcontroller pins as well as the input power supply voltage and the regulated 5 V supply are available on a 32-way DIN41612-style female connector. Special application circuits can be constructed on low-cost prototyping board and connected to the single-board computer via a complementary 32-way male connector.

Power for the single-board computer comes from an external mains supply connected via low-voltage connector K1. The input voltage can be anywhere between 9 V and 12 V. The built-in fixed voltage regulator IC1 produces a stabilised 5 V output. LED D22 indicates when power is applied. If the input reverse polarity protection diode D1 and the regulator are dispensed with, battery operation from four NiCd cells (4.8 V total) is possible.

Construction of the circuit on the printed circuit board shown in **Figure 2** should present no problems; sockets should be used for all ICs and for the crystal. The circuit board —surprisingly for a single-board computer — is only single-sided and therefore inexpensive. The price for this is 18 wire links in the well-spaced layout.

All 13 of the microcontroller's port pins as well as the power supply are brought to the connector in the middle of the circuit board, next to which, as can be seen from the main photograph, the LC display is fitted. The electrical connection to the display can be made with a combination of SIL connectors or alternatively short wire links can be used. The switches shown in the circuit diagram can be replaced with jumpers.

Free programming software

A wide selection of literature is available on learning to program the PIC microcontroller family. A few starting points are given in the references, and the Internet is also a rich source of information, with numerous articles and items of hardware and software available. Also, almost every technical college will have some information on their homepage about the PIC microcontroller: just type 'PIC16F84' into your favourite search engine.

You will need some programming tools to develop assembler programs. The Windows program MPLAB.EXE (editor, assembler and simulator) and the DOS programs MPASM.EXE (assembler) and PSIM.EXE (simulator) produced by Microchip are recommended. These are freeware and can be freely downloaded from the Internet. Datasheets for the microcontroller and numerous example programs are also available.

One example of free programming software is **NTPicprog**, which can be found at http://home.swipnet.se/~w24528/NTPicprog (**Figure 3**). ICPROG.EXE, available from www.ic-prog.com also works well. When setting up the hardware, the PICee system appears as 'JDM Programmer' (**Figure 4**). The trusty **PIP02** software is also available for those who would rather work under DOS.

Once the source code for the program (*.asm) has been prepared and successfully converted to a *.hex file using the assembler, this can be downloaded into the flash program memory in the microcontroller.

A large number of example programs can be found on the project software disk ref. **010062-1**.

(010062-1)

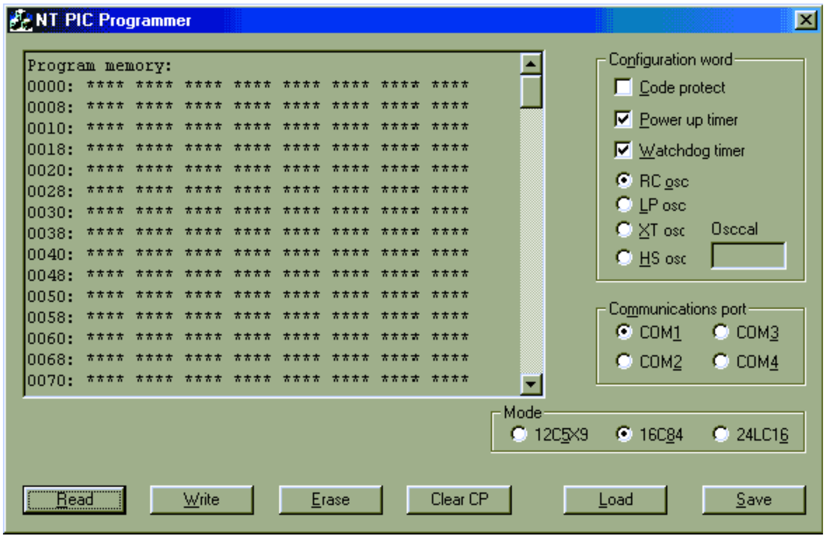


Figure 3. The NTPicprog programming software.

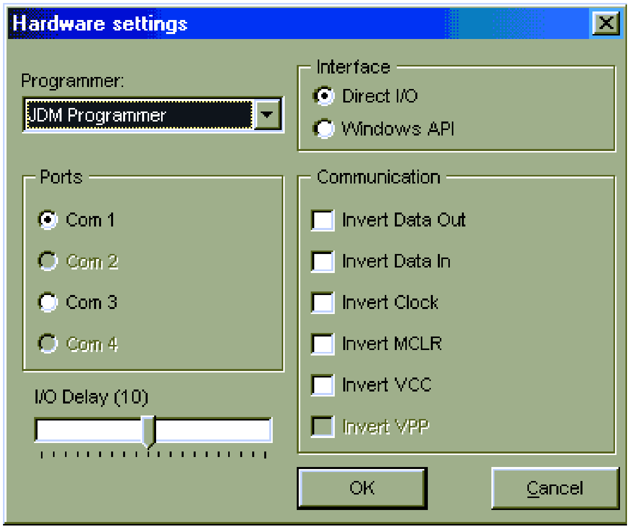


Figure 4. Hardware settings using ICPROG.

References:

David Benson
Easy PIC'n
Publisher: Square I

David Benson
PIC'n up the Pace
Publisher: Square I

F. Volpe
PICs in Practice
Publisher: Elektor Electronics (Publishing)

Relevant Internet sites:

http://www.microchip.com

http://www.wolfgang-kynast.de/pic.htm

http://www.ludwig-geissler-schule.de/docs/picee/picee.html

Back to school

This circuit was developed and tested at the Ludwig-Geissler school in Hanau, Germany with a particular view towards its use in teaching. The single-board computer has been used there very successfully for several years in various classes, both for training in the use of microcontrollers and in project work. For a component cost of only about thirty pounds, it also offers the radio amateur or electronics hobbyist an ideal platform for experimenting with and developing ideas.