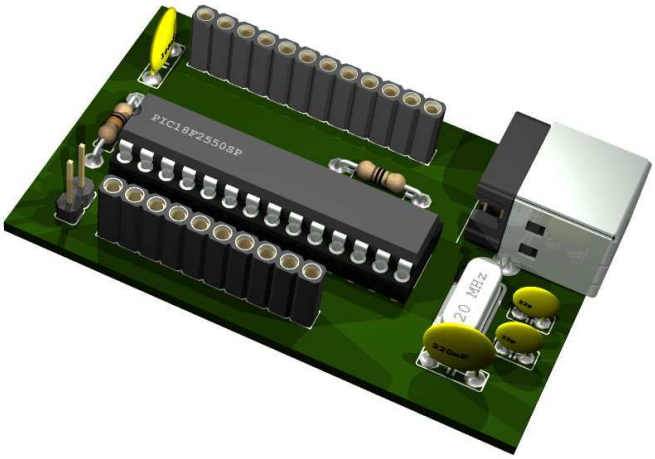
USB4all

V.10

Technical Description
&
User Manual



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Stand: 18.05.2012

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3 Terms of Use:

This handbook is an early draft probably full of typing errors and other mistakes. Normally I would not publish it in this bad condition, but I like to give the not german speaking users something into the hands to use my USB4all.
The handbook will be updated and “debugged” continuously to improve its quality

4 Introduction

The USB4all s an easily usable solution to connect a simple (e.g. self made) device to the PC via USB-bus. It is a PIC-microcontroller from Microchip (e.g. PIC18F2455) with a special firmware. It offers USB functionality without the need to understand USB or microcontrollers in detail.

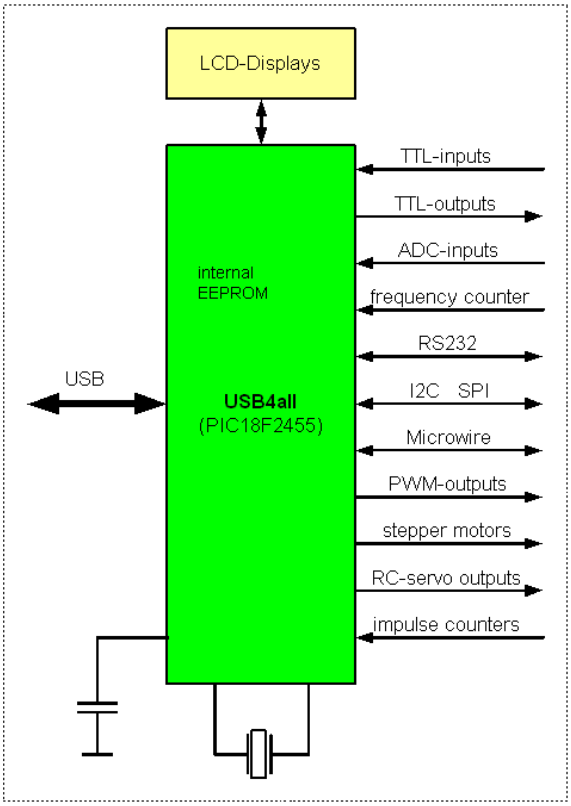

Figure 1 USB4all-Overview

The USB4all comes in two different flavors. The USB4all-**MCD** is controlled with functions of a special DLL. The USB4all-**CDC** is controlled via a virtual RS232-port.

The firmware was designed to collaborate with a USB-bootloader, but can be used as stand alone firmware too.

USB4all offers to the user the following connectivity via USB:

- 20 or 31 digital Input/Output Pins (TTL)
- 10 analogue ADC-inputs (0..5V) with 10 or 12 bits resolution
- 1 frequency counter (up to 50 MHz)
- one RS232-interface
- one I2C-Master-interface
- one SPI- interface for up to 6 slave-select-wires
- one microwire- interface
- one shift-register-interface
- interface for 2 LCD-dot-matrix-displays
- 2 PWM-Outputs
- 4 stepper motor interfaces for ABCD-phase-connections
- 4 stepper motor interfaces for L297-circuits
- Connections for 13 model-servos.
- 2 impulse-counter-inputs
- 192 Byte internal EEPROM-memory

5 Hardware

5.1 Schematic for USB4all

USB4all is by default a PIC18F2455 microcontroller with special firmware. Instead of the PIC18F2455 a different type can be used. The following table lists the possible types and the resulting number of digital IO-pins and the ADC resolution:

PIC-Type	Number of digital IO-Pins	ADC resolution
PIC18F**2455** / PIC18F2550	20	10 bit
PIC18F4455 / PIC18F 4550	31	10 bit
PIC18F2458 / PIC18F 2553	20	12 bit
PIC18F4458 / PIC18F 4553	31	12 bit

++Information++
In several figures of this document a PIC18F2550 is shown. However, it can be used a PIC18F2455 in all circuitries.
The 28-pin-firmware works without any modification is PIC18F4455/4550/4458/4553 (40 or 44 pins), but their additional pins are not used and their pin numbers are not identical to the pin numbers in the schematics of this document.
The 40-pin-firmware can use 11 additional digital IO-Pins. But the pin numbers are not identical to the pin numbers in the schematics of this document.

Error! Reference source not found. shows the typical circuitry for a simple USB-device with USB4all.

- L2 and C8 build up a filter for the supply voltage. C8 should be at least 1 uF.. 10uF.
- C1 is a filter for the internal 3,3V voltage regulator of the chip.
- R2 and JP1 can be used to activate the bootloader.
- Q1, C2 und C3 generate the clock for the chip.

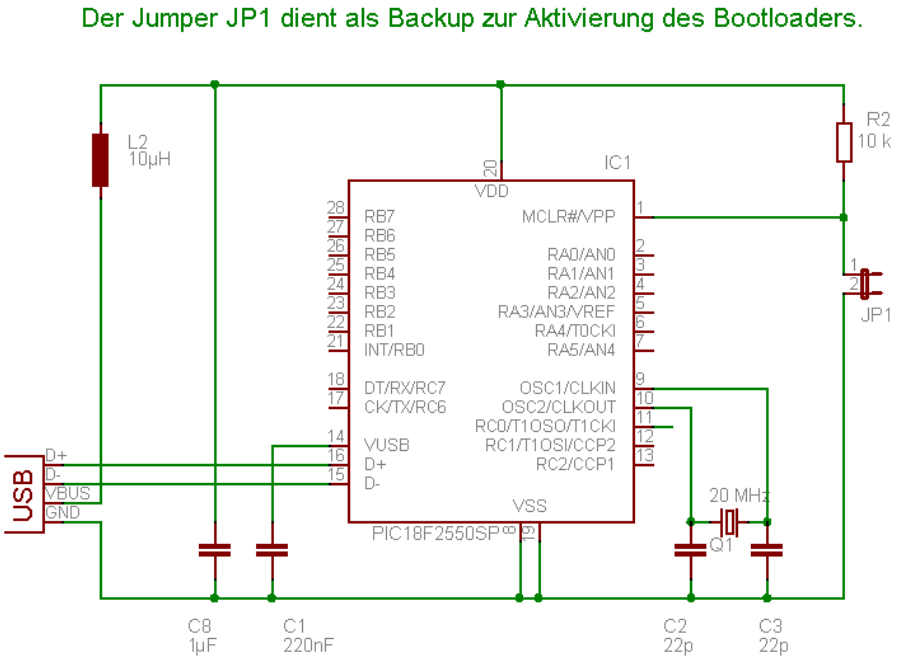

Figure 2 Typical circuitry for USB4all

The front-page of this document shows such a device. All usable Pins are connected to sockets.
The next figure shows a simplified circuitry for cost sensitive applications.

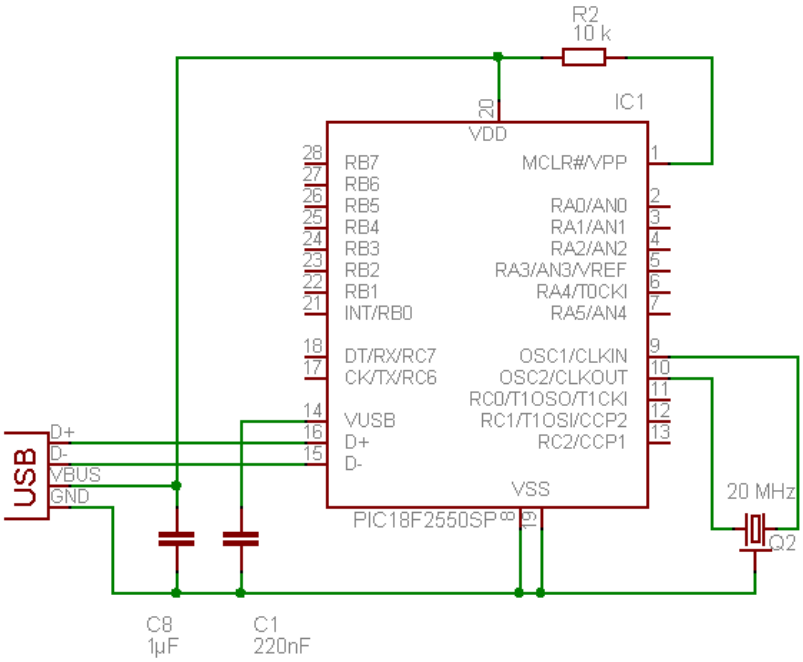

Figure 3 Minimum circuitry for USB4all

The clock source can be a 20-MHz-crystal or a 20-MHz-resonator. A crystal requires load capacitors at both terminals of the crystal. (C2 & C3) A resonator works without such

capacitors.

++ATTENTION++
If a resonator is used, then the precision of the frequency counter is limited to 0.5%.

5.2 Usable Interfaces

Die following tables shows which pins are usable for what kind of interface function. One can see that some interfaces can not be used at the same time in parallel. Thus LCD1 can not be used in parallel to I2C, SPI, Motor1 or Motor2. But one can use ADC (the 5 inputs AN0..AN4), the frequency counter, RS232, I2C, LCD2, PWM1 and PWM2 in parallel.

5.2.1 Interfaces with 28-pin Control PIC

The PIC18F2455 / 2550 / 2458 / 2553 have 28 Pins.

Pin	IO-Port	ADC	FRQ	RS 232	I2C	SPI	Mwire/ SR	LCD 1	LCD 2	PWM	Motor 1..4	L297 1..4	Servo	Counter
2	RA0	AN0									A3			
3	RA1	AN1									B3			
4	RA2	AN2									C3			
5	RA3	AN3									D3			
6	RA4		FRQ											C1
7	RA5	AN4				(SS)								
10	RA6													
21	RB0	AN12			SDA	SDI	SDI	E1			A1	CL1	SB0	
22	RB1	AN10			SCL	SCL	SCL				B1	DIR1	SB1	
23	RB2	AN8				(CS1)		RS	RS		C2	CL2	SB2	
24	RB3	AN9				(CS2)		R/W	R/W		D1	DIR2	SB3	
25	RB4	AN11				(CS3)		D4	D4		A2	CL3	SB4	
26	RB5					(CS4)		D5	D5		B2	DIR3	SB5	
27	RB6					(CS5)		D6	D6		C2	CL4	SB6	
28	RB7					(CS6)		D7	D7		D2	DIR4	SB7	
11	RC0								E2		A4		SC0	C3
12	RC1									PWM2	B4		SC1	
13	RC2									PWM1	C4		SC2	
17	RC6			TX							D4		SC6	
18	RC7			RX		SDO	SDO						SC7	

These microcontrollers are available in 28-pin-DIL-housing (PDIP) and 28-pin SMD-housing (SOIC). The following figure shows the pinout.

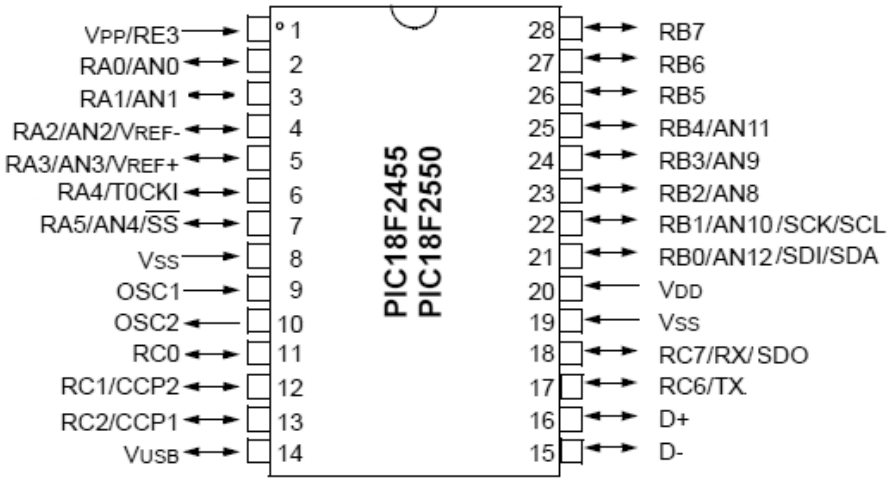

Figure 4 Pinout of the PIC18F2455 / 2550 / 2458 / 2553

5.2.2 Interfaces with 40/44-pin Control PIC

The PIC18F4455 / 4550 / 4458 / 4553 have 40 or 44 Pins.

Pin	IO-Port	ADC	FRQ	RS 232	I2C	SPI	Mwire/ SR	LCD 1	LCD 2	PWM	Motor 1..4	L297 1..4	Servo	Counter
2	RA0	AN0									A3			
3	RA1	AN1									B3			
4	RA2	AN2									C3			
5	RA3	AN3									D3			
6	RA4		FRQ											C1
7	RA5	AN4				(SS)								
14	RA6													
33	RB0	AN12			SDA	SDI	SDI	E1			A1	CL1	SB0	
34	RB1	AN10			SCL	SCL	SCL				B1	DIR1	SB1	
35	RB2	AN8				(CS1)		RS	RS		C2	CL2	SB2	
36	RB3	AN9				(CS2)		R/W	R/W		D1	DIR2	SB3	
37	RB4	AN11				(CS3)		D4	D4		A2	CL3	SB4	
38	RB5					(CS4)		D5	D5		B2	DIR3	SB5	
39	RB6					(CS5)		D6	D6		C2	CL4	SB6	
40	RB7					(CS6)		D7	D7		D2	DIR4	SB7	
15	RC0								E2		A4		SC0	C3
16	RC1									PWM2	B4		SC1	
17	RC2									PWM1	C4		SC2	
25	RC6			TX							D4		SC6	
26	RC7			RX		SDO	SDO						SC7	
19	RD0													
20	RD1													
21	RD2													
22	RD3													
27	RD4													
28	RD5													
29	RD6													

30	RD7													
8	RE0													
9	RE1													
10	RE2													

These microcontrollers are available in 40-pin-DIL-housing (PDIP) and 44-pin SMD-housing (SOIC, TQFP or QFN). The following figure shows the 40-pin-pinout.

