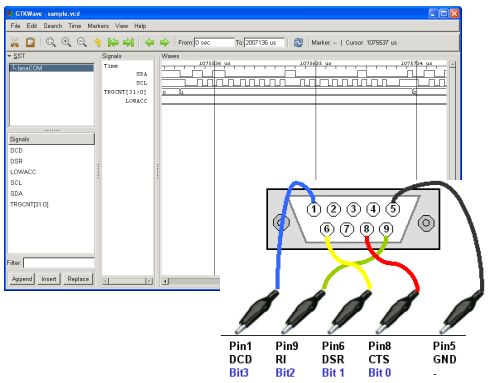



```
527338 us:  S a0 A  02 A  P
527566 us:  S a1 A  00 A  00 A  00 N  P
528001 us:  S a0 A  05 A  P
528231 us:  S a1 A  01 A  01 N  P
528568 us:  S a0 A  05 A  01 A  01 A  P
```

l a n a C O M –
v c d T r a n s –

(**L**)ogic (**Ana**)lyzer using (**COM**)-port Interface

including **vcdTrans**, a protocol analyzer Module for **I²C**, **SPI** and **V24**

Table of Contents

1. Highlights and Principles

- **Logic Analyzer**
  lanaCOM is a command line tool implementing a **logic analyzer**
  (a logic analyzer is an electronic instrument that displays signals in a digital circuit).

- **VCD Output format**
  Any VCD waveform viewer can be used to view the results. *LanaCOM* generates its output file in VCD-format. This is a standard format which can be read with any VCD-waveform viewer. 'GTKwave' is a pretty good and free VCD- waveform viewer.

- **I^2C, SPI and V24 Protocol Analyzer**
  vcdTrans is a postprocessing command line tool which takes *lanaCOMs* output file and allows for analyzing I2C, SPI and V24 protocols.

- **Zero hardware cost**
  No additional hardware is required. The four flow-control and modem signals of the PC serial COM port, CTS, DCD, DSR and RI are used for probes the signals. According to RS232 specification signals from +/-25V can be applied with no additional buffering required.

- ***LanaCOM* software is free**
  Permission is granted to copy, distribute and/or modify the software and this document under the terms of the GNU Free Documentation License, Version 1.1 or any later.

- **400 kilo samples per second**
  The sample rate depends on the actual PC speed. About 400 kSamples/s are common.

- **Huge trace buffer space**
  The PC-DRAM is used to store the samples during acquisition. File output is created during a post-processing step. About 1MB of DRAM is required per sampling second. With a 1GB of DRAM on common PC hardware buffering of 500 seconds and more at max. resolution will not be a problem.

- **Indication of potential inaccuracies**
  As *lanaCOM* runs in a multitasking OS environment, the sampling process might be interrupted due to higher priority OS tasks. *LanaCOM* indicates whenever the sampling process is interrupted - this includes any hardware related interrupts like DRAM refreshes etc.

- **Trigger counter**
  A virtual signal counts the number of trigger conditions to support orientation within a huge trace buffer.

2. Installation

Unpacking

Unzip the distribution into a new 'lanCOM' directory. The will create a directory structure as shown below:

-

Windows

1. For Windows Systems precompiled binaries of 'lanaCOM.exe' and 'vcdTrans.exe' are provided. Additionally, 'cygwin1.dll', 'cygpopt-0.dll' and 'cygioperm-0.dll' will be required and are provided together with the distribution.

2. To compile *lanaCOM* and vcdTrans from scratch requires the 'cygwin' environment (www.cygwin.org). If Cygwin is installed, change to the 'csrc'-directory and at the command prompt type:

   ```
   # make
   ```

   This will create the 'lanaCOM.exe' and 'vcdTrans.exe' executables.

3. Under Windows NT/2K/XP, direct I/O access is not possible without a special I/O device driver. *LanaCOM* supports two different device drivers:

   ***Ioperm*:** ioperm is the preffered solution under Cygwin environment. The I/O driver can be activated through the command: ioperm –i –v

   ***Giveio*:** Another option is the Giveio device driver. This driver comes together with the *lanaCOM* distribution. See the 'Credits' section for the download location.

