LAUTERBACH
DEVELOPMENT TOOLS

Verilog Debug Back-End

MANUAL

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Introduction

The Verilog Transactor is used to interact with a software Verilog RTL Simulator. Software RTL simulator models can be extremely slow. Therefore the focus of using the transactor is to test the design together with TRACE32 rather than to debug an application. TRACE32 is no ASIC verification tool, but it provides PRACTICE as scripting language to automate tests and access the model by its debug modules.

It is not intended to use the Verilog Transactor with emulators because the transactor is not accelerated and would slow down the emulation.

TRACE32 PowerView provides special commands to allow a minimum of sequences to be send to the simulation to test a certain feature.

Related Documents

- **"T32Start"** (app_t32start.pdf): The T32Start application assists you in setting up multicore / multiprocessor debug environments, and software-only debug environments. T32Start is only available for Windows.

  For more information about software-only debug environments, please refer to: **"Software-only Debugging (Host MCI)"** (app_t32start.pdf).

Contacting Support

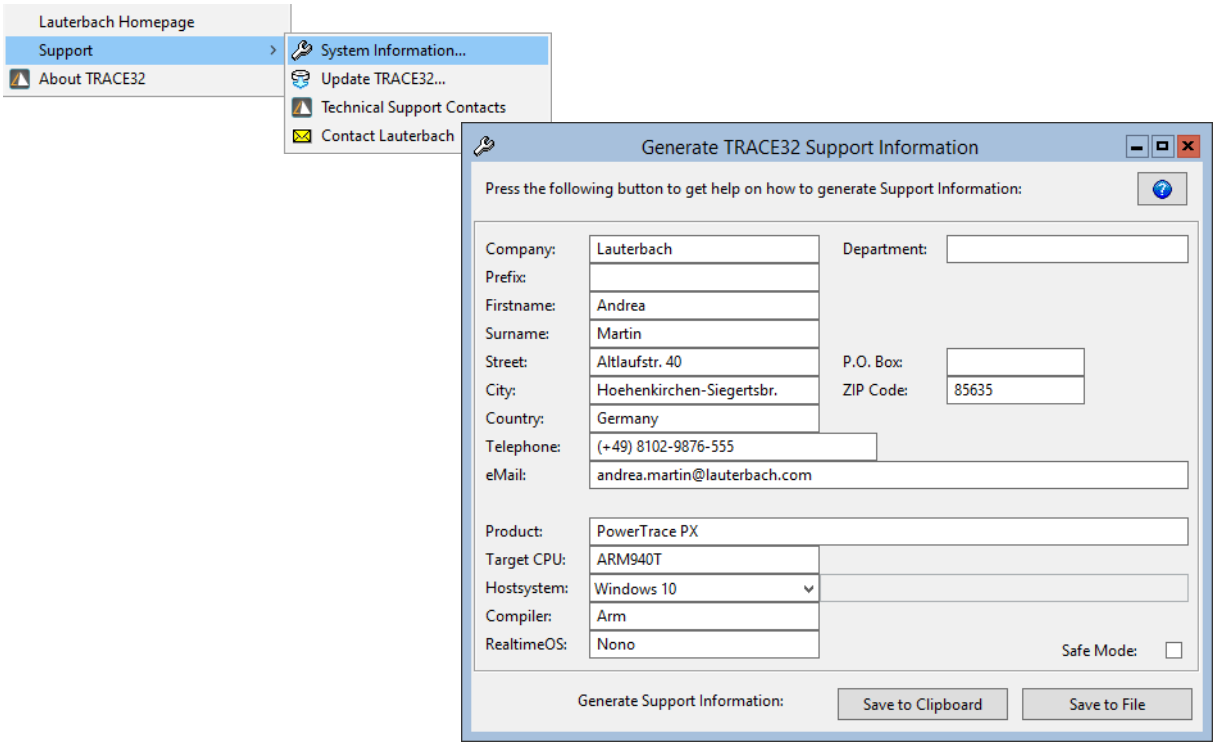
Use the Lauterbach Support Center: https://support.lauterbach.com

- To contact your local TRACE32 support team directly.
- To register and submit a support ticket to the TRACE32 global center.
- To log in and manage your support tickets.
- To benefit from the TRACE32 knowledgebase (FAQs, technical articles, tutorial videos) and our tips & tricks around debugging.