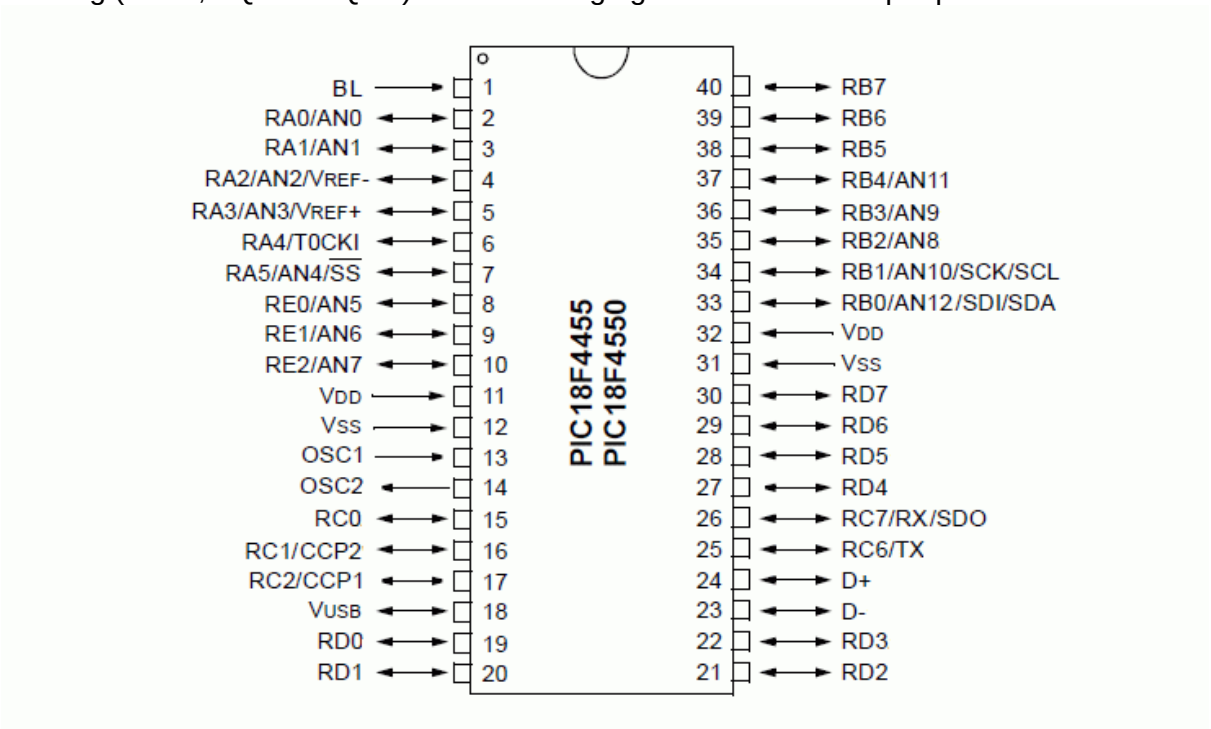

Figure 5 Pinout of the PIC18F4455 / 4550 / 4458 / 4553

5.2.3 Output Pins

The following picture shows a simplified diagram for an output pin of the USB4all. (for all pins, including RA4)

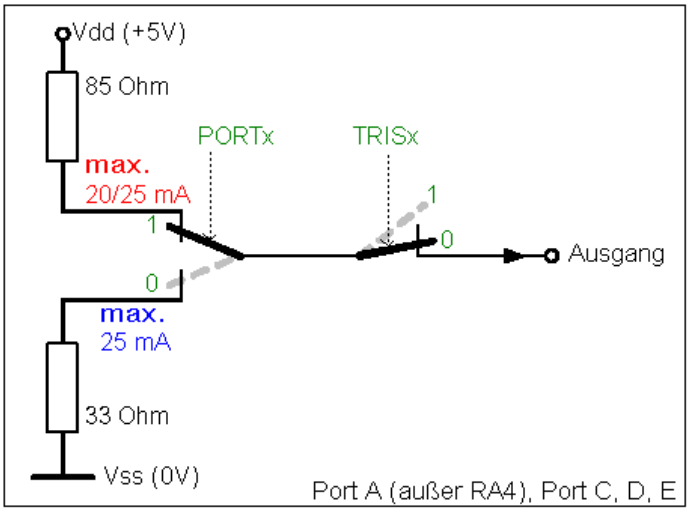

Figure 6 Output Pin - simplified

The output current for any pin should not exceed 20mA. The sum of all currents from all output pin don't has to exceed 200mA (USB4all: limited to 100mA).

The output voltage level is:

Level	**general**	**at Vdd=5V**
High at 8,5 mA Load	> (Vdd-0,7V)	> 4,3V
Low at -3,5 mA Load	< 0,6V	< 0,6V

The output stage is made up from MOSFET-transistors with relatively high internal resistivity. Because of this the output voltage depends on the load current.

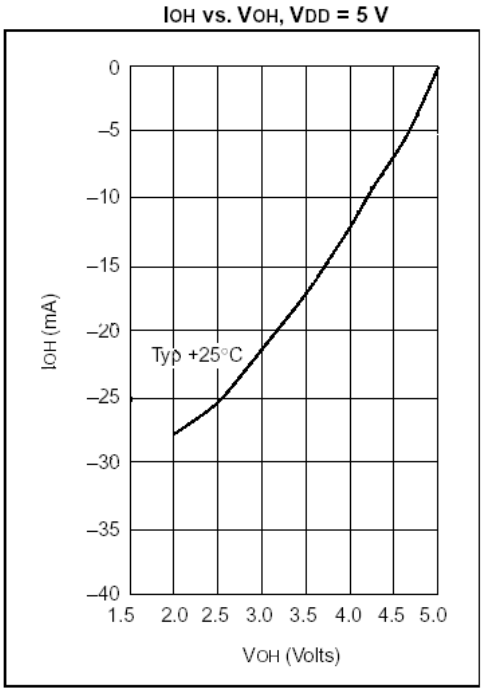

Figure 7 High level at different load

At loads up to 20mA the standard TTL-level is guarantied.

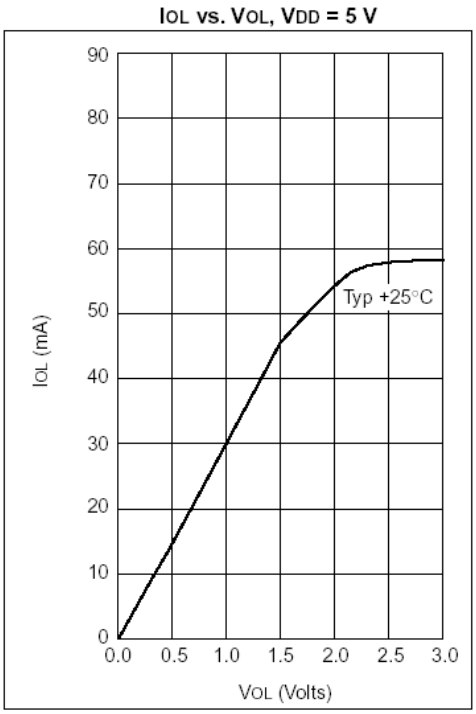

Figure 8 Low level at different load

5.2.4 Input Pins

The most pins of Ports A (RA0..RA3, RA5, RA6) and all pins of Port B (RB0..RB7) are normal TTL-input pins.
The pin RA4 and all pins of Port C are Schmitt-trigger-inputs (ST). The following tables list the typical input voltages:

IO-Input	Function	Input-low-Level	Input-high- Level
RA0..RA3, RA5, RA6, RB0..RB7	TTL	< 0,15 Vdd	>(0.25Vdd+0.8V)
RA4, RC0..RC7	ST	< 0,2 Vdd	> 0,8 Vdd

At a supply voltage level of 5V this results in:

IO-Input	Function	Input-low- Level	Input-high- Level
RA0..RA3, RA5, RA6, RB0..RB7	TTL	< 0,75 V	> 2.05 V
RA4, RC0..RC7	ST	< 1 V	> 4 V

The input current of any pin will not exceed 1 uA.

All pins of Port B have internal pull-up resistors, which can be activated is needed. They pull up the input pins to Vdd with 50 .. 400 uA. (This is an equivalent to 25 kOhm resistors.)

++Attention++
Input voltages above Vdd or below Vss are limited by clamp diodes. The clamp current don't has to exceed 20mA. If such input voltages are possible, then the clamp current has to be limited by resistors.

5.3 TTL-IO-Port-Pins

A detailed description of the TTL-IO-Ports is available (in Germans) at:
http://www.sprut.de/electronic/pic/grund/ioports.htm#rx

5.4 ADC-Input

The ADC can measure voltage levels between the reference values Vss (0V) and Vdd (+5V) with 10 Bit resolution (4.88 mV) or 12 Bit resolution (1.22 mV). The resolution depends on the type of the control PIC:

- 10 Bit: PIC18F2455/2550/4455/4550
- 12 Bit: PIC18F2458/2553/4458/4553

To guarantee a high precision the internal resistivity of the voltage source should not exceed 2,5kOhm.
Input voltages above Vdd or below Vss are limited by clamp diodes. The clamp current don't has to exceed 20mA. If such input voltages are possible, then the clamp current has to be limited by resistors. This resistor would increase the internal resistivity of the voltage source.
By default Vss and Vdd are used as reference voltages (maximum and minimum voltage the ADC can measure). If a smaller voltage range is required, then other reference voltages can be used. These voltages have to be connected to special input pins. This 1..2 pins can then not be used as ADC inputs.
The upper reference voltage (upper limit for the ADC) has to be connected to AN3 (Pin 5). The lower reference voltage (minimum voltage for the ADC) has to be connected to AN2 (Pin 4). Both reference voltages have to be in the range between Vdd and Vss. The difference between both reference voltages should not be smaller then 2 V.

5.5 Frequency Counter Input

The frequency counter (FRQ, Pin 6) can measure frequencies up to 50 MHz. the input pin has a Schmitt-trigger (ST). The high part of the input signal has to be higher then 4V (0.8 x Vdd) and the low part has to be below 1 V (0.2 x Vdd).
Input voltages above Vdd or below Vss are limited by clamp diodes. The clamp current doesn't has to exceed 20mA. If such input voltages are possible, then the clamp current has to be limited by a resistor.

5.6 RS232-Interface

The RS232-interface-pins of the USB4all-chip transmit and receive signals at TTL-voltage level. They have to be converted to regular RS232-values by a regular RS232-driver circuit. (e.g. MAX232).
(+5V->-12V: 0V->+12V).

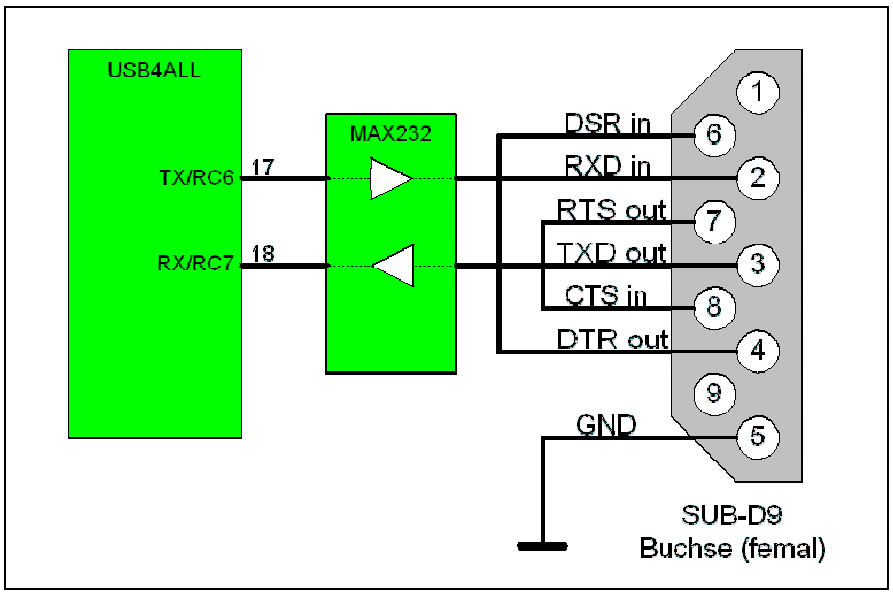

Figure 9 RS232-Interface with external driver

Additional information is available (in German) at:
http://www.sprut.de/electronic/interfaces/rs232/rs232.htm
http://www.sprut.de/electronic/pic/grund/rs232.htm

For short RS232-connections such an external driver may not be necessary. In this case only a current limiting resistor inside the RX-line is needed to connect the USB4all with a regular RS232-port. In this case the signal levels do not meet the official RS233-specifications, but the most modern PC-mainboards will accept these signals.

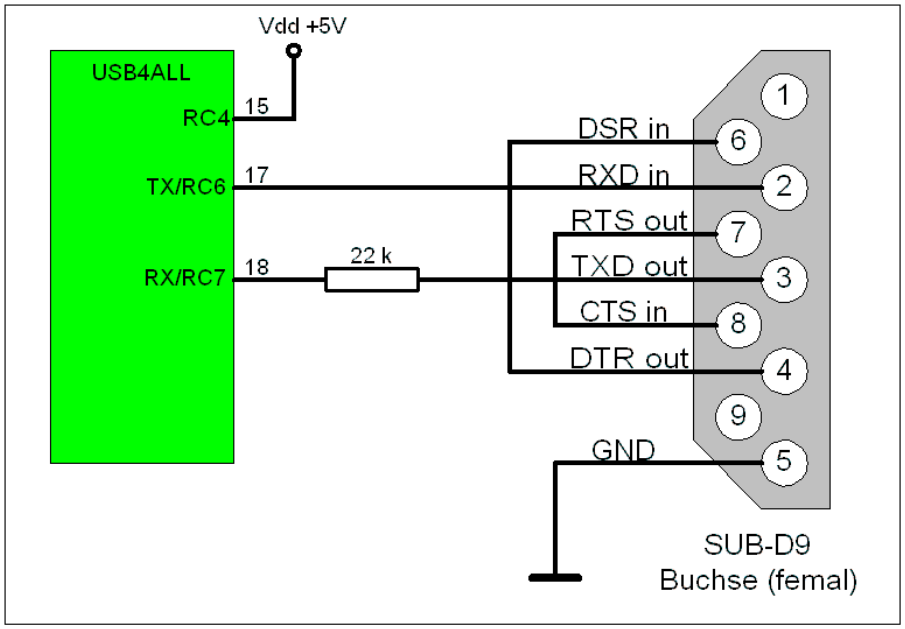

Figure 10 RS232-Interface without external driver

During the initiation of the RS232-interface the interface version (with or without external driver) has to be specified.

5.7 I2C- Interface

USB4all can act as Master for one I2C-bus. Both wires of the bus (SDA and SDC) need external pull-up-resistors of 1,8 Kilo-Ohm.
Additional information is available (in German) at:
http://www.sprut.de/electronic/pic/grund/i2c.htm

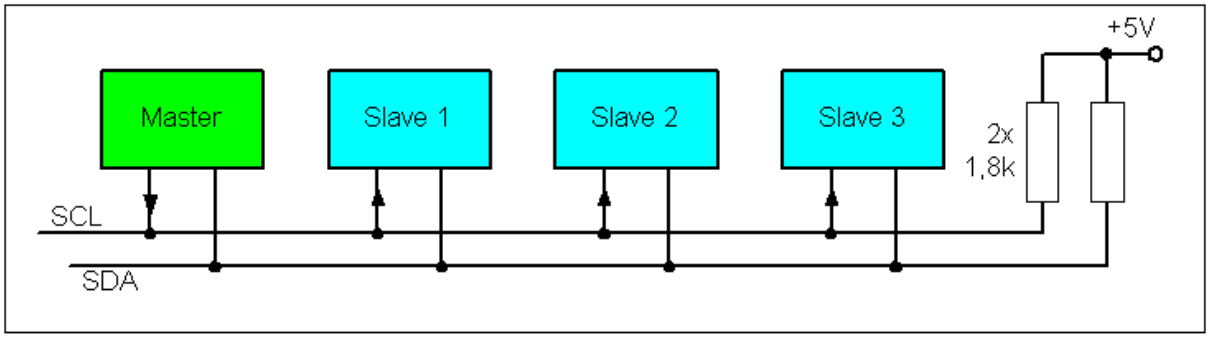

Figure 11 I2C-Interface

5.8 Dot-Matrix LCD-Interface

USB4all can control up to 2 HD44780-compatible LCD-dot-matrix-displays.
Each display can have up to 2x40 or 4x20 positions for symbols.
Alternative a single display with up to 4x40 symbols can be controlled.

The display-pins can be directly connected to the pins of USB4all. The pins D0..D3 of the display are not needed.
The pins Vdd (+5V) und Vss (0V) of the display have to be connected to Vdd and Vss of the USB4all.
The pin Vo has to be connected to a (display type specific) contrast voltage. For the most display types (normal temperature displays) this voltage is in the range of 0V … 1V.

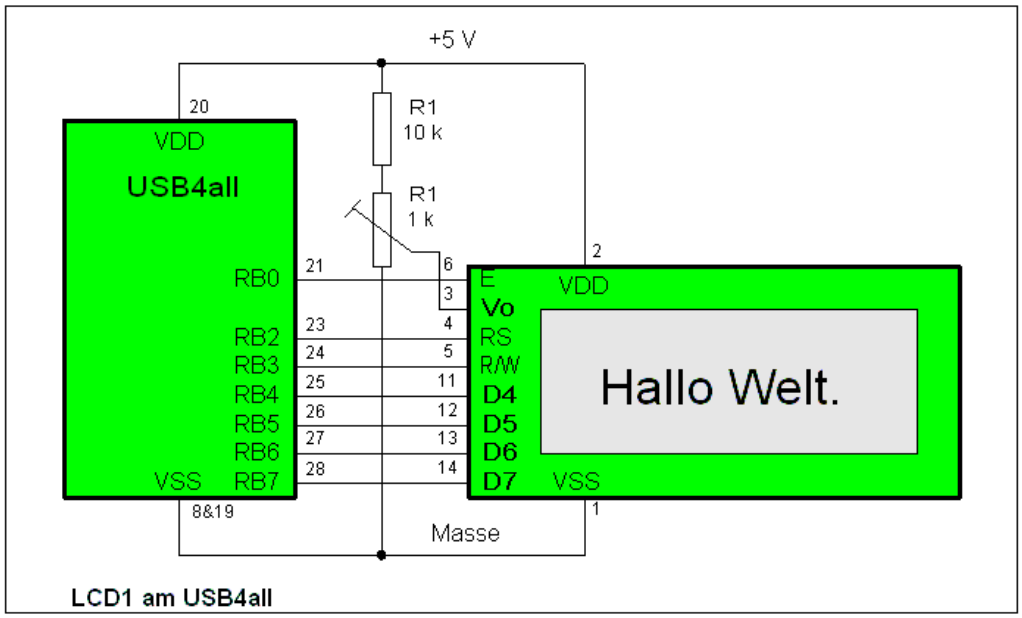

Figure 12 Dot-Matrix-LCD Interface

The figure shows the typical connection between one display and USB4all. A second display would be connected in parallel to the first display with the exception of the “E”-pin. The E-pin of the second display would be connected to pin RC0 of USB4qall.