Once you have prepared the above, open a command window, go to the *lanaCOM* 'bin' directory and call `'lanaCOM -?'` and `'vcdTrans -?'` to get the appropriate help information.

Linux

For Linux systems, compilation of the source files is required. Just change to the 'csrc'-directory and at the command prompt type:

```
# make
```

This will create the 'lanaCOM.exe' and 'vcdTrans.exe' executables. *LanaCOM* must be run as 'root' because it directly accesses I/O addresses.

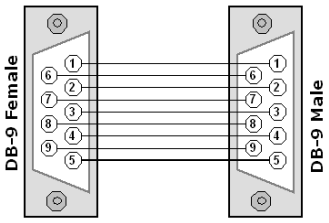
Waveform-Viewer

Additionally to the *lanaCOM* program itself a Waveform-viewer is required to view the captured results. An excellent free viewer is GTKwave, see the 'Credits' section for a download location.

3. The Probes

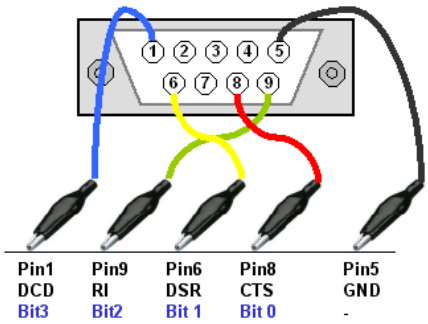
Modem Cables

Usually, some kind of cable will be used to connect to the COM-port. Best choice will be a fully connected modem cable or a simple flat-ribbon cable. These cables are straight through connected like shown in the figure below (for a DB-9 cable).

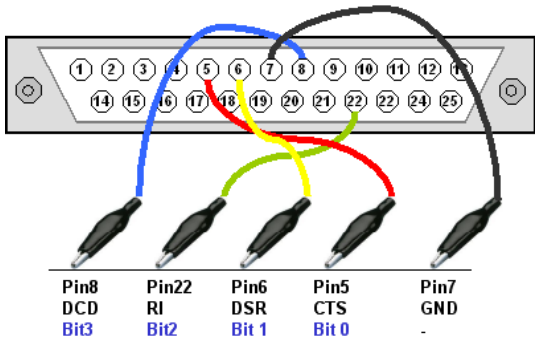


PC side Probe Side

Up to four probes can be connected to a 9-pin or 25-pin modem-cable. This is shown in the figures below.



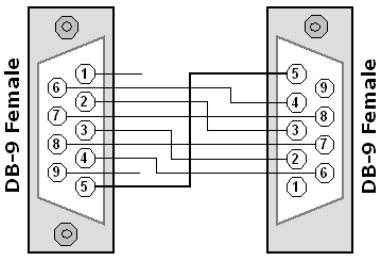
DB-9 male



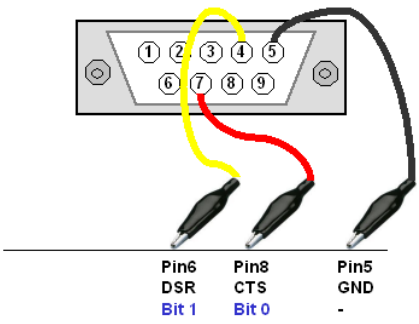
DB-25 male

Null Modem Cables

Null modem cables are used to connect two PCs. A variety of cable types are available which do not have all of the handshake and modem signals connected. Even the so called 'fully connected' null modem cables do usually not provide the modem signals RI and DCD. So in general it is **not a good idea** to choose a null modem cable for connecting the probes. If used the cable connections should be double checked first. The figures below show how to connect two probes to a null modem cable.



PC side Probe Side



DB-9 Female

4. Quick Start Guide

This example shows how to trace I^2C bus traffic (signals SDA and SCL) and how to trigger on the I^2C start condition.