Or send an email in the traditional way to support@lauterbach.com.

Be sure to include detailed system information about your TRACE32 configuration.

1. To generate a system information report, choose **TRACE32** > **Help** > **Support** > **Systeminfo**.



NOTE:	Please help to speed up processing of your support request. By filling out the system information form completely and with correct data, you minimize the number of additional questions and clarification request e-mails we need to resolve your problem.

2. Preferred: click **Save to File**, and send the system information as an attachment to your e-mail.
3. Click **Save to Clipboard**, and then paste the system information into your e-mail.

Abbreviations and Definitions

AMP	Asymmetric Multi-Processing
DUT	Device Under Test. A DUT is the part of the model that is being tested.
RTL	Register Transfer Level. Models of this level describe a digital system by registers, signals and processes, not using a complete net list with timing information.
RTL simulator	A software RTL simulator executes a model on RTL level without using special acceleration hardware.
Transactor	A transactor is a part of a system that interacts with the DUT in order to analyze and control the DUT by an external tool.
Verilog	Hardware description language on RTL level.
VPI	Verilog Procedural Interface. The Verilog Procedural Interface is used to interface from Verilog models into behavioral system parts written in the programming language “C”.

Features

Supported Transactors and Simulators

Supported transactors are:

- JTAG Transactor

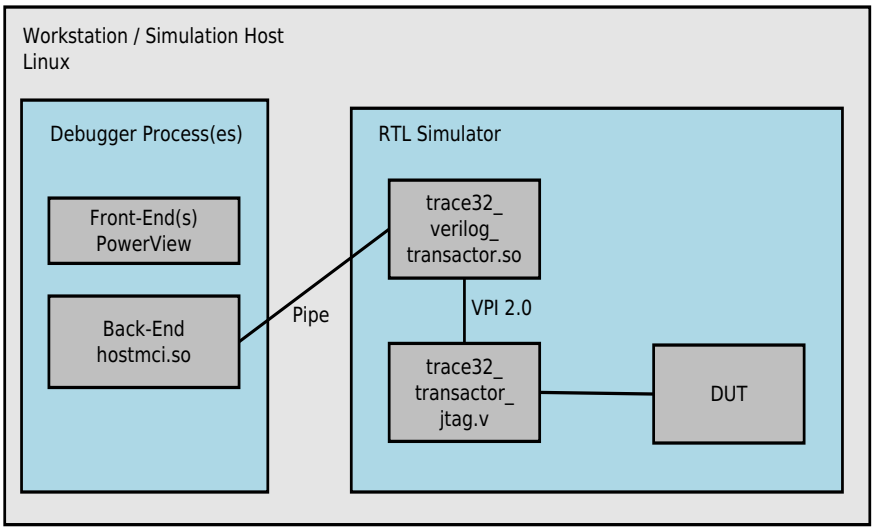
All simulators are supported that interface by VPI 2.0 (Verilog Procedural Interface) such as:

- Cadence NC-Verilog
- Synopsys VCS
- GPLCVER
- and many others

JTAG Transactor

The JTAG Transactor provides the following features:

- Access to JTAG signals using **JTAG** commands and API functions described in **"API for Remote Control and JTAG Access in C"** (api_remote_c.pdf), chapter **"ICD TAP Access API Functions"**.
- JTAG shift engine including Arm RTCK
- Runtime Counter by Run-Line or Stopped-Trigger-Line
- Virtual PodBus Trigger
- Reset signal trigger
- Artificial high JTAG frequency to encounter JTAG protocol overhead



In all cases, the shared library file `trace32_verilog_transactor.so` must be started together with the RTL simulator. The RTL simulator calls the library through the VPI 2.0 interface in the module `trace32_transactor_jtag.v` that exports the JTAG signals.