Additional information is available (in German) at:
http://www.sprut.de/electronic/lcd/index.htm

5.9 PWM-Output

There are 2 PWM-output (pulse width modulated square wave) pins. Both pins generate signals of the same frequency, but the can have different duty cycle.

5.10 Stepper Motor Output

5.10.1 Stepper-Motor-Interface with ABCD-Phase-outputs

This interface can be used for low-power unipolarer stepper motors.
Every channel has 4 output-pins. They have to be driven to reach the necessary current for the motor. The driver can be made from single transistors or from special integrated circuitries (e.g. den ULN2075B or L298).
The following figure shows an example circuit with bipolar transistors.

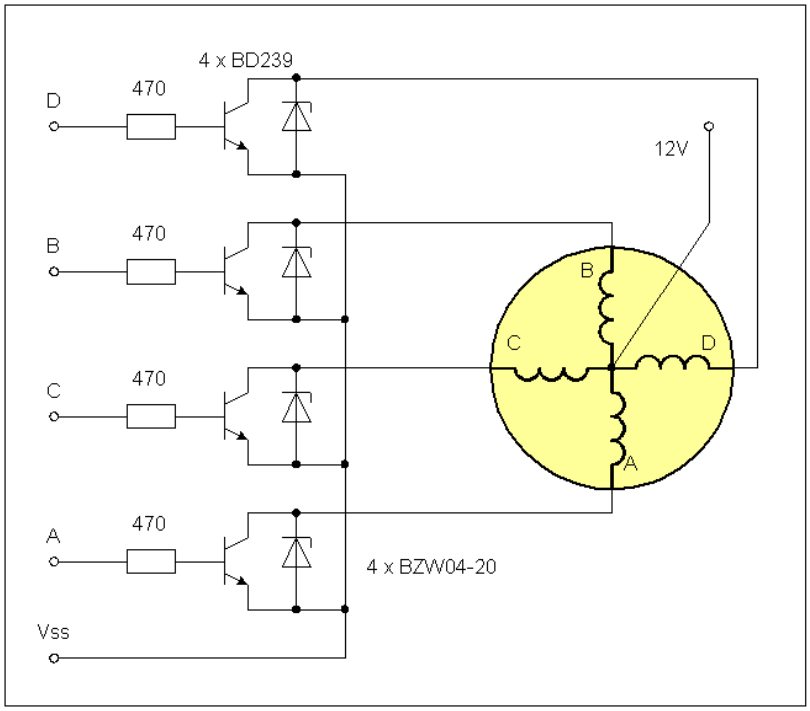

Figure 13 simple Stepper Motor Interface

5.10.2 Stepper Motor Interface with L297

The integrated circuit L297 together with the L298 is a popular solution to drive stepper motors. USB4all can control up to 4 channels with these chips.

The two output pins of each USB4all-channel have to be connected to the pins “clock” (CLK) and “direction” (CW/CCW) of the L297. The “enable”-pin of the L297 has to be connected to High-level. The “half/full”-pin of the L297 has to be connected with the correct level for the required mode.

5.11 Model-Servo-Output

There are up to 13 outputs to drive standard model servos. The output signals are positive pulses (TTL level). These can be directly fed into a model servos input pin.

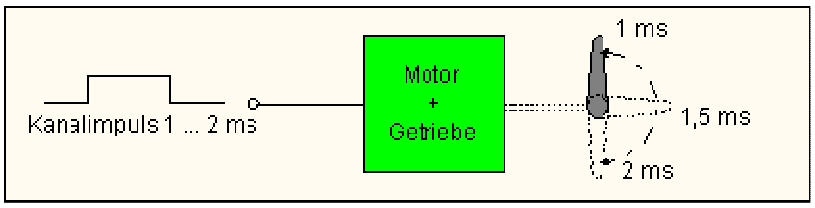

Figure 14 Model-Servo

6 Software

6.1 USB-Device

The heart piece of USB4all is the USB4all-firmware. It would be possible to burn it directly into the PIC18F2455 (by a programmer) but I don't suggest this.

It is much smarter to burn only the bootloader into the PIC18F2455. After this was done, you can use this bootloader to load the latest firmware into the chip.

If the USB4all is connected to the PC, then under normal condition the firmware is launched. But is the bootloader is required (e.g. to load a new version of the firmware), it can be activated by an electric connection between pin1 and Vss. In may layouts exists a jumper for this porpoise. The jumper has to be closed before the device is connected to the PC.

The software USBoot (which is necessary to use the bootloader) can activate the bootloader of USB4all-MCD (but not of USB4all-CDC) even without this jumper.

6.2 PC

The USB4all comes in two flavors:

USB4all-CDC
This version can be controlled via a virtual RS232-interface (e.g. COM3 or COM4). On windows-systems it needs the **USB RS-232 Emulation Driver**. The use of the virtual COM-port allows the use of simple terminal programs or other simple means to control this device.

USB4all-MCD
This version needs the **Microchip Custom Driver.** The device can be controlled by functions that are contained inside a special DLL.

6.2.1 Driver Installation

The drivers have to be installed before the device is connected to the PC.

The USB4all-MCD needs the **Microchip Custom Driver** (mpusbapi.dll). The driver is aviable from the Microchip homepage but is contained in my USB4all-ZIP-file too.
The same driver is needed by my programmer Brenner8/9 and the bootloader.
By the way: you should not connect Brenner8/9 and USB4all-MCD to the same PC in parallel. The USB4all-test-software might be confused.

The USB4all-CDC needs the **USB RS-232 Emulation Driver**. This driver is part of Windows. Vou will have to use the inf-file from the ZIP-file to install this driver.
The bootloader of USB4all (Bootloader-5) needs the **Microchip Custom Driver**.
Consequently users of USB4all-CDC have to install both drivers.

6.2.2 Installation: Microchip Custom Driver

Detailed description of driver installation is contained in the German version of this document only.

6.2.3 Installation: USB RS-232 Emulation Driver

Detailed description of driver installation is contained in the German version of this document only.
If the USB4all is connected to the PC after driver installation, the USB4all-CDC should be detected as additional COM-port (device manager)

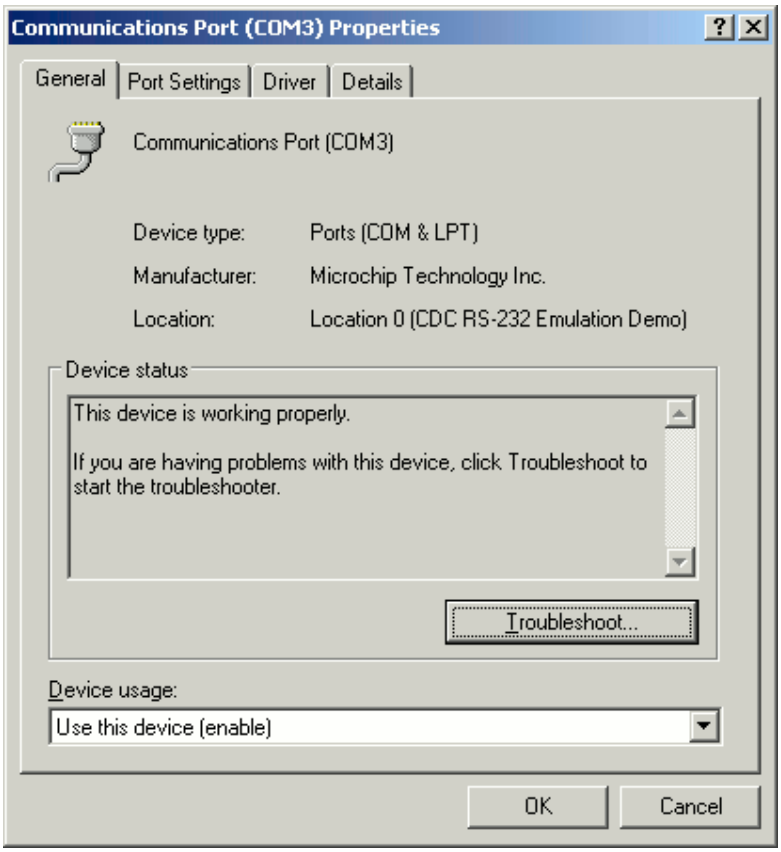

Figure 15 USB4all-CDC as emulated COM3-Port

7 List of Commands

The USB4all is controlled by commands. Every command is a short string of bytes. The string is send via USB to the USB4all, the device works off this command and sends back a report. This report is a string of 16 bytes.

The length of the command string can not exceed 64 bytes. However, the most commands need only 2 … 4 bytes.

For the USB4all-CDC the bytes of the command string have to be converted into an ASCII-string. This text-string is 3 times longer then the byte string. This text string doesn't has to exceed a length of 64 bytes! This limits the number of command-bytes for the USB4all-CDC to 20 only (instead of 64 for the USB4all-MCD).

The first byte is addressing the subsystem of USB4all, which will receive and work off the command (e.g. RS232 or ADC). The following subsystems exist:

- 0x50 TTL-IO-Pins
- 0x51 10-Bit-ADC
- 0x52 frequency counter
- 0x53 SPI-Interface
- 0x54 I2C-Interface
- 0x55 Dot-matrix-LCD-Display Nr. 1
- 0x56 Dot-matrix-LCD-Display Nr. 2
- 0x57 PWM-output 1
- 0x58 PWM-output 2
- 0x59 RS232-Interface
- 0x5A internal EEPROM
- ~~*0x5B key-matrix*~~
- 0x5C stepper-motor Nr. 4
- 0x5D stepper-motor Nr. 1
- 0x5E stepper-motor Nr. 2
- 0x5F stepper-motor Nr. 3
- 0x60 L297 stepper-motor Nr. 1
- 0x61 L297 stepper-motor Nr. 2
- 0x62 L297 stepper-motor Nr. 3
- 0x63 L297 stepper-motor Nr. 4
- 0x64 model-servo-channel B
- 0x65 model-servo-channel C
- 0x66 Shift register
- 0x67 Micro wire
- 0x68 Counter 0
- 0x69 Counter 3
- 0xFF Reset

The second byte contains the command. For the most subsystems this byte has the following meaning:

- 0x00 deactivate the subsystems
- 0x01 initiate the subsystems
- 0x02 send one byte
- 0x03 read one byte
- 0x04 send a string of bytes
- 0x05 receive a string of bytes

If additional data is needed, then it will follow starting with the 3d byte.

7.1 TTL-IO-Pins

Electrical specification
USB4all has 20 or 31 digital IO-pins. Each can be used as output or as input for digital (TTL) signal levels. If a pin is switched into the output-mode, then it can deliver up to 25 mA. The sum of all output currents don't has to exceed 200 mA.
(Because of USB-limitations the maximum current should not exceed 100 mA).

All input-pins have clamp diodes to Vss (ground) and Vdd (+5V). If input voltage level can be above Vdd or below Vss, then a serial resistor has to be used inside the input line to limit the clamp-current to not more then 20 mA.
An input voltage of +12V requires an input-serial-resistor of at least 350 Ohms.

After power-up all pins are configured as digital input-pins.

The primary 20 IO-pins are available in all USB4all-Versions They are organized in 3 ports:

- PortA contains 7 pins: RA0..RA6
- PortB contains 8 pins: RB0..RB7
- PortC contains 5 pins: RC0..RC2 and RC6..RC7

If any other subsystem needs pins, then it will borrow these pins if the subsystem is initiated. If later this subsystem is switched off, then it will give these pins back top the TTL-IO-pin subsystem.

There are 8 different commands for IO-pins:

Byte0 Subsystem	**Byte1 Command**	**Byte 2**	**Byte 3**	**Byte 4**	**Byte 5**
0x50 IO-Pins	0x00 off switch off all Output-Pins	-	-	-	-
	0x01 initiate	In/out-mask for PortA	In/out- mask for PortB	In/out- mask for PortC	Pull-up for PortB: 0: off 1: on
	0x02 write to all ports	Value for PortA	Value for PortB	Value for PortC	-
	0x03 read from all Ports	-	-	-	-
	0x04 Switch selected pins to Input	In- mask for PortA	In- mask for PortB	In- mask for PortC	-
	0x05 Switch selected pins to Output	Out- mask for PortA	Out- mask for PortB	Out- mask for PortC	-
	0x06 Set selected pins to 5V	High- mask for PortA	High- mask for PortB	High- mask for PortC	-
	0x07 Set selected pins to 0V	Low- mask for PortA	Low- mask for PortB	Low- mask for PortC	-

USB4all will answer with a 16 byte long reply. Only for command 3 this reply contains usable data:

Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5
0x50	0x03	Value from PortA	Value from PortB	Value from PortC	-

The 20 TTL-IO-pins of the 3 ports are controlled by 3 bytes (MaskA, MaskB, MaskC). Every IO-pin is represented by exactly one bit in one of the 3 masks.

Mask	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
MaskA	-	RA6	RA5	RA4	RA3	RA2	RA1	RA0
MaskB	RB7	RB6	RB5	RB4	RB3	RB2	RB1	RB0
MaskC	RC7	-	-	RC4	-	RC2	RC2	RC0

0x03-Read from all ports
Command 0x03 reads the values of all IO-pins and reports this values in 3 bytes (the masks) to the PC. A low level at a pin is represented by a 0 inside the mask and a high level by a 1.

0x01-inititiate
Generally the TTL-IO-pin-subsystem is operational even without any initializing. After power-up the command 0x03 can be used to red the levels at all IO-pins. But all pins are configured as input-pins by default. One can read the voltage level applied from the outside to this pin, but one can not put out any signal (e.g. to control a LED).

Before a pin can put out a voltage, it has to be configured as output-pin by the command 0x01.
This command contains 3 masks (byte 2...4). Inside these masks for every pin exists a single bit. If this bit is “0” then the related pin will be set to “output”. In the bit is “1” then the pin becomes an “input”-pin.
After the 3 masks follows the byte 5. If this byte has the value 1 then all internal pull-ups of PortB will be activated.

The string (0x50-0x01-0x00-0x00-0x00-0x00) sets all pins to “output”.
The string (0x50-0x01-0xFF-0xFF-0xFF-0x00) seta all pins back to “input” again.

0x04-switch selected pins to Input
0x05- switch selected pins to Output
The command 0x01 will always influence all pins.
If one likes to switch only some pins to output or to input (without a change to the function off all other pins), then the commands 0x04 and 0x05 may be the better choice.

These commands contain 3 masks for the 3 ports, but there function is different then in command 0x01. A bit with the value”0” means, that the related pin will not be modified. But all pins with a “1” in the related mask-bit will be switched to input (command 0x04) or output (command 0x05).

The string (0x50-0x04-0x01-0x80-0x00) switches the pins RA0 & RB7 to input.
The string (0x50-0x05-0x01-0x00-0x00) switches the pins RA0 to output.

0x02-Write to all ports
With this command one can change the output value of all output pins from all 3 ports. The command contains 3 masks. A “0”-bit in the masks stands for a low-output-level (0V) and a “1” for a high output level (5V).

Input-pins will of course not react. But they will store the value for later use. If any input pin will later be switched to output-state, then it will immediately drive the output voltage value from this command.

0x06-set selected pins to +5V
0x07- set selected pins to 0V
The command 0x02 will always change the output value of all output-pins.
If the values of only some output pins have to be changed, then the commands 0x06 and 0x07 can be used.

These commands contain 3 masks for the 3 ports, but there function is different then in command 0x02. A bit with the value”0” means, that the output value of this pin will not be changed. But all output-pins with a “1” in the related mask-bit will be switched to High (command 0x06) or to Low (command 0x07).

The string (0x50-0x06-0x01-0x80-0x00) will switch the pins RA0 & RB7 to High.
The string (0x50-0x07-0x01-0x00-0x00) will switch the pin RA0 back to Low.

7.1.1 40/44 pin version

The special 40-pin-firmware for USB4all supports 11 additional IO-pins. They are organized in the Ports D and E.

The additional IO-pins are:

- PortD contains 8 pins: RD0..RD7
- PortE contains 3 pins: RE0..RE2

These pins are controlled via 2 additional masks (MaskD & MaskE).

Mask	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
MaskA	-	RA6	RA5	RA4	RA3	RA2	RA1	RA0
MaskB	RB7	RB6	RB5	RB4	RB3	RB2	RB1	RB0
MaskC	RC7	-	-	RC4	-	RC2	RC2	RC0
MaskD	**RD7**	**RD6**	**RD5**	**RD4**	**RD3**	**RD2**	**RD1**	**RD0**
MaskE	**-**	**-**	**-**	**-**	**-**	**RE2**	**RE2**	**RE0**

To initiate all 5 ports the user has to use the command 0x11 (instead of command 0x01). On 28-pin devices the commands 0x01 and 0x11 are identical. But on 40-pin devices the command 0x11 contains the IO-masks for the additional pins in byte 5 and byte 6 and the pull up-command is located in byte 7.

The commands 0x02 up to 0x07 contain the necessary information for the both additional port in the bytes 0x05 and 0x06.

