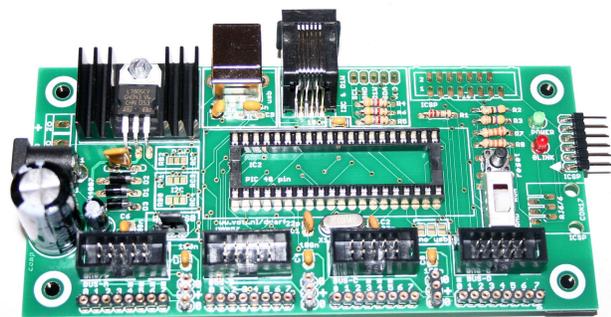


## Dwarf Boards

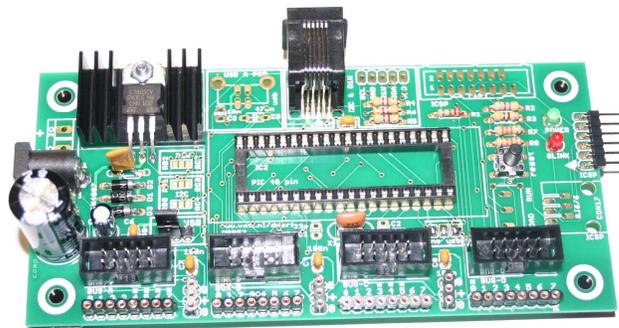
### DB057 : 40-pin controller board

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DB057 for USB PIC



DB057 for non-USB PIC

## Introduction

This document describes the Dwarf Board DB057. This board is a complete controller board, suited for educational use, experiments or prototyping. The board uses a 40-pin PIC microcontroller. Either a non-USB chip, like the 16F887 or the 18F4520, can be used, or and USB chip like the 18F4455 or 18F4550. Depending on this choice the board is populated differently.

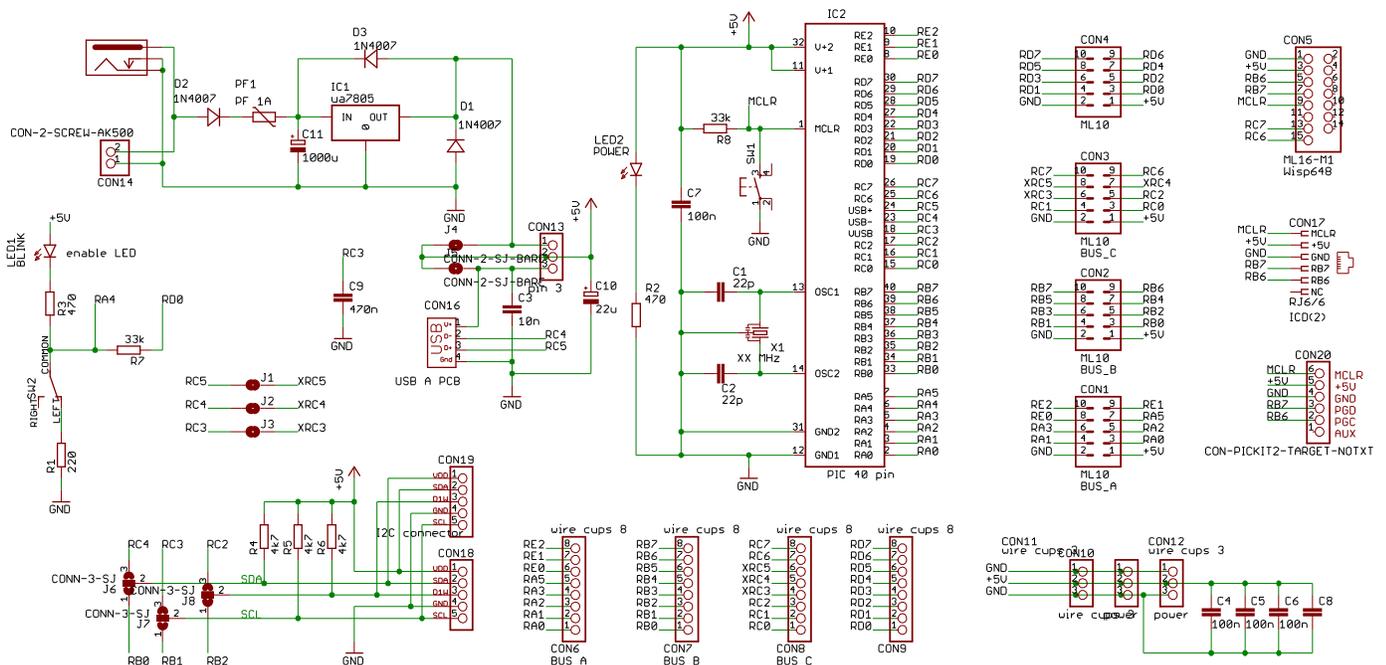
The board has an on-board 5 Volt regulator, which must be fed with 9 .. 18 Volt. The board itself uses very little current, but when external circuits draw significant current the heat sink can get warm. The 7805 regulator and a polyfuse provide protection against overload and short-circuit conditions. When populated for USB the 5 V can be supplied by the host PC.

