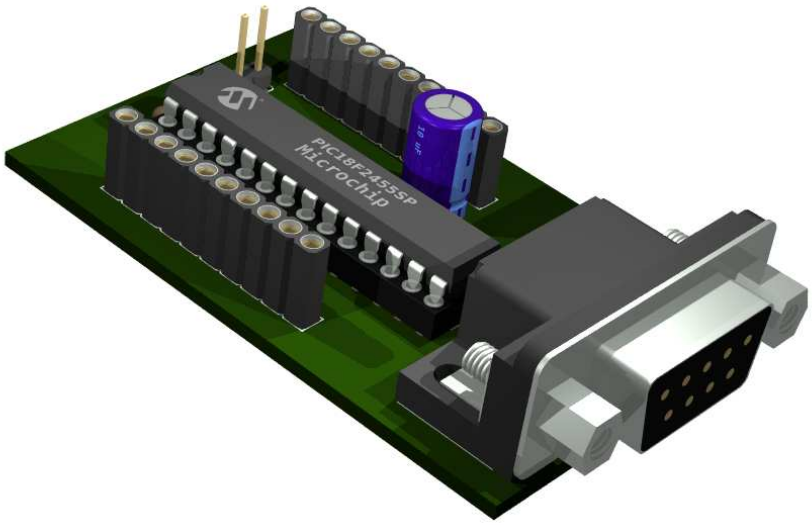
RS4all

V.1

Technical Description
&
User Manual



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Stand: 03.04.2012

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4 About this Document

The Rs4all is based on the USB4all-CDC. The most of the interfaces and control commands atre identical. Because of this, the primary document for the Rs4all ist the handbook of the USB4all.
This Rs4all-handbook only describes the differences between Rs4all and USB4all. These are:

- Different interface to the PC (RS232 instead of USB)
- Separate 5V-power-supply
- SPI is not supported
- Microwire is not supportet
- RS232 is used for communication with the PC and can not be used for anything else
- Only 3 ABCD-phases-stepper-motor interfaces (instead of 4)
- 2 digital IO-pins less
- 2 model-servos less
- Shift-register interface is using an other outout-pin
- Other frequencies for the both PWM-outputs

5 Introduction

The Rs4all s an easily usable solution to connect a simple (e.g. self made) device to the PC via RS232-interface. It is a PIC-microcontroller from Microchip (e.g. PIC18F2455) with a special firmware.

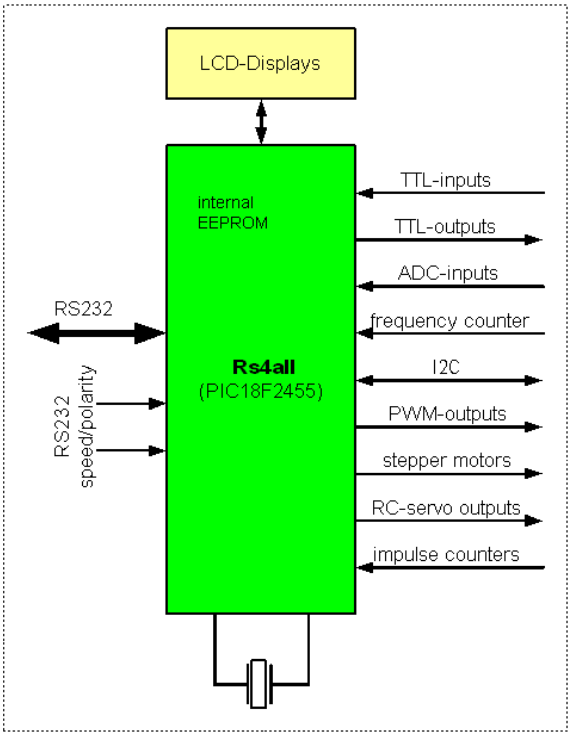

Figure 1 Rs4all - overview

The Rs4all is controlled via a RS232-port.

Rs4all offers to the user the following connectivity:

- 18 or 29 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 I2C-Master-interface
- one shift-register-interface
- interface for 2 LCD-dot-matrix-displays
- 2 PWM-Outputs
- 3 stepper motor interfaces for ABCD-phase-connections
- 4 stepper motor interfaces for L297-circuits
- Connections for 11 model-servos.
- 2 impulse-counter-inputs
- 192 Byte internal EEPROM-memory

6 Hardware

6.1 Type of PIC-Microcontroller

Rs4all is by default a PIC18F2455 microcontroller with special firmware. Instead of the PIC18F2455 another 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.