There are 9 different commands for IO-pins on 40-pin devices:

Byte0 Subsystem	**Byte1 Command**	**Byte 2**	**Byte 3**	**Byte 4**	**Byte 5**	**Byte 6**	**Byte 7**
0x50 IO-Pins	0x00 off switch off all Output-Pins	-	-	-	-	-	-
	0x01 initiate	In/out-mask for PortA	In/out- mask for PortB	In/out- mask for PortC	Pull-up for PortB: 0: off 1: on		
	0x11 initiate	**In/out-mask for PortA**	**In/out- mask for PortB**	**In/out- mask for PortC**	**In/out- mask for PortD**	**In/out- mask for PortE**	**Pull-up for PortB: 0: off 1: on**
	0x02 write to all ports	Value for PortA	Value for PortB	Value for PortC	**Value for PortD**	**Value for PortE**	-
	0x03 read from all Ports	-	-	-	**-**	**-**	-
	0x04 Switch selected pins to Input	In- mask for PortA	In- mask for PortB	In- mask for PortC	**In- mask for PortD**	**In- mask for PortE**	-
	0x05 Switch selected pins to Output	Out- mask for PortA	Out- mask for PortB	Out- mask for PortC	**Out- mask for PortD**	**Out- mask for PortE**	-
	0x06 Set selected pins to 5V	High- mask for PortA	High- mask for PortB	High- mask for PortC	**High- mask for PortD**	**High- mask for PortE**	-
	0x07 Set selected pins to 0V	Low- mask for PortA	Low- mask for PortB	Low- mask for PortC	**Low- mask for PortD**	**Low- mask for PortE**	-

USB4all will answer with a 16 byte long reply. Only for command 3 this reply contains usable data:

Byte 0	**Byte 1**	**Byte 2**	**Byte 3**	**Byte 4**	**Byte 5**	**Byte 6**
0x50	0x03	Value from PortA	Value from PortB	Value from PortC	**Value from PortD**	**Value from PortE**

7.2 10-Bit / 12-Bit-ADC

USB4all contains an ADC with 10 selectable analog inputs. It can measure voltage levels from 0V to 5V with 10 bit (4.88 mV) or 12 bit (1.22 mV) resolution. The resolution depends on the type of the control PIC:

- 10 Bit: PIC18F2455/2550/4455/4550
- 12 Bit: PIC18F2458/2553/4458/4553

The following list shows the names of the analog inputs and their pins:

- AN0 = RA0
- AN1 = RA1
- AN2 = RA2
- AN3 = RA3
- AN4 = RA5 (!)
- AN8 = RB2
- AN9 = RB3
- AN10 = RB1
- AN11 = RB4
- AN12 = RB0

After power-up all pins are digital inputs. To use the ADC, it has to be initiated by the command 0x01. With this command the user decides, how many digital IO-pins should be converted into analog input pins for the ADC.
As long they are analog pins, they are not part of the digital IO-pins-subsystem. If the ADC will be switched off by the command 0x00, then the analog pins are converted back into digital pins, and handed over to the digital-IO-pin-subsystem.

Four different commands are available to control the ADC.

Byte 0 **Subsystem**	**Byte1** **Command**	**Byte 2**	**Byte 3**
0x51 10-Bit-ADC	0x00 Switch ADC off, al ADC-pins become digital pins	-	-
	0x01 Initiate ADC	Number of analog ADC-inputs (0..10) 0: no input (nonsense) 1: AN0 2: AN0..AN1 3: AN0..AN2 4: AN0..AN3 5: AN0..AN4 6: AN0..AN4,AN8 7: AN0..AN4,AN8..9 8: AN0..AN4, AN8..10 9: AN0..AN4, AN8..11 10: AN0..AN4, AN8..12	Reference voltages: 0: Vss=Vref-/Vdd=Vref+ 1: Vss=Vref-/AN3=Vref+ 2: AN2=Vref-/Vdd=Vref+ 3: AN2=Vref-/AN3=Vref+
	0x02 Select one ADC-input for the following measurements	0: AN0 1: AN1 2: AN2 3: AN3 4: AN4 5: AN8 6: AN9	-

		7: AN10 8: AN11 9: AN12	
	0x03 Measure the voltage	-	-

USB4all returns 16 bytes to the PC. Only after command 0x03 these bytes contain data:

Byte 0	**Byte 1**	**Byte 2**	**Byte 3**
0x51	0x03	Low	High

The ADC-result is 10 or 12-bit wide. Byte 2 (Low) contains the lower 8 bit while byte 3 (High) contains the upper bits (2 or 4) of the result.

Reference Voltages
The ADC measures the input voltage in reference to a minimum reference voltage (Vref-) and a maximum reference voltage (Vref+). If an input voltage is equal to Vref-, then it will be converted into the value 0. If the voltage is equal to Vref+, then it will be converted into 1023.

To keep it simple one can use Vss as Vref- and Vdd as Vref+. In this case the ADC will measure voltages from 0V up to 5V with 4.88 mV resolution (5V/1024) or 1.22 mV resolution (5V/4096). The ADC will use Vss and Vdd as reference voltages, if the 3d byte of the command 0x01 is equal to 0.

The string (0x51 - 0x01 - 0x01 - 0x00) initiates the ADC and selects AN0 as input.
The string (0x51 - 0x02 - 0x00) selects AN0 as input.
The string (0x51 - 0x03) measures the voltage at AN0.
A possible reply of USB4all with 1-/bit-ADC may be (0x51 - 0x03 - 0x12 - 0x03 - ..).

The result of the measurement is the hexadecimal number 0x0312. This is 786 in the decimal system. Because Vss (0V) and Vdd (5V) are used as reference voltages, this result is equal to
5V / 1023 * 786 = 3,84V.

The supply voltage (Vdd) of digital circuitries is normally not stable enough to use the 10-bits of resolution of this ADC. For good precision a stable and accurate reference voltage is needed. Stable external reference voltages can be connected to the pins AN2 and AN3 to the USB4all. Of course these pins can then not be used as normal analog inputs for the ADC.
Byte 3 of the command 0x01 controls the use ox external or internal reference voltages. External reference voltages don't have to be above Vdd or below Vss. The difference between both reference voltage levels should be at least 2 V to use the full resolution of the ADC.

It is often a good compromise to use internal Vss as Vref- and to connect only a external Vref+ (von 2,5 .. 5V via AN3) to the ADC. In this case AN2 can be used as normal analog input for the ADC.

+NOTICE+
If the user wants to change the number of analog inputs of a running ADC, then the ADC should first switched off (command 0x00) before it will be re-initiated with the new number of input channels (command 0x01).

7.3 Frequency Counter

USB4all has one input to measure frequencies. It can measure signals from 150 kHz up to 50 MHz with 5 decimals resolution (error < 0.013%). At lower frequencies the error don't exceeds 10 Hz... 20 Hz.
The frequency counter has a Schmitt trigger input. The high-part of the input signal has to be above 4 V and the low part below 1 V.

FRQ-input is using a pin of PortA:

- FRQ = RA4

The frequency counter doesn't needs to be initiated. At the begin of the measurement the pin RA4 is switched to input state. After the measurement it stays in this state.

There are 2 possible commands for the frequency counter:

- Command **0x05** (autorange mode) selects the ideal prescaler and measures the frequency with best precision (100ms period). The result is the frequency in Hertz as 32-bit value.
- Command **0x03** (manual mode) is less convenient. Here the user has to choose the prescaler ratio and the counting period. The result is the raw counting result (16-bit). The user has to calculate the signal frequency by himself.

++ATTENTION++
The counter interrupts all other processes of USB4all for up to 100 ms. That means, that the RS232-port will not receive data, the stepper motors will stop … during this time.

Byte 0 **Subsystem**	**Byte1** **Command**	**Byte 2**	**Byte 3**
0x52 FRQ	0x03 Frequency measurement manual	Internal prescaler: 8: 1:1 0: 2:1 1: 4:1 2: 8:1 3: 16:1 4: 32:1 5: 64:1 6: 128:1 7: 256:1	Period (time to count): 0: 10ms 1: 1ms 2: 10ms 3: 100ms
0x52 FRQ	0x05 Frequency measurement autorange	-	-

USB4all replies 16 byte. After command 0x03 the reply contains the counting result, after command 0x05 it contains the frequency:

Byte 0	**Byte 1**	**Byte 2**	**Byte 3**	**Byte 4**	**Byte 5**
0x52 : ok 0xFF: out of range	0x03	Low	High	-	-
0x52 : ok 0xFF: out of range	0x05	0. Byte (Low-Bye)	1. Byte	2. Byte	3. Byte (High-Byte)

The counting result (command 0x03) is a 16-bit value. Low (byte 2) contains the lower 8 bit and High (byte 3) contains the upper 8 bit.
The frequency (command 0x05) is a 32-bit value (byte 2.. byte 5).

The use of the **aurorange** mode (0x52-0x05) is:
The string (0x52 - 0x05) starts the measurement.
A possible answer is the string (0x52 - 0x05 - 0x40 - 0x78 - 0x7D - 0x01 - ...).
The result is the hexadecimal number 0x017D7840. This is converted into decimal 25000000. The frequency counter has measured 25 MHz.

The use of the **manual** mode (0x52-0x03) is much more difficult. I don't suggest using it. However, if one likes to use the manual mode, then he should red the details described in the German version of this handbook.

7.4 RS-232

The USB4all contains an RS232-port for asynchronous serial communication with speed from 9600 baud up to 115200 baud. It transfers always 8 bits without parity.

The RS232 is using 2 pins of the PortC:

- TX = RC6
- RX = RC7

The pins should be driven by normal RS232 driver circuits (e.g. MAX232) to guarantee correct signal level and polarity. However, for short RS232-connections it is possible to omit the external driver.

After power-up these pins are digital inputs. Command 0x01 initiates the RS232-interface and converts these pins into RS232-pins.
After the RS233 subsystem is switched off (command 0x00) the pins are again part of the digital-IO-subsystem

The RS232-subsystem supports the following 8 commands:

Byte 0 **Subsystem**	**Byte 1** **Command**	**Byte 2**	**Byte 3**	**Byte 4**	**Byte 5**
0x59 RS232	0x00 off	-	-	-	-
	0x01 initiate	Bit3..0: baud rate - 0: 19200 Baud - 1: 115200 Baud - 2: 57600 Baud - 3: 19200 Baud - 4: 9600 Baud Bit7 (no) driver - external driver - no external driver	-	-	-
	0x02 transmit one byte	Symbol/byte	-	-	-
	0x03 Receive one byte	-	-	-	-
	0x04 Transmit a string	Length of String	1. symbol/byte	2. symbol/byte	.....
	0x05 Receive a string	Length of String	-	-	-
	0x06 Read number of byte in buffer	-	-	-	-
	0x07 Erase buffer	-	-	-	-

The length for a transmit string (command 0x04) is limited to 61 bytes (for USB4all-MCD) or 20 bytes (USB4all-CDC).
The length for a receive string (command 0x05) is limited to 13 bytes.

USB4all sends 16 bytes back to the PC. Only after commands 0x03, 0x05 and 0x06 these bytes contain data:

Byte 0	**Byte 1**	**Byte 2**	**Byte 3**	**Byte 4**	**Byte 5**

	command				
0x00 or 0xFF	0x03	Received byte	-	-	-
0x59	0x05	Length of received string	1. symbol/byte	2. symbol/byte	.....
0x59	0x06	Length of string in buffer	-	-	-

USB4all has a 32 byte (USB4all-MCD) or 20 byte (USB4all-CDC) large internal receive buffer. After the RS232 interface was initiated (command 0x01) all via RS232 received signals are written into this buffer.
The commands 0x03 and 0x05 read data from this buffer.

If the buffer is full with data, then USB4all will ignore any additional data from the RS232 interface until the buffer (or a part of it) was emptied by command 0x03, 0x05 or 0x07.

Command 0x03 reads only one byte from the buffer and sets byte 0 to the value 0x00 (received successfully). If the buffer was empty, then byte 0 is set to 0xFF (nothing received).

Command 0x05 tries to read the requested number of bytes from the buffer. If the number of bytes inside the buffer is smaller, then the available bytes are read. In byte 2 then number of bytes is reported back to the PC.

Command 0x06 reports the number of bytes that are contains in the receive buffer.

Command 0x07 erases the buffer.

Command 0x01 - initiate
The RS232-interface supports only the 8-bit mode without parity or flow control. This is the most popular mode anyway. Fife different baud rates are available. The baud rate is selected by the 4 lower bits of the byte 2.

The bit 7 of byte 2 can be set to invert the RS232-signals. If an external driver (e.g. MAX232) is used, then this bit has to be set to 0. But if no external driver is used and the pins of the USB4all-Chip are (via current limiting resistor) directly connected to an RS232-port, then this bit has to be set to 1.

7.5 I2C-Interface

USB4all contains one I2C-interface. It can operate in master-mode (but not as slave).
It is not possible to use the I2C-interface in parallel with the SPI-interface, the shift-register-interface or the microwire-interface.

The I2C-interface is using the following 2 pins of PortB:

- SDA = RB0
- SDC = RB1

After power-up these pins are digital inputs. Command 0x01 initiates the I2C-interface and converts these pins into I2C -pins.
After the I2C subsystem is switched off (command 0x00) the pins are again part of the digital-IO-subsystem

The I2C -subsystem supports the following 6 commands:

Subsystem	Command	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
0x54 I2C	0x00 off					
	0x01 initiate	0: Master	0: 100 kHz 1: 400 kHz 2: 1 MHz			
	0x02 Write one byte	address (7 Bit)	Databyte			
	0x03 Read one byte	address (7 Bit)				
	0x04 Write a string	address (7 Bit)	Number of bytes	1. Databyte	...	...
	0x05 Read a string	address (7 Bit)	Number of bytes	-	-	-
	0x12 Write one byte	addressH (upper 2 Bit)	addressL (lower 8 Bit)	Databyte		
	0x13 Read one byte	addressH (upper 2 Bit)	addressL (lower 8 Bit)			
	0x14 Write a string	addressH (upper 2 Bit)	addressL (lower 8 Bit)	Number of bytes	1. Databyte	...
	0x15 Read a string	addressH (upper 2 Bit)	addressL (lower 8 Bit)	Number of bytes		

The length for a transmit string (command 0x04, 0x14) is limited to 60 bytes.
The length for a receive string (command 0x05, 0x15) is limited to 12 bytes.

USB4all sends 16 bytes back to the PC. Only after commands 0x03, 0x05, 0x13 and 0x15 these bytes contain data, which was read from the I2C-slave(s).

Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
0x00 or error code	0x03	Received byte				
	0x05	address	Number of bytes	1. Databyte	...	....
	0x13	Received byte				
	0x15	addressH	addressL	Number of bytes	1. Databyte	....

The commands 0x02 ... 0x15 will access to the I2C bus to read or write data. If this was successful, then the byte 0 of the response string will be set to 0. If not, then this byte will contain an error code:

- 0x00 - no error
- 0xFF - bus-collision during read access
- 0xFE - „bus device responded with NOT ACK“ during write access
- 0xFD - „return with write collision error” during write access

Notice for 7-Bit-Address

The commands from 0x02 up to 0x05 are for communication with 7-bit address-slaves.
The 7-bit address is really really really only 7 bit long. USB4all will add a 0 or 1 to the end of the address to convert this into an 8-bit-write ore read-address.
But the user has to send to USB4all only the 7 bit long core address without the additional 1 or 0.
The MSB of byte 2 is zero. (“0xxxxxxx”)

Notice for 10-Bit-Address

The commands from 0x12 up to 0x15 are for communication with 10-bit address-slaves.
A 10-bit address doesn’t fits into a single byte. Consequently the 10-bit address is spitted into to parts. Byte 2 contains the upper 2 bits. The 6 upper bits of this byte are set to zero. (“000000xx”)
The lower 8 bits of the address are contained in byte 3.

7.6 SPI-Interface

USB4all contains one SPI-interface.
It is not possible to use the SPI-interface in parallel with the I2C-interface, the shift-register-interface, the microwire-interface or the RS232-interface.

The SPI-interface is using the following 2 pins:

- SDO = RC7
- SDI = RB0
- SCK = RB1
- SS = RA5 (in Slave-Mode with Slave-Select only)
- CS = RB2... RB7 (optional in Master-Mode)

After power-up these pins are digital inputs. Command 0x01 initiates the SPI -interface and converts these pins into SPI -pins.
After the SPI subsystem is switched off (command 0x00) the pins are again part of the digital-IO-subsystem

The SPI -subsystem supports the following 4 commands:

Subsystem	Command	Byte 2	Byte 3	Byte 4	Byte 5
0x53 SPI	0x00 off	-	-	-	-
	0x01 initiate	Number of slaves	Clock	Mode	Sample
	0x02 Transmit 1 bytes	Chip select	Databyte	-	-
	0x03 receive one byte	Chip select	-	-	-
	0x04 Transmit multiple bytes	Chip select	Number of databytes	1. Databyte	2. Databyte

USB4all sends 16 bytes back to the PC. Only after commands 0x02 and 0x03 these bytes contain data, which was read from the SPI-slave(s).

Byte 0	Byte 1	Byte 2	Byte 3	Byte 4
0x53	0x02	Chip select	0 - ok 255- error	-
0x53	0x03	Chip select	Received byte	-

Deactivate (0x00)
This command switches off the SPI-subsystem. The SPI-pins are handed over to the IO-Pin-subsystem.