The board has a pickit2 / Wisp648 compatible connector for In-Circuit Serial Programming. The board also has room for an ICD2/ICD3 RJ6/6 jack, and a DB16 Wisp648 connector (but neither are present in the kit). Other programmers can be used with a suitable conversion cable. The board also has a small pushbutton reset switch, a boot/run switch (for use with an USB bootloader), and power and signal LEDs.

Except for the signal LED the board does not contain any peripherals. The I/O pins of the microcontroller are available on four Dwarf Bus (ML10) connectors for connecting Dwarf Board peripheral boards, and on wire cups for making connections to a solderless breadboard. An RJ6/6 jack is meant for connecting Dallas 1-wire or I2C peripherals.

A bootloader is available for use with the 18F4455 (or compatible) chip. This allows downloading of an application program over the USB connection, without the use of a programmer.

# Circuit



The circuit consists of the following sections:

- a power supply and USB connector (IC1 top left, USB connector in the centre)
- the PICmicro chip (IC2, top middle)
- the Dwarf Bus connectors (ML10 CON-1 .. CON-4, and wire cups CON-6 .. CON-9)
- the ICSP connectors (CON-5, CON17, CON-20, right side)
- a boot/run switch and LED (SW2, LED1, left side)
- Dallas and I2C solder jumpers and connectors (bottom left)

The power supply is a standard application of an 7805 (IC1). A wall-wart must be connected to the barrel-style power connector, or wires can be soldered directly to the PCB, or a 2-pin screw cups connector (not included in the kit) can be used. A 12 Volt DC 1 Ampere wall-wart is recommended, which allows the total circuit (the DB057 and the connected peripherals) to use up to 1 Ampere. Note that with such a current IC1 and its cooling can get too hot to touch. Diode D3 protects the 7805 against reverse current. Diode D2 protects against a reverse connection of the wall-wart. The polyfuse protects against a sustained current of more than 1 Ampere. Elco C10 provides extra filtering (a wall-wart often provides very poor filtering). R2 and LED-1 (green) provide a visible indication that power is present.

When the board is populated for USB, USB connector CON16, and the capacitors C3 and C9 are placed. When the board is populated for non-USB, the solder jumpers J1, J2 and J3 are bridged, to connect the PIC pins to the Dwarf Bus connectors. For USB these pins are dedicated to the USB connection and not available on the Dwarf Bus connectors.

A jumper on pin header CON-13 selects either the 7805 power supply or the USB connector as the source of 5V power for the circuit. Alternatively the pin-header can be omitted and one of the two solder bridges can be closed. Diode D1 protects the circuit when 5 Volt is applied via one of the Dwarf Bus connectors.