6.2 RS232-Interface to the PC

The RS4all is connected to the PC via an RS232-interface. The RS232-pins of the microcontroller generate and expect TTL-level-signals. These signals have to be inverted and amplified by an external RS232-driver circuit. The following figure shows the typical connections between microcontroller, driver-IC and RS232-connector.

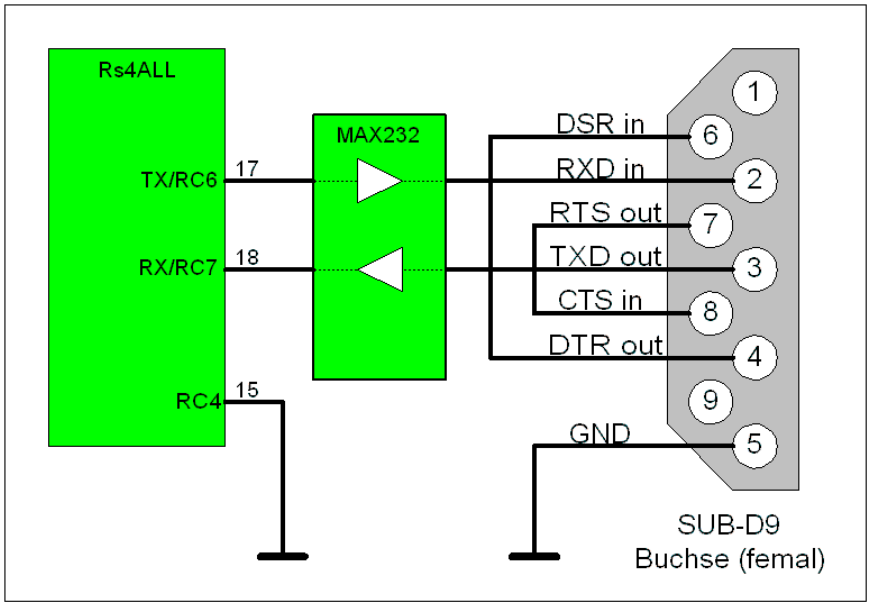

Figure 2 RS-232-Interface with driver

If the serial cable between Rs4all and PC is not very long, then the driver-IC may not be necessary. Many PC-motherboards will accept TTL-level-signals at the RS-232-Ports. A serial resistor in the receive-line of the Rs232 will prevent the microcontroller from being damaged by to high voltage levels.

Depending on the presence of the driver-IC the microcontroller has to operate with normal or inverse polarity at the RS232-interface-pins. This is controlled by the voltage level at the RC4-pin (D-). This is pin 15 (28 pin housing) or pin 23 (40 pin housing) or pin 42 (44 pin housing). If a driver is used, then this pin has to be connected to ground (Vss). If no driver is used, then this pin has to be connected with +5V (Vdd).