Initiate (0x01)
This command initiates the SPI-interface. It selects clock-frequency, clock-polarity and clock-idle-level. These settings are based on data in the bytes 2 … 5.

As an SPI-master the USB4all can control up to 6 chip select (CS) lines to control up to 6 slaves via the same SPI-bus. The number of required CS-lines is in byte 2. The CS-lines

are borrowed from the IO-Pin-subsystem.
After the SPI-subsystem is switches off (command 0x00) these lines will become part of the IO-Pin-subsystem again.

Byte 2	CS1	CS2	CS3	CS4	CS5	CS6
0	-	-	-	-	-	-
1	RB2	-	-	-	-	-
2	RB2	RB3	-	-	-	-
3	RB2	RB3	RB4	-	-	-
4	RB2	RB3	RB4	RB5	-	-
5	RB2	RB3	RB4	RB5	RB6	-
6	RB2	RB3	RB4	RB5	RB6	RB7

The interface can operate with one of 4 bus-master-mode-clock-frequencies and in one of 2 Slave-Modes. The modes are controlled by data in byte 3.

Byte3	Mode	Clock-frequencies
0	Default (Master)	Default (750 kHz)
1	Master	12 MHz
2	Master	3 MHz
3	Master	750 kHz
4	Reserved - do not use!	Reserved - do not use!
5	Slave with Slave-Select (Pin 7)	from master
6	Slave without Slave-Select	From master

The interface can operate in one of 4 different transmit modes:

Byte 4	Transmit at the …	Clock idle level-
0	Default (rising edge)	Default (low)
1	rising edge	low
2	falling edge	high
3	falling edge	low
4	rising edge	high

The interface can read the voltage level of the SDI-pin at one of to possible point in time:

Byte 5	Read the data …
0	Default (at the end of data-out-time)
1	In the middle of data-out-time
2	In the middle of data-out-time

Transmit one byte (0x02)
This command will send the byte 3 via SPI-interface. If byte 2 contains an existing slave number, then the CS line for this slave will be activated. If bit 6 of byte2 is set, then the CS-line will not be deactivated at the end of the data transfer.

Byte 2	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit0
Meaning	-	0: finally CS switch off CS 1: don't switch off CS	-	-	Number of the slave (0 .. 6)			

The byte 3 of the reply is by default set to 0. If a bus collision happened during transmission, then this byte will be set to 255.

Receive one byte (0x03)

This command will read one byte from the SPI-interface. If byte 2 contains an existing slave number, then the CS line for this slave will be activated. If bit 6 of byte2 is set, then the CS-line will not be deactivated at the end of the data transfer.

Byte 2	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Meaning	-	0: finally CS switch off CS 1: don't switch off CS	-	-	Number of the slave (0 .. 6)			

Transmit multiple bytes (0x04)
This command can send multiple databytes via SPI. Byte 3 contains the number of databytes to. The byte 4 is the first databyte.
With a single command can be send up to 60 databytes (USB4all-MCD) or 16 databytes (USB4all-CDC).

If byte 2 contains an existing slave number, then the CS line for this slave will be activated. If bit 6 of byte2 is set, then the CS-line will not be deactivated at the end of the data transfer
If bit 7 of byte2 is set, then the CS-line will be deactivated between the individual databytes.

Byte 2	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit0
Meaning	0: CS for the whole block 1: CS for every byte	0: finally CS switch off CS 1: don't switch off CS	-	-	Number of the slave (0 .. 6)			

If more then 60 databytes (USB4all-MCD) or 16 databytes (USB4all-CDC) have to be transferred, then the command 0x04 can be used multiple times in a sequence. For every transfer (except the last one) the bit 2 of byte 6 should be set to 1. Thus the CS-line is kept active between the transfers. For the last call of command 0x04 this bit should not be set. This will deactivate the CS-line after the last transfer.

7.7 Microwire (jet not tested)

USB4all contains one microwire-interface.
It is not possible to use the microwire -interface in parallel with the I2C-interface, the shift-register-interface, the SPI-interface or the RS232-interface.

The microwire-interface is using the following pins:

- SDO = RC7
- SDI = RB0
- SCK = RB1
- SS = RA5

After power-up these pins are digital inputs. Command 0x01 initiates the microwire-interface and converts these pins into microwire-pins.
After the microwire subsystem is switched off (command 0x00) the pins are again part of the digital-IO-subsystem

The microwire -subsystem supports the following 4 commands:

Subsystem	Command	Byte 2	Byte 3	Byte 4
0x67 Microwire	0x00 off	-	-	-
	0x01 initiate	0: 750 kHz 1: 12 MHz 2: 3 MHz 3: 750 kHz	-	-
	0x02 Transmit one byte	databyte	0-do not wait 1- wait until ready	-
	0x03 Receive one byte	low	high	-

USB4all sends 16 bytes back to the PC. Only after command 0x03 these bytes contain data, which was read from the microwire bus.

Byte 0	Byte 1	Byte 2	Byte 3	Byte 4
0x67	0x03	Received databyte	-	-

7.8 Shift-Register Interface

The USB4all can control external shift-registers.
It is not possible to use the shift-register-interface in parallel with the I2C-interface, the microwire-interface, the SPI-interface or the RS232-interface.

This interface is a kind of slow, software-controlled SPI, which can transmit and receive several bytes at the same time.
The data-output-line SDO has to be connected to the data-input of a shift register (e.g. 74166) or a chain of shift registers. The data-input-line SDI has to be connected with the output of a shift register (e.g. 74166) or of a chain of shift registers. The clock-output-line SCK has to be connected to the clock input of the shift register(s).

USB4all can now shift one or multiple bytes into the shift register while it is reading out the content from the shift register at the same time to transfers this content to the PC.

The shift-registers-interface is using the following 3 pins of PortB:

- SDO = RC7
- SDI = RB0
- SCK = RB1

Depending on the circuitry it may be necessary to use an additional pin to control the load-input-pin of shift registers. This signal would have to be generated by a regular I/O-pin.

After power-up these pins are digital inputs. Command 0x01 initiates the shift-register-interface and converts these pins into shift-register-pins.
After the shift-register subsystem is switched off (command 0x00) the pins are again part of the digital-IO-subsystem

The shift-register-subsystem supports the following 3 commands (the commands 0x02 and 0x03 are identical):

Subsystem	Command	Byte 2	Byte 3	Byte 4
0x66 Shift register	0x00 off	-	-	-
	0x01 initiate	Mode and clock 0x0? : 50 kHz 0x4? : 5 kHz 0x8?: 500 Hz 0xC?: 50 Hz	-	-
	0x02 or 0x03 Transmit and receive bytes	Number of databytes	1. databyte	2. databyte

USB4all sends 16 bytes back to the PC. Only after command 0x03 and 0x03 these bytes contain data, which was read from the shift register(s):

Byte 0	Byte 1	Byte 2	Byte 3	Byte 4
0x66	0x02 or 0x03	Number of databytes Bytes	1. databyte	2. databyte

Deactivate (0x00)

This command switched off the shift register subsystem. The pins RB1 and RC7 will be handed over to the I/O-pin subsystem. They will not be switched to input state.

Initiate (0x01)
This command initiates the shift register interface. It sets clock frequency, clock polarity and clock idle voltage level.
The necessary information is in byte 2.

Bit:	**Bit 7**	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
Meaning:	FRQ1	FRQ0	-	SAMPLE	-	-	MODE1	MODE0

The subsystem can use one of 4 possible clock frequencies. The clock frequency is selected by the bits 6 and 7 of byte 2.

FRQ1	**FRQ0**	**Clock frequency**
0	0	50 kHz
0	1	5 kHz
1	0	500 Hz
1	1	50 Hz

The subsystem can work in one of 4 different transmit modes. The modes have different clock polarity and different clock idle voltage level.

MODE1	**MODE0**	**Transmit on**	**Clock idle level**
0	0	Rising clock	Low
0	1	falling clock	High
1	0	Rising clock	Low
1	1	falling clock	High

The interface can read the value of the input pin SDI at one of the following to points in time:

SAMPLE	**Point of time to read data**
0	At the end of the data-out-time
1	In the middle of the data-out-time

Transmit and receive in parallel (0x02 und 0x03)
This command can write one or multiple databytes into a shift register while it read out one or multiple databytes from a shift register at the same time.
Byte 2 of the command contains the number of databytes. These databytes follow starting with byte 3.

USB4all send the command-string back to the PC, but the databytes are replaced with the bytes read from the shift registers.
The reply is always 16 bytes long, consequently not more then 13 bytes can be read from the shift register(s) with one command. Longer shrift register chains have to be red in multiple steps.

The number of databytes that can be written into shift registers with a single command is limited to 61 (USB4all-MCD) or 17 (USB4all-CDC).

7.9 LCD-Interface

USB4all can control up to 2 LCD-Dotmatrix-Displays with HD44780-controller.
Supported are displays with 2 lines and up to 40 symbols per line (40x2) or with up to 4 lines and up to 20 symbols per line (20x4).
The interfaces are called LCD1 and LCD2. Both interfaces can be combined to control displays with 4 lines and up to 40 symbols per line (40x4).

LCD1 uses the following pins of PortB:

- E = **RB0**
- RS = RB2
- RW = RB3
- D4 = RB4
- D5 = RB5
- D6 = RB6
- D7 = RB7

LCD2 uses the same pins, except RB0. The enable-pin (E) of LCD2 is the pin RC0:

- E = **RC0**
- RS = RB2
- RW = RB3
- D4 = RB4
- D5 = RB5
- D6 = RB6
- D7 = RB7

After power-up these pins are digital inputs. Command 0x01 initiates the LCD-interface and converts these pins into LCD-interface-pins.
After the LCD-subsystem is switched off (command 0x00) the pins are again part of the digital-IO-subsystem

++HINT++
The LCD1-iinterface can NOT be used in parallel with I2C- or Microwire-interface.
In contrast the LCD2-interface CAN be used in parallel with I2C or Microwire.

++ATTENTION++
If both LCD-interfaces are used in parallel, and then one of the both interfaces is switched off (command 0x00), then the remaining interface has to be initiated again, or RB2..RB7 have to be set to output using commands of the IO-port-interface.

The LCD-interface-subsystem supports the following 7 commands.

Subsystem	Command	Byte 2	Byte 3	Byte 4	Byte 5
0x55 / 0x56 LCD1 / LCD2	0x00 off	-	-	-	-
	0x01 initiate	Number of lines	Number of symbols per line	-	-
	0x02 Write one character	character	-	-	-
	0x03 Write one command	command (1= erase) (2= home)	-	-	-
	0x04 Write multiple character	length of the string	1. character	2. character	.....
	0x05 Multiple commands	Number of commands	1. command	2. command	....
	0x06 Goto position.	line: 0..3	symbol: 0..39	-	-

USB4all sends 16 bytes non-sense-data back to the PC.

Commands 0x04 and 0x05 can transfer up to 61 (USB4all-MCD) or 20 (USB4all-CDC) characters or commands.

Switch Off (0x00)
This command switches off the LCD-interface. The display itself is not switched off.

Initiate (0x01)
This command initiates the LCD-interface and initiates the LCD at this interface.
The display is erased and the cursor is set to the first symbol at the first line. The cursor is not visible.

Write one Character (0x02)
This command writes the character from byte 0x02 into the display and moves the cursor to the next position.

One control command (0x03)
This command sends control commands to the display controller. All typical commands for HD44780-controllers can be used, e.g.:

- 0x01 – erase display and move cursor to the 1st symbol of the first line
- 0x02 –move cursor to the 1st symbol of the first line

Write multiple Characters (0x04)
This command writes a string of characters to the display. The byte 0x02 contains the number of characters. The string follows starting in byte 0x03.

Multiple control commands (0x05)
This command writes a sequence of control commands in to the display controller (HD44780). The number of control commands is in byte 0x02. The first control command is in byte 0x03. Then follow the remaining commands.

Goto Position (0x06)
This command moves the (invisible) write-cursor to a specific position on the display. This position is described in the byte 0x02 (number of the line) and byte 0x03 (number of the symbol in this line).
The first line has the number 0. Thus line numbers from 0 up to 3 exist.
The first character is character 0. Thus character numbers from 0 up to 39 exist.

Nearly all 16x1 displays (one line with 16 symbols) have an internal 8x2 organization.
USB4all treats all 16x1 displays like 8x2 displays by default.
On real 16x1 displays (if they really exist) this may cause reduced contrast, and command 0x06 will not work for positions beyond the 7th symbol.

7.10 PWM1 und PWM2

The USB4all has 2 PWM-outputs.

The 2 PWM-output pins are using the following 2 pins of PortC:

- PWM1 = RC2
- PWM2 = RC1

After power-up these pins are digital inputs. Command 0x01 initiates PWM-subsystem and converts these pins into PWM-output pins.
After the PWM-subsystem is switched off (command 0x00) the pins are again part of the digital-IO-subsystem

The both PWM-channels are not independent. Both use the same frequency (period). But both channels can be set to different duty cycles.
If both channels should be used in parallel, then both have to be initiated (command 0x01) in the same way.

There are 3 commands for every PWM-channel:

Subsystem	Command	Byte 2	Byte 3	Byte 4
0x57 / 0x58 PWM1 / PWM2	0x00 Off	-	-	-
	0x01 Initiate	0: 47 kHz / 256 1: 480 kHz / 100 2: 120 kHz / 100 3: 30 kHz / 100 4: 187 kHz / 256 5: 47 kHz / 256 6: 12 kHz / 256 7: 47 kHz / 1024 8: 12 kHz / 1024 9: 3 kHz / 1024	-	-
	0x02 Set duty cycle	Lower 8 Bits	Upper 2 Bit-	-

For all commands the USB4all replies with 16 byte nonsense data.

The PWM-subsystem can be initiated in one of 9 predefined modes. Three modes have a resolution of 100 steps; three have 256-steps (8 bit) and the remaining tree have 1024 steps (10 bit).
The 3 modes with equal resolution have different frequencies.

The value in command 0x02 is the number of steps with high output level during each period. If e.g. a 100-step-mode is used, then the value 50 results in 50 steps high level and 50 steps low-level during each period. This is a duty cycle of 50%.

In modes with 100 or 256 steps, the byte 3 of the command 0x02 has to be zero. If a 1024-step-mode is used, then this byte contains the both leading bits.

++ATTENTION++
Please use the Bootloader-5. If any other bootloader is used, then the PWM-2-channel may not work.

7.11 Internal EEPROM

The USB4all contains 256 byte of internal, non-volatile EEPROM memory. It can be used to store data permanently. Not all the memory is free for user applications. The user should only use the **192 byte from address 0x00 to 0xBF**.

The EEPROM-subsystem supports 4 commands:

Subsystem	Command	Byte 2	Byte 3	Byte 4	Byte 5
0x5A EEPROM	0x02 Write one byte	Address	databyte	-	-
	0x03 Read one byte	Address	-	-	-
	0x04 Write string	Start address	Number of databytes	1. databyte	....
	0x05 Read a string	Start address	Number of databytes	-	-

USB4all sends 16 byte back to the PC. Only after the commands 0x3 and 0x5 this reply contains information:

Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5
0x5A	0x03	databyte	-	-	-
	0x05	Start address	Number of databytes	1. databyte	....

The length of a string for command 0x04 is limited to 60 bytes (USB4all-MCD) or 16 bytes (USB4all-CDC).
The length of a string for command 0x05 is limited to 13 bytes.

The EEPROM-subsystem has no security feature to prevent spurious write access. If e.g. the PCs by accident sends 54-02 or 54-04 to a USB4all, then EEPROM-data may be lost. The probability for such data losses are very small - but not 0%.

7.12 Stepper-Motor-Interfaces

USB4all knows two ways to control stepper motors.
The normal interface generates for every stepper-motor 4 electric signals (phases A, B, C, D). These signals can via a driver circuit be connected to the 4 terminals of the motor.
The alternate interface controls motors via the popular L297-circuit.

7.12.1 Stepper-Motor-Interface with ABCD-phases

The USB4all has 4 channels to control ABCD-stepper-motors. Every interface has 4 output pins and need external drivers.
The user can use all channels or only some or a single channel. The interface has no motor-current control. Consequently the torque is decreasing with increasing speed of the motor.

Channel No 1 (Subsystem 0x5D) uses the following pins of PortB:

- A1 = RB3
- B1 = RB2
- C1 = RB1
- D1 = RB0

Channel No 2 (Subsystem 0x5E) uses the following pins of PortB:

- A2 = RB7
- B2 = RB6
- C2 = RB5
- D2 = RB4

Channel No 3 (Subsystem 0x5F) uses the following pins of PortA:

- A3 = RA0
- B3 = RA1
- C3 = RA2
- D3 = RA3

Channel No 4 (Subsystem 0x5C) uses the following pins of PortC:

- A4 = RC0
- B4 = RC1
- C4 = RC2
- D4 = RC6

After power-up these pins are digital inputs. Command 0x01 initiates the stepper-motor-subsystem and converts these pins into stepper-motor-output pins.
After the stepper-motor-subsystem is switched off (command 0x00) the pins are again part of the digital-IO-subsystem
The four channels can be switched on and off independently.