The transactor library communicates through named pipes with another shared library `hostmci.so`. This library contains the low-level algorithms that do high-performance accesses, requiring low latency.

PowerView System Configurations

The TRACE32 PowerView instances can be set up in different ways.

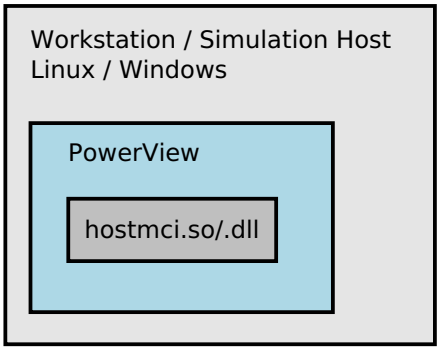
1. A single TRACE32 PowerView instance runs on the same host as the back-end, see Setup 1. This configuration can't handle AMP debug scenarios.
2. Multiple TRACE32 PowerView instances run on the same host as the back-end, see Setup 2.
3. The TRACE32 PowerView instances run on a dedicated workstation; the back-end runs on another host, see Setup 3.

The Lauterbach Debug Driver library (`hostmci.so` for Linux/Mac users and `hostmci.dll` for Windows users) can be integrated into the TRACE32 PowerView application or run as a separate process, called `t32mciserver`. Running it as a separate process provides two main benefits:

1. The MCI server can execute on one host, whilst one or more instances of TRACE32 PowerView execute on another host.
2. Multiple instances of TRACE32 PowerView can execute on a single host, sharing the MCI connection.

Setup 1

Setup with a single TRACE32 PowerView instance running on the same host as the back-end:

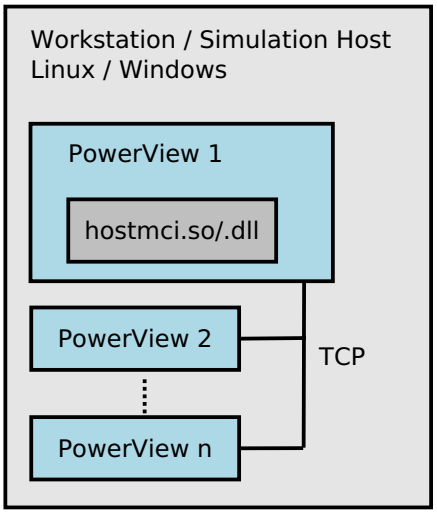


Modify the config.t32 file as follows:

```
PBI=MCILIB                          ; configure system to use hostmci.so
```

Setup 2

Setup with multiple TRACE32 PowerView instances (AMP) running on the same host as the back-end:

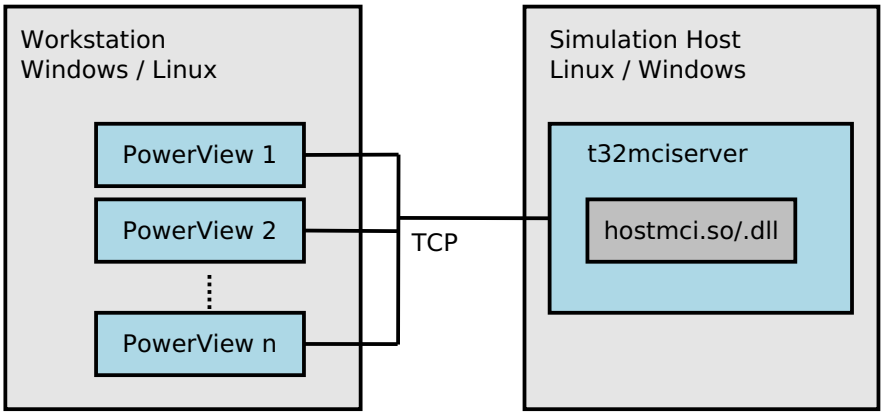


Modify the config.t32 as follows:

```
PBI=MCISERVER                ; set up the usage of hostmci.so and open
PORT=30000                   ; server at 30000 for the first instance.
INSTANCE=AUTO                ; consecutive number of instance or AUTO
```