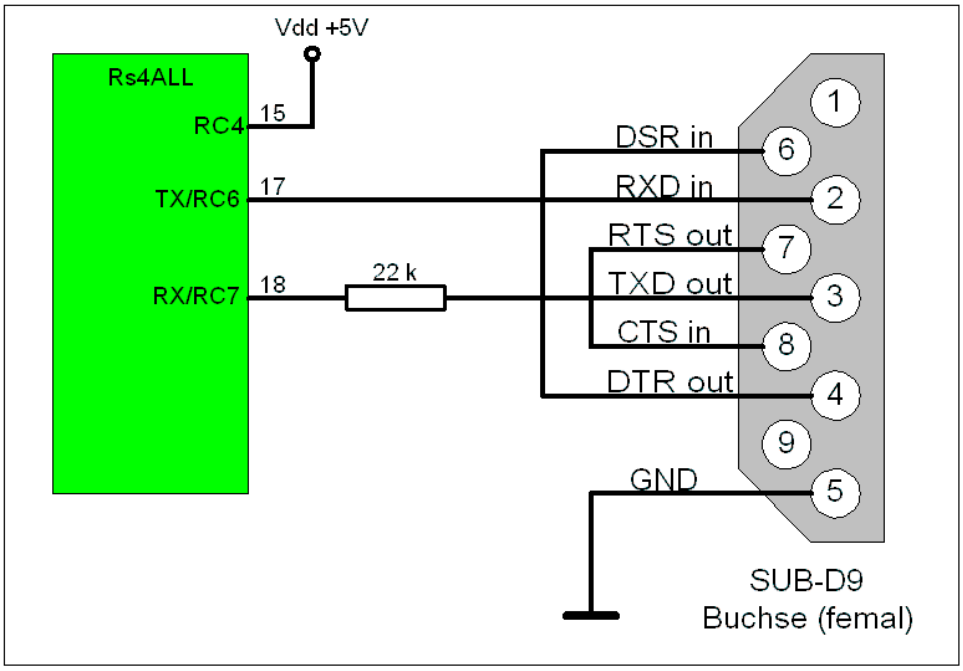

Figure 3 RS-232-Interface without driver

6.3 Microcontroller clock source

The Rs4all is by default clocked by an internal 8 MHz oszillator. The oszillator is calibrated und should have an error of less then 1% under normal conditions. Depending on the environmental temperature, the error of the oszillator can become larger:

- +25℃ ±2%
- -10℃ to +85℃ ±5%
- -40℃ to +85℃ ±10%

All clocks, the precision of the frequency counter and the RS232 baud rate depend on this clock.

If the precision of the internal oszillator don't meets the requirements, then an external 8-MHz-crystal can be connected to the pins OSC1 and OSC2 (Pin 9 & 10). Two 22pF capacitors have to be connected between these pins and Vss.
Rs4all will automatically use this crystal, if it is connected to the microcontroller at power-on.

6.4 Power supply

Rs4all needs 5V DC power. The function is guarantied from 4,2V up to 5,5V. The microcontroller will not need more then 10 mA. Additional loads will of course need additional current.

The result of the ADC measurement is only correct for a supply voltage of 5V. A larger or smaller supply voltage will produce an errorous result, except an external reference voltage is used. See the ADC-chapter for details.

6.5 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, Motor1 or Motor2. But one can use ADC (the 5 inputs AN0..AN4), the frequency counter, I2C, LCD2, PWM1 and PWM2 in parallel.

6.5.1 Interfaces with 28-pin Controll PIC

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

Pin	IO-Port	ADC	FRQ	I2C	SR	LCD 1	LCD 2	PWM	Motor 1..3	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										
10	RA6											
21	RB0	AN12		SDA	SDI	E1			A1	CL1	SB0	
22	RB1	AN10		SCL	SCL				B1	DIR1	SB1	
23	RB2	AN8				RS	RS		C2	CL2	SB2	
24	RB3	AN9				R/W	R/W		D1	DIR2	SB3	
25	RB4	AN11				D4	D4		A2	CL3	SB4	
26	RB5					D5	D5		B2	DIR3	SB5	
27	RB6					D6	D6		C2	CL4	SB6	
28	RB7					D7	D7		D2	DIR4	SB7	
11	RC0						E2				SC0	C3
12	RC1				SDO			PWM2			SC1	
13	RC2							PWM1			SC2	