There are 4 commands for every stepper-motor-channel:

Subsystem	Command	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
0x5C..0x5F STEP1..4	0x00 off	-	-	-	-	-
	0x01 initiate	-	-	-	-	-

	0x02 turn motor	Number of steps (lower 8 bits)	Number of steps (upper 7 bits)	Bit 0: 0–right turn (CW) 1–left turn (CCW) Bit 1: 0-halve steps 1-full steps Bit 2: 0-asynchron 1-synchron Bit 3: 0-keep power 1-power off Bit 4: 0-halve-/full steps 1-wave mode Bit 5: 0-constant speed 1-accel./decel. Bit 6: 0-normal speed. 1-10-times faster	Period [ms]	-
	0x03 Number of remaining steps	-	-	-	-	-
	0x04 Acceleration table	0 - standard	-	-	-	-
		2 - write	value 0	value 1	value 2	.....
		3 - read	-	-	-	-

For all commands the USB4all replies with 16 byte.
After command 0x03 these bytes contain the number of remaining steps in asynchronous mode.
After command 0x04 the bytes contain the 8 bytes of the acceleration table.

Byte 0	**Byte 1**	**Byte 2**	**Byte 3**	**Byte 4**	**Byte 5**
0x5C..0x5F	0x03	Remaining steps (lower 8 bits)	Remaining steps (upper 7 bits)	-	-
0x5C..0x5F	0x04	0x03	value 0	value 1	....

0x02 turn the motor
The command 0x02 turns the motor. The motor can make right turn or left turns, it can be turned in halve-steps, full steps or in wave mode. All this is controlled by 4 data bytes in command 0x02.

Number of steps
The number of steps can be any number from 1 up to 32000. It is transferred in the bytes 2 and 3 of the command 0x02.

If the halve-step-mode is used, then the number of steps is in reality the number of halve-steps.

Mode
The stepper-motor is turned around by changing the signal levels at the 4 pins A, B, C and D in a specific way - step by step. The following tables and figures show the 3 different ways to drive the motor.
A right way turn is realized by incrementing the step number in the table, for a left turn the step number is decremented.

In **full-step-mode**: A = - B and C = - D.
If for this mode a driver circuit with internal inverters is used, then this driver will have 2 input pins only. Connect these pins with A and C. In this case B and D are not needed.

If in bye 4 the bit 4=1, then **wave**-mode is used. In this mode always exactly one output pin is active. If halve-step-mode is selected at the same time, then the motor is moved after every second step only. Pay attention to this fact while you calculate the necessary number of steps.

Halve-step-mode

Step	A	B	C	D
0	0	1	0	1
1	0	0	0	1
2	1	0	0	1
3	1	0	0	0
4	1	0	1	0
5	0	0	1	0
6	0	1	1	0
7	0	1	0	0

Full-step-mode

Step	A	B	C	D
0	0	1	0	1
1 (2)	1	0	0	1
2 (4)	1	0	1	0
3 (6)	0	1	1	0

Wave mode

Step	A	B	C	D
0 (1)	0	0	0	1
1 (3)	1	0	0	0
2 (5)	0	0	1	0
3 (7)	0	1	0	0

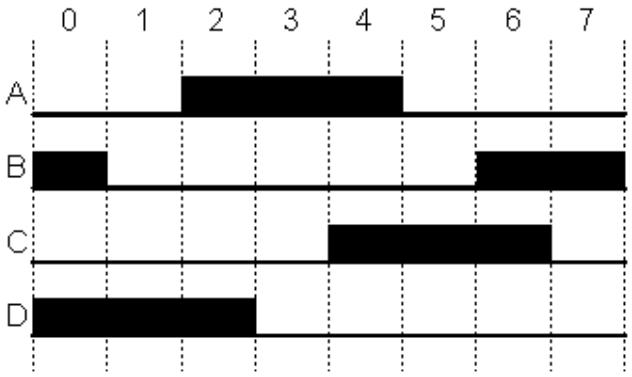

Figure 16 Halve-step-mode

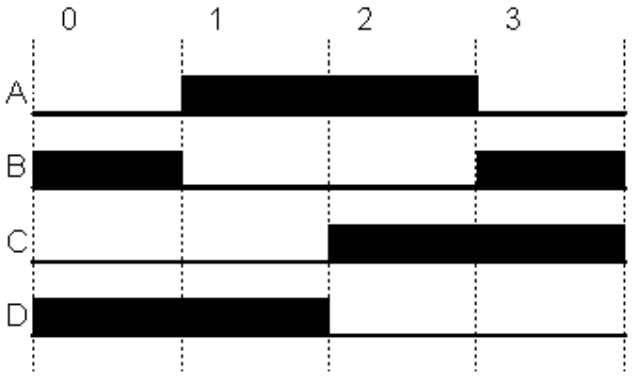

Figure 17 Full-step-mode

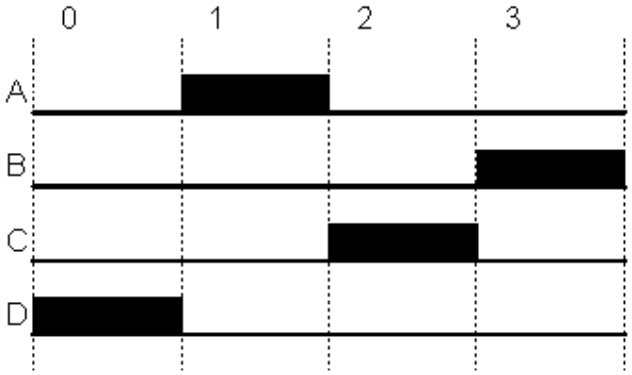

Figure 18 Wave mode

Asynchronous to USB

If in byte 4 the bit 2=0, then USB4all received the command (to turn the stepper-motor) and send a reply back to the PC immediately. The USB4all is the ready to receive the next command, while it turns the stepper-motor (in the background).

Command 0x03 can now be used to read out the number of the remaining steps for this turn-command. The working cannel should not get additional turn-commands before the number of remaining steps is zero (or the last command would be discarded and replaced by the new command).

In this asynchronous mode multiple channels can be used in parallel to turn multiple motors. But the speed of all motors would be the same. The period (step-increment-time) would be the summed period of all active channels.

Synchronous to USB
For short motor-turns (less then one second) the synchronous mode can be used. This mode is activated, if in byte 4 the bit2=1. In this mode a turn-command is finished before the reply is send to the PC.

If it needs too much time to turn the motor, then USB-timeouts can happen. If e.g. a timeout of 1 second is selected, then every motor turn of more then 1 second would trigger a time-out.
For example 500 steps with 1000 Hz would not cause any problem, because this turn needs 0.5 seconds only.
But 32000 steps with 4 Hz (2 hours and 13 minutes) would result in a time-out.

The synchronous mode should be the exception.

Power off
If in byte 4 the bit 3=1, then after the last step all output pins are switched to Zero. Then no coil of the motor will be energized anymore.
After the last step the USB4all wait a short time (period + 10 ms), before power is switched off for the motor. Thus the motor really stops and not slips some steps after power is deactivated.

Keep power
If in byte 4 the bit 3=0, then the output pins of the channel keep (the after the last step) the final voltage level. The coils of the motor will be energized to keep the motor in its position.

Period
The rotation speed of the motor is determined by byte 5 (period). This value is the interspace between two steps or halve-steps in milliseconds. A value of 1 results in a step-clock of 1000 Hz (1000 steps per second). The maximum value of 255 results in 3.92 Hz. If byte 5 has the value 0, then a default clock of 1000 Hz is used.

Small motors may be able to handle much higher clocks. If in byte 4 the bit 6 is set to 1, then a 10 times higher clock is used. Then clocks from 32 Hz up to 10000Hz are possible. Acceleration- and deceleration-values would be divided by 10 too.

Acceleration and Deceleration
If in byte 4 the bit 5=1, then the motor movement will be accelerated at begin and decelerated at the end. This prevents a loss of steps, if a high speed is used.

Acceleration happens during the 8 first steps. The interspace from step to step will be reduced, until the required period is reached.
Deceleration happens during the 8 last steps. The interspace from step to step will be increased, until the required period is reached.

Every channel has an own table with 8 acceleration/deceleration-values. The user can red and change this values. The default values are:

Nr.	Value 1	Value 2	Value 3	Value 4	Value 5	Value 6	Value 7	Value 8
Step period	10 ms	8 ms	7 ms	6 ms	5 ms	4 ms	3 ms	2 ms

During the first 8 steps of a motor turn, the controller compares the values from the table with the period from command 0x02 byte 5. The larger value will be used as period for this step. At the end of the motor-turn, the same is done reverse.

The default values can only be used, if the step-period is less then 10 ms (clock > 100 Hz). To double the values for a specific table the following command-string can be used:
0x5D - 0x04 - 0x02 - 20 - 16 - 14 - 13 - 10 - 8 - 6 - 4
The following string sets the table back to default:
0x5D - 0x04 - 0x00

7.12.2 L297-Stepper-Motor-Interface

The USB4all has 4 channels to control stepper motors via the popular integrated circuit L297. Every channel has 2 pins. This pins have to be connected to the L297. The user can use one, two tree or all 4 channels.

The L297, the driver circuit and the motor have to be fed from a separate power supply (USB is not powerful enough). The GND-terminal of the motor power-supply has to be connected to Vss of the USB4all.

L297-Channel No 1 (Subsystem 0x60) uses the following pins of PortB:

- Clock1 = RB0
- Direction1 = RB1

L297-Channel No 2 (Subsystem 0x61) uses the following pins of PortB:

- Clock2 = RB2
- Direction2 = RB3

L297-Channel No 3 (Subsystem 0x62) uses the following pins of PortB:

- Clock2 = RB4
- Direction2 = RB5

L297-Channel No 4 (Subsystem 0x63) uses the following pins of PortB:

- Clock2 = RB6
- Direction2 = RB7

The L297-IC has a halve-step/full-step-control-pin and an enable-pin. The enable-pin has to be permanently connected to high-level (Vdd). The halve-step/full-step-control-pin has to be connected to the required voltage level.

After power-up the clock and direction pin of all channels are digital inputs. Command 0x01 initiates the L297-subsystem and converts these pins into L297-channel-output pins. After the L297-subsystem is switched off (command 0x00) the pins are again part of the digital-IO-subsystem
The four channels can be switched on and off independently.

There are 4 commands for every L297-channel. They are based on the commands for the

ABCD-stepper-motor-channels.

Subsystem	Command	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
0x60 .. 0x63 L297_1 .. L297_4	0x00 off	-	-	-	-	-
	0x01 initiate	-	-	-	-	-
	0x02 Turn motor	Number of steps (lower 8 bits)	Number of steps (upper 7 bits)	Bit 0: 0–right turn (CW) 1–left turn (CCW) Bit 2: 0-asynchron 1-synchron	Period [ms]	0x00 (reserved)
	0x03 Read remaining steps	-	-	-	-	-

For all commands the USB4all replies with 16 byte.
After command 0x03 these bytes contain the number of remaining steps in asynchronous mode

Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5
0x60 / 0x63	0x03	Remaining steps (lower 8 bits)	Remaining steps (upper 7 bits)	-	-

0x02 turn the Motor
The command 0x02 turns the motor. The motor can make right turn or left turns, it can be turned in halve-steps or full steps. All this is controlled by 4 data bytes in command 0x02.

The number of steps can be any number from 1 up to 32000. It is transferred in the bytes 2 and 3 of the command 0x02.
If the halve-step-mode is used, then the number of steps is in reality the number of halve-steps

Asynchronous to USB
If in byte 4 the bit 2=0, then USB4all received the command (to turn the stepper-motor) and send a reply back to the PC immediately. The USB4all is the ready to receive the next command, while it turns the stepper-motor (in the background).

Command 0x03 can now be used to read out the number of the remaining steps for this turn-command. The working cannel should not get additional turn-commands before the number of remaining steps is zero (or the last command would be discarded and replaced by the new command).

In this asynchronous mode multiple channels can be used in parallel to turn multiple motors. But the speed of all motors would be the same. The period (step-increment-time) would be the summed period of all active channels.

Synchronous to USB
For short motor-turns (less then one second) the synchronous mode can be used. This mode is activated, if in byte 4 the bit2=1. In this mode a turn-command is finished before the reply is send to the PC.

If it needs too much time to turn the motor, then USB-timeouts can happen. If e.g. a timeout of 1 second is selected, then every motor turn of more then 1 second would trigger a time-out.
For example 500 steps with 1000 Hz would not cause any problem, because this turn needs 0.5 seconds only.
But 32000 steps with 4 Hz (2 hours and 13 minutes) would result in a time-out.

The synchronous mode should be the exception.

Period
The rotation speed of the motor is determined by byte 5 (period). This value is the interspace between two steps or halve-steps in milliseconds. A value of 1 results in a step-clock of 1000 Hz (1000 steps per second). The maximum value of 255 results in 3.92 Hz. If byte 5 has the value 0, then a default clock of 1000 Hz is used.

7.13 Servos

USB4all has outputs for up to 13 model servos. These ate the same servos that are used in model airplanes or model ships to move control surfaces.

The servos are organized into two independent groups. These groups have to be controlled separately. The first group is named Servo-B (at Port B) and contains 8 servos (SB0 … SB7). The second group is named Servo-C (at Port C) and contains 5 servos (SC0, SC1, SC2, SC6, SC7).

All outputs generate digital pulses with positive polarity. The pulsewidth can be changed from 1 ms to 2 ms in 100 steps.

The pulse frequency depends on the number of used servo groups. If only Servo-B is in use, then the frequency is 50 Hz. If only Servo-C is in use, then the frequency is 80 Hz. If both groups are used in parallel, then the frequency is 30 Hz. However, the pulse frequency is not very important for the function of the servos.

For every servo group are 4 commands supported:

Subsystem	Command	Byte 2	Byte 3	Byte 4	... Byte
0x64 Servo-B or 0x65 Servo-C	0x00 off	-	-	-	-
	0x01 initiate	Bitmask: 0: pin off 1: pin on	-	-	-
	0x02 Set servo positions	Servo SB0 or Servo SC0	Servo SB1 or Servo SC1	Servo SB2 or Servo SC2	Servo SB... or Servo SC...
	0x03 Set middle position	Middle position	-	-	-

USB4all will reply for every command with 16 nonsense bytes.

0x00 Servos off
All outputs stop the pulse generation and are set to low level.

0x01 initiate
This command can activate all or only some servo-outputs of a servo group. Byte 2 contains a bitmask. Every bit represents one servo output. If a bit is set to 1, then its output becomes active and starts to generate pulses.
The other pins (with bits set to 0) will not become servo outputs and can be used for other interfaces.

The initial pulse with is by default 1.5 ms. This represents the middle position of a typical servo. If a longer or shorter initial pulse width in needed, then a command **0x02** has to be used before the command 0x01 to define this pulse width.

The following tables show the relationship between the individual bits in the mast (byte 2) and the output pins of both servo-groups:

Mask	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Pin	RB7	RB6	RB5	RB4	RB3	RB2	RB1	RB0
Servo	SB7	SB6	SB5	SB4	SB3	SB2	SB1	SB0

Mask	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Pin	RC7	RC6	-	-	-	RC2	RC1	RC0
Servo	SC7	SC6	-	-	-	SC2	SC1	SC0

0x02 Set Servo-Positions

The position of a servo depends on the length of the control pulse. The pulse widths of all outputs are controlled by 8 bytes in command 0x03. Every servo is controlled by one specific byte. The control bytes can have values from 0 up to 100. The servo middle position is represented by the value 50.

Control bytes for not-active servo-outputs have to be sent to the USB4all, but are ignored. The command for servo-group C contains 3 dummy bytes (byte 5 ... 7). Their value is unimportant, but they have to be sent.

Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	Byte 8	Byte 9
0x64	0x02	SB0	SB1	SB2	SB3	SB4	SB5	SB6	SB7
0x65	0x02	SC0	SC1	SC2	-	-	-	SC6	SC7

If a value of 100 is not enough to reach the end position of a servo, then larger values (up to 255) can be used.
If a value of 0 is not enough to reach the start position of a servo, then the servos middle position has to be modified by command 0x03.

0x03 Set Servo Middle Position

The with of the generated pulse is

PW = Position x 10 us + MiddlePosition x 5us.

Where Position is an individual value for each servo output from command 0x02 and MiddlePosition is by default 200. If Position is changed from 0 to 100, then the pulse width is changed from 1 ms to 2 ms.

The value of MiddlePosition can be changed by command 0x03. But this change will be efficient for all servo outputs.

MiddlePosition	pulse width for position=0	pulse width for position=100	pulse width for position=255
0	0 us	1000 us	2550 us
200	**1000 us**	**2000 us**	3550 us
255	315 us	1315 us	2865 us

A modified MiddlePosition is not stored permanently. After rest or power-up the default value of 200 is used.

++ ATTENTION ++
Servo control will interrupt all other processed for the time of pulse generation. (13 ms up to 33 ms). Consequently the clock of parallel running stepper motors (in asynchronous mode) is reduced to 80 Hz to 30 Hz.

