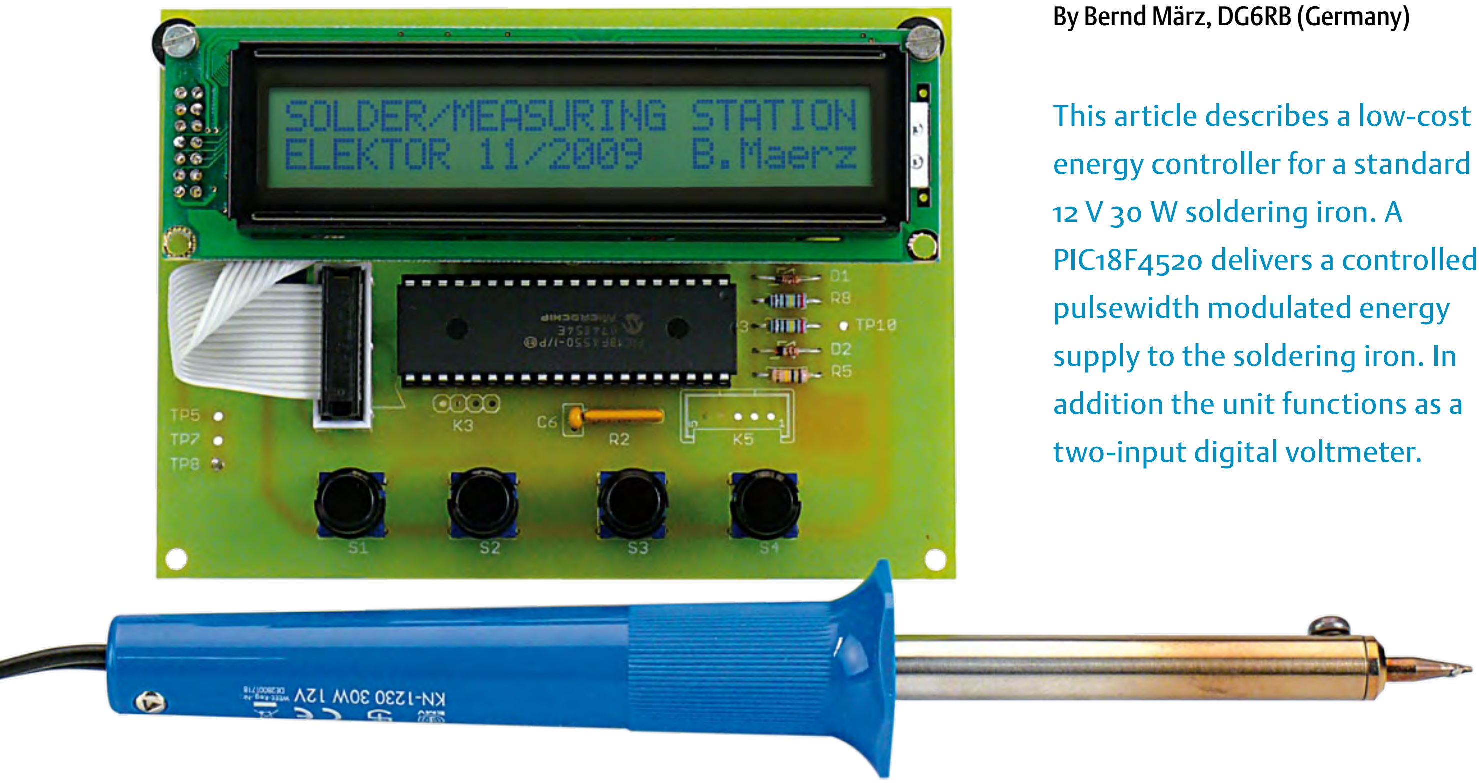
Solder Station 'Plus'

temperature control and DVM in one unit



By Bernd März, DG6RB (Germany)

This article describes a low-cost energy controller for a standard 12 V 30 W soldering iron. A PIC18F4520 delivers a controlled pulsewidth modulated energy supply to the soldering iron. In addition the unit functions as a two-input digital voltmeter.