- Choose a free COM port:

```
--comport=com2
```

- Connect SCL to RI (DB-9.pin9) and SDA to CTS (DB-9.pin8) and provide alias names. Make sure that these lines are connected within the serial cable:

```
--RI=SCL     (Analyzer bit 2)
--CTS=SDA    (Analyzer bit 0)
```

- Determine the trigger condition e.g. I^2C start condition is SCL=1 and falling edge of SDA:

```
--mode=edge
--mask=0x05
--edgedata1=0x05
--edgedata2=0x04
```

- Set the trace buffer size to 2 seconds

```
--buffsize=2s
```

- Redirect the output to file ‘sample.vcd’

```
--ofile=sample.vcd
```

- The complete command will then look like this:

```
./lanaCOM --comport=com2 --CTS=SDA --RI=SCL --mode=edge --mask=0x05 \
          --edgedata1=0x05 --edgedata2=0x04 --buffsize=2s --ofile=sample.vcd
```

- After data acquisition the waves can be viewed with e.g. GTKwave (or any other VCD-viewer). Don’t forget to add the file-parameter ‘sample.vcd’. Without flie-parameter gtkwave will exit immediately without starting its graphical user interface.

```
gtkwave sample.vcd
```

The pictures below show different zooms of the sampled data. In this example the data was acquired from an Atmega8535 accessing an RTC8583 real time clock I^2C slave device:

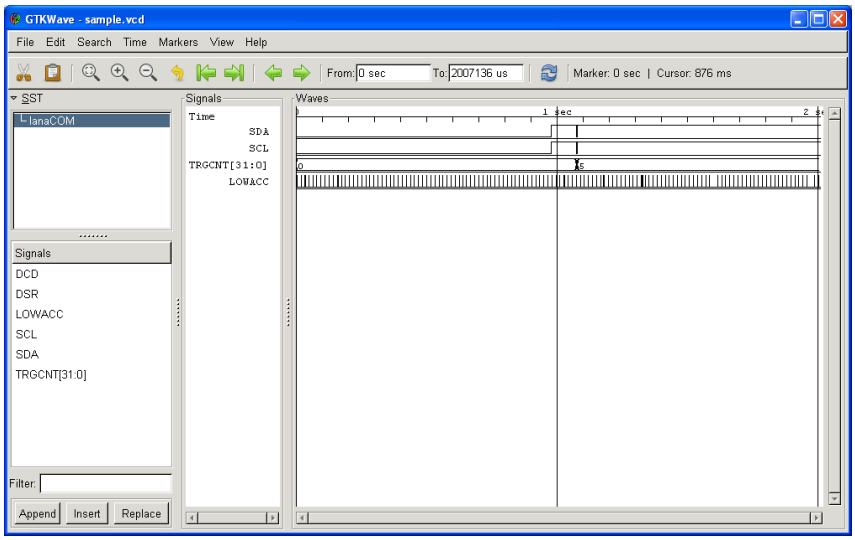


Figure 1: Full zoom of the trace buffer

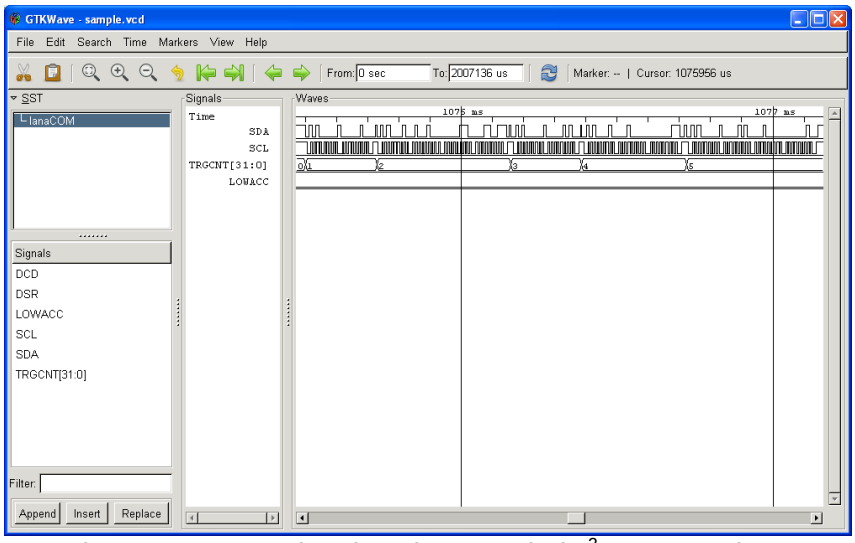


Figure 2: Zoom showing the sampled I^{2}C transactions

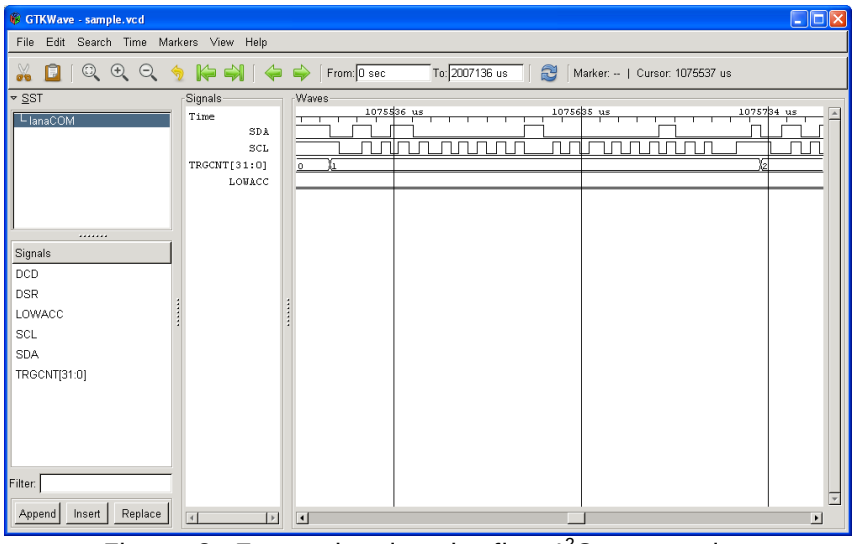


Figure 3: Zoom showing the first I^{2}C transaction

I^{2}C protocol analysis can be done using *vcdTrans*. The following command takes the captured VCD-File.

```
vcdTranslate --ifile=sample.vcd --type=i2c –scl=SCL –sda=SDA
```

This command will create an output to the console window similar to the one shown below:

```
430003 us:  P
527338 us:  S a0 A  02 A  P
527566 us:  S a1 A  00 A  00 A  00 N  P
528001 us:  S a0 A  05 A  P
528231 us:  S a1 A  01 A  01 N  P
528568 us:  S a0 A  05 A  01 A  01 A  P
```