7.14 Impulse Counter

The USB4all contains two counters for electrical impulses (Counter_0 and Counter_3). They can count the digital electric pulses at the pins RA4 and RC0.

- Counter_0 - RA4
- Counter_3 - RC0

Counter_0 is incremented on the falling side of the input pulse at RA4.
Counter_3 is incremented on the rising side of the input pulse at RC0.
The high- and low parts of impulses should not be shorter then 60 ns. Both pins have Schmitt-Trigger-inputs. The input-low-level has to be below 1V and the high-level has to be above 4 V.

Both counters are 16 bit wide and can count up to 65535. Beyond this value the counters start at 0 again.

The initiation (command 0x01) resets the counters to 0.

The counter subsystem supports 5 commands:

Subsystem	Command	Byte 2	Byte 3
0x68 Counter_0 or 0x69 Counter_3	0x00 off	-	-
	0x01 initiate	-	-
	0x02 Read counter value	-	-
	0x03 Set counter to a value	Low-Byte	High-Byte
	0x04 Reset counter to 0	-	-

USB4all will answer for all commands with 16-byte. Only after the command 0x02 these bytes contain information:
.

Byte 0	Byte 1	Byte 2	Byte 3
0x68 / 0x69	0x02	value (Lower 8 Bits)	value (Upper 8 Bits)

0x00 Counter off
The counter is deactivated. Its input pin becomes a normal digital IO-pin.

0x01 initiate counter
The counter is activated. Its input pin is set to “input” and removed from the digital IO-subsystem. The counter is set to the value 0.

0x03 Read Counter Value
The 16-bit value of the counter is read to the PC.

0x04 Set Counter to a Value
The counter will be set to a specific 16-bit value. The counter will now increment from this

value.

0x04 Reset counter to Zero
The counter is set to the value 0, but stays active.

7.15 Reset the USB4all

USB4all-MCD can be ‘reseted’ into the power-up-state with this command. The USB4all will disconnect from the USB-bus and the reconnect to the USB-bus.

Subsystem	Command	Byte 2	Byte 3	Byte 4	Byte 5
0xFF RESET	-	-	-	-	-

USB4all will **NOT** send any reply to the PC.

++ATTENTION++
This command will not fork with the USB4all-CDC. If the USB4all-CDC received this command, then its firmware will crash.

8 How to control the USB4all

The USB4all is controlled by commands. Every command is a short string of bytes. The USB4all-MCD receives these commands by help of a DDL. The USB4all-CDC receives these commands via an emulated RS232-interface.

The USB4all works off the command and sends a reply to the PC.

8.1 USB4all-CDC

Not all people like to write software that uses DLL-functions. For these users it may be more convenient to use the USB4all-CDC. If the USB4all-CDC is connected to the PC, then a virtual COM-port (e.g. COM3) is created. Not the device can be treated like a device that is connected via an RS232-interface to the PC.

After the USB4all-CDC is connected to the PC one can use the device manager to find out the USB4alls COM-port number. If the COM-port number is known even a simple terminal program (Hyper-Terminal or Putty) can be used to control the USB4all-CDC

By the way: baud rate, stop-bits or flow-control have no meaning for this virtual COM-port. Don't care about these parameters.

The dataflow through a RS232-interface is not organized in blocks but in symbols/bytes. Because of this we have to define start- and stop-symbols for the command strings.

Every command-string starts with the prefix '#'. This is an ASCII-symbol with the value **0x23**.

As stop-bye can be used **0x00** (zero terminated), **0x0A** or **0x0D**;

In between start- and stop-symbols are the data bytes. To simplify the use of the commands it is common method to transfer not the raw data bytes. Instead ASCII-symbols re used. Every data byte is converted into a 2-symbol-ASCII-string. The byte 0x5A has to be converted into the ASCII-string '4A'. It is made from two ASCII-symbols and consequently 2 bytes long. To separate the data bytes additional spacer-symbols are injected between these 2-symbols long strings.

All this triples the length of the data string, but the transfer is fast enough.

The length of the command string doesn't has to exceed 64 bytes. This limits the number of data byte in one command string to not more then 20.

Example:
To initiate the LCD1 the following 4 bytes have to be sent to the USB4all:
0x55, 0x01, 0x02, 0x16

For the USB4all-CDC this 4 bytes are "encoded" into the following 13 bytes long ASCII-string:
'#55-01-02-16'+0x00

The trailing 0x00 represents the 'stop-byte' (zero terminated). As spacer symbol I have used '-'. Generally every ASCII-symbol can be used as spacer, except #,0,1,2,3,4,5,6,7,8,9,a,b,c,d,e,f,A,B,C,D,E,F.
Instead of '01 one can write '1', leading zeros can be ignored.

The following code-snippet (Delphi/Pascal) demonstrates the conversion of a raw-byte-string into an ASCII-string. The bytes are initially stored in the array **send_buf**. Finally the string is in **asciistr** and will be transferred to the USB4all by the function

Comport1.WriteStr.

```
  var
    k           : integer;
    asciistr    : string;
    send_buf    : array[0..63] of byte;
.
.
.
    asciistr :='#';
    for k:=0 to 15 do asciistr := asciistr + inttohex(send_buf[k],2)+'-';
    asciistr := asciistr + chr($0d);
    Comport1.WriteStr(asciistr);
```

The USB4all receives the command, works off the command and finally sends a reply back to the PC. This reply is a terminal-compatible ASCII-string. The prefix (start-symbol) is a '@' (0x40), then follow 16 data-bytes (as 2-symbol long ASCII-strings), the spacers are '**-**' and at the end (stop-sequence) follow the 3 bytes 0x0A,0x0D,0x00.
The hexadecimal byte-strings use upper case letters (A … F). Leading zeros are not ignored.
All this results in a fixed length of the string, it is 50 bytes long.

If the reply contains useful information, then this information has to be extracted. The following code-snippet (Delphi/Pascal) extracts the 16 data bytes from the reply-string:

```
//Hilfsroutine: Wandeln eines ASCII-Zeichens in einen Zahlenwert
//wäre mit ORD einfacher zu schreiben, ist aber so übersichtlicher
function asciiwert(ch:char):integer;
begin
  result:=0;
  case ch of
  '1': result:=1;
  '2': result:=2;
  '3': result:=3;
  '4': result:=4;
  '5': result:=5;
  '6': result:=6;
  '7': result:=7;
  '8': result:=8;
  '9': result:=9;
  'A': result:=10;
  'B': result:=11;
  'C': result:=12;
  'D': result:=13;
  'E': result:=14;
  'F': result:=15;
  end;
end;
.
.
.
  var
    nrrx        : integer;
    k           : integer;
    rxstr       : string;
    receive_buf : array[0..63] of byte;
.
.
.
```

```
    //empfangen über comport mit ReadStr(var Str: String; Count: Integer): Integer;
    nrrx:=Comport1.ReadStr(rxstr, 50);
    for k:=0 to (nrrx div 3)-1 do begin
      receive_buf[k]:=asciiwert(rxstr[3*k+2])*16 + asciiwert(rxstr[3*k+3]);
    end;
.
.
.
```

Every programming language should support the use of the serial COM-ports. In Delphi I use the free ComPort-Component from Dejan Crnila.

8.2 USB4all-MCD

To use the USB4all-MCD the user has to be able to write byte-strings into the USB4all and to read such strings from this device.
I wrote the following function to do this in Delphi/Pascal. It takes N bytes of data from a byte array (send_buf), transfers them to the USB4all-MCD and reads back N bytes of data. The received data is finally stored in the byte array receive_buf. The functions used in this routine are supported by **mpusbapi.dll**.

A detailed description of the functions of this DLL can be found in the PDF handbook of the microchip USB-FS test board.

```
//N Bytes senden und M Bytes empfangen
//timeout ist 100 ms bzw 1s
procedure Sende_Empfange(N,M :byte);
var
   selection   : DWORD;
   RecvLength  : DWORD;
   fehler      : integer;
begin
  selection:=0;

  myOutPipe:= _MPUSBOpen(selection,vid_pid,out_pipe,MP_WRITE,0);
  myInPipe := _MPUSBOpen(selection,vid_pid,out_pipe,MP_READ,0);
  if ((myOutPipe = INVALID_HANDLE_VALUE) or (myInPipe = INVALID_HANDLE_VALUE)) then
  begin
    info('USB Error, no pipes');
    exit;
  end;
  RecvLength:=M;
  fehler:=SendReceivePacket(send_buf,N,receive_buf,RecvLength,100,1000);
  if Fehler<>1 then  info('USB Error :'+inttostr(fehler));

  _MPUSBClose(myOutPipe);
  _MPUSBClose(myInPipe);
  myInPipe:= INVALID_HANDLE_VALUE;
  myOutPipe:=INVALID_HANDLE_VALUE;
end; // sende_empfange
```

At program launch I test if a USB4all-MCD is connected to the PC. Then I use only this function (**`Sende_Empfange(N,M)`**) for the whole communication with the device.

8.3 Example Code to use USB4all

These are some examples for the use of USB4all. All code-examples are written in Delphi/Pascal.

8.3.1 Example: Write one byte into the EEPROM

This code writes the value 0x55 into the EEPROM-cell with address 0x00.

USB4all-MCD:

```
send_buf[0]:=$5A;       // EEPROM
send_buf[1]:=2;         // schreiben
send_buf[2]:=0;         // Adresse   = 0
send_buf[3]:=$55;       // Datenbyte = 0x55
Sende_Empfange(16, 16);
```

USB4all-CDC:

```
Comport1.WriteStr('#5A-2-0-55'+chr(0));       // EEPROM
Comport1.ReadStr(rxstr, 50);                  // Quittung
```

8.3.2 Example: Measure a Voltage

This code initiated the ADC with inputs AN0... AN3 and measures the voltage at pin AN2.

USB4all-MCD:

```
send_buf[0]:= $51;      // ADC
send_buf[1]:=1;         // initialisieren
send_buf[2]:=4;         // AN0..AN3
send_buf[3]:=0;
Sende_Empfange(16, 16);

send_buf[0]:= $51;      // ADC
send_buf[1]:=2;         // set AN
send_buf[2]:=2;         // AN2 ist der aktive Eingang
Sende_Empfange(16, 16);

send_buf[0]:= $51;      // ADC
send_buf[1]:=3;         // Spannung messen
Sende_Empfange(16, 16);
Spannung:=receive_buf[3];                  //high (obere  2 Bit)
Spannung:= Spannung *256+ receive_buf[2];  //low  (untere 8 Bit)
```

USB4all-CDC:

```
Comport1.WriteStr('#51-1-4-0'+chr(0));        // initialisieren
Comport1.ReadStr(rxstr, 50);                  // Quittung

Comport1.WriteStr('#51-2-2'+chr(0));          // set AN2
Comport1.ReadStr(rxstr, 50);                  // Quittung

Comport1.WriteStr('#51-3'+chr(0));            // Spannung messen
Comport1.ReadStr(rxstr, 50);                  // Quittung mit Messwert
```

8.3.3 Example: Measure the Frequency

This code measures the frequency at pin RA4.

USB4all-MCD:

```
send_buf[0]:= $52;      // Frequenzmesser
send_buf[1]:=5;         // messen mit Autorange
```

```
Sende_Empfange(16, 16);

Frequenz:=receive_buf[5];                  //high (obere   8 Bit)
Frequenz:= Frequenz *256+ receive_buf[4];  //next (nächste 8 Bit)
Frequenz:= Frequenz *256+ receive_buf[3];  //next (nächste 8 Bit)
Frequenz:= Frequenz *256+ receive_buf[2];  //low  (untere  8 Bit)
```

USB4all-CDC:

```
Comport1.WriteStr('#52-5'+chr(0));           // Frequenzmessung
Comport1.ReadStr(rxstr, 50);                 // Quittung mit Messwert
```

8.3.4 Example: Write "Hallo" to the LCD-Display

This code initiates the LCD-Display and writes "Hallo" on the display:

USB4all-MCD:

```
send_buf[0]:=$55;         // LCD
send_buf[1]:=1;           // init
send_buf[2]:=2;           // 2  Zeilen
send_buf[3]:=16;          // 16 Zeichen pro zeile
Sende_Empfange(16, 16);

send_buf[0]:=$55    ;   // LCD
send_buf[1]:=4;         // String schreiben
send_buf[2]:=5;         // 5 Zeichen lang
send_buf[3]:=ord('H');  // 'H'
send_buf[4]:=ord('a');  // 'a'
send_buf[5]:=ord('l');  // 'l'
send_buf[6]:=ord('l');  // 'l'
send_buf[7]:=ord('o');  // 'o'
Sende_Empfange(16, 16);
```

USB4all-CDC:

```
Comport1.WriteStr('#55-1-2-10'+chr(0));       // initialisieren
Comport1.ReadStr(rxstr, 50);                  // Quittung

Comport1.WriteStr('#55-4-5-48-61-6c-6c-6f'+chr(0));          // Hallo
Comport1.ReadStr(rxstr, 50);                  // Quittung
```

8.3.5 Example: Switch on an LED at Pin RC0

This code switches the pin RC0 into output mode and sets this pin to "high" level:

USB4all-MCD:

```
send_buf[0]:=$50;       // IO-Pins
send_buf[1]:=5;         // Pin auf output setzen
send_buf[2]:=0;         // TRISA: keines
send_buf[3]:=0;         // TRISB: keines
send_buf[4]:=1;         // TRISC: nur Pin RC0
Sende_Empfange(16, 16);

send_buf[0]:=$50;       // IO
send_buf[1]:=6;         // Pin auf high setzen
send_buf[2]:=0;         // TRISA: keines
send_buf[3]:=0;         // TRISB: keines
send_buf[4]:=1;         // TRISC: nur Pin RC0
```

```
Sende_Empfange(16, 16);
```

USB4all-CDC:

```
Comport1.WriteStr('#50-5-0-0-1'+chr(0));      // RC0 auf Ausgang schalten
Comport1.ReadStr(rxstr, 50);                  // Quittung

Comport1.WriteStr('#50-6-0-0-1'+chr(0));      // RC0 High-Pegel einschalten
Comport1.ReadStr(rxstr, 50);                  // Quittung
```

8.3.6 Example: Turn Stepper-Motors

This code initiates the 2nd ABCD-phase-stepper motor interface and turns the motor 10000 half-steps CCW..

USB4all-MCD:

```
send_buf[0]:=$5E;         // 2 Schrittmotorkanal
send_buf[1]:=1;           // on
Sende_Empfange(16, 16);

send_buf[0]:=$5E;
send_buf[1]:=2;           // dreh
send_buf[2]:=$10;         // 10000 low-Teil
send_buf[3]:=$27;         //       high-Teil
send_buf[4]:=1;           // links, halbschritte, asynchron, power-off
send_buf[5]:=0;           // 1000 Hz
Sende_Empfange(16, 16);

// warten auf das Ende der Drehung
Repeat
    Sleep(10);                      // 10ms Pause
    send_buf[0]:=$5E;
    send_buf[1]:=3;                 // lese Restschrittzahl
    Sende_Empfange(16, 16);
    wert:=receive_buf[3];           // high
    wert:=wert*256+ receive_buf[2]; // low
until (Wert < 1);
```

USB4all-CDC:

```
Comport1.WriteStr('#5E-1'+chr(0));            // initialisieren
Comport1.ReadStr(rxstr, 50);                  // Quittung

Comport1.WriteStr('#5E-2-10-27-1-0'+chr(0));  // drehen
Comport1.ReadStr(rxstr, 50);                  // Quittung

//es fehlt hier noch die Warteschleife, falls man warten möchte
```

8.3.7 Example: Measure the Temperature with LM75 via I2C

This code initiates the I2C-bus and reads the temperature from a LM75-sensor chip at this bus.

USB4all-MCD:

```
send_buf[0]:=$54;
send_buf[1]:=1;           // on
send_buf[2]:=0;           // Master
```

```
send_buf[3]:=0;           // 100 kHz
Sende_Empfange(16, 16);

send_buf[0]:=$54;
send_buf[1]:=3;           // string lesen
send_buf[2]:=$48;         // Adresse des LM75 = 100_1000
send_buf[3]:=2;           // 2 Bytes lesen
Sende_Empfange(16, 16);
; receive_buf[4] enthält die Temperatur in Grad
; receive_buf[5] enthält die Nachkommastelle
```

USB4all-CDC:

```
Comport1.WriteStr('#54-1-0-0'+chr(0));        // on Master 100kHz
Comport1.ReadStr(rxstr, 50);                  // Quittung

Comport1.WriteStr('#54-3-48-2'+chr(0));       // Temperatur auslesen
Comport1.ReadStr(rxstr, 50);                  // Quittung mit Temperaturwert
```

8.3.8 Example: Reset the USB4all

This code resets the USB4all (as at power-up), and reconnects it to the USB-bus.

USB4all-MCD:

```
send_buf[0]:= $FF;          //RESET DEVICE;
Sende_Empfange(1,0);
```

8.4 How to use USB4all-MCD on Linux-Systems

Of course USB4all can be used on Linux-systems. This part of the documentation is based on examples written by Roland Wundrig.