Main Features

- Suitable for use with 12 V / 30 W (max.) soldering irons.
- Temperature control using PWM.
- Power supplied from a low-cost 12 V /3.33 A mains adapter.
- Two DC voltage measurement inputs.
- Measurement ranges: 0 to 10 V (channel 1), 0 to 40 V (channel 2)
- Displays supply voltage.
- Microcontroller PIC18F4520 with flash memory
- LC display 2 lines of 24 characters (with HD44780 controller)
- Software calibration of measurement channels.

The author is a radio amateur and a member of the German Amateur Radio Club (DARC). Each year the club organises a practical activity for the younger electronics enthusiasts to occupy them during the holidays. Every year the members come up with a new circuit design to build, the main criteria are that is should be low-cost, useful, simple and fun to build. The project described here was the subject of one of these events.

All together the materials for this solder station/DVM design cost around 25 pounds. The same amount of money would probably buy you a simple soldering station but it would not give you the same satisfaction as one that you built yourself and besides it would not have the energy control or DVM features of this design with its in-built microcontroller. A combined soldering iron and DVM would undoubtedly be a useful addition to the workbench of any young engineer or electronics enthusiast.

Measurement and Control

A low cost microcontroller type PIC18F4520 (IC2) from Microchip is the main element in the circuit diagram shown in **Figure 1**, its clock is derived from an economical ceramic 4 MHz resonator (X1). The firmware stored in microcontroller flash memory performs temperature control of the soldering iron and all the measurement functions. The four pushbuttons (S1 to S4) are used to select menu options.

The display (LCD1) shows two lines of text with 24 characters per line. It is an LCD with an on-board HD44780 compatible controller. To reduce costs this type of display can often be salvaged from an old telephone or similar piece of redundant equipment. Alternatively it is a completely standard display which can also be ordered quite cheaply from the majority of component suppliers To reduce the number of microcontroller I/O pins required by the LCD it is driven in 4-bit mode. The spare I/O pins are connected to the pin header K2 to K4. With suitably modified software these pins could

