ICD Tutorial

Version 16-Apr-2019

About the Tutorial

What is it about?

This is a tutorial for all In-Circuit Debuggers (TRACE32-ICD) that are implemented using an on-chip debug interface. Typical examples for on-chip debug interfaces are BDM, JTAG, or ONCE.

Preconditions:

The tutorial assumes that the TRACE32 debugger software is already installed. Also a basic knowledge of software debugging and the C-programming language is helpful. This is required in order to be able to follow the example code found in this tutorial. In addition working with the Windows operating system is assumed as known. Also a basic knowledge of the target processor and used assembler/compiler is necessary to get your debug system running.

Purpose of this tutorial:

The purpose of this tutorial is to do the basic steps in setting up the debug environment. This means we will configured the TRACE32 for the host computer, start the debugger, write PRACTICE scripts (*.cmm) to automate the start-up and to make you **familiar with the main features** of the In-Circuit Debugger.

How to use this tutorial:

The tutorial contains a guided debug session. It uses a simple C-program example to show you the most important debug features. You should perform a number of exercises as you read this tutorial. We recommend to **go completely through all chapters**, since besides the tour (written in normal text format) there are very helpful remarks (*written in italics*) which will not be repeated in other chapters.

Where can I get more information:

The common TRACE32 user interface contains a detailed online help that offers the most current description of all debug features. Refer to the "**Online Help**" on how to start the online help system.

How long does it take?

60 minutes

Set up the Program Environment

After installing the TRACE32 on your host PC in accordance to ***Quick Installation for TRACE32-ICD*** you will the get the system files of TRACE32 (the program executables) in the TRACE32 system directory. You will also find entries in the Windows Start program list. The installation set up a default working environment for TRACE32. This configuration should be adapted to your debugging environment on your host PC.
NOTE: The abbreviation PC in the context of TRACE32 is mostly used for Program Counter; therefore we will use the term host rather than PC for the debugging device which runs the debugger-GUI.

To adapt the environment to your personal settings, check the following configuration:

1. Definition of a user specific configuration file.

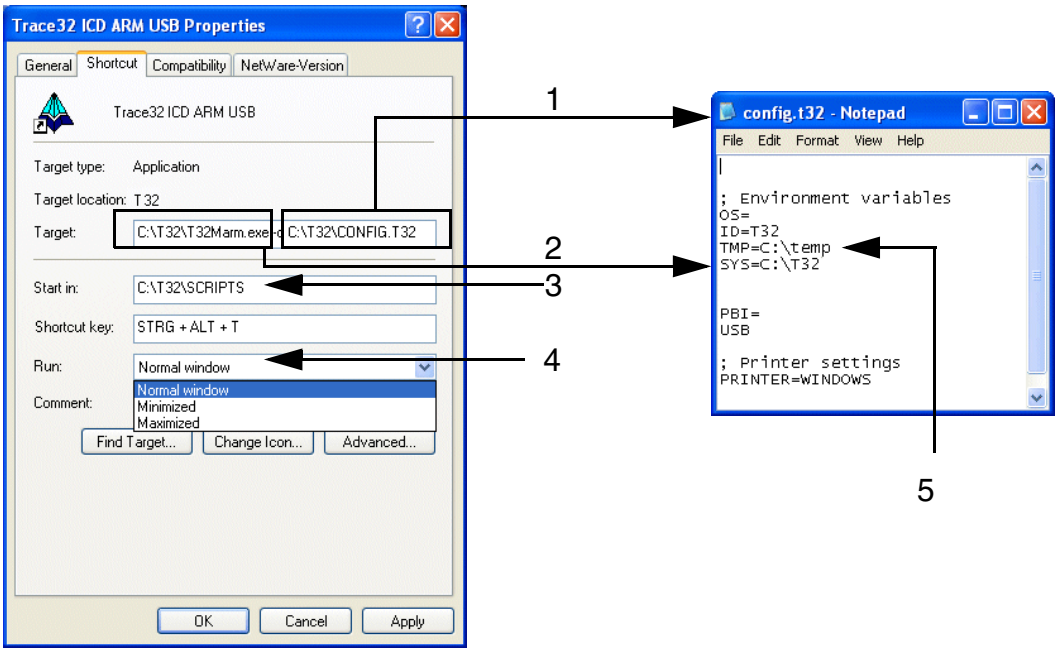
   By default the configuration file **`config.t32`** in the system directory is used. The option **`-c`** allows you to define your own location and name for the configuration file. For more information on the configuration file refer to ***Quick Installation for TRACE32-ICD***

2. The system directory. It is specified during the installation on TRACE32. Normally you do not have to change anything here.

3. Definition of your working directory. It is recommended to set up your own working directory.

4. Definition of the size of the application window.

5. Temporary files of the debugger are placed here. Normally you do not have to change anything here.

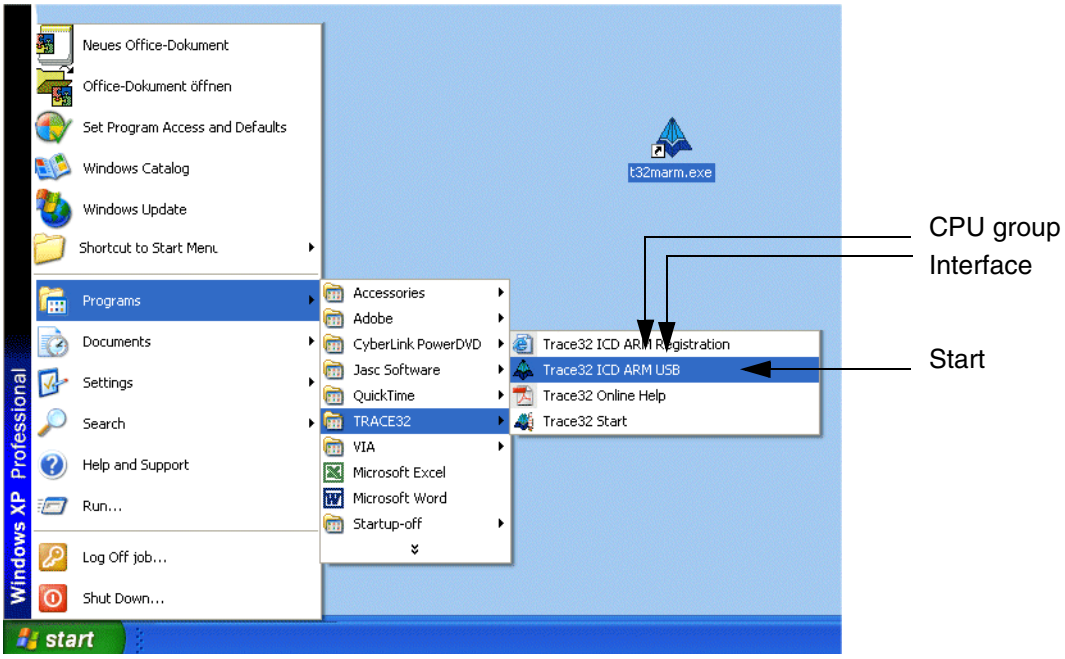


Next power up your debug system first and then the target.

	To work with the In-Circuit Debugger (ICD) a working target system is required!

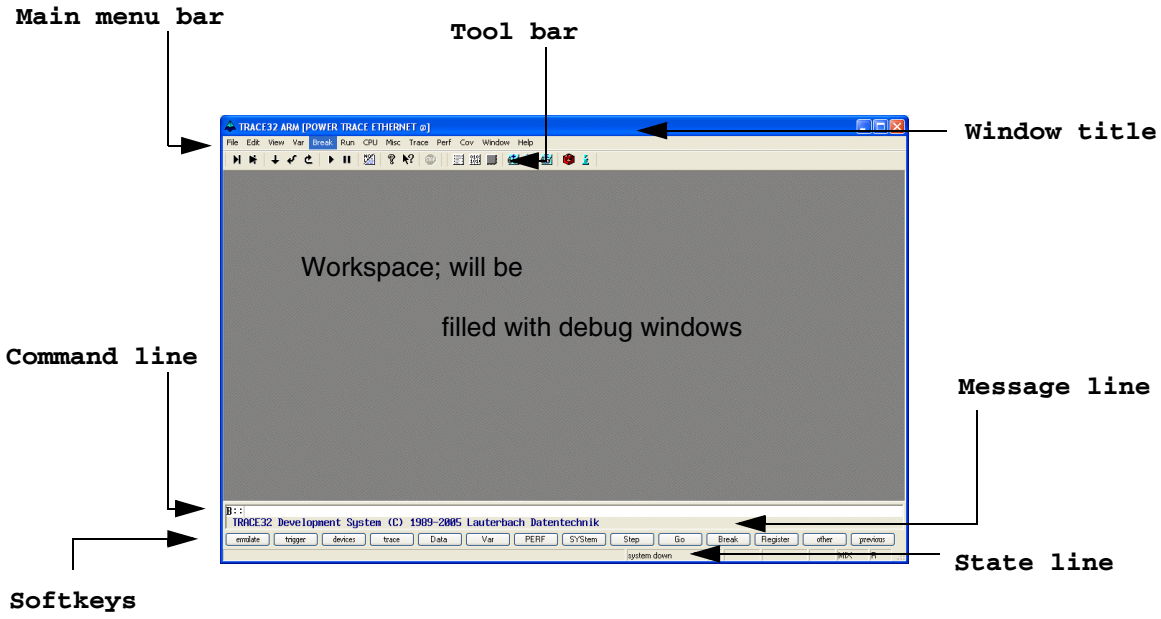
	Take care of the proper sequence on powering up/down: • Power Up: debugger - target • Power down: target - debugger

To start the debugger software on your host open the **TRACE32** folder in the start menu and start the TRACE32 user interface. If you have generated an icon on your desktop, double click there. In the example below the software for the ARM processor family is installed.



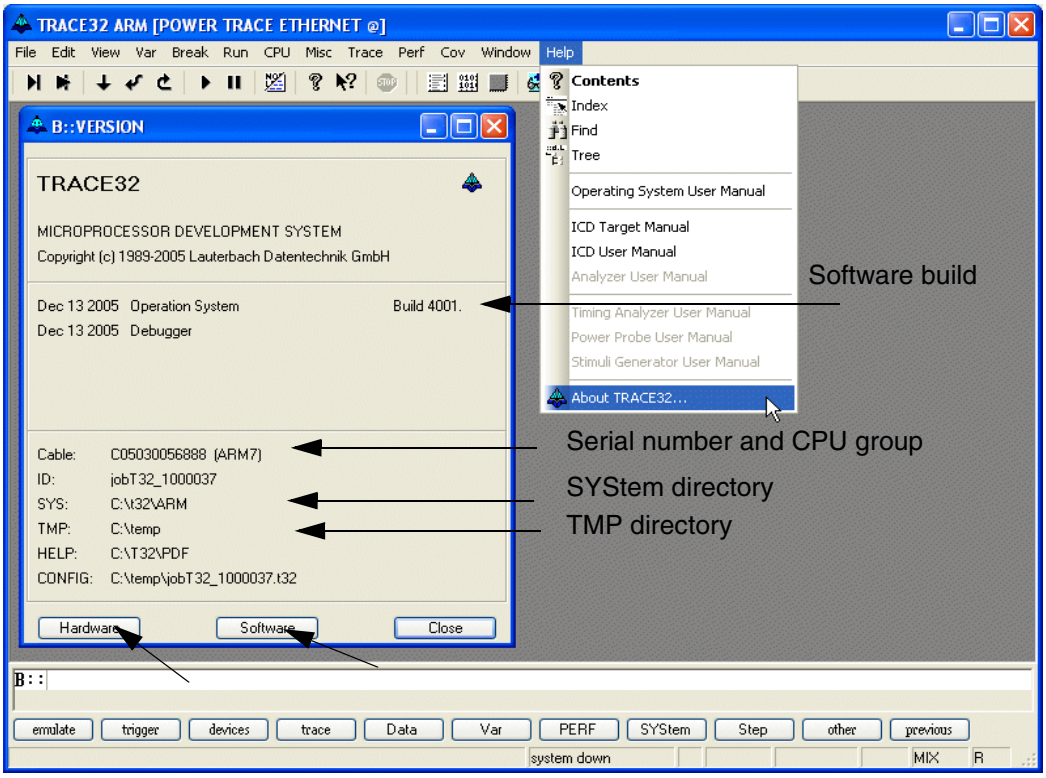
Main Window of TRACE32

After starting TRACE32 the main window of the debugger is presented:



The TRACE32 is up and running now.

The ***About TRACE32…*** command in the ***Help*** menu provides version information for all parts of TRACE32-ICD.



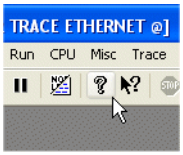
Pushing the buttons "***Hardware***" or "***Software***" at the bottom of the window will display further information about the installed debugging hardware and software and should be known, if support is needed. You will also see, the program environment as set up in accordance with **Set up the Program Environment.**

Getting Online Help

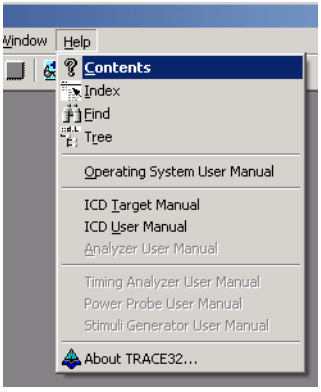
The online help system consists of several documents. They are accessible as PDF-files directly from the TRACE32 software and can be found in the HELP-directory. The specific information for the CPU is placed in den files debugger_*<architecture>*.PDF.

There are different ways to open the TRACE32 online help:

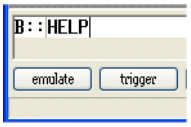
- **Help Topics** button on the toolbar
- **Help** menu **> Contents**
- **HELP** command in the command line



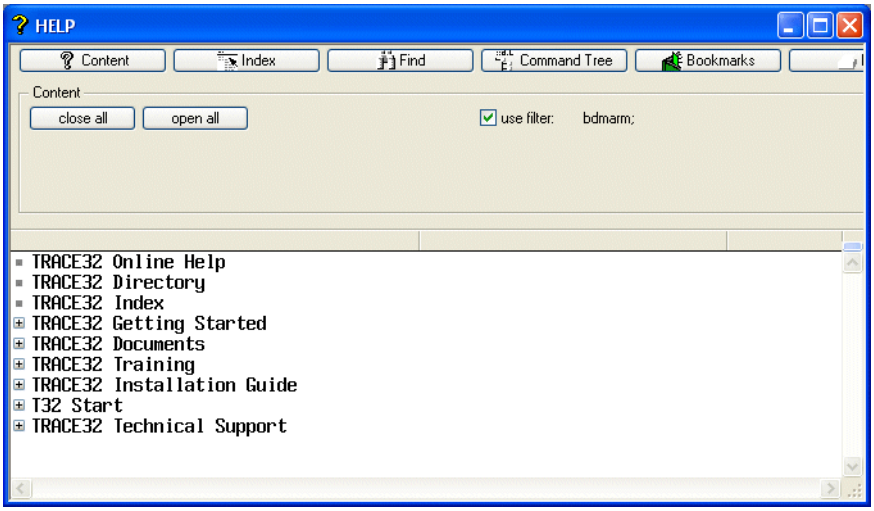
help button in toolbar



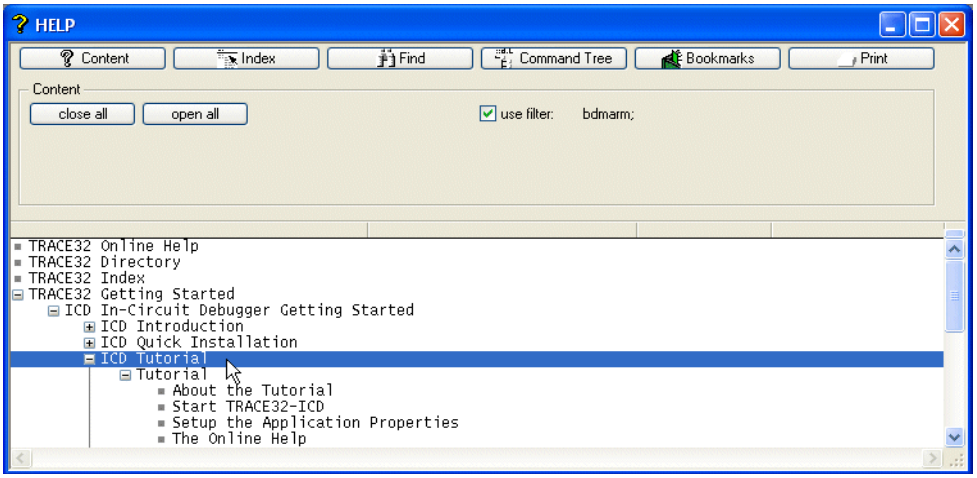
help menu in menu bar



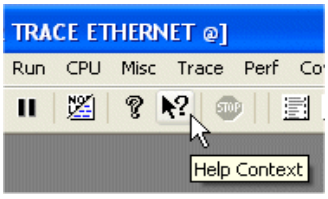
help command
entered in command line



The help system is organized in a multilevel structured way. The screen below shows how to find this tutorial.