A lower-current wall-wart can be used, provided that the total circuit does not draw more current than the wall-wart can supply. It is recommended that a suitable (lower rated) polyfuse is used. An AC wall-wart can be used, but the maximum current must be calculated by the user, based on the wall-wart voltage, the single-phase rectification, the filter capacitor C11 and the minimum input voltage required by IC1. A DC wall-wart with a lower voltage can be used, provided that the minimum input voltage of IC1 is maintained.

For USB PICs the the boot/run switch can be used to instruct the PIC to either run the bootloader or the application program. PIC pins RA4 and RD0 can be used to read the selection. Pin RA4 (which is not available on the Dwarf Bus connectors) can also be used to blink the LED. This can be used as a minimum (blink-a-led) test function without using any external hardware.

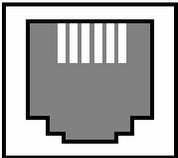
IC2 is the PICmicro controller. For USB use an 18F4455 or 18F4550 with a 20 MHz crystal is recommend (PIC and crystal are not included in the kit). For the non-USB version other 40 pin chips can be used, for instance a 16F887 or an 18F4520. R8 is the /MCLR (reset) pull-up. C7 provides power decoupling.

The four Dwarf Busses are available on the ML10 connectors CON-1 .. CON4, and on the wire-cups CON6 .. CON9. Note that BUS\_A has 5 pins from PIC port A and 3 from PIC port E. For the USB version 3 pins of BUS\_C (RC3, RC4, RC5) are not connected.

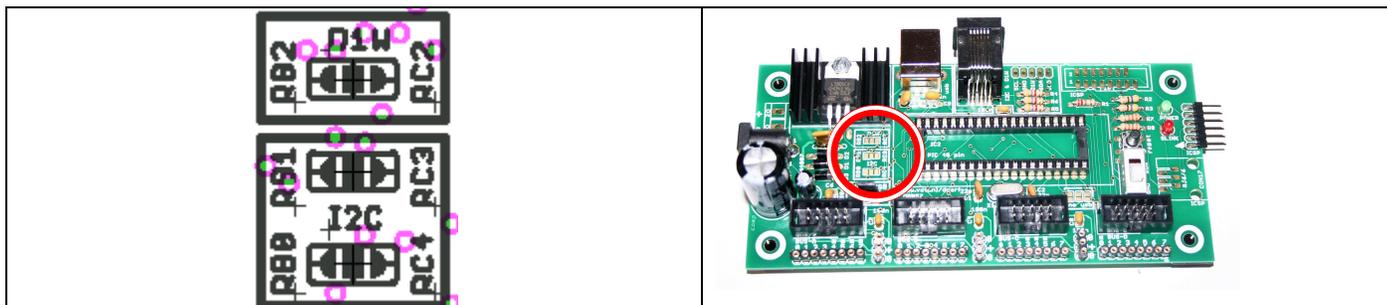
The pin-header connector CON20 can be used to program the PIC chip[ in-circuit using a pickit2, pickit3 or Wisp648 programmer. The board also has place for an RJ 6/6 connector for and ICD2 or ICD3, and for an ML16 pin header for use with a Wisop648. Those connectors are not included in the kit.

## Connector pinout – RJ6/6 connector

The pinout of the black RJ6/6 connector (at the far side of the PCB, next to the USB connector) is shown in the table below. These signals are also available on the five solder connections next to the connector. These signals are intended for connection to Dallas 1-wire and/or I2C peripherals.

	Pin	function
	1	Vdd (+5V)
	2	I2C SDA (data)
	3	Dallas 1-wire data
	4	Ground
	5	I2C SCL (clock)
6	Not connected	

Some PIC chips have an on-chip I2C peripheral, which is connected to two fixed pins. Unfortunately these pins are not the same on all PIC chips. The PCB providers their two-way solder jumpers, that make it possible to connect the Dallas 1-wire and I2C signals to different PIC pins. Check the datasheet for your PIC chip to decide which pins you want to use.