5. lanaCOM – Usage

The text below is the output of the command '`lanaCOM --help`':

```
-------------------
l a n a C O M -- 4 bit (l)ogic (ana)lyzer using (COM) port interface

Usage: lanaCOM [[-c port]|[-a ioaddr]] [Options]
 -c, --comport=port  Any serial port COM[1..4] with legacy I/O address
 -a, --address=ioad  Use (non legacy) ioaddr as base I/O address

General trigger options
 -b, --buffsize=b    'b' can be either the number of sample points or a time
                     specification with unit e.g.: 243us, 51ms, 2s
 -p, --post=p        Acquire 'p' samples after trigger was found. 'p' can be
                     either the number of sample points or a time specific.
                     with unit e.g.: 243us, 51ms, 2s
 -m, --mode=m        Trigger mode: one of 'level', 'edge', 'time'
 -k, --mask=k        Logically 'and' sampled data with 'k'
                     (k[3]/k[2]/k[1]/k[0]) = (DCD/RI/DSR/CTS)

Level trigger options:
 -t, --trigger=t     Trigger if: (sample & k) == t
                     (t[3]/t[2]/t[1]/t[0]) = (DCD/RI/DSR/CTS)
 -i, --invert        Trigger if: (sample & k) != t

Edge trigger options:
 trigger if: ((previous_sample & k) == e) && ((curr_sample & k) == E)
 -e, --edgedata1=e   Compare value for previous sample
                     (e[3]/e[2]/e[1]/e[0]) = (DCD/RI/DSR/CTS)
 -E, --edgedata2=E   Compare value for current sample
                     (E[3]/E[2]/E[1]/E[0]) = (DCD/RI/DSR/CTS)

VCD file options:
 -f, --ofile=file    VCD output file name (default=stdout)
 -3, --DCD=alias     Alias name for DCD
 -2, --RI=alias      Alias name for RI
 -1, --DSR=alias     Alias name for DSR
 -0, --CTS=alias     Alias name for CTS

Environmental options:
 -P, --priority=p    Set process priority (-20=max,+20=min,-1=default)
 -v, --verbose=v     Verbosity level (default=2 is warning+info)
                     3 = Warnings + Infos + Debug
                     2 = Warnings + Infos (default)
                     3 = Warnings
                     0 = (silent)
 -V, --version       Print program version
 -?, --help          This help

lanaCOM uses the RS232 flow-control and modem input signals as probes to
sample up to four signals. See the table below for the signal mapping.

 Analyzer  RS232    DB-9   DB-25            D              G
 bit       Signal   Pin#   Pin#             C              N
 ------------------------------            D              D
   0       CTS       8       5          _____________________
   1       DSR       6       6         \   1   2   3   4   5   /
   2       RI        9      22          \    6   7   8   9    /
   3       DCD       1       8           \_____________________/
                                            D       C   R
                                            S       T   I
                      C   D   G   D         R       S
                      T   S   N   C
                      S   R   D   D
  ___________________________________________________
  \   1   2   3   4   5   6   7   8   9  10  11  12  13   /
   \   14  15  16  17  17  19  20  21  22  23  24  25    /
    \_____________________________________________/
                                   R
                                   I

-------------------
```

6. lanaCOM – Detailed Parameter Description

This section describes all *lanaCOM* options in more detail. The description shows the 'long'-options only because these are more descriptive than their 'short' variants (please refer to section 5, 'Usage' for the short variants of all options).

Specifiying The I/O Address

`--comport=port`

This option specifies the COM-port from which *lanaCOM* will read the samples. 'port' can be one of 'COM1', 'COM2', 'COM3' or 'COM4' lower and upper case is valid. A single number '1', '2', '3' or '4' is valid as well.
Example: `--comport=com2`

`--address=ioad`

If the COM-port address is not one of the legacy addresses, then this option allows to specify a non-legacy address. This is usually the case when COM-ports on PCI I/O-cards are uses. Please refer also to section 10 – which in detail describes how to discover non-legacy addresses.
Example: `--address=0x9000`

General Trigger Options

`--buffsize=b`

This option specifies the internal trace buffer size. By default *lanaCOM* will run as long as the trace buffer is filled with valid data. The easiest way is to specify the buffer size 'b' as a time. Valid time units are 'us' (microseconds), 'ms' (milliseconds) or 's' (seconds). If a plain number without unit extension is specified, *lanaCOM* interprets this as the number of samples to be taken.
Example1: `--buffsize=234us`
Example2: `--buffsize=572ms`
Example3: `--buffsize=5s`
Example4: `--buffsize=1000000`

`--post=p`

This option can be used to reduce the sample time after a trigger has been found. 'P' can specified a time or as a number of samples (see option -–buffsize). Once the trigger condition has been found 'p' specifies how many more samples will taken.
Example: `--post=5ms`

`--mode=m`

This option is mandatory and specifies the trigger mode. 'm' must be one of 'level', 'edge' or 'time'.

1. level mode: the trigger will be valid whenever the four sampled signals match the equation given by the specification of '--mask=k', '--trigger=t', '--invert'. The trigger equation itself will be specified later in this section.