Setup 3

Setup with multiple TRACE32 PowerView instances (AMP) running on another host:



Start t32mciserver on the simulation host:

```
./t32mciserver port=30000        ; start t32mciserver at port 30000
```

Modify the config.t32 file as follows:

```
PBI=MCISERVER                    ; set up connection to t32mciserver
NODE=192.168.0.1                 ; connect to IP 192.168.0.1
PORT=30000                       ; at port 30000
INSTANCE=AUTO                    ; consecutive number of instances
DEDICATED                        ; avoid to fall into Setup2 case
```

Linux example: To start TRACE32 PowerView with a specific config file, use e.g.:

```
bin/pc_linux/t32marm -c config.t32
```

In a multi-user, multi-simulation environment, the pipe name needs to be unique. Both shared libraries use a default file name that is derived from the `USER` environment variable:

```
/tmp/t32verilog_transactor_$USER
```

This pipe name can be redefined by specifying the environment variable `T32VERILOGTRANSACTORPIPE`. For `hostmci.so` the default pipe name can also be set up with the following command:

SYStem.CONFIG.TRANSACTORPIPENAME	Set up pipe name

RTL Simulator Integration

This section describes how to integrate the Verilog Transactor into the simulation. In a first step, the DUTs signals must be connected to the Verilog part of the transactor. In a second step, transactor library must be loaded together with the simulator.

Step 1: Connecting Signals

The JTAG transactor is implemented in the module `trace32_transactor_jtag.v`. The module `trace32_transactor_jtag_debugport_v1` is used to interface with TRACE32 by connecting it to the JTAG TAP Controller of the design. The module interfaces through multiple signals and parameters.

In most cases, the smaller interface of the module `trace32_transactor_jtag` can be used to connect only mandatory JTAG signals to the TAP of the DUT.

The following table describes the signals of `trace32_transactor_jtag_debugport_v1` and `trace32_transactor_jtag`:

Mandatory Signal	Direction	Description
tck_o	Out	TCK signal to DUT
tms_o	Out	TMS signal to DUT
tdi_o	Out	TDI signal to DUT
tdo_i	In	TDO signal from DUT
ntrst_o	Out	NTRST signal to DUT (low active)

The following table describes the additional signals of `trace32_transactor_jtag_debugport_v1:`

Additional Signal	Direction	Description
nreset_o	Out	NRESET signal to DUT (low active). The debugger uses this signal to reset the DUT.
nreset_i	In	NRESET signal from DUT (low active). The signal is used to detect a reset of the DUT e.g. when other transactors reset the simulation model.
power_i	In	POWER signal from DUT. When the level is 0, the TRACE32 will show Power Down.

Additional Signal	Direction	Description
trigger_i	In	A trigger signal from DUT. The trigger signal appears as PodBus trigger in TRACE32. By the **TrBus.state** dialog different actions can be programmed when a trigger appears.
trigger_o	Out	A trigger signal to the DUT. The trigger signal appears as PodBus trigger in TRACE32.
runline_i	In	A line to allow exact runtime measurement of code. When the line is “1” the runtime counter counts in simulation time. The time is displayed in the **RunTime.state** dialog.
rtck_i	In	RTCK signal from the DUT (used by some Arm architecture JTAG TAPs in order to signal that TDO is ready to sample.).

The following parameters are used to configure the input signals. A value of “0” means that a signal is ignored by the transactor. The input signal will be used when the value is “1”.

Parameter	Default	Description
instance	-1	Used to manage multiple instances in future versions. **Overwrite by “0” always!**
poll_frequency_hz	1000	Internal poll rate in Hz to trigger communication from PowerView. A high poll rate reduces the latency to hostmci.so, but consumes more simulation time.
has_reset_i	1	Specify if nreset_i signal shall be used.
has_power_i	0	Specify if power_i signal shall be used.
has_trigger_i	0	Specify if trigger_i signal shall be used.
has_runline_i	0	Specify if runline_i signal shall be used.
has_rtck_i	0	Specify if rtck_i signal shall be used.