## Connector pinout – Dwarf Busses

The tables below show the correspondence between Dwarf Bus pins and PICmicro controller pins. The four Dwarf Busses are available both on the ML10 connectors and on the wire cup connectors.

Dwarf Bus BUS_A	PICmicro port	Notes
pin_0	RA0	
pin_1	RA1	
pin_2	RA2	
pin_3	RA3	
	RA4	Connected to the bootloader switch and to the signal LED.
pin_4	RA5	
pin_5	RE0	
pin_6	RE1	
pin_7	RE2	

Dwarf Bus BUS_B	PICmicro port	Notes
pin_0	RB0	
pin_1	RB1	
pin_2	RB2	
pin_3	RB3	
pin_4	RB4	
pin_5	RB5	
pin_6	RB6	
pin_7	RB7	

Dwarf Bus BUS_C	PICmicro port	Notes
pin_0	RC0	
pin_1	RC1	
pin_2	RC2	
pin_3	RC3	These pins are not connected when the board is populated for USB.
pin_4	RC4	
pin_5	RC5	
pin_6	RC6	These pins are also connected to the DB16 Wisp648 connector to facilitate serial pass-through.
pin_7	RC7	

Dwarf Bus BUS_D	PICmicro port	Notes
pin_0	RD0	Connected to the bootloader switch via a 33k resistor.
pin_1	RD1	
pin_2	RD2	
pin_3	RD3	
pin_4	RD4	
pin_5	RD5	
pin_6	RD6	
pin_7	RD7	

## USB bootloader

A bootloader is available for 18F4455 (or compatible) chips. The source and .hex file for this bootloader can be found at the DB057 page, or a pre-programmed chip can be bought. You can use this bootloader to load an application program into the chip without the need for a programmer. The bootloader conforms to the HID protocol, so it does not need any USB driver or configuration file.

The USB bootloader is a slightly modified version of the Diolan bootloader (<http://www.diolan.com/pic/bootloader.html>). The bootloader is written in MPLAB assembler and covered by the GPL license. The modifications are:

- Adapted for a 18F4455 chip with a 20 MHz crystal
- No encryption of the image
- The VOTI USB VID and a dedicated PID are used
- Bootloader activation is controlled by pin RD0
- A LED on pin RA0 will blink twice when the bootloader is activated

The bootloader occupies the Flash locations 0 .. 0x7FFF, the application code must start at 0x800. For jal the compiler must be instructed to relocate the application accordingly, and to omit all fuses information from the application. The command line arguments to do this are

```
-loader18 2048 -no-fuse
```

When the PIC with the bootloader is started (powered up or reset) the PIC checks the level on pin RD0. When it is high the bootloader is activated and it will accept commands from the PC over the USB connection. On the DB057 the switch SW2 can be used to pull the pin low. Slide the switch towards the reset button and press the reset button, to activate the bootloader. Slide the switch away from the reset button (and press the button) to activate the application. Note that version 1.01 of the PCB has the words 'RUN' and 'LOAD' placed next to the switch, but these are swapped.

The PC application fw\_update.exe is a command-line tool that is used to download an application using to the PIC with the bootloader. The command line to download hex-file-name is

```
fw_update -e -w -v -vid 0x16C0 -pid 2 -ix hex-file-name
```

If you get the cryptical error message **Argument "size" is required for the selected operation** you have not compiled your application with the appropriate arguments (start address *must* be 0x800).

## Jal

Jal is a free (gratis and open source) compiler for a pascal-like language for PICs. A zip file with the Jal compiler and associated libraries can be downloaded from <http://code.google.com/p/jalib/>. A more bleeding-edge Jal (compiler only) can be available from its developer at <http://www.casadeyork.com/jalv2/>.