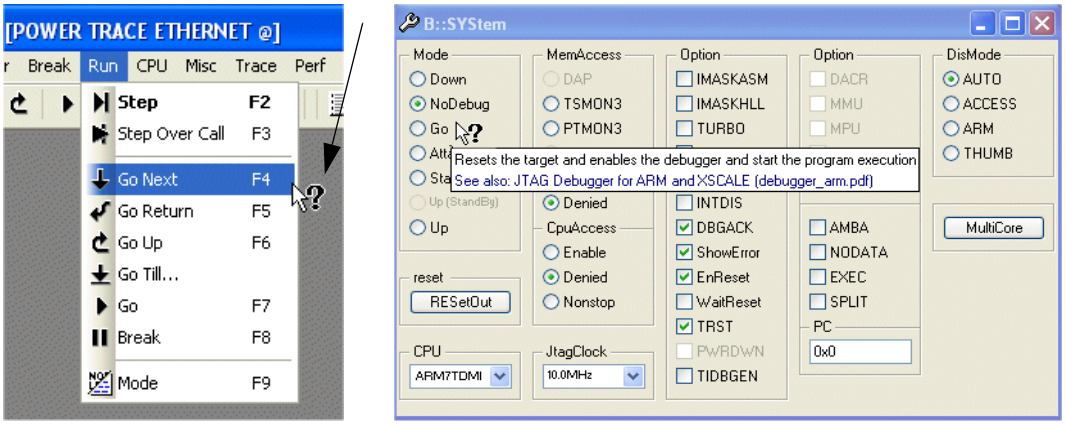


Besides that structured help, organized in several books, there is also a powerful context sensitive help. It provides help information about a specific program issue. Accessing the context help is a two step process. First activate the context help by pressing the following button:



Use the ***Help Context*** button on the tool bar to activate the context sensitive help

The cursor will change to a question mark after pressing the button. Now move the cursor on the topic you are interested in. A popup window is opened to display information about this object.



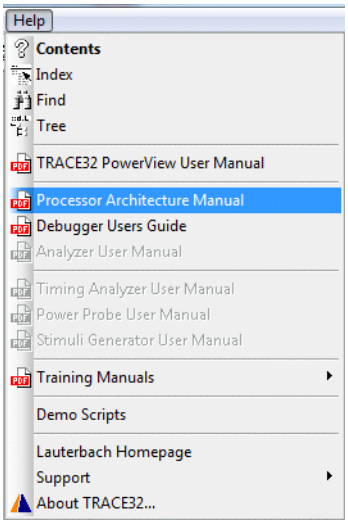
Like the command **Go** with a temporary breakpoint set to the next assembler command or next HLL line. This command can be used to overstep a subroutine call instruction or to leave a loop. See also the command **Step.Over**.

See also Go.Next Continue program

Set up the Debug Environment

In order to set up your debugger, you need some knowledge about your CPU and your target configuration. To be able to download your program to the target hardware, including all symbol and debug information, you also need some knowledge about your compiler.

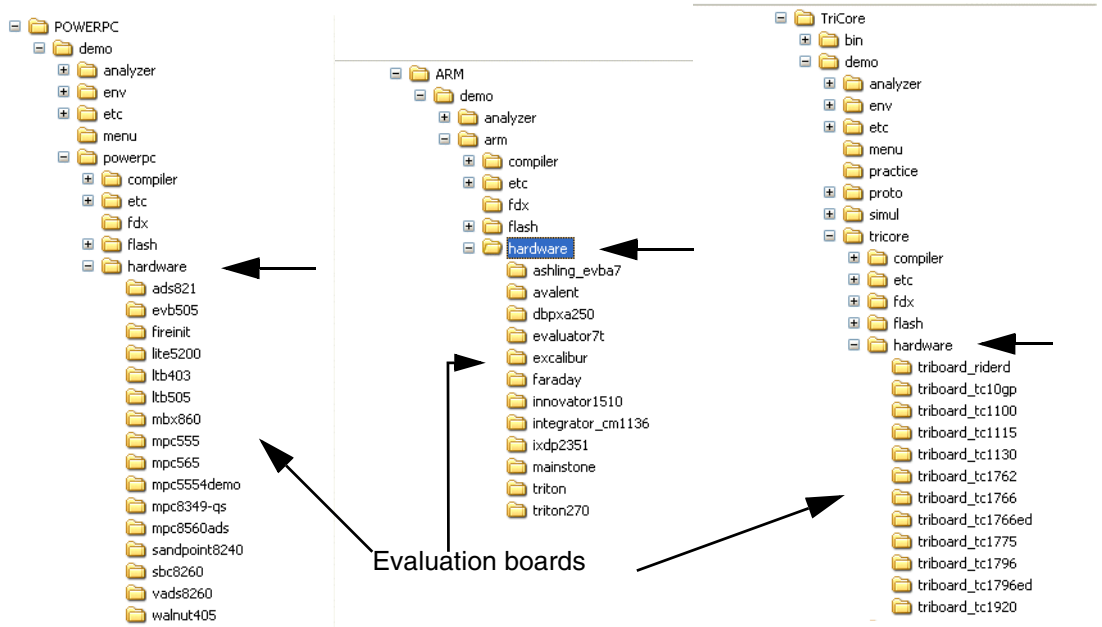
A basic start-up procedure and the CPU specific setting for the ICD-Debuggers are described in the **Processor Architecture Manual**. The following command will display it:



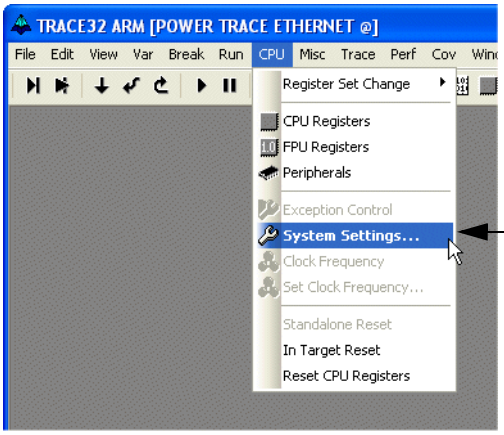
Processor Architecture Manual gives a quick access to the settings and additional features for your CPU

Besides this CPU specific commands all generic debugger commands are described in the ***Reference ICE/FIRE/ICD*** manual.

If you are using an evaluation board you may find the configuration in the ~~/demo directory. The following screen shows some examples for the Power PC, ARM, and TriCore.

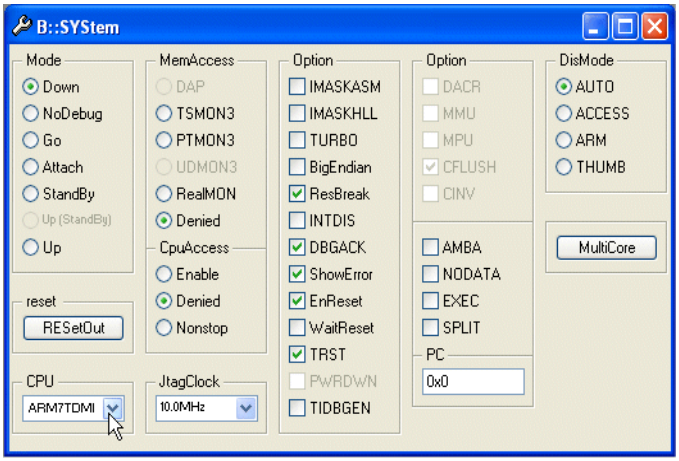


The next steps will describe a typical start-up procedure for the debugger. To demonstrate the steps needed, we will do a manual setup. Later on we will show a much faster way and use PRACTICE scripts (*.cmm) instead. The ***SYStem*** Window provides all CPU specific settings. Use one of the following ways to open the ***System Settings*** dialog:



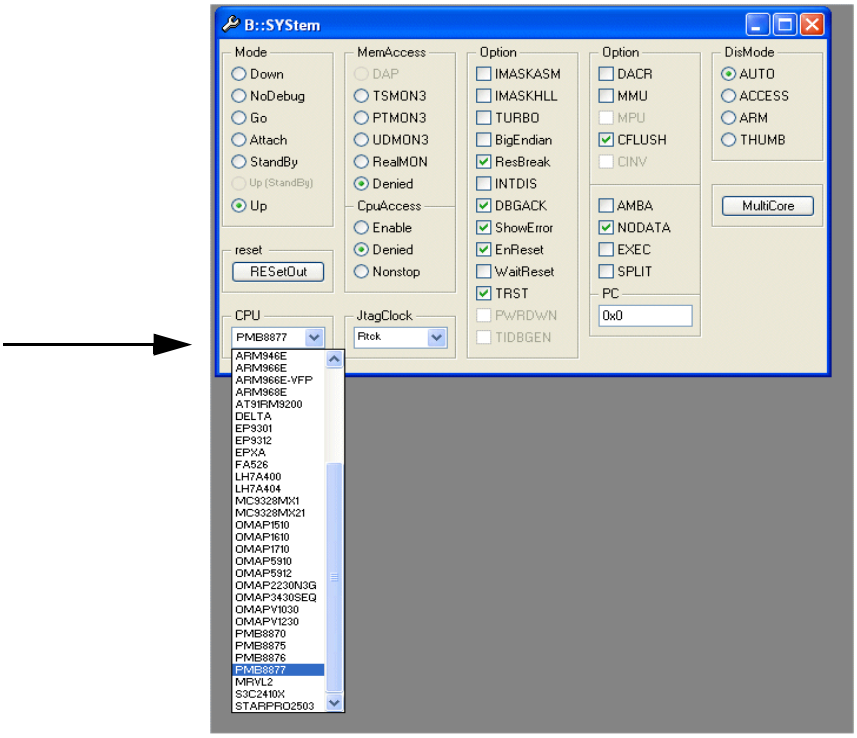
To open System settings dialog

CPUs are grouped (e.g. ARM, TriCore or Power PC).The SYStem window will show all parameters which are specific for the CPU group given. It will have different parameters for different CPU's. Below you will see the SYSTem window for the ARM family.



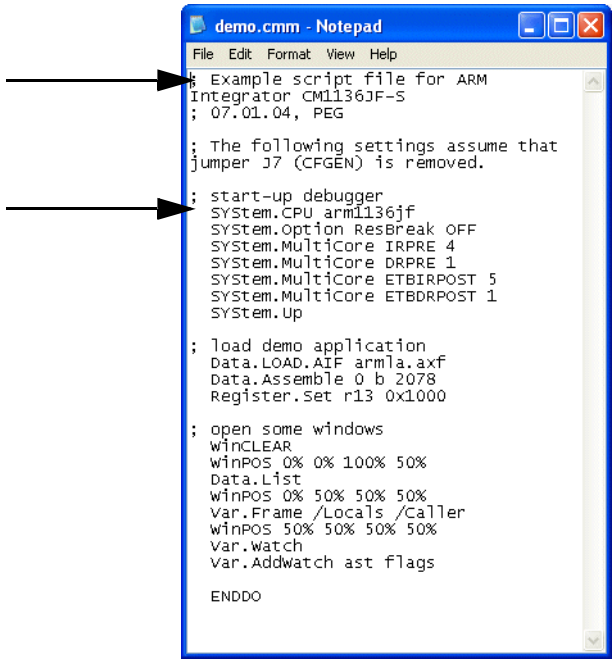
1. Inform TRACE32 about the CPU type on your target device, if an automatic detection of the CPU is not possible. Select the correct CPU type from the drop down list box ***CPU*** in the SYStem window.

   (Alternatively you may use the following command: **`SYStem.CPU <CPU type>`**)



Normally all further options are already set for a standard configuration. in the ~~/demo directory, which comes with the installation of TRACE32, you may find examples of the system configuration parameters.

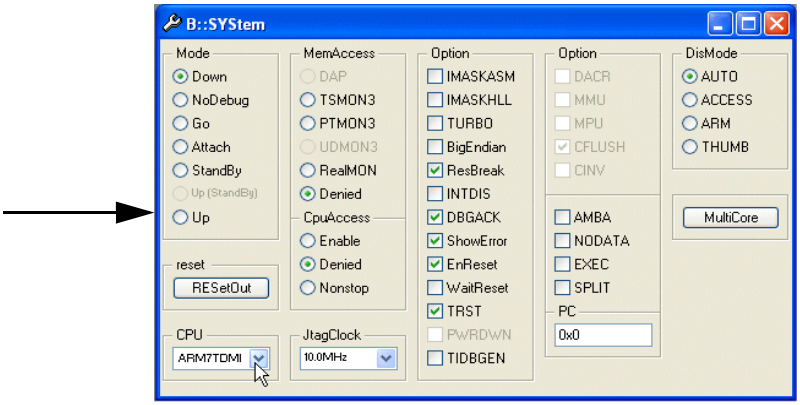
Select CPU type



2. Do initial startup and enter the debug mode.

   Select the ***Up*** button in the ***Mode*** section of the ***SYStem*** window to restart the CPU with debug mode enable.
   (Command: **`SYStem.Up`**)

   Now TRACE32 establishes the communication to the target´s microprocessor. It does a reset of the target CPU, brings the CPU to debug mode and stops it at the reset vector. If you get an error refer to the **Processor Architecture Manual**. If everything gets o.k. you should be able to access to target, e.g. it´s CPU and memory.

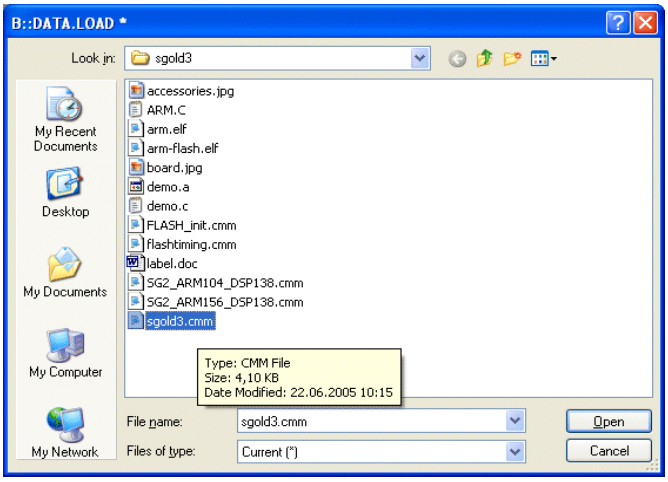


3. Do the target specific settings.

   The CPU is active, but stopped. Registers are set to default values. In the next steps we will configure the memory. This is done by writing to the special function registers using the **PER.Set** command. E. g. some CPUs need to set the chip selects in order to access memory. If you are using an evaluation board, the firmware in the board may also do the initialization of the board.

4. Download the application into the target. The next step is to download your application into the target memory. Because memory access at this point is very CPU-specific, please make sure, that your system is able to access the memory at this moment. In order to verify that, try to change the memory contents as done by the **Data.Set** command.

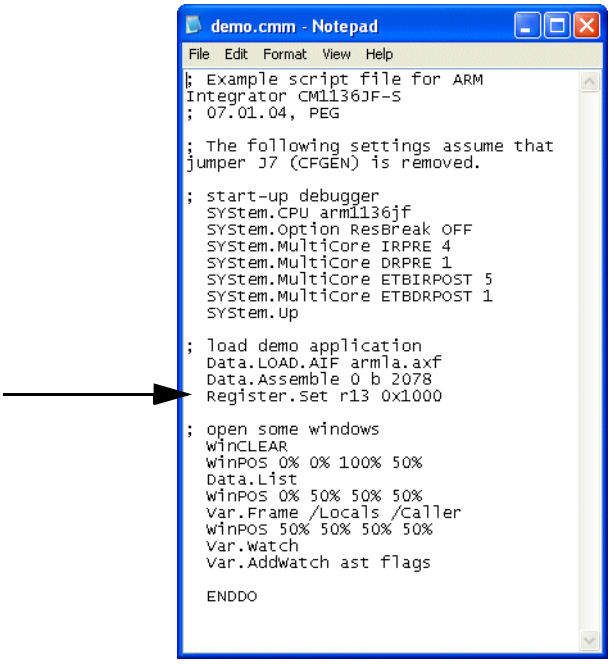
   Load your application by using the **Data.LOAD**-command (**Data.LOAD.<option> <file_name>**). The option required for your compiler can be found in the **Processor Architecture Manual** in the section ***Support / Compilers***. Alternatively you may use Data.LOAD * and select the file in the following window:



For flash programming refer to the **FLASH** command group and the section **TRACE32 Training / Training ICD In-Circuit Debugger / Training IDC Basics / Flash Programming**.