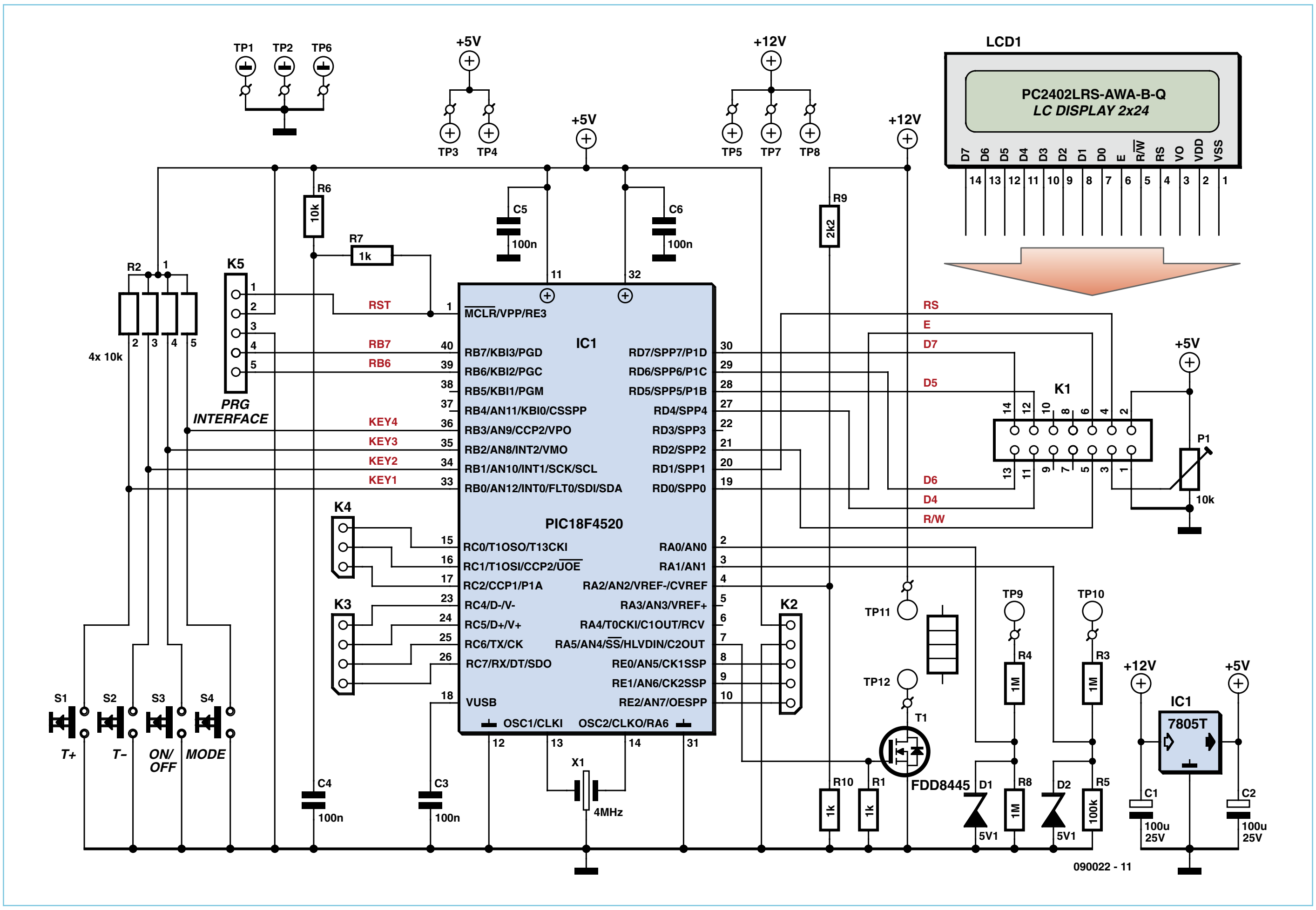


Figure 1. The simple circuit uses a PIC microcontroller for control and measuring.

be used in the future, for example, to measure values of capacitance.
Pin header K5 is the programming interface to the microcontroller allowing the software to be updated or changed as necessary.
A ribbon cable on K1 connects to the LCD and preset P1 is used to adjust the display contrast.

Pushbuttons S1 and S2 control the soldering iron temperature. These buttons change the on/off ratio of the Pulse Width Modulated (PWM) signal output from pin 7 of the microcontroller. The waveform switches power MOSFET T1 which supplies current to the soldering iron connected to points TP11 and TP12 on the circuit diagram. Power control is very smooth and the front panel display shows the amount of power supplied to the iron as a percentage of the irons power rating (30 W max). The type of soldering iron used is a standard low-cost 12 V iron without any temperature sensor.

The red measurement input sockets are wired to TP9 for channel 1 and TP10 for channel 2. Voltage divider networks on these inputs formed by (R4/R8 and R3/R5) scale the measured input voltages so that they are within the input range of the controllers ADC inputs pins 2 and 3. The 1 MΩ resistors define the impedance of the meter inputs. Zener diodes D1 and D2 prevent damage to the input if the applied input voltage is too high. The third ADC input of the microcontroller (pin 4) measures the power supply voltage (nominally 12 V) scaled by the voltage divider network R9/R10.

Power to the unit can be supplied by a 12 V DC mains adapter rated at 3 A (minimum). A quick trawl through some supplier's websites identified several 12 V switched-mode supplies with an output rated at 3.3 A retailing for less than 10 pounds. The 5 V supply for the circuit is produced by the 7805 voltage regulator IC1.