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

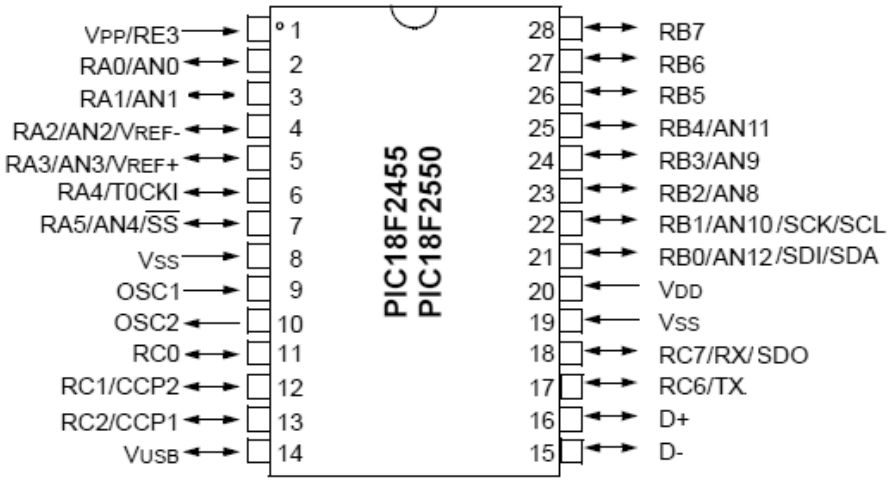

Figure 4 Pinout of the PIC18F2455 / 2550 / 2458 / 2553

6.5.2 Interfaces with 40/44-pin Controll PIC

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

Pin	IO-Port	ADC	FRQ	RS 232	I2C	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											
14	RA6												
33	RB0	AN12			SDA	SDI	E1			A1	CL1	SB0	
34	RB1	AN10			SCL	SCL				B1	DIR1	SB1	
35	RB2	AN8					RS	RS		C2	CL2	SB2	
36	RB3	AN9					R/W	R/W		D1	DIR2	SB3	
37	RB4	AN11					D4	D4		A2	CL3	SB4	
38	RB5						D5	D5		B2	DIR3	SB5	
39	RB6						D6	D6		C2	CL4	SB6	
40	RB7						D7	D7		D2	DIR4	SB7	
15	RC0							E2				SC0	C3
16	RC1					SDO			PWM2			SC1	
17	RC2								PWM1			SC2	
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.

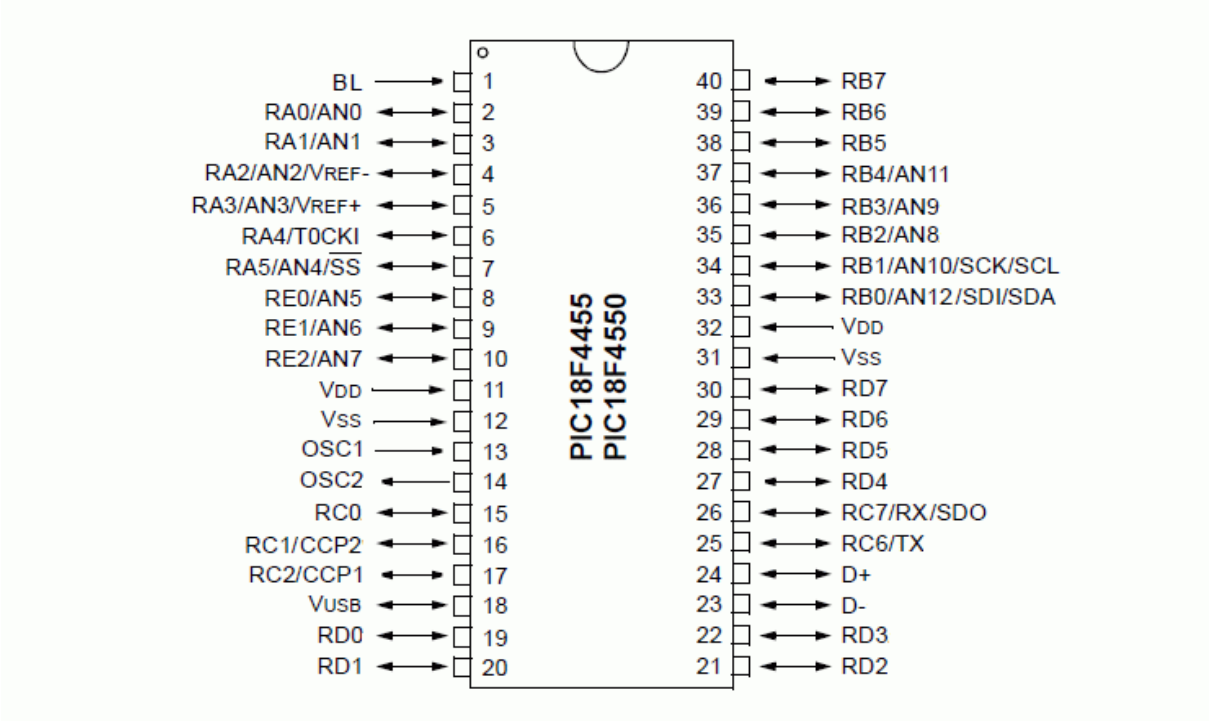

Figure 5 Pinout of the PIC18F4455 / 4550 / 4458 / 4553

6.5.3 Output Pins

See the USB4all handbook.

6.5.4 Input Pins

See the USB4all handbook.