To display the source code the compiled program must be equipped with debug information (frequently: compiler option “debug”). Then TRACE32 can load the compiler output formats directly.

5. Initialize program counter and stack pointer with the command **Register.Set**.
Many compilers add these settings in the startup code to the user program automatically.

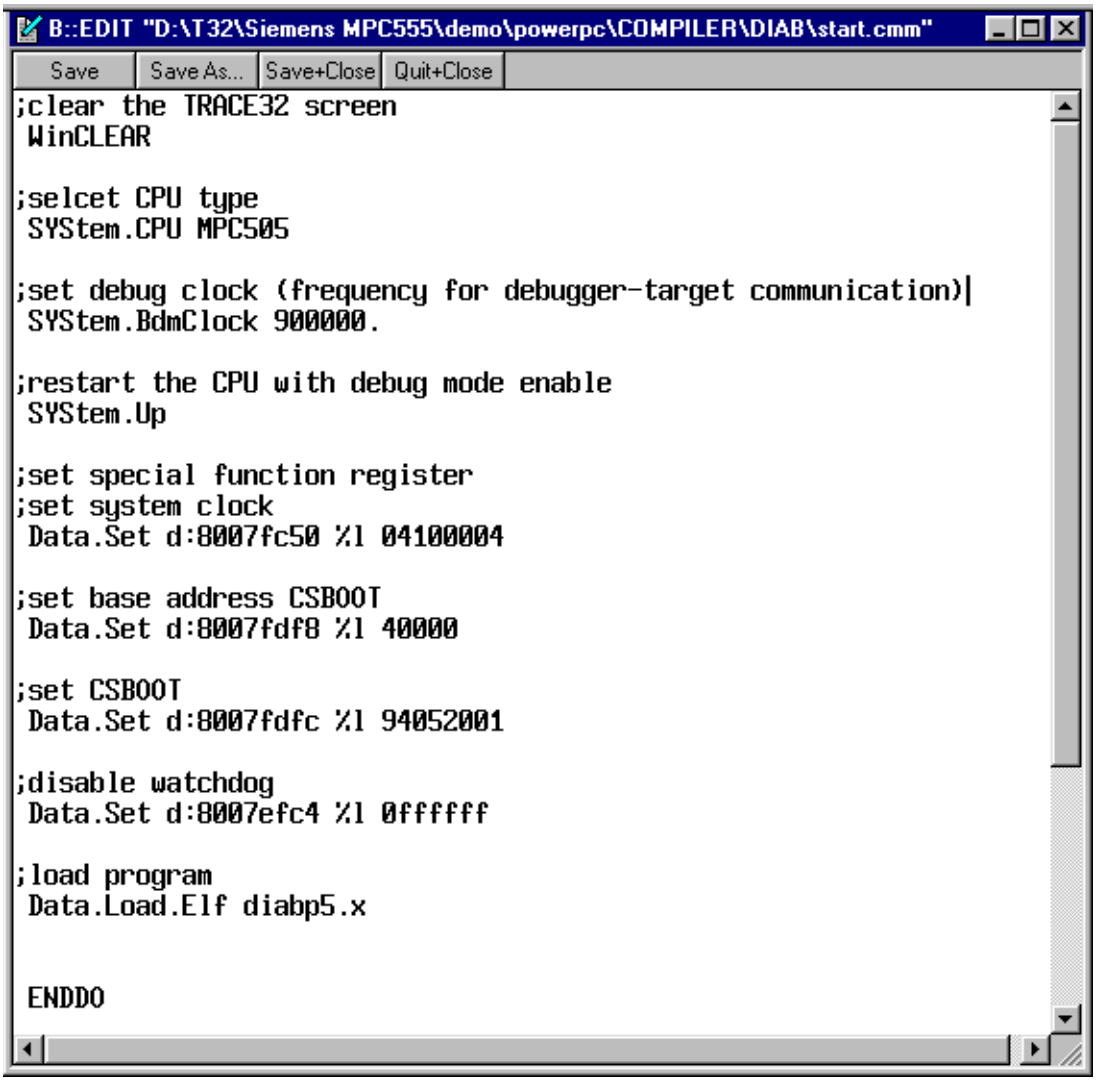


The preceding sequence demonstrated a manual setup of the debug environment. A much faster way is to use PRACTICE scripts (*.cmm) to do these steps automatically. It is recommended to write a PRACTICE script to set up the debugger to guarantee a proper start-up sequence. We will do it in the next section.

Create a new PRACTICE script file ***start.cmm*** in your working directory by using the command
PEDIT start.cmm

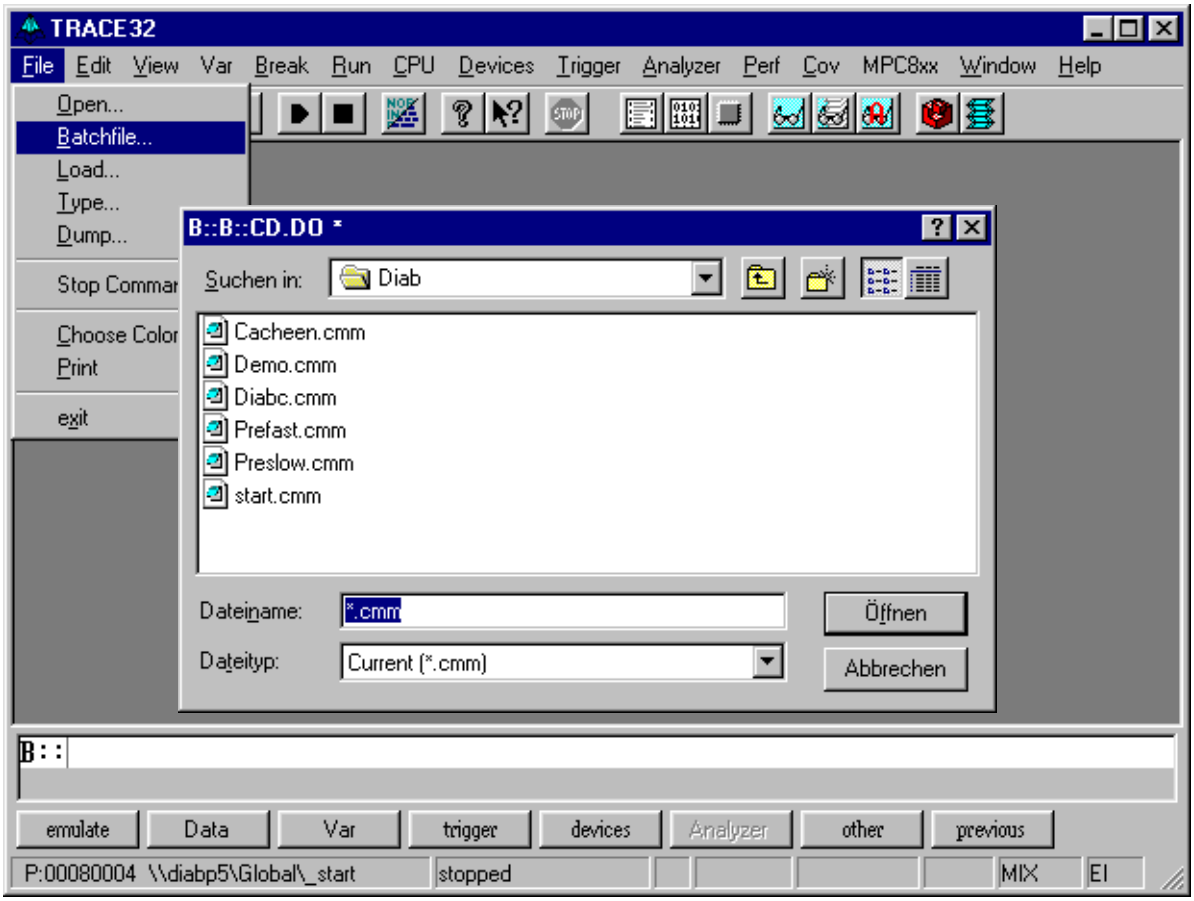
TRACE32 has its own script language. It is called PRACTICE and it is very powerful (see the **PRACTICE User's Guide** and **PRACTICE Reference** for more information). All commands of the TRACE32 development tools, commands for program flow, conditional commands and I/O commands are allowed. The default extension for PRACTICE script files is ".cmm".

Also debugging of a PRACTICE script is supported. Look at the description in the **PRACTICE User's Guide** and **PRACTICE Reference** (commands: **PLIST, PEDIT, PBREAK**).



Enter the required commands, finish the script by **ENDDO** and click the ***Save*** button. The picture above shows a start-up procedure for the PowerPC505.

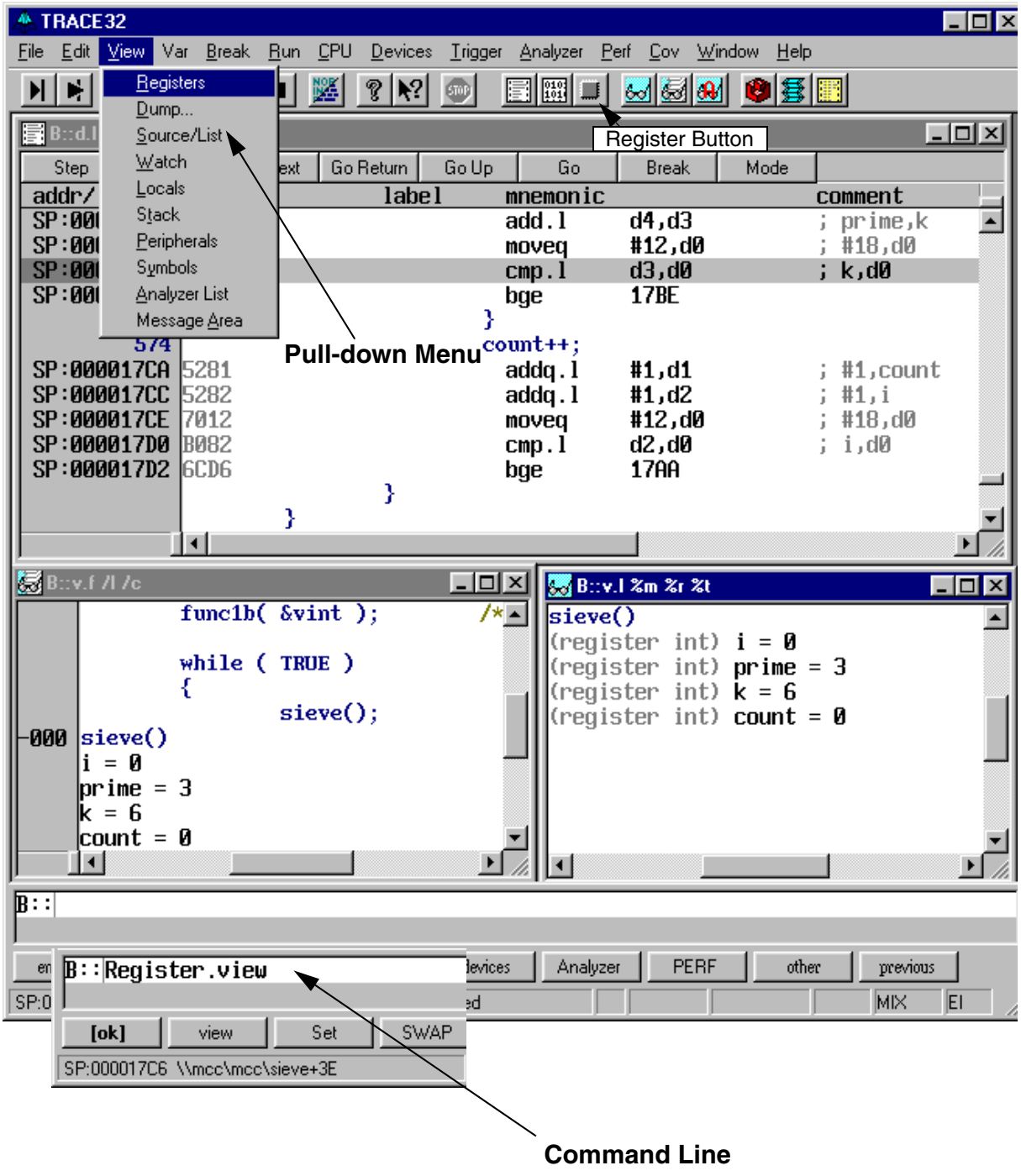
Start the startup procedure by using ***Batchfile…*** in the ***File*** pulldown menu.



To continue our tour take one of the example files you can find in the TRACE32 system directory under

~~/demo/<processor_family>/compiler/…
e.g. **~~/demo/powerpc/compiler/diab/diabc.cmm**.

or use your own PRACTICE script file, if you have already prepared one.

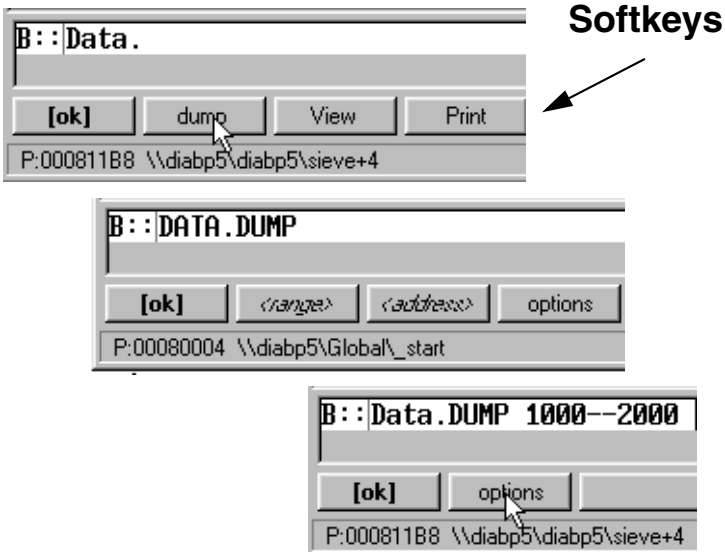


Open a window to display the CPU registers. You can alternatively select ***Registers*** from the ***View*** pull-down menu, push the ***Register*** button or enter **`Register.view`** at the prompt **`B::`** in the command line.

Most features can alternatively be selected from a pull-down menu, from a button in the main tool bar or from the command line. Please remember this even if we use just one way in the following chapters.

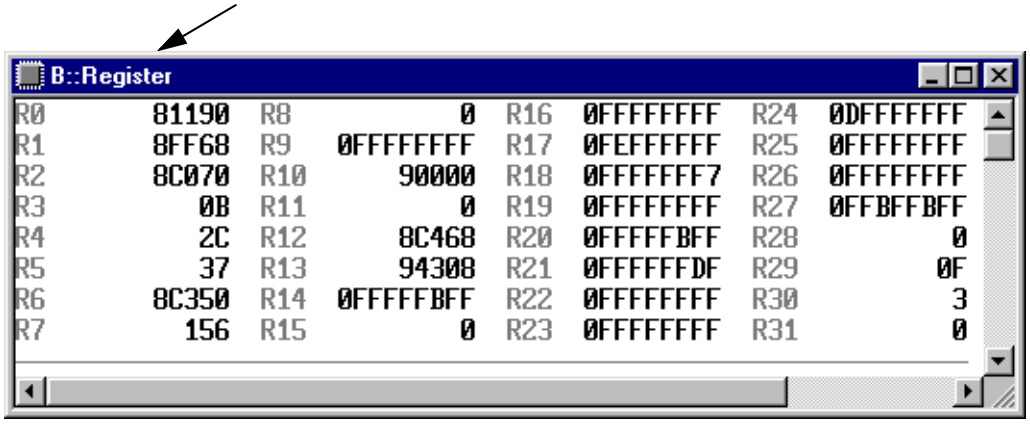
The TRACE32 commands are not case sensitive. In the TRACE32 books we use upper case letters for the characters that are significant for the command entry. E.g. `Register.view` can be shortened by `r`.
Another example which shows the typical TRACE32 command structure
`<command group>.<subcommand>` is `Data.List` that can be shortened to `d.l`.