Putting it all together

The simple single-sided PCB layout (**Figure 2**) ensures that construction is quite straight forward even for a novice. Start by fitting the IC socket ensuring that pin 1 lines up with 1 on the layout. Next fit the ceramic capacitors, the wire link between TP3 and C1, the resistors, diodes (make sure they are the right way round) and the preset resistor. The resistor network R2 is fitted so that pin 1 is nearest to C6.

Both electrolytic capacitors C1 and C2 must lie flat on the board otherwise there will not be enough room for the LCD which is fitted 15 mm above the PCB.
Voltage regulator IC1 is mounted on the board using a short M3 nut and bolt. The power FET T1 has an SMD outline and is the only component mounted on the underside of the board. It is not necessary to make any connection to the middle pin (see **Figure 3**).

COMPONENT LIST

Resistors

R1,R7,R10 = 1kΩ
R2 = SIL array 4x10kΩ (5 pins)
R3,R4,R8 = 1MΩ
R5 = 100kΩ
R6 = 10kΩ
R9 = 2.2kΩ
P1 = 10kΩ multiturn preset, vertical, top adjustment, e.g. Bourns type 3266X-1-103LF

Capacitors

C1,C2 = 100µF 35V radial
C3,C4,C5 = 100nF

Semiconductors

D1,D2 = zener diode 5.1V 0.5W
T1 = FDD8445 (Fairchild, N-channel MOSFET, 40V, 5A, 8.7mΩ)
IC1 = 7805
IC2 = PIC18F4520-I/P, programmed, Elektor Shop # **090022-41**

Miscellaneous

S1–S4 = pushbutton, single contact, e.g. Multimec 3FTL6 with cap 1D09
K1 = 14-way IDC connector for flatcable
LCD module, 2x24 characters (5.55mm height), 118x36x14 mm, e.g. Powertip PC2402LRS-AWA-B-Q (Farnell # 1671511) with connector and flatcable.
40-way DIL socket (for IC2)
X1 = 4MHz ceramic resonator, 3-pin
1 M3x5 screw with nut (for mounting IC1)
2 M3x20 screw with nuts (for LCD mounting)
2 plastic spacers, 15mm length (for LCD mounting)
12V / 30W soldering iron simple version without temperature sensor
PCB no. **090022-1** [1]

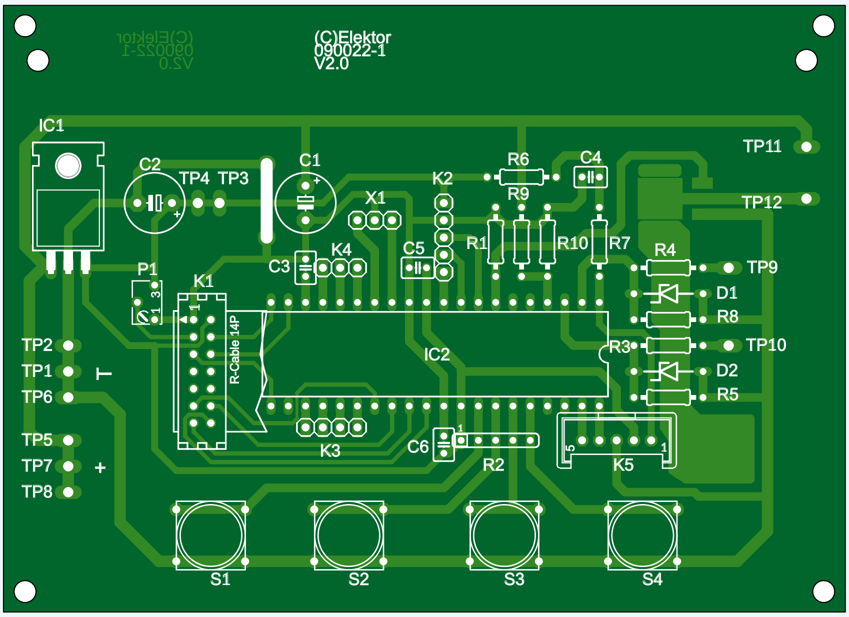


Figure 2. Fitting the components will be no problem on this single-sided PCB.