Step 2: Loading the trace32_verilog_transactor.so

The simulation process need to call the transactor shared library, therefore the library must be loaded by the simulation process. The library is located in ~~/demo/etc/verilog_transactor/bin. Depending to the environment the right library must be chosen. How the library is loaded depends to the simulator and is described in the manual of the simulator. In general the library fulfills the VPI interface standard.

GPLCVER-2.12a Simulator

On the Linux command line, run `cver` with the transactor and use `trace32_jtag_tb.v` as top level module to run a test bench that just contain a signle JTAG TAP:

```
/usr/bin/cver \
+loadvpi=trace32_verilog_transactor.so:vpi_compat_bootstrap \
trace32_jtag_tb.v
```

VCS Simulator

VCS need to be compiled with additional options:

```
VCS_OPTS += +vpi+1
VCS_OPTS += -P trace32_pli.tab
VCS_OPTS += trace32_verilog_transactor.so
```

Connecting TRACE32 to the Verilog Transactor

A typical start sequence is shown below. This sequence can be written to a PRACTICE script file (*.cmm, ASCII format) and executed with the command **DO** *<file>*.

```
RESet

;set up connection to Simulator and try to connect
SYStem.CONFIG.DebugPort VerilogTransactor0

;used to configure pipe name in case former transactor is used
;SYStem.CONFIG.TRANSACTORPIPENAME "/tmp/t32verilog_actuator_user"

;set up the JTAG clock (simulation clock based)
;find out the maximum JTAG frequency to speedup all operations!
SYStem.JtagClock 1Mhz

; configure usage of model time base instead host base to avoid timeouts
; while the emulation is paused.
SYStem.VirtualTime.TimeinTargetTime ON
SYStem.VirtualTime.PauseinTargetTime ON

;make the pauses and timeouts 100 times shorter
SYStem.VirtualTiming.TimeScale 0.01

;this will limit any pause statements to 10us target time
SYStem.VirtualTiming.MaxPause 10us

;this will limit any small time-out to read register to 1ms
SYStem.VirtualTiming.MaxTimeout 1ms

;select the CPU
SYStem.CPU CortexA9
;tell the system that a DAP is present
SYStem.CONFIG COREBASE APB:0x80009000

;connect to JTAG quickly
SYStem.Mode.Prepare

;access to busses now working
Data.Set DAP:0x00000000 %long 0x0 /Verify
```

Keep the Graphical User Interface Responsive

Due to slow RTL simulation, small operations such as reading the state or showing memory dumps take a long time. This chapter describes how to adjust the virtual time scale to ultra-slow simulators and how to reduce screen flicker caused by slow RTL simulation. To keep the user interface smooth multiple tuning options can be set.

The most important setting is **SETUP.URATE** to configure the update rate of the TRACE32 windows. The processors state is also polled by this rate.

```
SETUP.URATE 10s                    ; screen will be updated every 10s
```

To avoid screen update while PRACTICE scripts are running:

```
SCREEN.OFF                         ; switch off update of the windows when
                                   ; a PRACTICE script is executed

SCREEN                             ; trigger a manual update of the windows
                                   ; inside a PRACTICE script
```

To switch off state polling when the CPU is stopped, the command **SYStem.POLLING** can be used, but the debugger can't detect when another CPU changes the state from stopped to running e.g. by soft reset.

```
SYStem.POLLING DEF OFF             ; disable processor state polling when
                                   ; stopped
```

The command **MAP.UpdateOnce** can be used to read memory regions only one time after a break is detected.

```
MAP.UpdateOnce 0x0++0x1000         ; read memory of regions 0x0--0x1000
                                   ; only one time after break
```

For analysis and data display purposes it is recommended that you use the code from the TRACE32 virtual memory (VM:) instead of the code from the target memory. Therefore, the code needs to be copied to the virtual memory when an *.elf file is being loaded.

```
Data.Load.ELF *.elf /VM            ; download code to target and copy it to
                                   ; VM:
Data.List VM:                      ; open source window, but use VM: memory

Onchip.Access VM                   ; use VM memory for trace analysis
```

Timing Adaption

TRACE32 software includes of a set of efficient low-level driver routines to access the target. These routines have a certain timing that must be adjusted to ultra-slow simulators that can be million times slower than real silicon. In general, there are code parts that pause the execution, wait until a time-out is reached or just use a certain point of time.