A good hint is to look at the softkeys. They provide a guided command entry. All possible commands and parameters are displayed. Instead of writing to the command line you can assemble the correct command by clicking on the softkeys.
Example: Assembly of the `Data dump` command by using the softkeys.



More detailed information about the TRACE32 user interface can be found in the **Operating System User's Guide**.

In the window header the TRACE32 command that was executed to open the window is displayed.

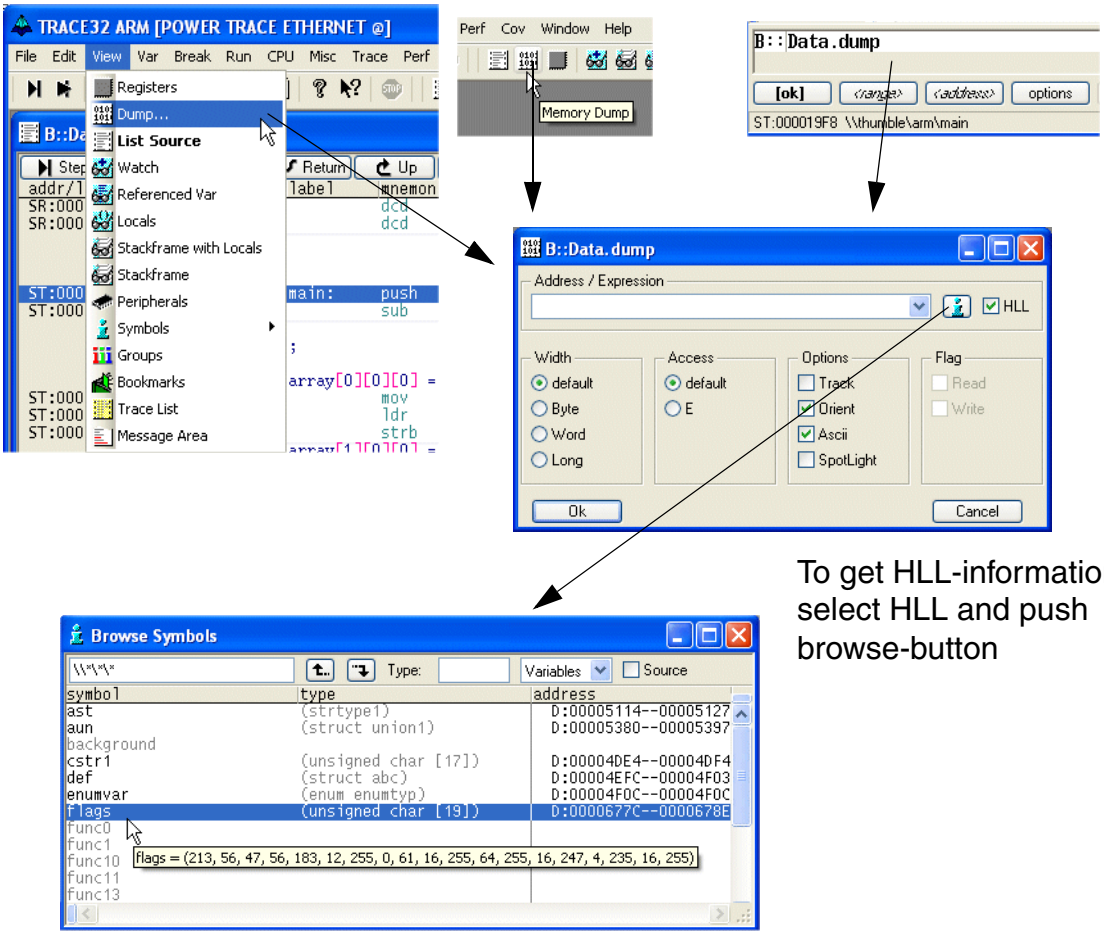


Display and Modify Memory

To inspect an address range in the memory use the **Data.dump** window as seen in the previous section. Type in the command data.dump *<address_range>* or select :

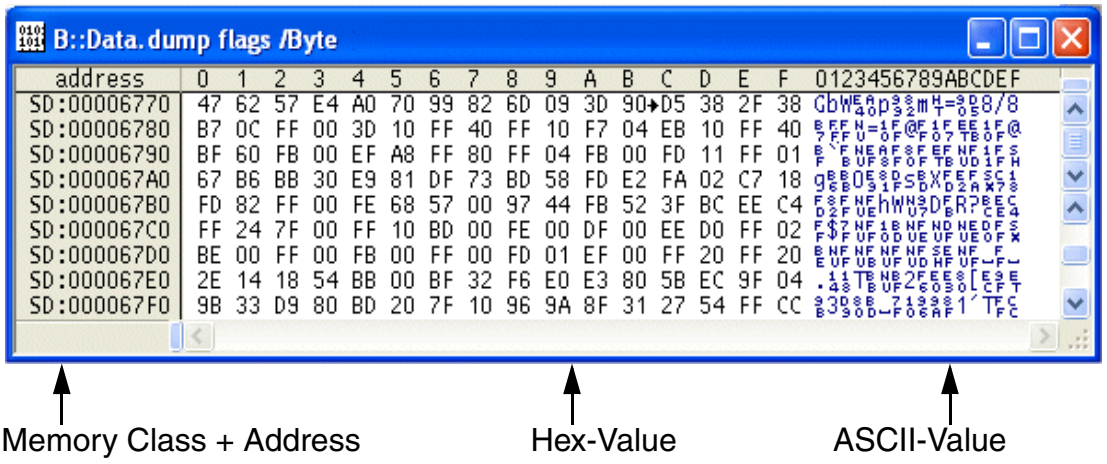
- ***Select Dump…*** from the ***View*** menu.
- Push the icon in the toolbar.
- Type in the command ***Data.dump.***

Next a dialog will be opened. Fill in data item to display in the following dialog box. Use the ***Browse*** button to browse through the symbol database. Select a label by a double-click and then confirm by pushing ***OK***. If using the command in the command line, you may also specify an address or symbol directly.



The data will be displayed in a dedicated window.

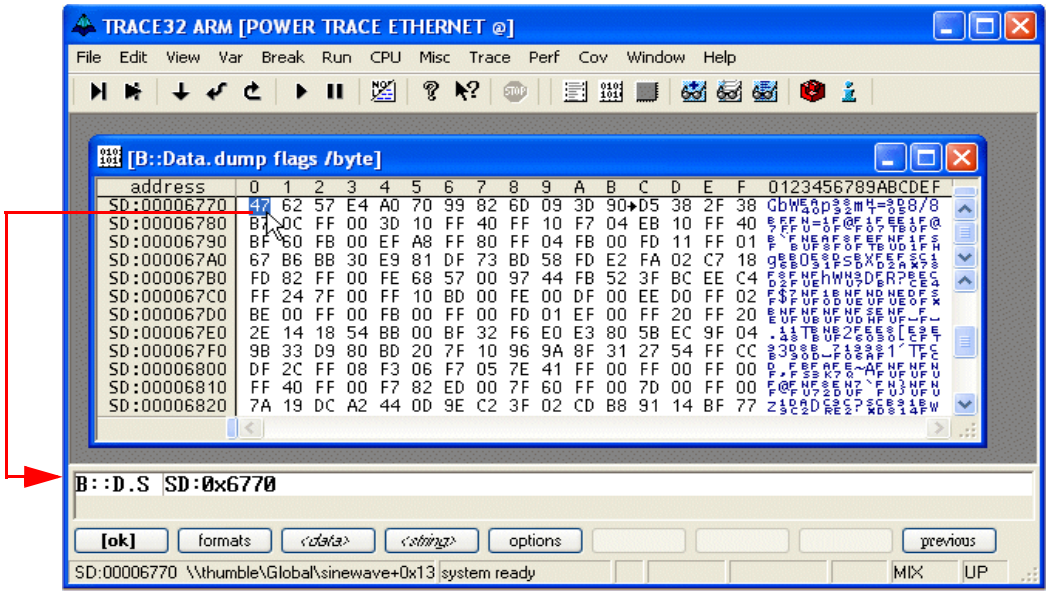
In the following screenshot it was called by a command in the command line.



There are different display options and ways to define an address range:

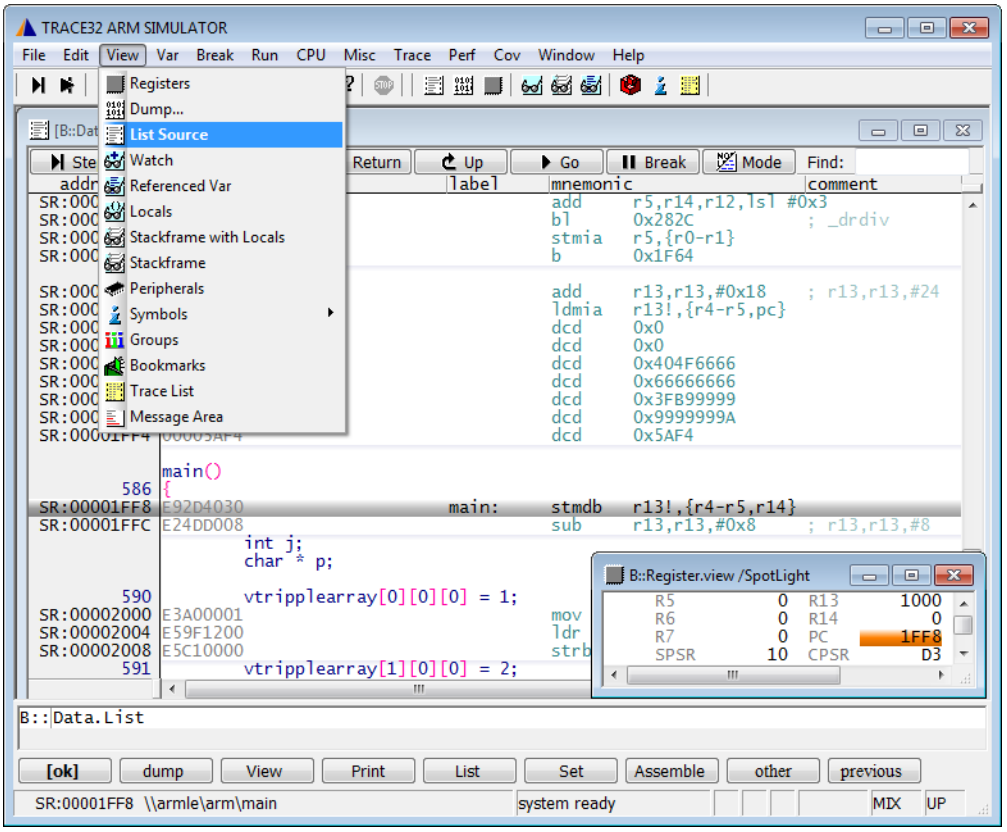
- *<start_address>--<end_address>*
- *<start_address>++<offset>*

The value at a memory address can be modified by a double click. A **Data.Set** command for the selected address is displayed in the command line. Enter the new value and confirm it with return.



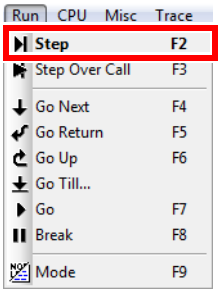
1. Choose **View** menu > **List Source** to open the **Data.List** window.

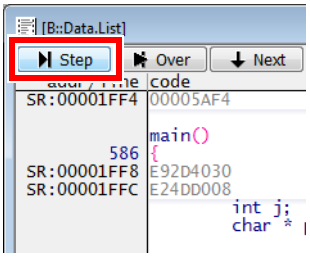
   The program listing around the program counter is displayed.



2. Single step through the program by doing one of the following:

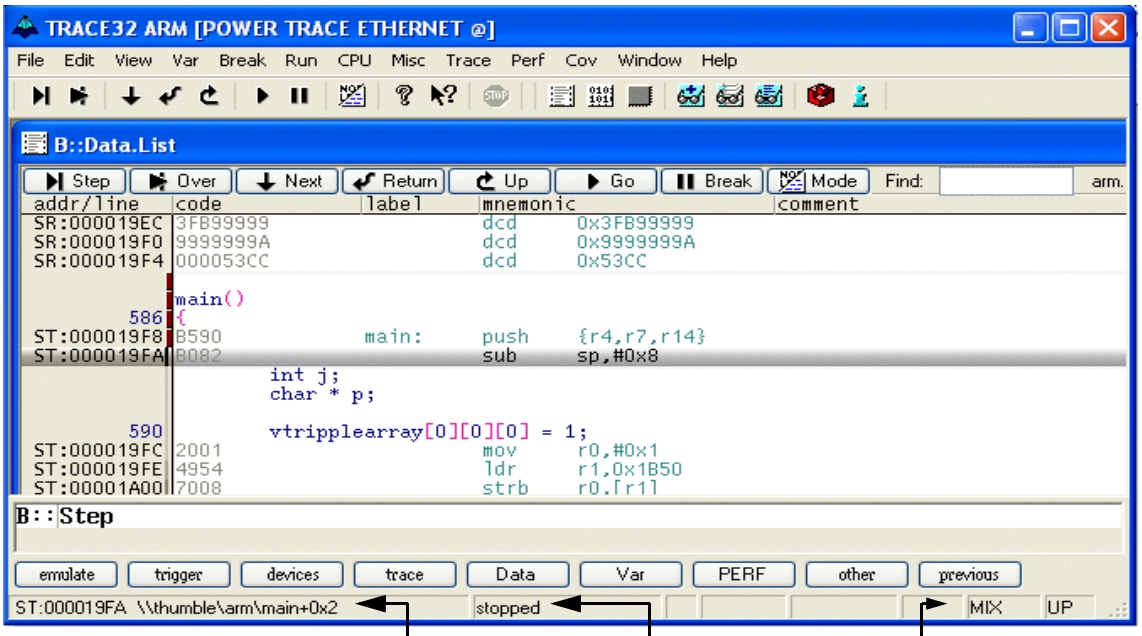
   - Choose **Run** menu > **Step**.
   - Press **F2** (as noted next to the **Step** option in the **Run** menu).
   - Click the **Step** icon on the toolbar.
   - Click the **Step** button in the **Data.List** window.
   - At the TRACE32 command line, type: **`Step`**





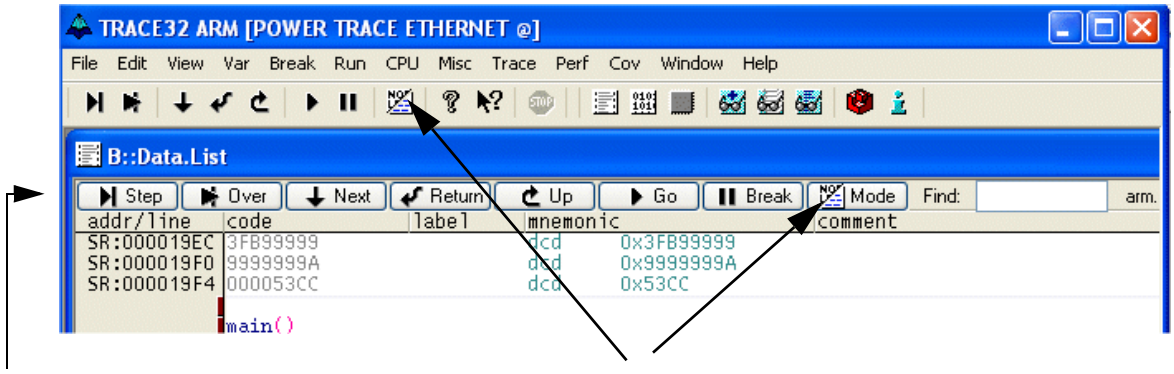
Now have a look at the state line: The address of the current cursor position (gray bar in active window) is displayed there.

The next field displays the state of the debugger: **stopped** means your application program is stopped. You can now for example inspect or change memory.