6.6 TTL-IO-Port-Pins

See the USB4all handbook.

6.7 ADC-Input

See the USB4all handbook.

6.8 Frequency Counter Input

See the USB4all handbook.

The precision of the frequency counter depends on the precision of the microcontroller's clock source. If no crystal is connected to the microcontroller, then an internal oszillator is used. The precision of this **internal oscillatior** depends on environmental temperature and power supply level.

- +25℃ ±2%
- -10℃ to +85℃ ±5%

- -40℃ to +85℃ ±10%

If an **8-MHz-crystal** is connected to the pins OSC1 and OSC2, then this crystal will be used by the microcontroller. In this situation the precision of the counter depends on the precision of the crystal. Standard crystals have errors of ±30 … ±50 ppm.

The frequency counter has a small additional systematic error.
In **automatic mode** this error is

- +20 ppm.

In **manual mode** the error depends on the selected counting interval.

- 1 ms not tested
- 10 ms +0.2%
- 100 ms +60 ppm

6.9 RS232-Interface

The RS232-interface is used for the communication with the PC, and can not be used for anything else.

6.10 I2C-Interface

See the USB4all handbook.

6.11 Dot-Matrix LCD-Interface

See the USB4all handbook.

6.12 PWM-Output

See the USB4all handbook.

6.13 Stepper Motor Output

See the USB4all handbook.

6.14 Model-Servo-Output

See the USB4all handbook.

7 Software

7.1 PC

The RS4all has to be connected to a RS232-port of the PC (e.g. COM1). The COM-port has to be set to:

- Baud rate 9600
- Data bits 8
- Stop bits 1
- Parity none
- Flow control none

The low baud rate was selected to guarantie a reliable communication via long RS232-cables. At 9600 baud a distance of 150 meters (5600 feet) is possible.

8 List of Commands

The Rs4all is controlled by commands. Every command is a short string of bytes. The string is send via RS232 to the Rs4all, 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 20 bytes. However, the most commands need only 2 … 4 bytes.

For the Rs4all 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 Rs4all to 20 only.

If e.g. the bytes 0x55, 0x01, 0x02, 0x16 have to be sent to the Rs4all, then the bytes have to be convertet into the following ASCII-string: '#55-01-02-16'+0x00
The string starts with the '#'-sybol, then follow the bytes as hexadezimal values. The bytes have to be separated by '-'-sybols. At the end of the string follows 0x0A, 0x0D or 0x00. In the exaple I used 0x00 (zero terminated string), but if one is using a terminal program to control the Rs4all, then the Enter-Key (0x0D) will do the job too.

The first byte is addressing the subsystem of Rs4all, which will receive and work off the command (e.g. PWM or ADC). The following subsystems exist:

- 0x50 TTL-IO-Pins
- 0x51 10-Bit-ADC
- 0x52 frequency counter
- 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
- 0x5A internal EEPROM
- 0x5D ABCD-stepper-motor Nr. 1
- 0x5E ABCD-stepper-motor Nr. 2
- 0x5F ABCD-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
- 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.

8.1 TTL-IO-Pins

See the USB4all handbook.

The 18 IO-pins are organized in 3 ports:

- PortA contains 7 pins: RA0..RA6
- PortB contains 8 pins: RB0..RB7
- **PortC contains 3 pins: RC0..RC2**

8.2 10-Bit / 12-Bit-ADC

See the USB4all handbook.

8.3 Frequency Counter

See the USB4all handbook.

8.4 RS-232

This interface can not be used, because it is needed for communication with the PC.

8.5 I2C-Interface

See the USB4all handbook.

8.6 SPI-Interface

Can not be used.

8.7 Microwire

Can not be used.

8.8 Shift-Register Interface

See the USB4all handbook.

In comparison with USB4all, a different pin is used as shift register outout.
The shift-registers-interface is using the following 3 pins of PortB:

- **SDO = RC1**
- SDI = RB0
- SCK = RB1

8.9 LCD-Interface

See the USB4all handbook.

8.10 PWM1 und PWM2

See the USB4all handbook.

The PWM-circuitries of Rs4all use other frequencies then USB4all.