## MPLAB assembler and C

Microchip provides the free (gratis) MPLAB IDE. The basic installation provides the tools for development in assembler.

The download also contains a separate installation file (started automatically, but you must click OK for it to run) for the free (formerly HiTech, now Microchip) C compiler for 14-bit core chips (12F, 16F). This compiler is



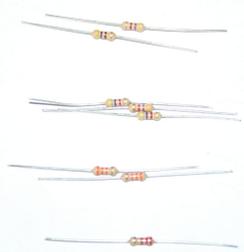
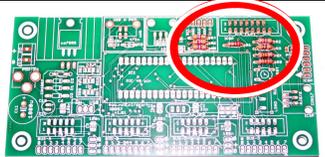
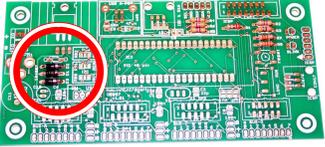
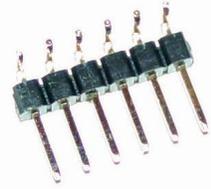
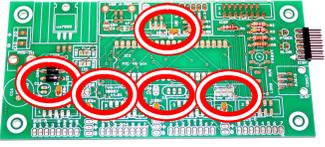
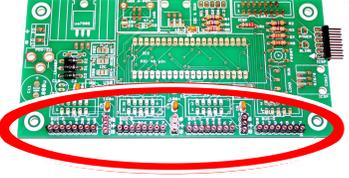
## Kit assembly

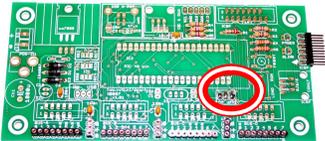
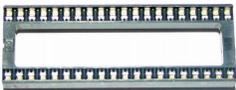
The kit contains all components for assembling either the USB or the non-USB version, except for the PIC chip and the resonator and/or crystal, and the optional connectors (ML16 for old-style Wisp648, RJ6/6 for ICD2/ICD3, two-pole screw connector for external power). You must choose for either the USB or the non-USB version, depending on the PIC chip you want to use.

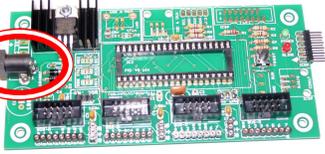
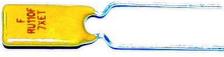
Assembling the kit is not difficult, no fine-pitched or SMD components are used. Just follow the instructions below carefully. Some soldering experience is recommended.

Orient the PCB as shown on the pictures and in the previous paragraph. The silkscreen (component side) text should be readable.

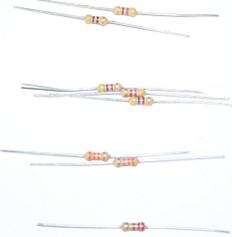
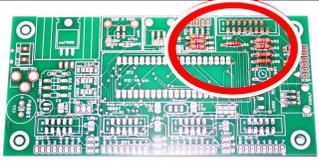
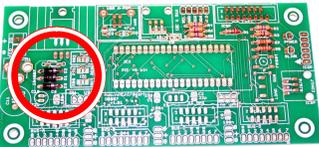
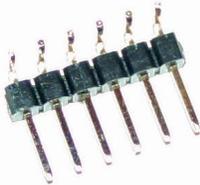
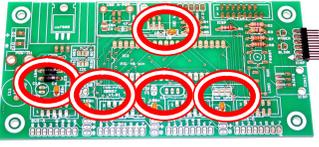
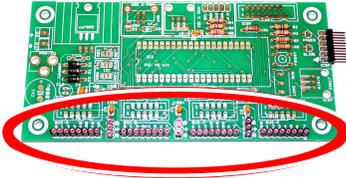
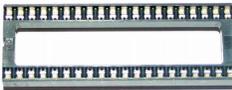
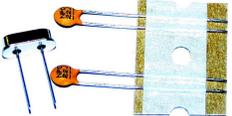
## Assembling the non-USB version