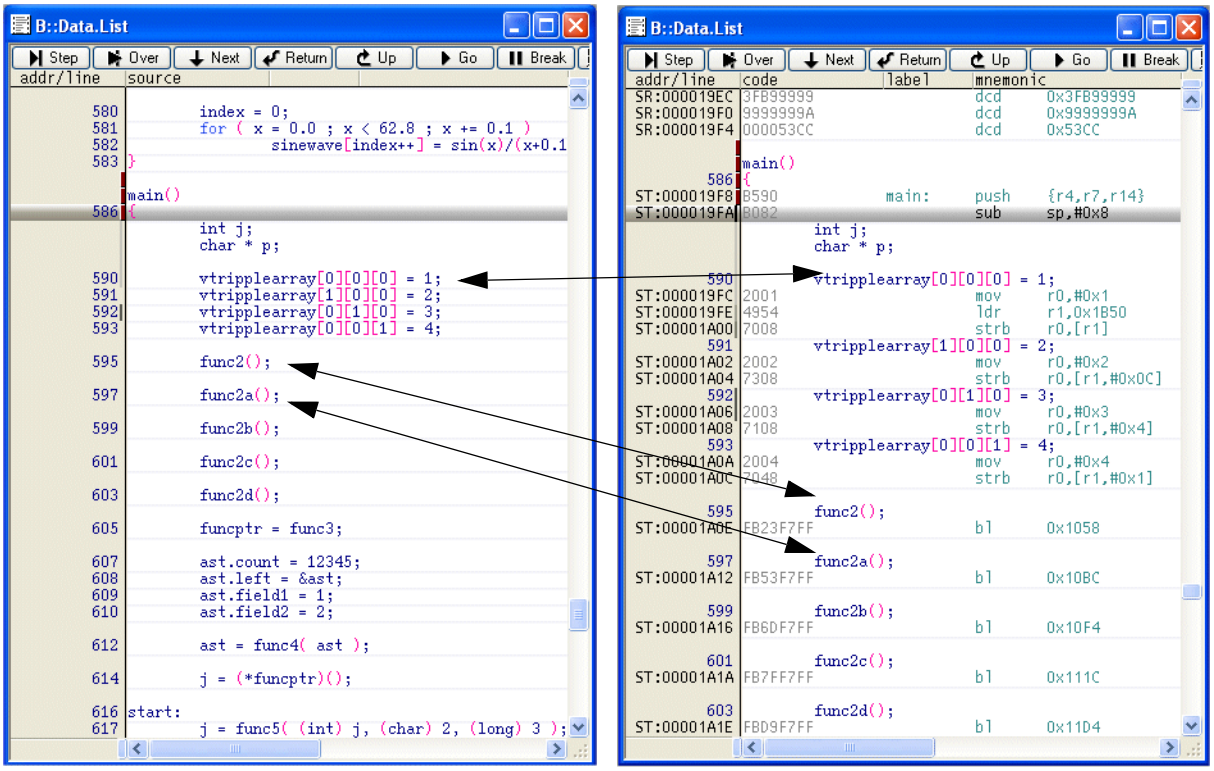
(symbolic) address at the cursor position **state of debugger** **debug mode**

Depending on the startup script which was used, the display of the code will be either HLL (High Level Language) only or a MIXed mode with HLL and it's corresponding assembler mnemonic. The debug mode field in the state line indicates, which mode is used. Pushing the mode button on top of the Data List windows will change to HLL or MIXed and vice versa. The state line always shows the debug mode.

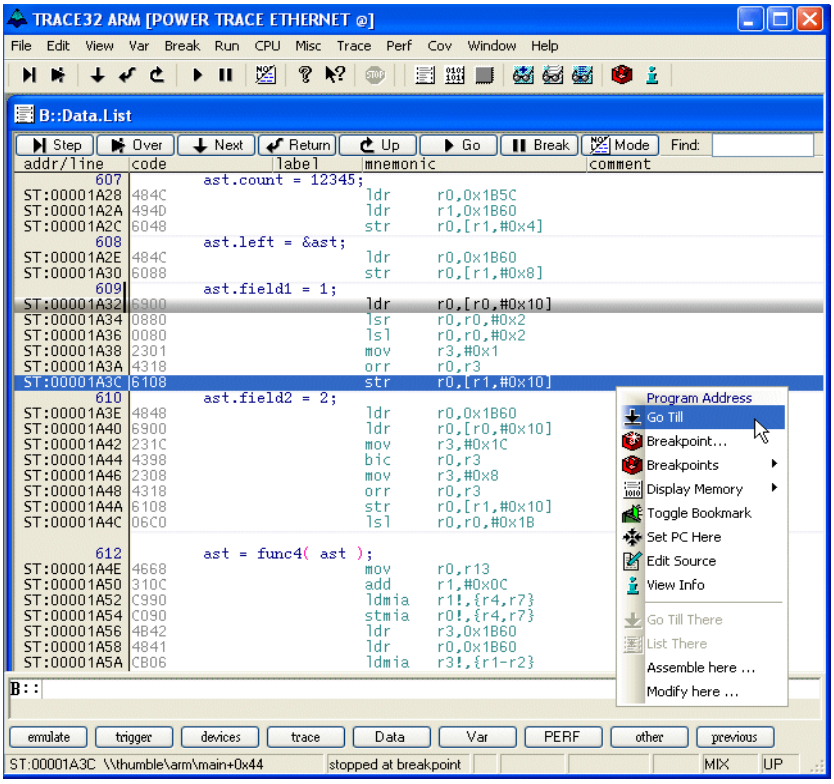


Local buttons for the Data.List window Toggle debug mode

Button to toggle between MIXed and HLL mode

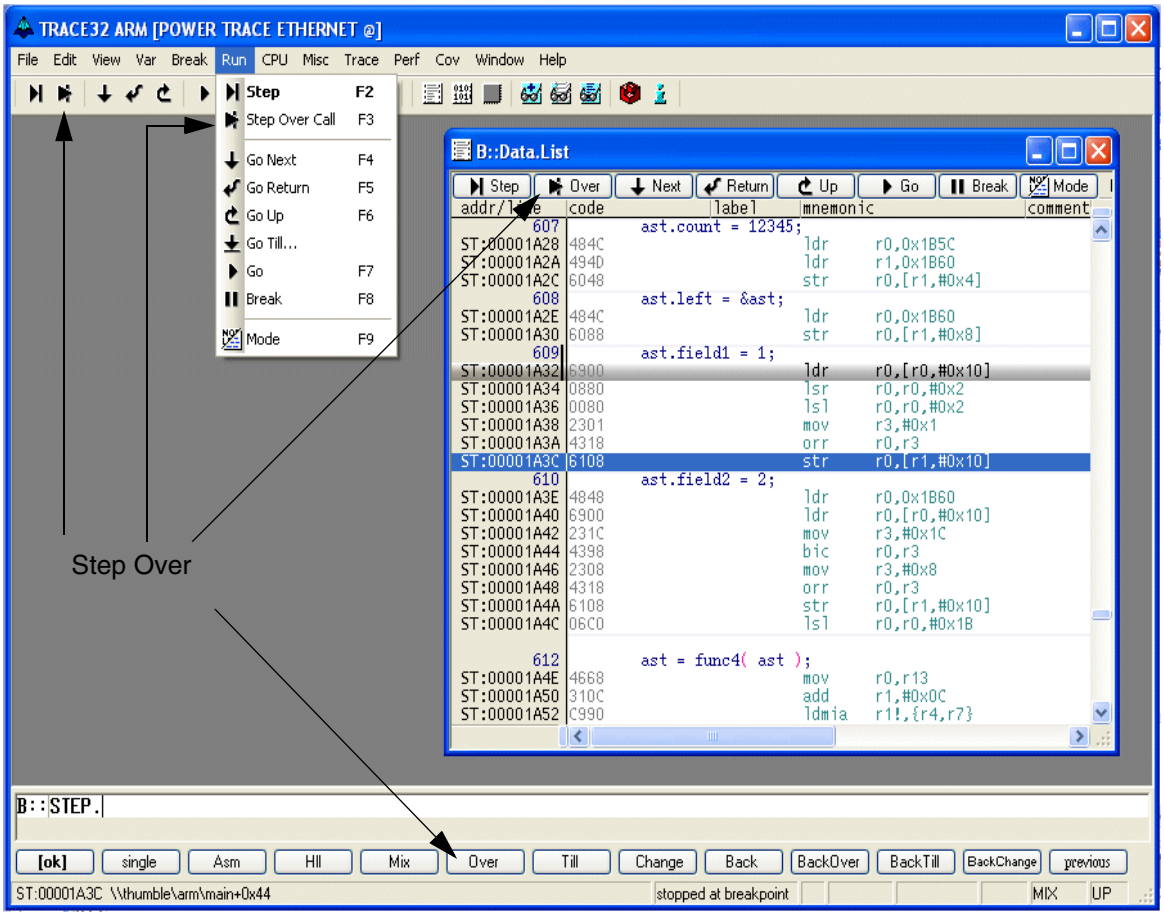


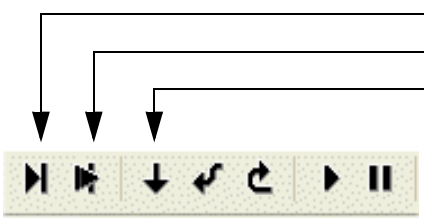
Toggle the debug mode to **HLL** and do another ***Step***. The step you did was a high level language step to the next HLL line. If you switch to MIX mode and push the step key, it will execute one assembler line.



Select a code line and press the right mouse button. If you select ***Go Till*** the program execution is started. It stops when the program reaches the selected code line.

Single Stepping is one of the basic debugging commands. Look at the ***Run*** pull-down menu, at the local buttons of the ***Data.List*** window or at the main tool bar for the other debug commands.





Single Step

Step over function call or subroutines.

Go to the next code line written in the program listing. Useful e.g. to leave loops of a function.

Break / Stop realtime execution

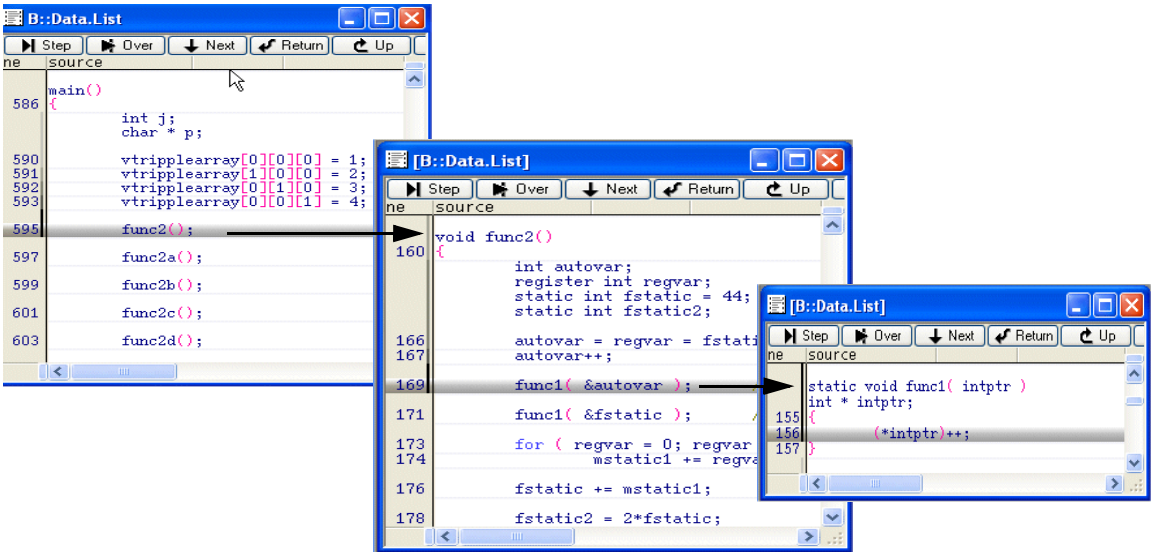
Go / Start realtime execution

Go Up / return to the caller function

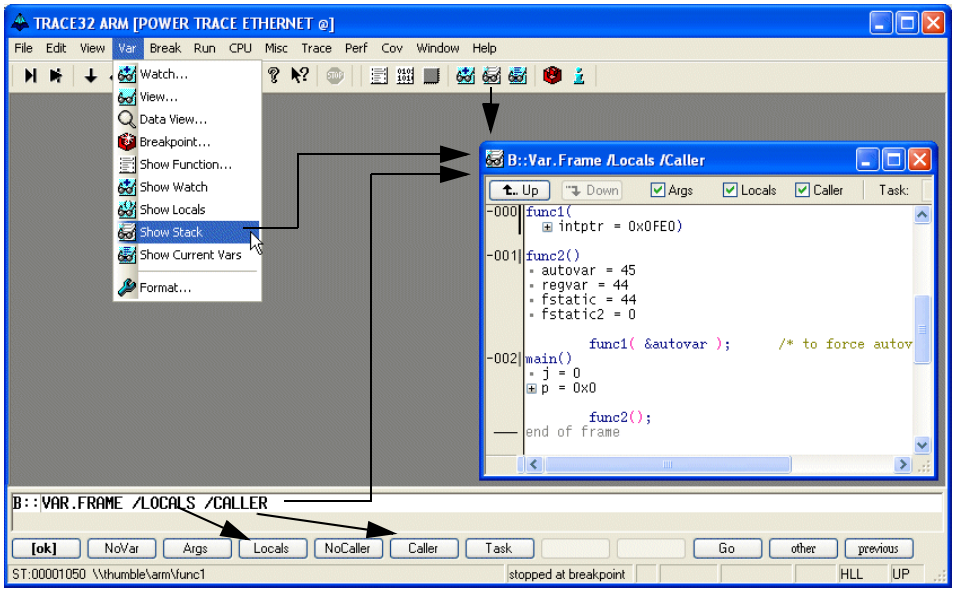
Go Return / Go to the last instruction

The commands Go Next, Go Return and Go Up are only available if the program is running in RAM or if the CPU provides on-chip breakpoints.

For the following example, assume we have a nesting of functions where main calls func2() and func2 calls func1().



The **Var.Frame** window displays the function nesting for your application program. With the option LOCAL the local variables of each function are displayed. When the option CALLER is set, a few lines from the C-code are displayed to indicate where the function was called. The following screen corresponds with the nesting and calling sequemce as mentioned above.



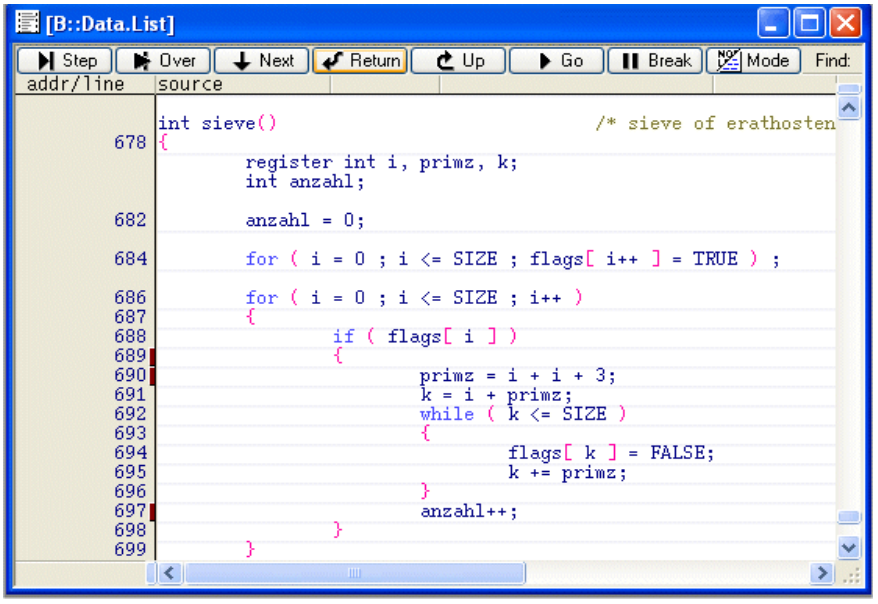
TRACE32-ICD provides also more complex debug control commands. You can run or step until an expression changes or becomes true. Example: `Var.Step.Till j>9` *single steps the program until the variable j becomes greater than 9. More detailed information can be found in the* ***Reference ICE/FIRE/ICD*** *book at the description of the commands* **Step.Change, Step.Till**, **Go.Change**, **Go.Till**, **Var.Step.Change**, **Var.Step.Till**, **Var.Go.Change** *and* **Var.Go.Till**.