2. edge mode: the trigger will be valid whenever the equation specified through the options '--mask=k', '--edgedata1=d1' and '--edgedata2=d2' changes from false to true. The trigger equation itself will be specified later in this section.
3. time mode: in this mode no trigger condition will be evaluated. *LanaCOM* will just sample the attached signals for the given duration. CTL-C can be type at any time to stop the sampling manually.

Example: --mode=edge

--mask=k

'k' specifies an AND-mask for the sampled data. Every sampled data will be logically 'anded' with mask before further evaluation in the trigger equation.
Example: --mask=0x5

Level Trigger Options

--trigger=t

The trigger equation will be true if: (sample & k) == t
Where 'sample' is actually sampled four bit data, and 'k' is the mask given through option '--mask=k'.
Example: --trigger=0x4

--invert

This is a modifier for the trigger equation: with this option the trigger equation will be true if: (sample & k) != t.

Edge Trigger Options

--edgedata1=d1
--edgedata2=d2

In edge trigger mode the trigger equation will be true if:
((previous_sample & k) == d1) && ((curr_sample & k) == d2)
Where 'previous_sample' is sampled data from the previous sample point and 'curr_sample' the currently sampled data and 'k' is the mask given through option '--mask'.

VCD-file options:

--ofile=file

*lanaCOM*s output is in VCD-format, which is specified by IEEE's Verilog. By default the output will be written to 'stdout'. With this option an output file can be specified.
Example: --ofile=sample.vcd

--CTS=alias
--DSR=alias
--RI=alias
--DCD=alias

These options allow to change the names of the signals in the created VCD-file. If for example an I2C bus is traced the default names can be overridden to have more descriptive names in the waveform.
Examples: --CTS=SCL --RI=SDA

Environmental Options

`--priority=prio`

As *lanaCOM* runs under multitasking environments processor resources are shared between all processes. Option '`--priority=prio`' will give higher priority to the *lanaCOM* process and make the sampling more accurate. 'prio' can be a value between –20 and 20 (according to the unix command 'nice'). –20 will be highest priority, 20 will be lowest priority. The default priority is '-1'. Attention: this option must be handled with care. Giving high priority to *lanaCOM* will potentially block keyboard and mouse and thus inhibit any possibility to stop the data acquisition process.

`--verbose=v`

This option controls the level of verbosity. Program messages will be written to 'stdout'.

v = 3	: Warnings + Infos + Debug
v = 2 (default)	: Warnings + Infos
v = 1	: Warnings
v = 0	: (silent - no message will be shown)

`--version`

Shows version information of *lanaCOM*.

`--help`

Shows a brief description of all options and probing connectivity for DB-9 and DB-25 COM-port connectors.

7. Virtual Signals

- TRGCNT[31:0] – Trigger Counter

  This signal indicates and counts the positions where the trigger condition goes true. This signal is very helpful for navigating within a huge trace buffer.

- LOWACC – Low Accuracy

  This signal indicates where the sampling has been interrupted by a higher priority OS task or hardware delay. When this signal is asserted the sample rate might be degraded and the samples at that time should be considered as suspicious.

8. vcdTrans – Usage

The text below is the output of the command '`vcdTrans --help`':

```
--------------------
vcdTrans -- analyze and translate vcd-file as I2C, SPI or V24

Usage: vcdTrans [Options]
 -i, --ifile=vcdfile VCD input filename (default=stdin)
 -o, --ofile=file    Output file name (default=stdout)
 -t, --type=type     Type is one of: 'i2c' or 'spi'

I2C options
 -c, --scl=signame   Name of SCL signal in VCD-file
 -d, --sda=signame   Name of SDA signal in VCD-file

SPI options
 -s, --ssn=signame   Name of SSN (select) signal in VCD-file
 -c, --sck=signame   Name of SCK (clock) signal in VCD-file
 -m, --mosi=signame  Name of MOSI (master out, slave in) signal in VCD-file
 -M, --miso=signame  Name of MISO (master in, slave out) signal in VCD-file
 -e, --edge=edge     Edge may be one of 'rising' (default) or 'falling'
 -O, --order=order   Order is one of 'msb' (default) or 'lsb'

V24 options
 -R, --rx=signame    Name of RX signal in VCD-file (required option)
 -T, --tx=signame    Name of TX signal in VCD-file
 -B, --baud=speed    Baudrate on serial line (default=9600)
 -I, --invert        Invert signal levels (start <= 0V, stop >= 3V)

Other options
 -v, --verbose       Verbose mode
 -V, --version       Print program version
 -?, --help          This help
--------------------
```