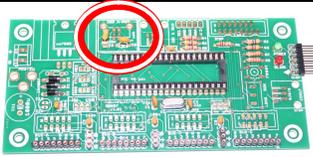
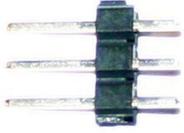
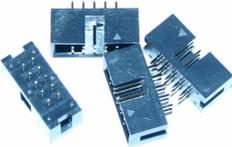
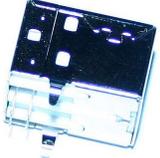
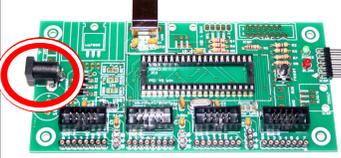
	<p>Place and solder the resistors. The silkscreen shows where each value must be placed:</p> <ul style="list-style-type: none"> <li>• 220 : red-red-brown (1)</li> <li>• 470 : yellow-purple-brown (2)</li> <li>• 4k7 : yellow-purple-red (3)</li> <li>• 33k : orange-orange-orange (2)</li> </ul>	
	<p>Place a solder jumper the three 1N4007 diodes. The white bands must point to the right (away from the edge of the PCB).</p>	
	<p>Place and solder the right-angled 5-pin header strip. The long pins stick out beyond the right edge of the PCB.</p>	
	<p>Place and solder the five 100nF capacitors (marked 104). (Note: don't use the 10nF and 470 nF capacitors in the set, marked 103 and 474.)</p>	
	<p>Place and solder the four 8-position and three 3-position wire cups.</p>	

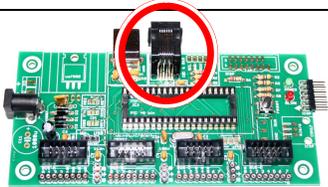
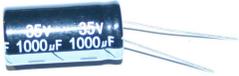
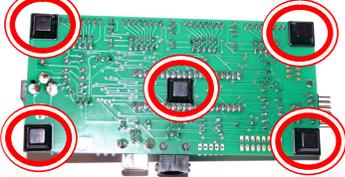
	<p>Place solder blobs on the three solder jumpers marked "no usb".</p>	
	<p>Place and solder the 40-pin IC socket.</p>	
	<p>Place and solder the two LEDs. The green LED is for the position marked 'power', the red LED is for the position marked 'blink'. Both LEDs must be oriented with their flattened side away from the edge of the PCB, and the longer of the two wires in the hole nearest to the (right) edge of the PCB.</p>	
	<p>If you want to use your PIC chip with a crystal (and capacitors) this is a good time to place and solder those components. Leave a millimeter between the bottom of the crystal and the PCB, to avoid shorting the PCB traces by the metal can of the crystal.</p>	
	<p>Place and solder the three-position pin header.</p>	
	<p>If you want to use your PIC chip with a resonator this is a good moment to place and solder that component.</p>	
	<p>Place and solder the four 10-pin boxed connectors. The gap in the plastic box must point towards the edge of the PCB.</p>	
	<p>Place and solder the reset switch.</p>	
	<p>Use the screw and nut to put the 7805 regulator and the heatsink in place. The legs of the 7805 regulator must be bent backwards to fit into the holes. When everything is properly in place, solder the legs of the 7805.</p>	