Software Breakpoints

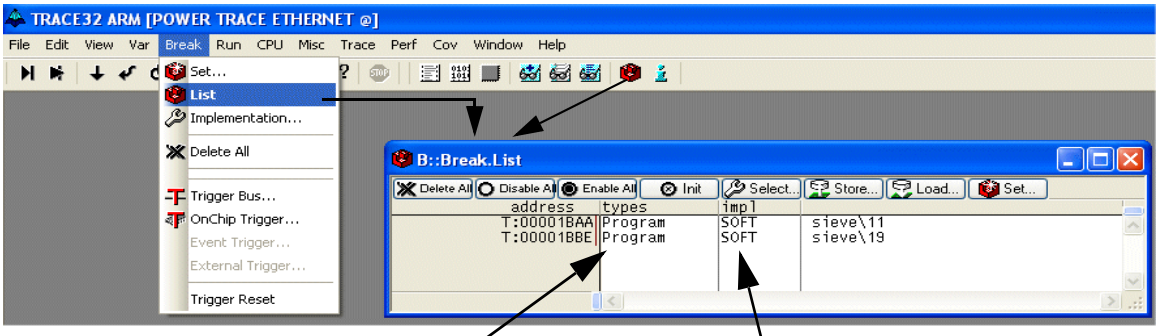
The ICD debugger use software breakpoints by default. When a software breakpoint is set to an instruction, the code at this address is replaced by a special instruction e.g. TRAP, that stops the realtime execution and returns the control to the on-chip debug system. **This method requires RAM at the break positions!** If you run your program within RAM the number of software breakpoints is unlimited.

If your program does not run in RAM, refer to **Breakpoints in ROM, FLASH or EEPROM.**

Back to the program. Double-click on the code line where you want to set a program breakpoint. Be aware to click the white space in the code line, and not the code literal. All code lines to which a program breakpoint is set are marked with a small red bar.



Use ***List*** from the ***Breakpoint*** menu to display the information about all breakpoints.



Breakpoint type program breakpoint

Breakpoint is set as software breakpoint

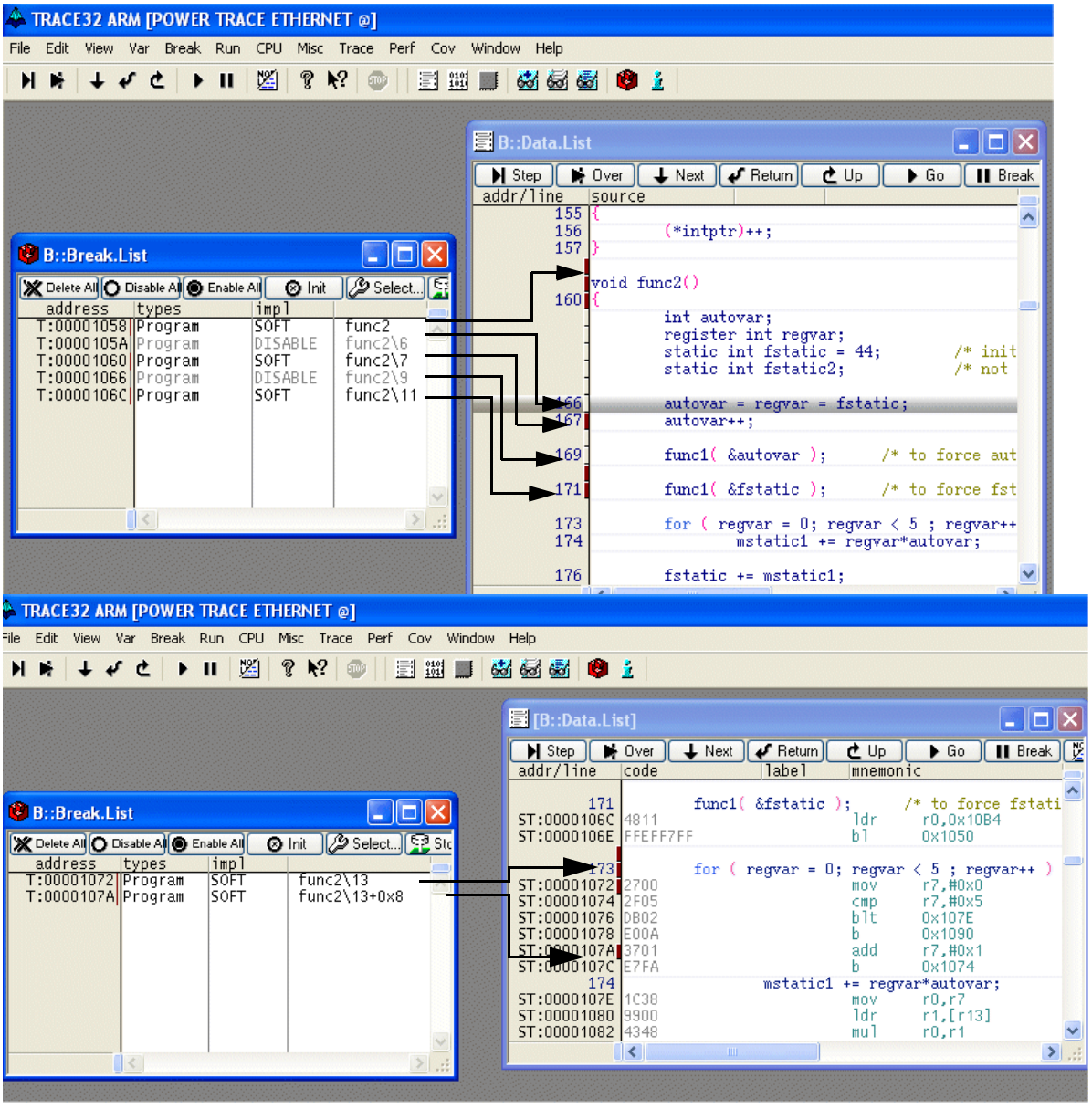
The format of the Break List is as follows

3. Column 1: hex address of breakpoint.

4. Column 2: type of the breakpoint.

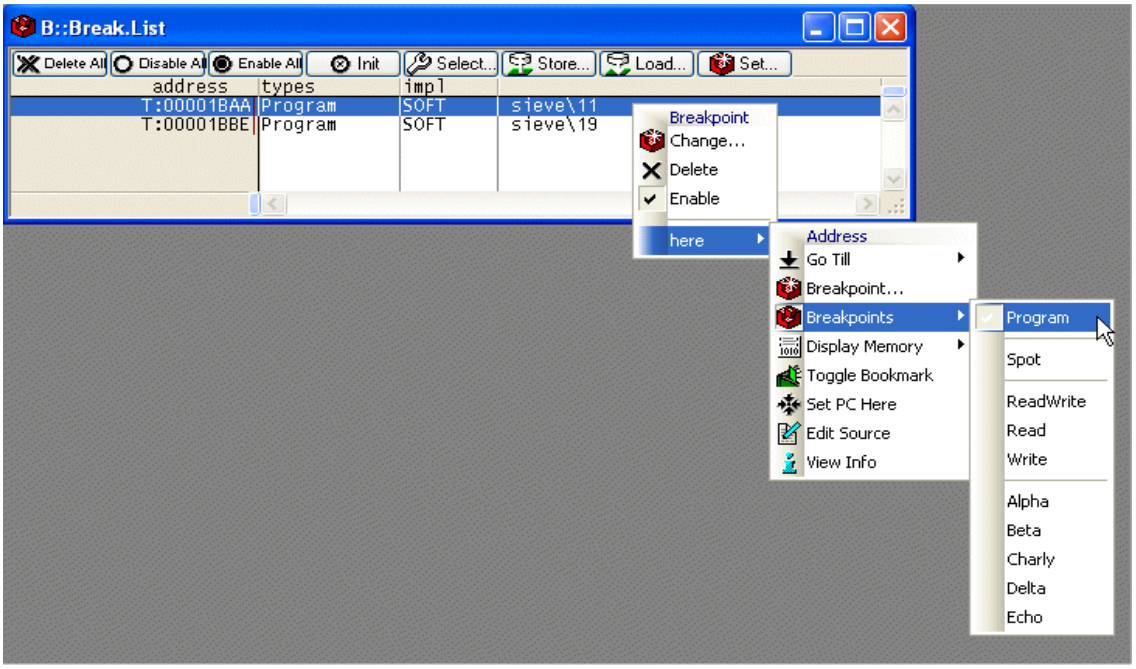
5. Column 3: indicates how breakpoint is realized - as SOFTware, ONCHIP or DISABLED. A gray bar in Data.List indicates a DISABLED breakpoint

6. Column 4: code line of breakpoint. E.g. func2\6 means HLL-line 6 in func2. func2\13+0x8 means HLL-line 13 in func2 plus 8 bytes (useful in display mode MIX only).

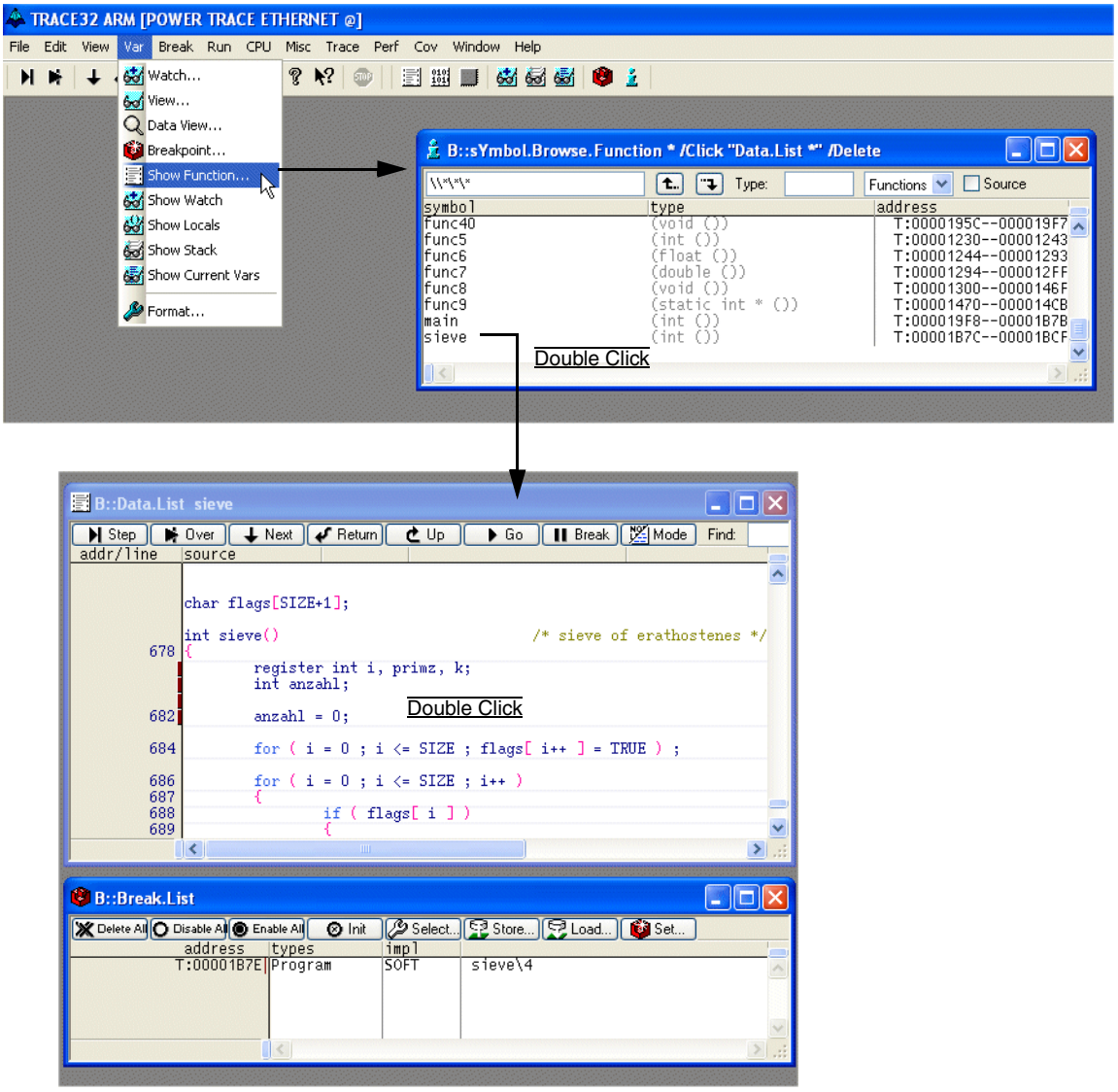


Start the program execution with ***Go***. If the program does not reach your breakpoint, you can stop the program execution with ***Break***.

You can remove the breakpoint by another double-click to the marked line or by toggling the breakpoint in the **Break.List** window.

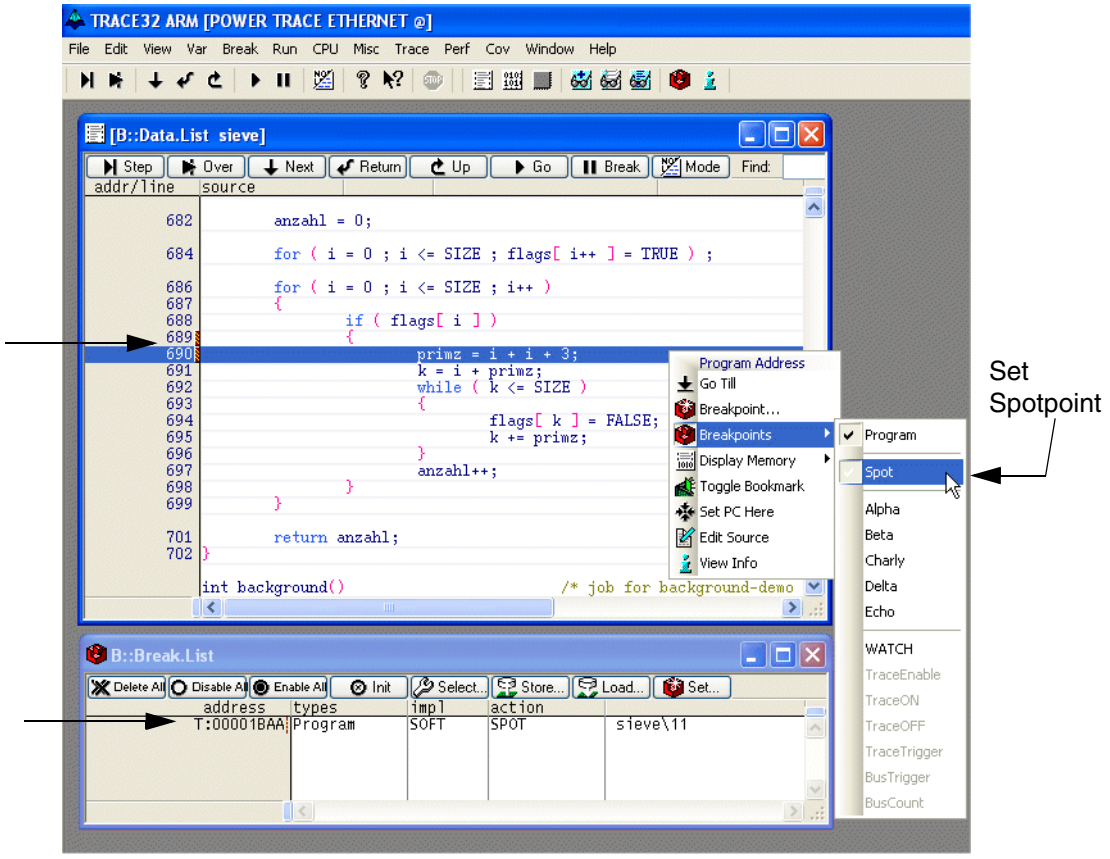


To set a program breakpoint to a code line, that is not displayed yet, select ***Show Function…*** in the ***Var*** menu. Double click the function to display it and then set the breakpoint by a double-click to the code line.

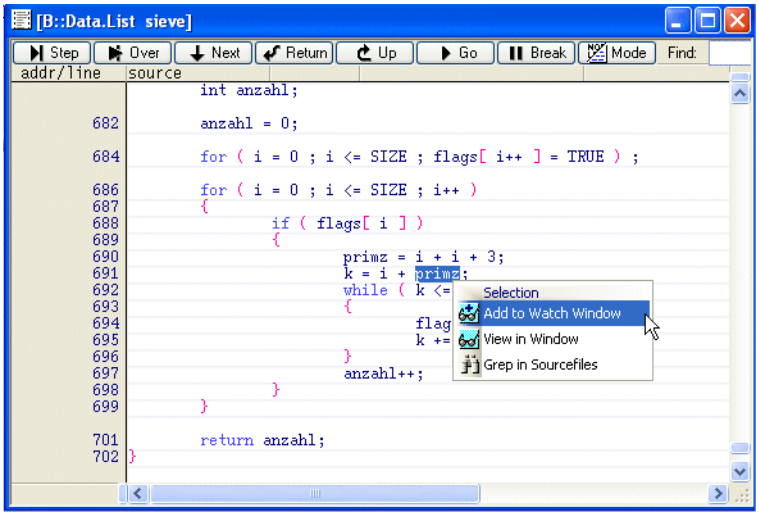


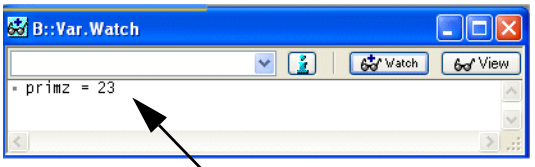
The second breakpoint type, that is available when software breakpoints are used, is a spot breakpoint. A spot breakpoint is a watchpoint, that stops the program execution for a short time to update all displayed information and then restarts the program execution.