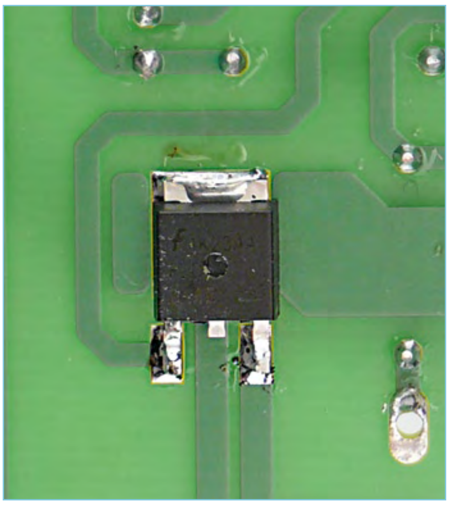


Figure 3. The power MOSFET is soldered to the PCB underside. No connection to the centre pin is necessary.

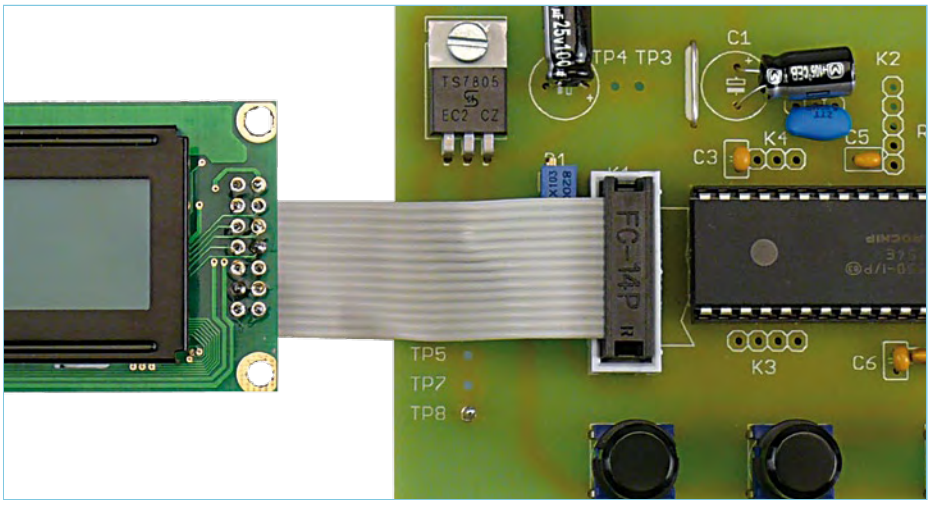


Figure 4. A 14-way ribbon cable connects the LCD module to the PCB.

The only cable required is a 14-pin connector and ribbon cable to connect between the PCB (K1) and the LCD module as shown in **Figure 4**. The pin headers K2 to K4 are available for future expansion of the circuit and K5 is not required unless you plan to program/reprogram the microcontroller 'in circuit'.

The 12 V mains adapter and 12 V soldering iron are the only two external components connected to the controller. The circuit does not include a diode in series with the input supply to protect against reverse polarity supply so it is important to ensure that the board is wired correctly to the mains adapter output. The polarity symbols are printed on the PCB: plus to TP7, minus to TP2. The polarity of the supply to the soldering iron itself is not important; connect the two wires from the soldering iron to TP11 and TP12.

This only leaves wiring between the PCB and the voltage measurement input sockets (two red and two black). The black sockets are wired to ground (TP1 or TP6). As already described the red socket for channel 1 (10 V range) is wired to TP9 and red socket for channel 2 (40 V range) with TP10.