	<p>Place the centre-pin style power connector. At the solder side of the PCB, bend the pins towards each other. Solder the connector.</p>	
	<p>Place and solder the polyfuse.</p>	
	<p>Place and solder the 22 uF capacitor. The white band must be towards the lower side of the board.</p>	
	<p>Place and solder the RJ 6/6 connector. Some force might be needed to insert the plastic feet of the connector.</p>	
	<p>Place and solder the 1000 uF capacitor. The white band must be towards the lower side of the board.</p>	
	<p>Peel the feet from their strip and place them at the bottom of the board, one each at the four corners and one at the centre of the board.</p>	
	<p>Place the jumper on the three pin header, on the left two pins (marked 'WW' for wall-wart).</p>	
	<p>The kit does not contain a PIC, you must select one yourself. Good choices are the 14-bit core 16F887 (successor to the popular 16F877 / 16F877A chips), or the 16-bit core 18F4520 (successor to the 18F452). For the 18F4520 a 10 MHz crystal or resonator will be needed to run the processor at its maximum frequency (with the x4 PLL).</p>	

## Assembling - the USB version

	<p>Place and solder the resistors. The silkscreen shows where each value must be placed:</p> <ul style="list-style-type: none"> <li>• 220 : red-red-brown (1)</li> <li>• 470 : yellow-purple-brown (2)</li> <li>• 4k7 : yellow-purple-red (3)</li> <li>• 33k : orange-orange-orange (2)</li> </ul>	
	<p>Place a solder jumper the three 1N4007 diodes. The white bands must point to the right (away from the edge of the PCB).</p>	
	<p>Place and solder the right-angled 5-pin header strip. The long pins stick out beyond the right edge of the PCB.</p>	
	<p>Place and solder the five 100nF capacitors (marked 104). (Note: don't use the 10nF and 470 nF capacitors in the set, marked 103 and 474.)</p>	
	<p>Place and solder the four 8-position and three 3-position wire cups.</p>	
	<p>Place and solder the 40-pin IC socket.</p>	
	<p>Place and solder the two LEDs. The green LED is for the position marked 'power', the red LED is for the position marked 'blink'. Both LEDs must be oriented with their flattened side away from the edge of the PCB, and the longer of the two wires in the hole nearest to the (right) edge of the PCB.</p>	
	<p>Assuming you have bought a PIC chip and a crystal, place and solder the crystal and the two 22pF capacitors. Leave a millimeter between the bottom of the crystal and the PCB, to avoid shorting the PCB traces by the metal can of the crystal.</p>	

	<p>Place and solder the 10nF capacitor (marked 103) and the 470 nF capacitor (marked 474.)</p>	
	<p>Place and solder the three-position pin header.</p>	
	<p>Place and solder the four 10-pin boxed connectors. The gap in the plastic box must point towards the edge of the PCB.</p>	
	<p>Place and solder the reset switch.</p>	
	<p>Place and solder the USB connector.</p>	
	<p>Place the centre-pin style power connector. At the solder side of the PCB, bend the pins towards each other. Solder the connector.</p>	
	<p>Place and solder the polyfuse.</p>	
	<p>Place and solder the 22 uF capacitor. The white band must be towards the lower side of the board.</p>	

	<p>Place and solder the RJ 6/6 connector. Some force might be needed to insert the plastic feet of the connector.</p>	
	<p>Use the screw and nut to put the 7805 regulator and the heatsink in place. The legs of the 7805 regulator must be bent backwards to fit into the holes. When everything is properly in place, solder the legs of the 7805.</p>	
	<p>Place and solder the 1000 uF capacitor. The white band must be towards the lower side of the board.</p>	
	<p>Peel the feet from their strip and place them at the bottom of the board, one each at the four corners and one at the centre of the board.</p>	
	<p>Place the jumper on the three pin header, on the left two pins (marked 'WW' for wall-wart).</p>	
	<p>The kit does not contain a PIC, you must select one yourself. Good choices are PICs with USB, for instance the 18F4455 or 18F4550.</p>	

**Version 1.01 of the PCB has the words 'RUN' and 'LOAD' placed next to the boot/run switch, but these are swapped! Slide the switch towards the reset button to select the bootloader.**

## Change notes

The latest version of this document can be downloaded from <http://www.voti.nl/DB057>

version	date	notes
1.0	2011-11-21	first version