For example, when the simulation is 1,000,000 times slower than real time, these commands can be used to adjust the timing in most cases:

```
; configure usage of model time base instead host base to avoid timeouts
; while the emulation is paused.
SYStem.VirtualTiming.TimeinTargetTime ON
SYStem.VirtualTiming.PauseinTargetTime ON

;make the pauses and timeouts 100 times shorter
SYStem.VirtualTiming.TimeScale 0.01

;this will limit any pause statements to 10us target time
SYStem.VirtualTiming.MaxPause 10us

;this will limit any small time-out to read register to 1ms
SYStem.VirtualTiming.MaxTimeout 1ms
```

The following timing **SYStem** commands are available:

SYStem.VirtualTiming.MaxPause	Limit pause
SYStem.VirtualTiming.MaxTimeout	Override time-outs
SYStem.VirtualTiming.PauseinTargetTime	Set up pause time-base
SYStem.VirtualTiming.PauseScale	Multiply pause with a factor
SYStem.VirtualTiming.TimeinTargetTime	Set up general time-base
SYStem.VirtualTiming.TimeScale	Multiply time-base with a factor
SYStem.VirtualTiming.HardwareTimeout	Can disable hardware timeout
SYStem.VirtualTiming.HardwareTimeoutScale	Multiply hardware timeout
SYStem.VirtualTiming.InternalClock	Base for artificial time calculation
SYStem.VirtualTiming.OperationPause	Insert a pause after each action to slow down timing.

Troubleshooting the JTAG Transactor

After the signals and parameters are connected with the TAP of the DUT, PowerView JTAG diagnostic should run:

```
;show results and errors
AREA.view

;set up connection to Simulator
SYStem.CONFIG.DebugPort VerilogTransactor0

;use simulation time as time base
SYStem.VirtualTiming.TimeinTargetTime ON
SYStem.VritualTiming.PauseinTargetTime ON

;set up JTAG clock (simulation clock based)
SYStem.JtagClock 1Mhz

;analyze JTAG chain for testing purposes
SYStem.DETECT.DAISYCHAIN /GENERIC /TRST
```

Symptom	Cause	Remedy
Status line shows “power down”	TRACE32 can’t connect to the simulator.	1. Check that the simulation is running and executing the DUT when TRACE32 start to connect. 2. Check that hostmci.so is started in the same user context or modify the pipe names by **SYStem.CONFIG.TRANSACTORPIPENAME**. The plug-in will create a pipe in “/tmp” starting with “t32verilog_transactor” 3. Check that the parameter “instance” is set to “0” 4. Check that the simulator console output contain lines beginning with “T32VT:”. They indicate that the plug-in is active. 5. Check that the simulation has loaded the transactor plug-in. 6. Check that DUT code call the function “$trace32_transactor_jtag_init”
Status line shows “power down”	TRACE32 can’t connect to the simulator.	The transactor plug-in can only communicate with hostmci.so when the simulation executes the model.

Symptom	Cause	Remedy
When the IR and DR length are both “0”	Probably TDI is connected to TDO without a DUT JTAG TAP between them.	See **Step 1: Connecting Signals**.
TDO stays constantly high or low	TDO signal is not connected or the DUT TAP does not work, e.g. is held in reset.	See **Step 1: Connecting Signals**.
Chain lengths cannot be determined	JTAG frequency might be too high.	Use **SYStem.JtagClock** to lower the JTAG frequency.
Chain lengths cannot be determined	The TAP state remain undefined.	Connect TRST pin to the TAP controller or assign an initial value to the TAP state.

NOTE:	The maximum clock of the TAP can be determined by the command **SYStem.DETECT JtagClock**, but the final frequency that can be used also depends to model behind the TAP. The detected frequency is just the upper limit. The optimal frequency depends to the state of the simulation and can change during one debug session.