TRACE32®工具的RISC-V

调 试 和 跟 踪 方 案

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LAUTERBACH
DEVELOPMENT TOOLS

议题

- **LAUTERBACH公司简介**
- **TRACE32®工具的RISC-V 调试和跟踪方案**
- **RISC-V 调试相关的文档/培训/支持**

公司简介

- **近20年中国支持经验**
  - 贴近本土开发者要求
  - 中文语言
- **开放的设计**
  - 第三方工具接口 (XCP/ETK/MATLAB PIL 等)
  - 用户API 接口（ C/C++/Python/TCL等)
  - 动态连接库 (用户自定义指令集，寄存器，协议等)
- **产品开发全周期**
  - 系统开发和原型验证 （Virtual Prototype, HW Emulation, FPGA等)
  - 芯片的“Bringup” （首次启动)
  - 系统集成（BootLoader, RTOS内核等)
  - 应用调试（用户进程，动态Modules 等)
  - 集成测试和验证（自动测试)
  - 成品调试（通过CAN接口调试 等)

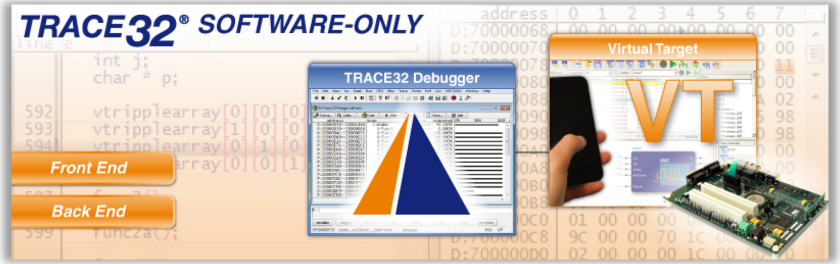
LAUTERBACH DEVELOPMENT TOOLS

- **全球领先**
  - 市场占有率遥遥领先
- **40+年历史**
  - 丰富的嵌入式芯片调试经验
- **广泛芯片类型支持**
  - 支持100+种芯片内核
  - 支持5000+种芯片类型
- **模块化产品设计**
  - 保证投资节约高效
- **丰富的调试跟踪功能**
  - 调试/复杂断点/OS调试/Cache/MMU
  - 程序/数据跟踪，外设数据跟踪/历史程序调试
  - 热点代码分析/系统性能分析/任务调度
  - 数字/模拟信号，协议/能耗分析

议题

- LAUTERBACH公司介绍
- TRACE32®工具的 RISC-V 调试和跟踪方案
- RISC-V 调试相关的文档/培训/支持

TRACE32®型号介绍



调试和跟踪对比

调试方案

调试+跟踪方案

基本功能

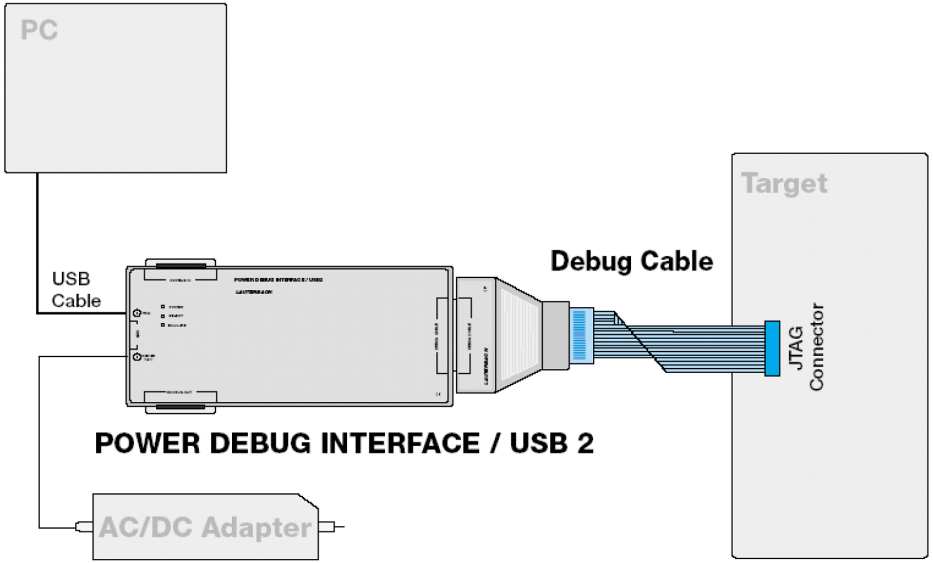
- 单步、断点
- 源代码观察
- 变量观察
- 内存分析
- FLASH烧写
- OS调试
- 多核调试