9. vcdTrans – Detailed Parameter Description

This section describes all *vcdTrans* options in more detail. The description shows the 'long'-options only because these are more descriptive than their 'short' variants (please refer to section 8, 'Usage' for the short variants of all options).

General Options

`--ifile=file`

This option specifies the filename of the input file. The input file must be in VCD-format. The output file generated by lanaCOM is in VCD-file format. If this option is omitted vcdTrans will read its input from <stdin>.
Example: `--ifile=sample.vcd`

`--ofile=file`

This option specifies the filename of the output. If this option is omitted vcdTrans will write its output to <stdout>.
Example: `--ofile=i2c_log.txt`

`--type=type`

This option is mandatory and is used to specify the protocol type. Type must be one of 'i2c', 'spi' or 'v24'
Example: `--type=i2c`

I²C Options

`--scl=signame`
`--sda=signame`

These options specifies the signal names for SCL and SDA in the VCD-file.
Example: `--scl=SLC_SIG`

SPI Options

`--ssn=signame`
`--sck=signame`
`--mosi=signame`
`--miso=signame`

These options specify the signal names for all SPI signals SSN, SCK, MOSI and MISO in the VCD-file.
Example: `--miso=MISO_SIG`

`--edge=edge`

This option specifies, whether data is sampled on rising or falling edge of the SCK signal. Edge may be one of 'rising' or 'falling'. 'rising' is the default value if this option is omitted.
Example: `--edge=falling`

`--order=order`

Bit-ordering within the transmitted bytes is not specified through the SPI specification. This option allows for setting bit-order to either ‘msb’ (default) or ‘lsb’. ‘msb’ means that transmittion of bits is: bit7, bit6, … bit0. ‘lsb’ means bit0, bit1, … bit7.
Example: `--order=lsb`

V24 Options

`--rx=signame`
`--tx=signame`

These options specify the signal names of the V24 signals RX and TX in the VCD-file. At least one of the signals RX or TX must be specified.
Example: `--rx=RXD`

`--baud=speed`

This options specifies the baudrate of the v24 signals. Default is 9600 baud.
Example: `--baud=4800`

`--invert`

This option can be used, if the measurement is taken directly from pins with V24 levels. The default assumes that the measurement is taken from pins connected to the micro-controller (without level shifters).

Other Options

`--verbose`

This option can be used if a more detailed information of the program flow is required. It is for debugging, mainly.

`--version`

Shows version information of *vcdTrans*.

`--help`

Shows a brief description of all options and probing connectivity for DB-9 and DB-25 COM-port connectors.