To set a spot breakpoint, select the code line where it makes sense, that the displayed information is updated. Press the right mouse button and select ***Spotpoint*** from the pull-down menu.



To watch for example all changes on the variable primz, select the variable by the mouse, press the right mouse button and apply ***Add to Watch Window*** from the pull-down menu.





If you now start the program execution with ***Go***, you can watch the changes on the variable primz.

Most processor types (not 6833x and 6834x) provide a small number of on-chip breakpoints. These breakpoints are used by TRACE32-ICD to set program or spot breakpoints even if the program doesn't run in RAM.

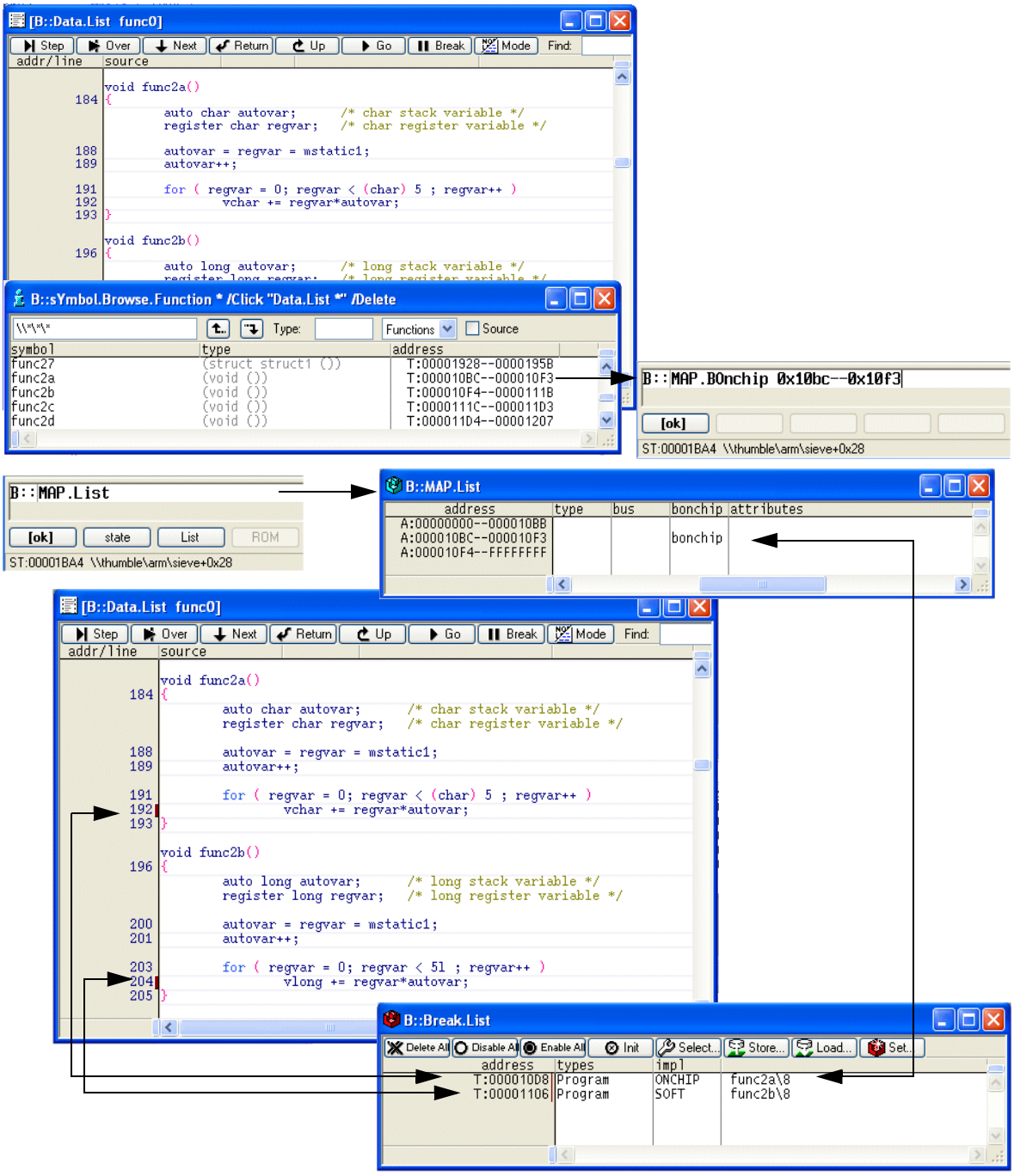
Since the debugger uses software breakpoints by default, you must inform the debugger that the on-chip breakpoints should be used!

```
MAP.BOnchip <address_range>
```

The command **MAP.BOnchip** indicates that whenever a program or spot breakpoint is set within the specified address range, the debugger should use an on-chip breakpoint.

In the following example we will set up an on-chip breakpoint together with a regular soft breakpoint. For the ease of the example we assume, that func2a resides in non-volatile Memory like ROM, FLASH or EEPROM and func2b stays in RAM. As a consequence func2a needs on-chip breakpoints whereas func2b may use soft breakpoints:

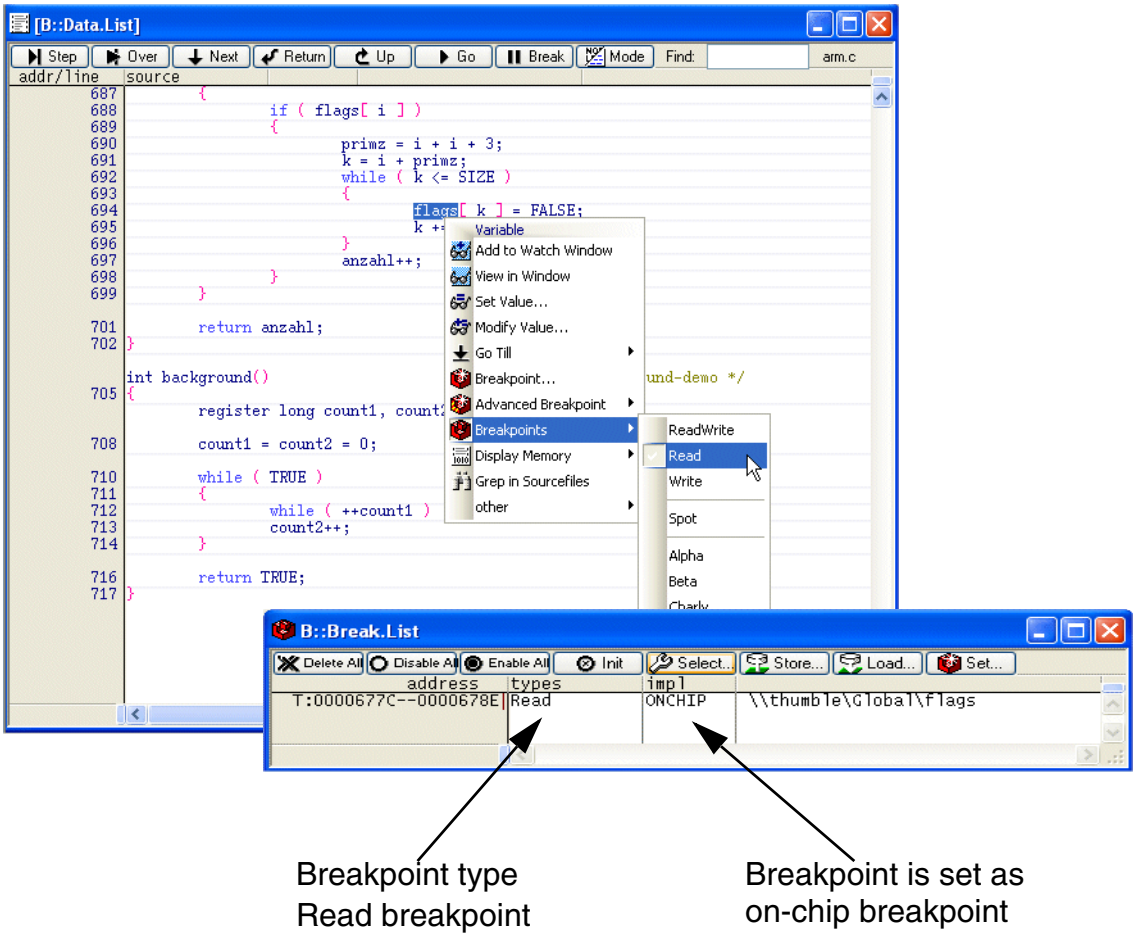
1. Get address range of func2a and func2b ("Show Function" in menu "Var")
2. Assign func2a to be in non-volatile Memory (MAP.BOnchip). In order to check the mapping of the memory use: MAP.List.
3. Assign a breakpoint in func2a and func2b.
4. Check breakpoints by doing a Break.List.



When the number of available on-chip breakpoints is exceeded, the following error message is displayed. To continue debugging remove the supernumerary breakpoints:

For most CPUs the provided on-chip breakpoints can also be used by TRACE32-ICD to stop the program execution when a read or write access occurs to a specific address location.

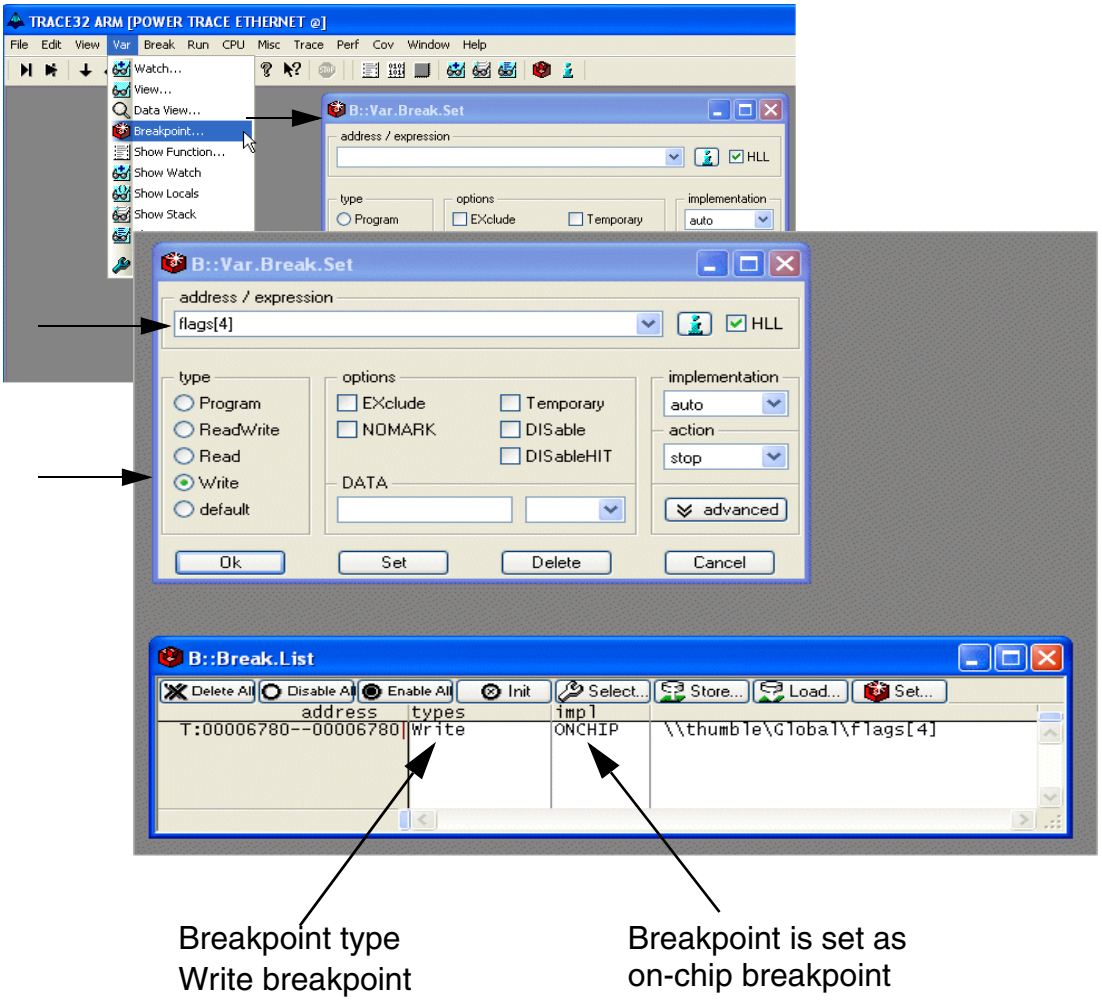
To stop the program execution on a read access to a variable, select the variable with the cursor, press the right mouse button and select ***Read*** from the ***Breakpoint…*** pull-down.



Start the program execution with ***Go***. If the program does not reach your breakpoint, you can stop the program execution with ***Break***.

To stop the program execution on a write access to a variable, you can also use ***Breakpoints…*** from the ***Var*** pull-down.

- ***Browse*** through the symbol database to find the variable, select it by a double click, select ***Write*** in the ***Variable Breakpoint Set*** dialog box. Push ***OK*** to set the breakpoint.
- Or enter the variable name or the HLL expression (e.g. to indicate only an element of an array) in the ***Expression*** field of the ***Variable Breakpoint Set*** dialog box. Select ***Write*** and push ***OK*** to set the breakpoint.

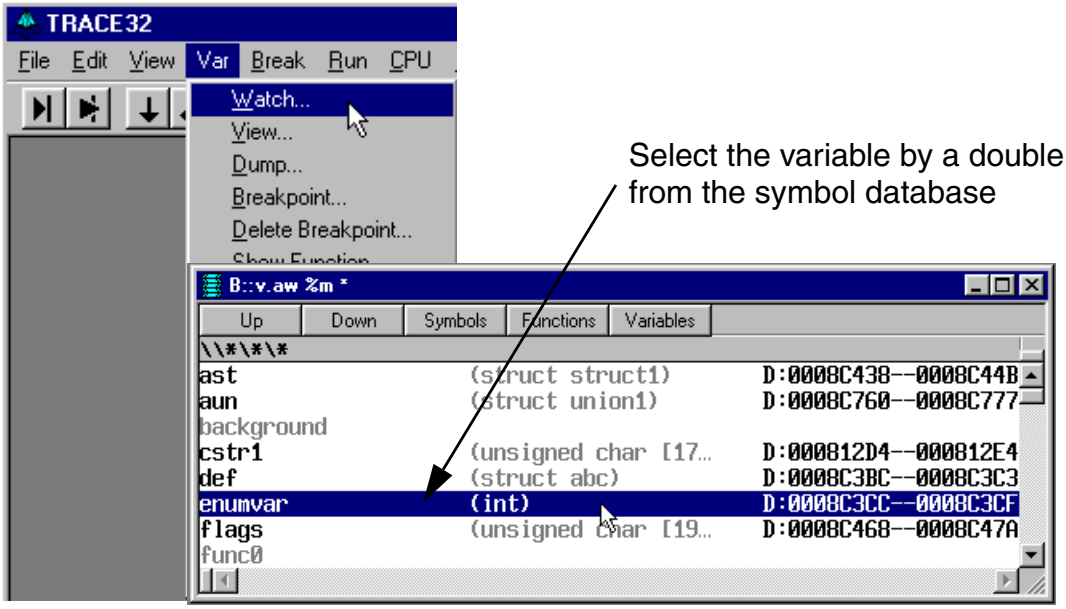


Start the program execution with ***Go***. If the program does not reach your breakpoint, you can stop the program execution with ***Break***.

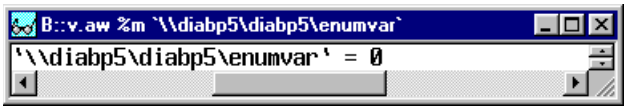
Most CPUs also provide more complex break- and trigger configurations. The support for these features by the TRACE32-ICD user interface varies for each CPU. For more information refer to the **Processor Architecture Manual**.