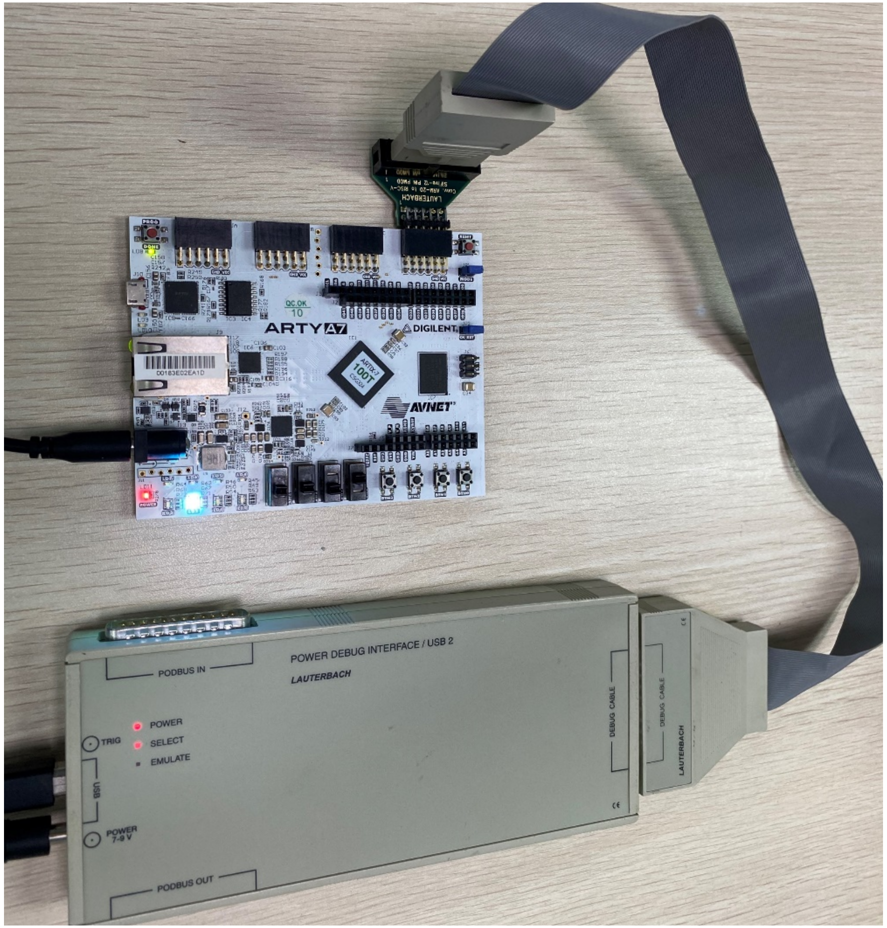
高级扩展功能

- 灵活扩展
- 程序流实时记录
- 数据流实时记录
- CPU性能分析
- 代码、数据回溯分析
- 代码覆盖率统计

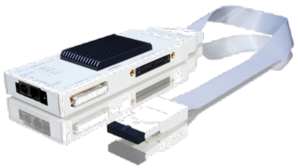
TRACE32®调试功能

- 如何进行调试

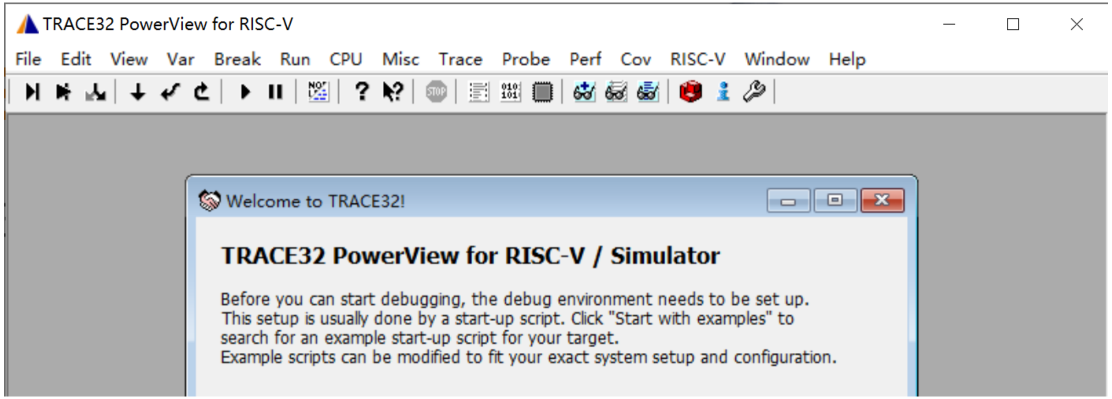




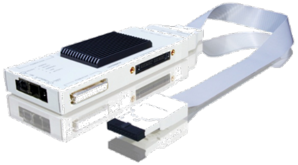