10. Discovering Non-Legacy COM-Port Addresses

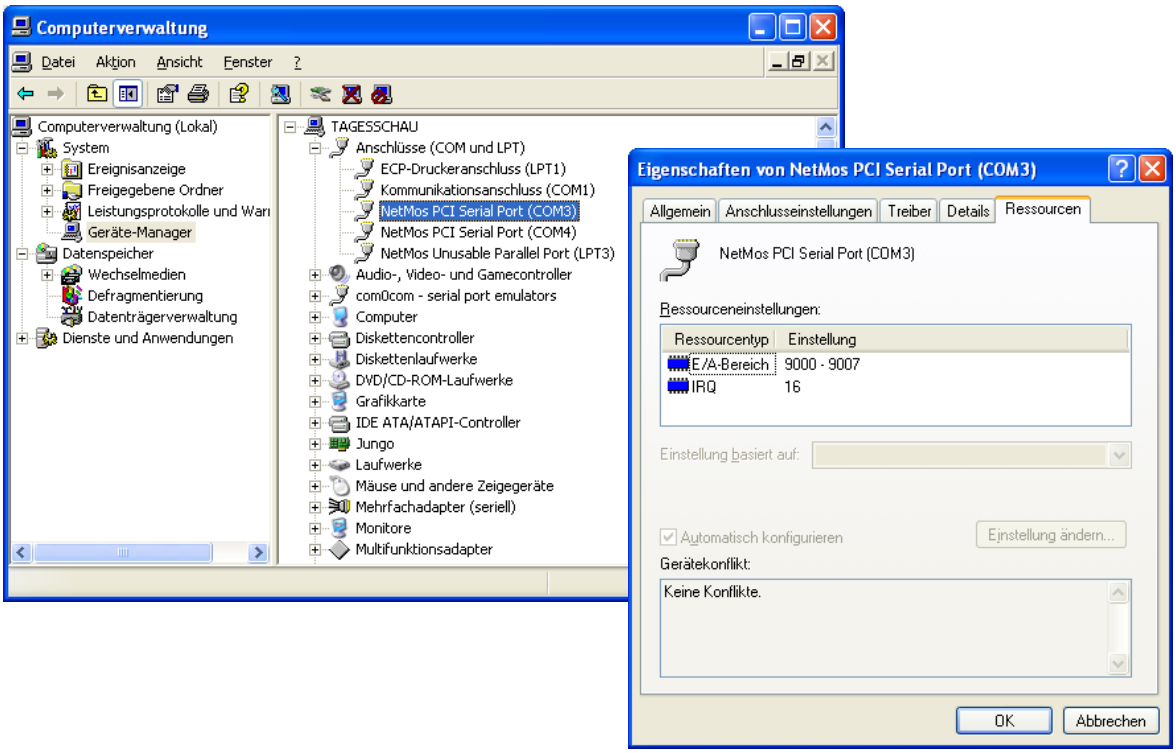
The table below shows the legacy COM-port addresses for COM port 1 to 4:

Device	I/O address range	IRQ
COM1	0x3F8 - 0x3FF	4
COM2	0x2F8 - 0x2FF	3
COM3	0x3E8 - 0x3EF	4
COM4	0x2E8 - 0x2EF	3

When used with parameter '`--comport=`', *lanaCOM* accesses the UART registers under their legacy addresses. If a UART cannot be found there, a corresponding error message will be displayed. In this case the I/O address of the COM port may be different from the legacy address. On Windows platforms the real I/O address can obtained through:

Desktop -> Manage -> Device Manager -> COM and LPT ports

Select the corresponding COM port and right click to open the properties menu. The I/O address can be read in the resources tab. The example below shows the I/O address of an NetMOS PCI Serial Port (COM3) at address 0x9000-0x9007.



Once the correct I/O address has been determined *lanaCOM* can be started with option

'`--address=0x9000`'

for the example above.

11. Credits

- The design of *lanaCOM* was very much inspired by:

  A serial-la (analyzer using serial port)
  http://www.consistent.org/serial-la/
  Written in 1999 by Terran Melconian terran@consistent.org

  Digitrace (analyzer using parallel port)
  http://www.xs4all.nl/~jwasys/old/diy2.html
  JWA Systems, Arian van Dorsten

- A good description about programming the PC COM-port
  http://www.lammertbies.nl/comm/info/RS-232.html

- A good description about programming PC timers/counters
  http://www.geocities.com/zebra9.geo/pctimer.htm

- The GTKwave tool is a free waveform viewer for VCD-files
  http://home.nc.rr.com/gtkwave/
  http://www.geocities.com/SiliconValley/Campus/3216/GTKWave/gtkwave-win32.html

- The Giveio device driver enables I/O accesses under Windows NT/2K/XP
  http://sourceforge.net/project/showfiles.php?group_id=46487&package_id=77441&release_id=150767/&abmode=1/