Display and Modify HLL Variables

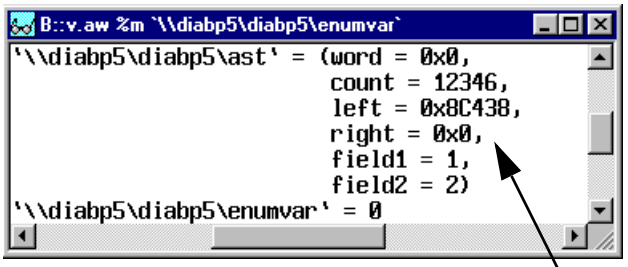
To display HLL variables use the ***Watch*** command from the ***Var*** pull-down menu.



Select the variable by a double click from the symbol database

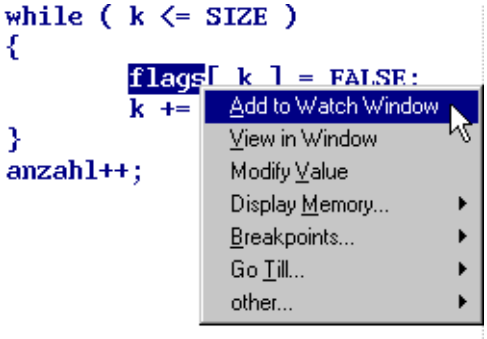


The selected variable is displayed at the top of the **Watch** Window



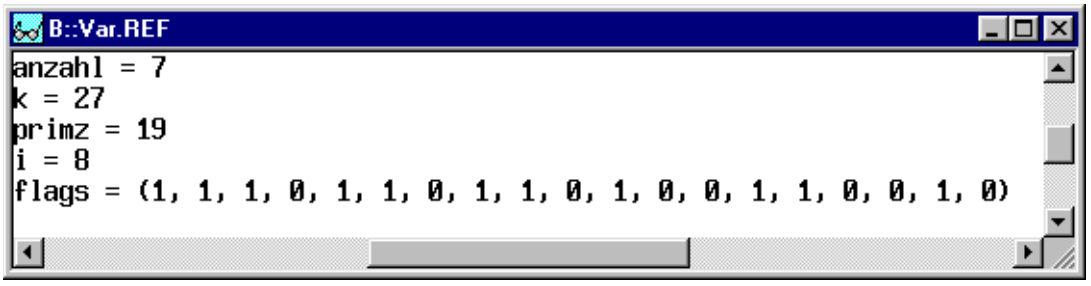
Every time you use ***Watch*** from the ***Var*** menu, the new variable is added to the top of the window. Resize the window to see all entries in the ***Watch*** Window.

A quicker way to look at a variable is to mark the variable in the **Data.List** window by the cursor and to press the right mouse button. From the ***Var pull-down*** menu select ***Add to Watch Window***.



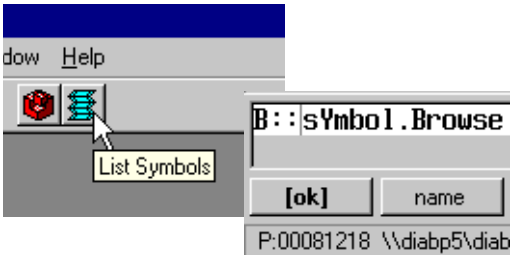
If you want to display a more complex structure or an array in a separate window use ***View…*** in the ***Var*** pull-down menu.

If you just want to watch all variables accessed by the current program context use ***Show Current Vars*** from the ***Var*** pull-down menu and execute a few single steps.

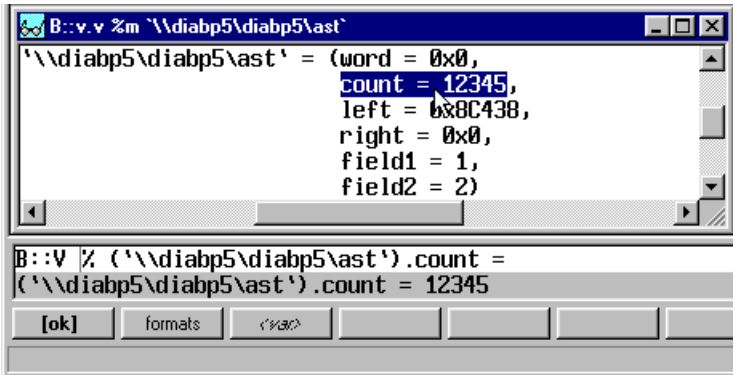


In most windows a context sensitive menu can be used with the right mouse button. If you select a variable you get access to the Var pull-down menu, that provides all features for displaying and modifying variables.

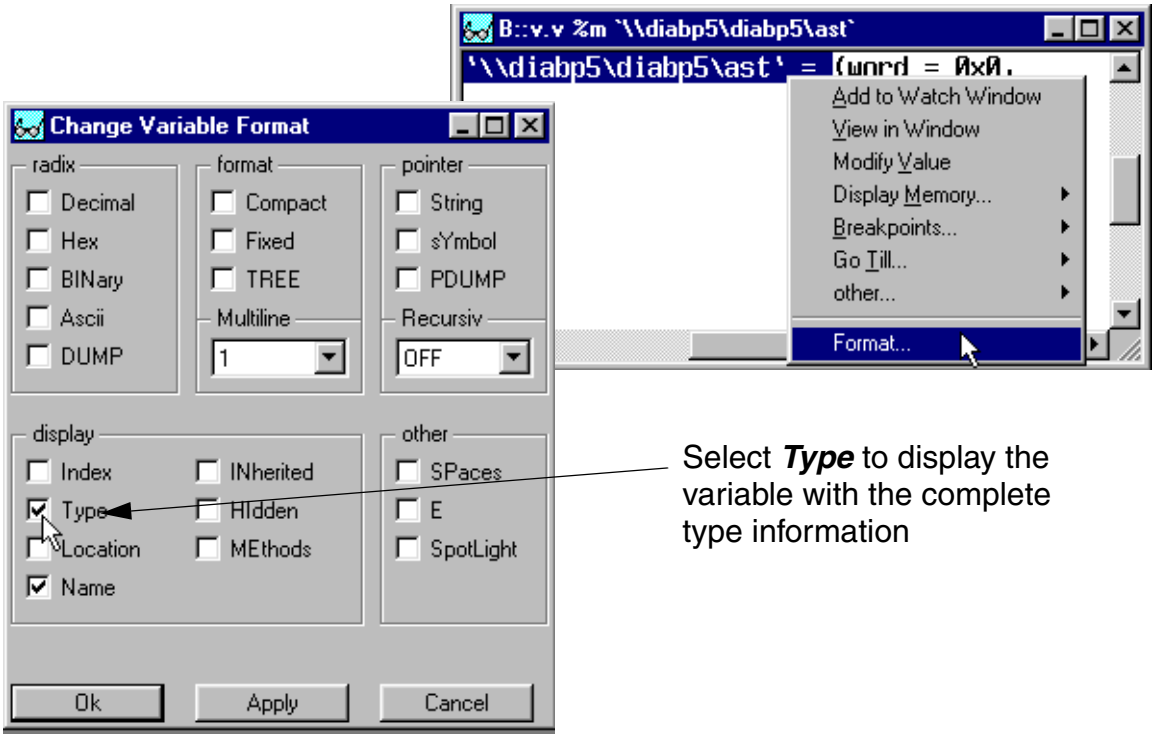
You want to inspect a variable and you are not sure about the spelling open the symbol browser to display all symbols stored in the internal symbol database.



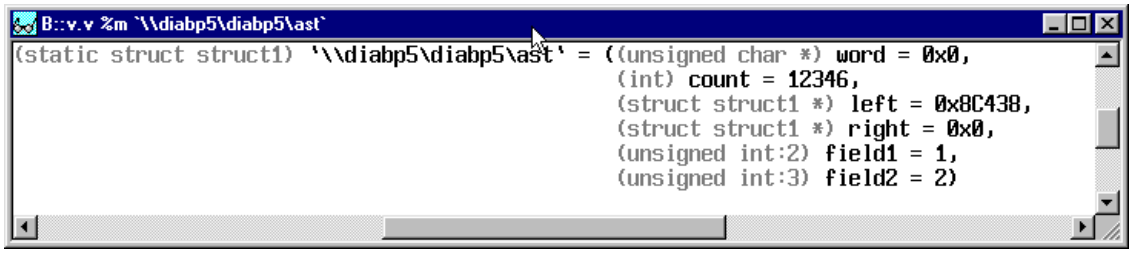
If you want to modify a variable value, double click to the value. The appropriate **Var.set** command will be displayed in the command line. Enter the new value and confirm with return.



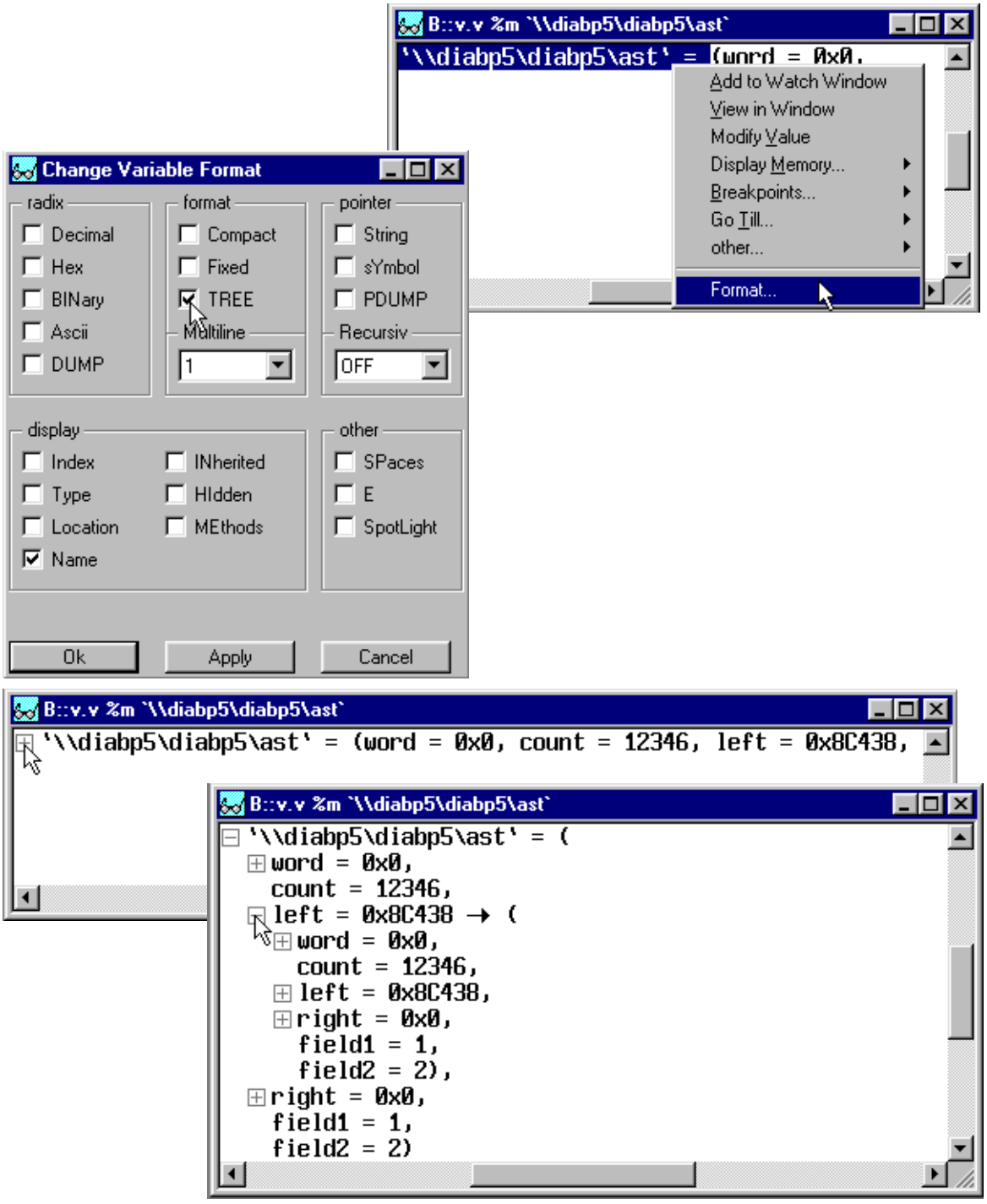
To adapt the display of a variable to your needs, select the variable name, press the right mouse and select ***Format…*** from the ***Var pull-down*** menu.



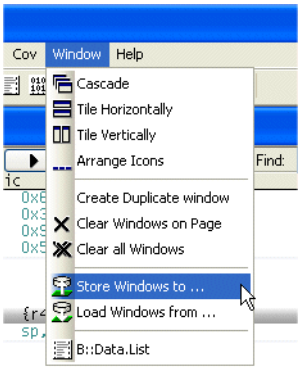
Select ***Type*** to display the variable with the complete type information

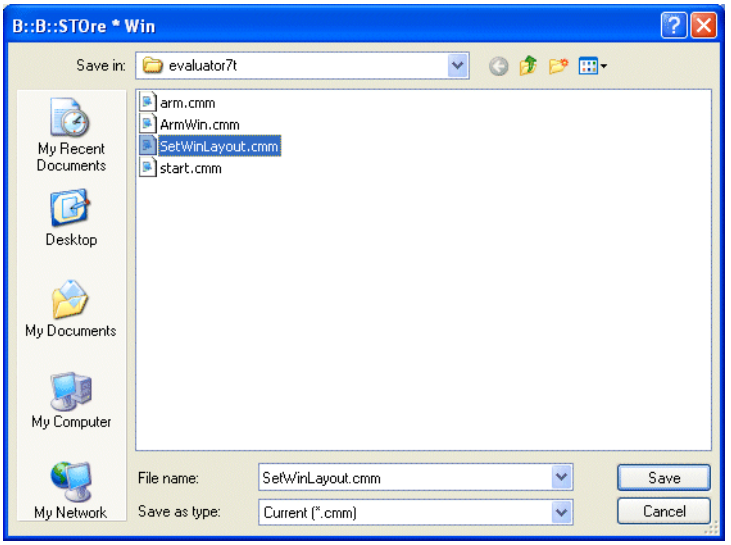


If you display more complex HLL structures, select ***TREE*** in the ***Format*** field of the ***Change Variable Format*** dialog box. This formatting allows to select the display for each member of the structure by clicking on **+** or **-**.



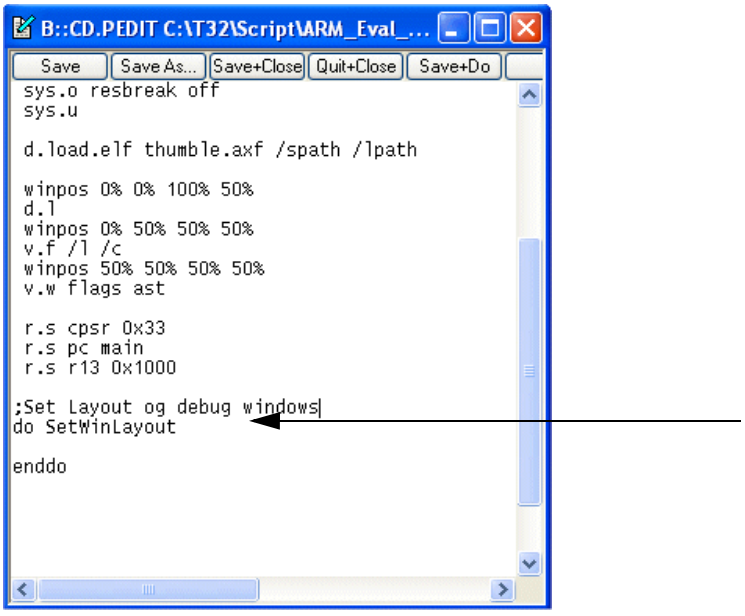
To save the window configuration for your TRACE32-ICD use ***Store windows to…*** from the ***Window*** menu. Store layout generates a PRACTICE file, that includes all commands to reactivate your complete window configuration automatically. Enter a filename for the PRACTICE file into the ***File name*** field of the ***Store*** dialog box and push ***Save*** to generate the PRACTICE file.





The saved window layout can be loaded again for the next debug session with the ***Load windows from …*** in the ***Window*** menu.

Besides that, since PRACTICE supports a modular program structure, you can enter a call for the automatic window configuration into your start-up file.



To exit from TRACE32-ICD use ***Exit*** in the ***File*** menu.

	Take care of the proper sequence on powering up/down: • Power Up: debugger - target • Power down: target - debugger