For access to USB4all-MCD the **libusb**-library can be used (http://libusb.wiki.sourceforge.net/). It is part of nearly all distributions and should be installed by the packet manager.

Because he access to USB4all is not using a kernel module, root rights are required. To enable access to normal users a file "**/etc/udev/rules.d/99-sprutbrenner.rules**" has to be created. The content of this file has to be:

```
SUBSYSTEM=="usb", SYSFS{idProduct}=="ff0b", SYSFS{idVendor}=="04d8",GROUP =
"plugdev"
```

After this all members of the **plugdev** group (all USB-device users have to be plugdev-group members anyway) can use USB4all-MCD.

The files **usb4all.h** and **usb4all.c** contain all necessary functions and data structures to use the USB4all-MCD:

- `int usb4all_initialize(struct usb4all_t *usb4con)`
- `int usb4all_connect(struct usb4all_t *usb4con)`
- `int usb4all_data_io(struct usb4all_t *usb4con,`
  `unsigned char *data_in, int data_in_cnt,`
  `unsigned char *data_out, int data_out_cnt)`
- `int usb4all_finalize(struct usb4all_t *usb4con)`

usb4all_initialize
This function initiates the libusb and the data structure.

usb4all_connect
This function searches for a USB4all at the USB-bus.

usb4all_data_io
This function is used for data exchange with USB4all-MCD.

usb4all_finalize
This function will close the connection to USB4all.

The source code of all examples is part of the ZIP-file. It is contained in the /linux subfolder.

9 Bootloader

From time to time a new version of the firmware will be published to fix errors and to integrate new features. The bootloader is a simple to use tool to load the new firmware into the PIC.

The bootloader is small software, which has to be programmed into a special area of the control PIC of the USB4all. To Program it into the control PIC am a PIC programmer is needed. This can be a Brenner5 (with Windows-Software P18) or a Brenner8 (Firmware 0.5 or later; software US-Burn V1.2 or later).

The bootloader is a separate hex-file contained in the USB4all-ZIP-file. The bootloader for USB4all is the **Bootloader-5**. If any other bootloader is used instead, then the function of the 2nd PWM channel is not guarantied.

The bootloader needs the **Microchip Custom Driver**.

The USB4all-CDC is by default using a different driver. Consequently this version of USB4all has to be disconnected and reconnected to the PC during the process of activation and deactivation of the bootloader.
Users of the USB4all-MCD can switch over between firmware and bootloader while the device is connected to the PC

From now I assume that the bootloader is programmed in the Control PIC of the USB4all

9.1 How to Activate the Bootloader

The bootloader is not needed during the normal operation of the USB4all. It stays inactive. But if new firmware has to be loaded into the USB4all, then the bootloader has to be activated. There are two ways to do this:

- Activation by software (USB4all-MCD only)
- Activation by jumper JP1

9.1.1 Activate the Bootloader via Software

To activate the bootloader by software on has first to write the value 0xFF into the EEPROM-cell 0xFE. Then one has to reset the UISB4all or disconnects it for some seconds from the PC.

For the **USB4all-CDC** a simple terminal program can be used to send '**#5A-2-FE-FF**' to the USB4all.

USB4all-CDC:

```
Comport1.WriteStr('#5A-2-FE-FF'+chr(0));      // EEPROM (0xFE)=0xFF
Comport1.ReadStr(rxstr, 50);                  // Response
```

After this was done, the device has to be disconnected and reconnected to the PC.

For the **USB4all-MCD** the software USBoot can activate the bootloader automatically.
If this software detects a USB4all-MCD, then it shows the button "**Activate Bootloader**". A click on this button activates the bootloader. This includes a reboot of the USB4all.

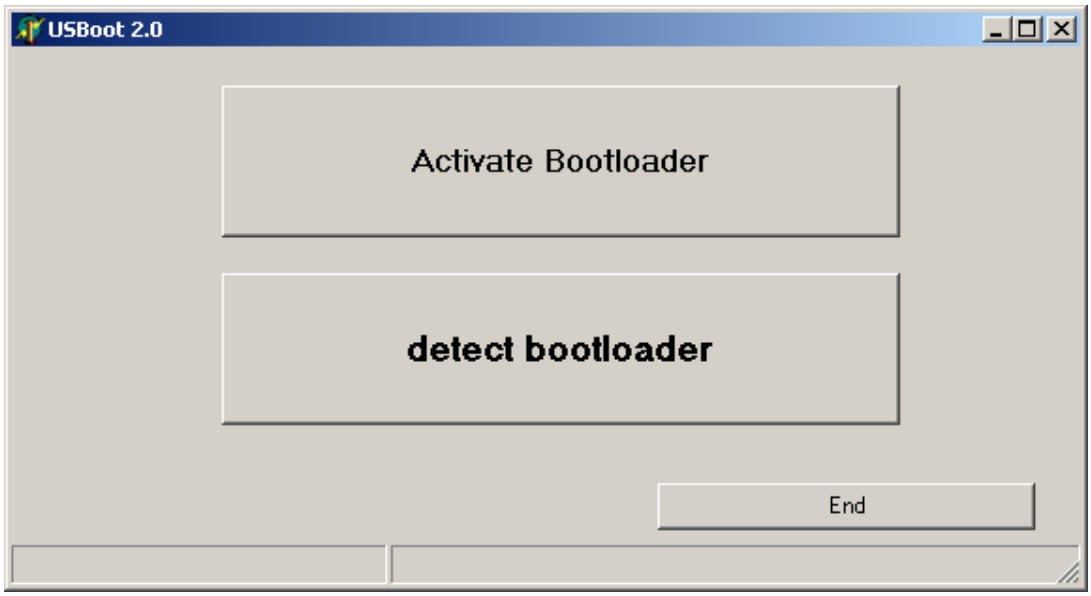

Figure 19 USBoot can activate the Bootloader

After the reboot of USB4all the "**detect Bootloader**"-button can be clicked to use the bootloader.

Now the new firmware can be loaded into the USB4all.

9.1.2 Activate the Bootloader with Jumper JP1

First disconnect the device from the PC. Then close the jumper JP1 and connect the device with the PC. Now the bootloader is active and the jumper can be removed.

If you hardware is missing the JP1, then simply connect pin 1 of the PIC with ground (Vss) while you reconnect the device with the PC.

9.1.3 Load new Firmware into the USB4all

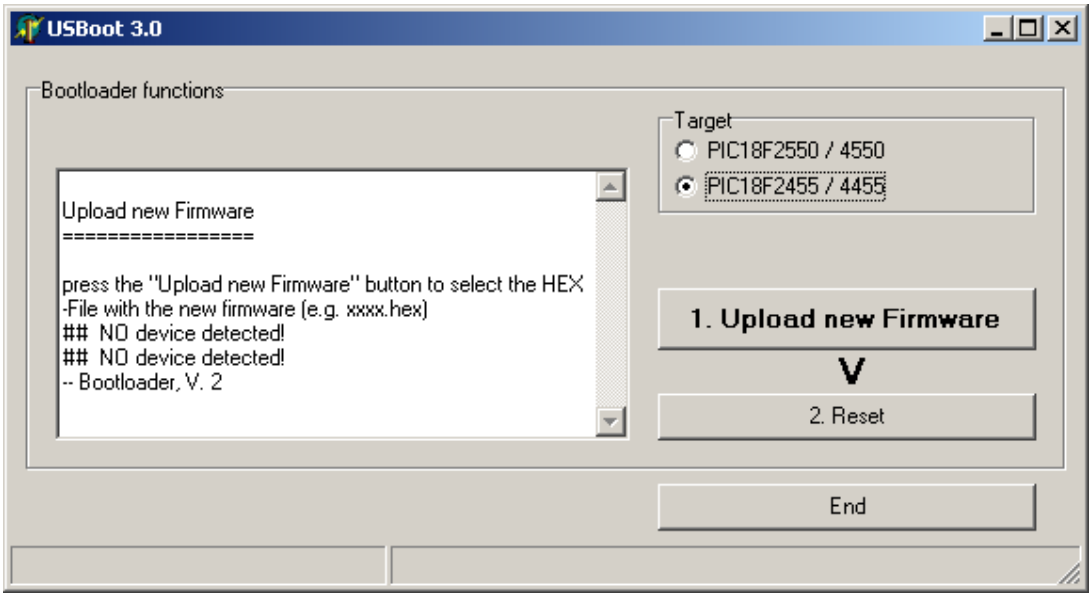

Figure 20 Upload new Firmware into the USB4all

If USBoot detects an active bootloader, then it shows this program window. In the upper right corner of this window, the user has to choose the correct PIC-type - for example PIC18F2455.

Then click on the button **1. Upload new Firmware**. A file selection window opens. The user has to select the correct HEX-file with the new firmware. If this was done, USBoot will:

- Load the HEX-file,
- Flash the new firmware into the control PIC of the USB4all,
- Check the flashed firmware for correctness and
- Mark the new firmware as valid.

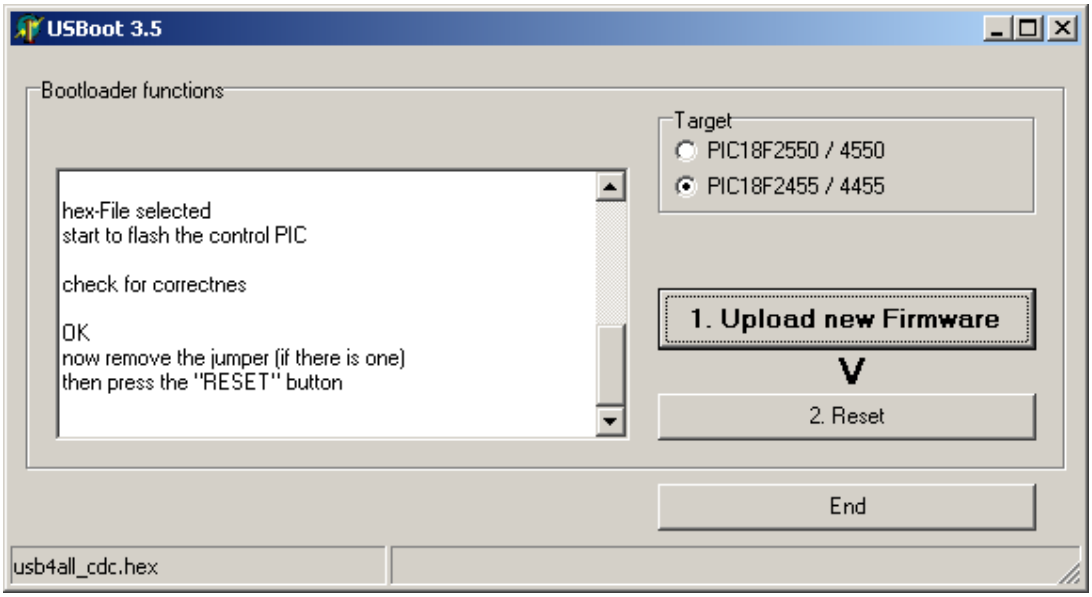

Figure 21 New Firmware was loaded

If you forgot to remove the jumper JP1, then please do it now.

A click on the button **2. Reset** restarts the USB4all. An USB4all-MCD will be operational after 2 seconds. But an USB4all-CDC has to be disconnected and reconnected to the PC to become operational again.

The bootloader will not touch the user-data inside the EEPROM (address 0x00 … 0xBF) - if there is any.

9.1.4 Oops, I used the wrong HEX-File

The bootloader can not know, if the selected HEX-file is really a valid firmware. If by accident a wrong HEX-file was selected, then the bootloader will flash it into the USB4all. Of course then the USB4all will not be operational anymore, but nothing is lost (except the old firmware).

The bootloader will not be damaged, and the user can always use the jumper JP1 to activate the bootloader. Then you can try again to select the correct HEX-file.

10 Troubleshooting with USB-Devices

10.1 General

The first step is the most difficult.
USB-hardware is simple. However, it can happen, that a new assembled device will not be detected by the PC or don't works as expected. In this situation you may be a little bit lost.

I will try to help you.

10.2 Driver and Device (Windows)

USB-devices are plug&play-devices, the operating system of the PC selects the correct driver for the device automatically. But how can e.g. windows know, which driver is the correct one?

This information is contained in the driver's inf-file.

Every USB-device has an unambiguous identifier: the VID-PID-information. This is a combination of two numbers. The first number (VID) identifies the producer of the device (vendor-ID). The second number was chosen by the producer for this specific device (product-ID).
The inf-file contains the information, for which VID-PID-combination this driver should be used.

The inf-file for my USB4all-MCD contains the following lines:

```
[DeviceList]
%DESCRIPTION%=DriverInstall, USB\VID_04D8&PID_FF0B
```

The driver should be used, if a device with the VID 0x04D8 and PIC 0xFF0B is detected. Windows stores this information during the driver installation. If later a device with this specific VID-PID is connected to the PC, then it will use this driver.

10.3 Connection to the PC

What exactly happens, if one connects a USB-device to a PC?

The USB-connector has 4 pins. Two pins are a bit longer. They are responsible for the supply voltage. They are labeled ground (GND) and +5V (VBUS).

The two shorter pins are data-lines. They are called D+ and D-.

The device is fed with 5V but the signal level on the data-lines is 3.3V. Because of this the device contains a 3.3V-voltage regulator. The USB-PICs contain such a voltage regulator too. This regulator needs an external capacitor at the pin VUSB. (100nF … 470nF)

After the device was connected to the PC it will pull one of the both data-lines to 3.3V (which pin is pulled up depends on the USB-speed of the device)

The PC detects the 3.3V. It knows that something is connected to the USB-port. The type

of the device is still unknown, consequently the PC will call it now “an unknown device”.

The PC will now try to communicate with the new device. It will read out the VID-PID. If this VID-PID is known to the PC, then it will use the related driver. If the VID-PID is unknown, then it will ask the user to install the driver for the new device.

After this was done, the device will show up in the device-manager with it correct description and in it correct device-class.

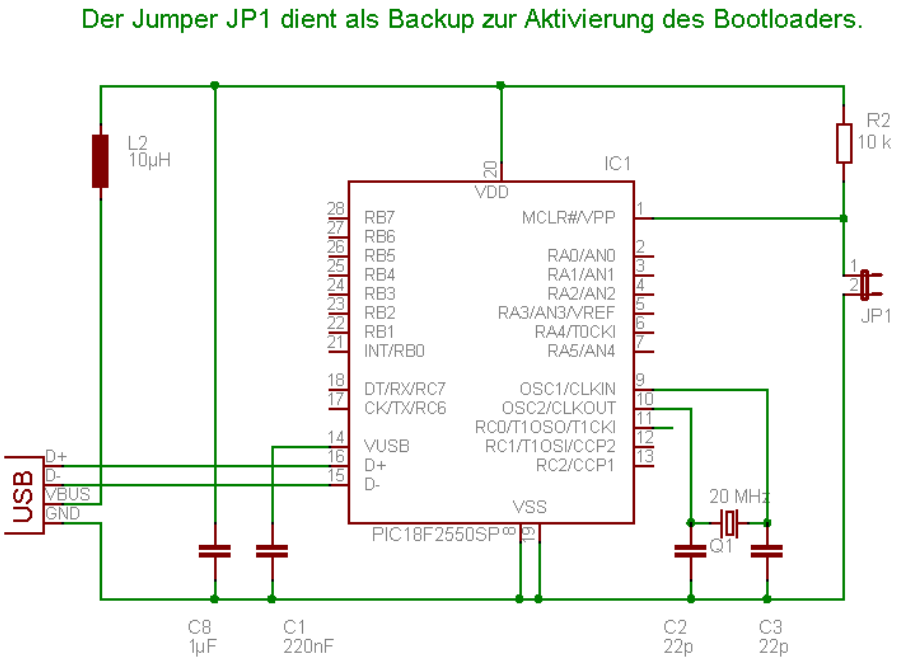

Figure 22 The basic USB circutry for a PIC

10.4 Typical Problems

The PC shows no reaction at all, if the device is connected to the PC
Oops. In this case even the 3.3V are not applied to the data-line by the device. Maybe the PIC has no supply voltage. Measure the voltage between Vdd and Vss of the PIC. It should be 4.5V … 5.5V.

If this voltage is ok then measure the voltage between the pins of the VUSB-capacitor (the capacitor between the VUSB-pin and Vss). This voltage should be about 3.3V. If this voltage is missing, then the PIC was not correctly programmed.

The PC identifies the device al “unknown device”
The 3.3V are on the data-line, but the PC was not able to communicate with the attached device.
A typical reason for such a problem would be a wrong clock. If e.g. instead of a 20-MHz-crystal a 18.3-MHz-crystal is used, then one would see this error.

A second possible reason for the problem is swapped data-lines D+ and D-.

The device is detected correctly, but during longer transmissions show up errors.
This can be an undervoltage problem, caused by to small capacitors. Check the correct soldering of the VUSB-capacitor.
Check the value of the capacitor between Vdd and Vss. It should be much larger then 100nF.

A second reason for such errors is a timeout. The USB4all should answer for every command in a limited timeframe (e.g. 1 second). If the USB4all needs to long to work off the command, then a timeout-error is reported. Normally only stepper-motor interfaces in synchronous mode can cause this problem.