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: 8 kHz / 256 1: 80 kHz / 100 2: 20 kHz / 100 3: 5 kHz / 100 4: 31 kHz / 256 5: 8 kHz / 256 6: 2 kHz / 256 7: 8 kHz / 1024 8: 2 kHz / 1024 9: 488 Hz / 1024	-	-
	0x02 Set dutycycle	Lower 8 Bits	Upper 2 Bit-	-

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

8.11 Internal EEPROM

See the USB4all handbook.

8.12 Stepper-Motor-Interfaces

See the USB4all handbook.

8.12.1 Stepper-Motor-Interface with ABCD-phases

See the USB4all handbook.

This device supports only 3 Interfaces with ABCD-phases. The interface number 4 is not supported.

8.12.2 L297-Stepper-Motor-Interface

See the USB4all-Handbook.

8.13 Servos

See the USB4all-Handbook.

The group Servo-B is identical to USB4all, but the group Servo-C contains only 3 outputs (SC0, SC1, SC2). The outputs SC6 and SC7 are not supported.

8.14 Impulse Counter

See the USB4all handbook.

8.15 Reset the Rs4all

Rs4all can be reseted into the power-up-state with this command.

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

Rs4all will **NOT** send any reply to the PC.

9 How to Control the Rs4all

The Rs4all is controlled by ASCII-string received via RS232-interface. Nearly every programming language should support communication via RS232 (COM-ports). Even terminal programmes (HyperTerminal, Putty…) can be used.

Every command-string starts with the prefix "#'. Then follow the bytes. Every byte is a 2 digit long hexadezinmal number. The individual bytes are interspaced by"-" symbols. At the end has to follow a byte with the value 0x0D (begin of line) or 0x0A (next line) or 0x00 (zero terminated).

The whole ASCII-string doesn't has to be longer then 64 symbols. Consequently it can not contain more then 20 bytes.

Example:
To initiate the 1st LCD the following 4 bytes have to be send to the Rs4all:
0x55, 0x01, 0x02, 0x16

The correct formatted string looks like this:
'#55-01-02-16'+0x00

The"0x00" at the end stands for a byte 00, the string is zero terminated. Instaed of 0x00 it would be possible to use 0x0D (enter) or 0x0A.
As spacer between the bytes I used the "-"-symbol. Practically any 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.
Instaed of '01' it is possible to write '1'. Leading zeros can be removed.

The following Delphi/Pascal-Code converts 16 bytes (stored in send_buf) into an ASCII-string and sends it to Rs4all (by the function Comport1.WriteStr)

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

The Rs4all will answer for every command (excep reset) with an ASCII-string. The prefix is a '@', the separator is '-' and at the end follow the 3 bytes 0x0A,0x0D,0x00.

The string contains 16 numbers, every number is written as a 2 digit long hexadezimal number. All letters are upper-case letters.

All this adds up to a length of 50 bytes.

The following Delphi/Pascal-code extracts the 16 bytes from a received string:

```
//Helper-function: convert ASCII-Symbold into numbers
//would be simpler with ORD-function
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;
.
.
.
    //receive via COM-port with 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;
.
.
.
```

9.1 Example Code to use Rs4all

These are some examples for the use of Rs4all. All code-examples are written in Delphi/Pascal.

9.1.1 Example: Write one byte into the EEPROM

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

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

9.1.2 Example: Measure a Voltage

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

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

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

Comport1.WriteStr('#51-3'+chr(0));            // measure voltage
Comport1.ReadStr(rxstr, 50);                  // Reply with result
```

9.1.3 Example: Measure the Frequency

This code measures the frequency at pin RA4.

```
Comport1.WriteStr('#52-5'+chr(0));            // measure the frequency
Comport1.ReadStr(rxstr, 50);                  // Reply with result
```

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

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

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

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

9.1.5 Example: Switch on an LED at Pin RC0

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

```
Comport1.WriteStr('#50-5-0-0-1'+chr(0));      // RC0 becomes output
Comport1.ReadStr(rxstr, 50);                  // Reply

Comport1.WriteStr('#50-6-0-0-1'+chr(0));      // switch RC0 to high-level
Comport1.ReadStr(rxstr, 50);                  // Reply
```

9.1.6 Example: Turn Stepper-Motors

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

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

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

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

9.1.7 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.

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

Comport1.WriteStr('#54-3-48-2'+chr(0));       // read temperature
Comport1.ReadStr(rxstr, 50);                  // Reply with temperature
```