The mechanical layout is simplified if the 4 mm sockets for the measurement channel inputs are positioned to the right of the PCB and mounted on the front panel of a suitable enclosure. The PCB itself can either be mounted behind the front panel in which case cut-outs will be required for the display and pushbuttons or the simpler solution used by the author is to fit the PCB on the outside of the front panel. The result is not quite so neat but allows easy access to the circuit.

Programming and Function

The simple option is to buy the PIC controller ready-programmed from the Elektor Shop but alternatively if you prefer to compile and program the chip yourself all the C source files including the compiled program file are available for free download from the Elektor website [1]. The author has written the firmware in C using the CCS-C-Compiler for PIC18 processors [2] and the MPLAB V8.20 development environment from Microchip [3]. The last link in the chain if you are programming yourself is the Microchip ICD2 programmer which connects to the target board at the pin header connector K5. Fuses HS, NOWDT, NOPROTECT and NOLVP must be set in the software.

Before the circuit is first powered-up spend a few minutes checking all solder joints and the polarity of the wires from the mains adapter to the PCB. Check that the microcontroller is correctly inserted in its socket (and of course don't forget to program the controller firmware into flash memory!). When the circuit is powered up it enters soldering mode and the display indicates the soldering iron power level (**Figure 5**). Should you see nothing on the display try adjusting the contrast (P1) failing that it could be a hardware failure (check your soldering!) or (hopefully not) a software problem. Pushbuttons S1 to S4 provide the following control:

S1: Increase bit temperature.
S2: Decrease bit temperature
S3: Soldering iron ON/OFF
S4: Switch the unit between soldering and voltage measurement modes.

Pressing S4 toggles the unit through the following modes:

1. Solder (Figure 5)
2. Voltage measurement on channel 1, DC 0 to 10 V (Figure 6)
3. Voltage measurement on channel 2, DC 0 to 40 V (Figure 7)
4. Voltage measurement on channel 3, the 12 V nominal DC input to the circuit (Figure 8)
5. Display all three measurements (Figure 9).

Calibration and use

Before we can have any confidence in the measured voltages it will be necessary to calibrate the unit. The circuit enters calibration mode when button S1 is held down as the circuit is powered up. The display shows Multi1: 1000 indicating calibration mode for multimeter input 1 where 1000 is the multiplication factor of the measured value. Using the calculation: measured value x Multi1/1000. The unit can be accurately calibrated using a reference level. Pushbuttons S2 and S3 are now used to change the displayed value. S4 switches to the next channel for calibration using S2 or S3 as before. The measurement functions of the unit are designed for low voltage applications only. This includes jobs such as measuring dry or rechargeable cell voltages, DC test point voltage level monitoring in a circuit or adjustment of DC input voltage to a circuit. It is vital that the input is **never connected to mains voltage!**

Power control of the soldering iron is not as sophisticated as you might expect from a professional workstation costing a couple of hundred pounds but it is suitable for a beginner or anyone who only occasionally needs to use a soldering iron. It gives very fine control of power to the soldering bit and with a little practice it's possible to produce good results on different types of soldering jobs. Another advantage of this design is that it uses a low-cost iron which can be replaced quite cheaply. Any low-voltage 12 V iron, for example fine soldering irons with a power rating of 6 W or 7.5 W (up to 30 W maximum) are suitable for use with this design. The display indicates power supplied to the iron as a percentage of the iron rating.

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Figure 5. The start menu at power-up shows the soldering iron control.

Figure 6. Measurement using channel 1 (range 10 VDC).

Figure 7. Measurement using channel 2 (range 40 VDC).

Figure 8. Channel 3 measures the supply voltage to the circuit (12 V nominal).

Figure 9. Display of all three channels.

Internet Links

[1] www.elektor.com/090022

[2] www.ccsinfo.com

[3] www.microchip.com