TRACE32®调试功能



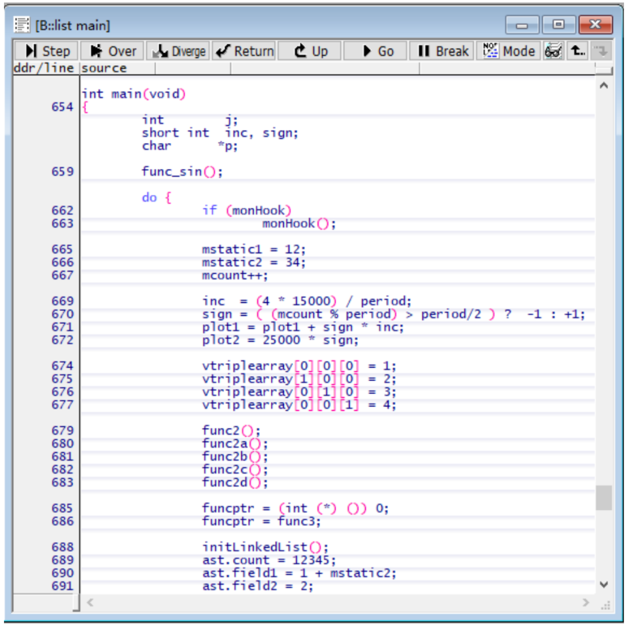
- TRACE32主界面

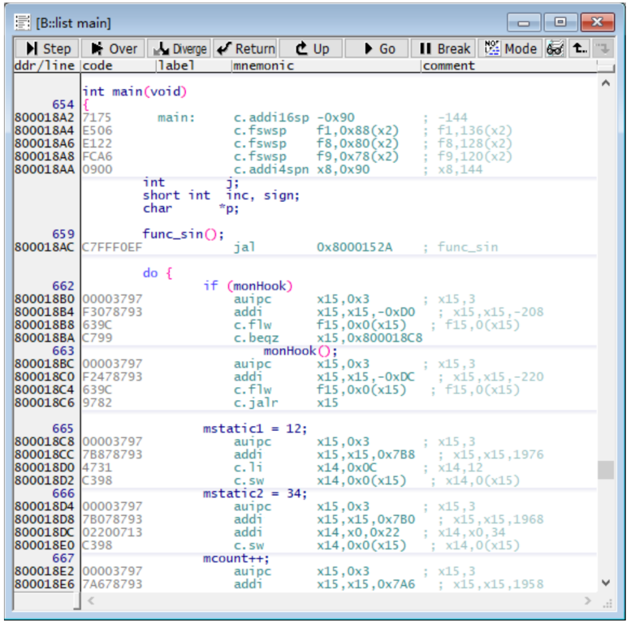


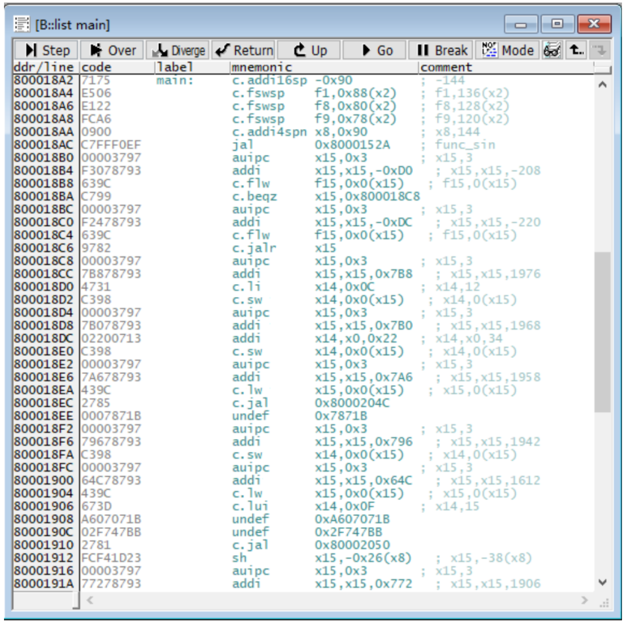
TRACE32®调试功能



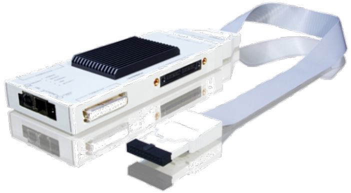
- 支持汇编、C/C++、混合代码调试





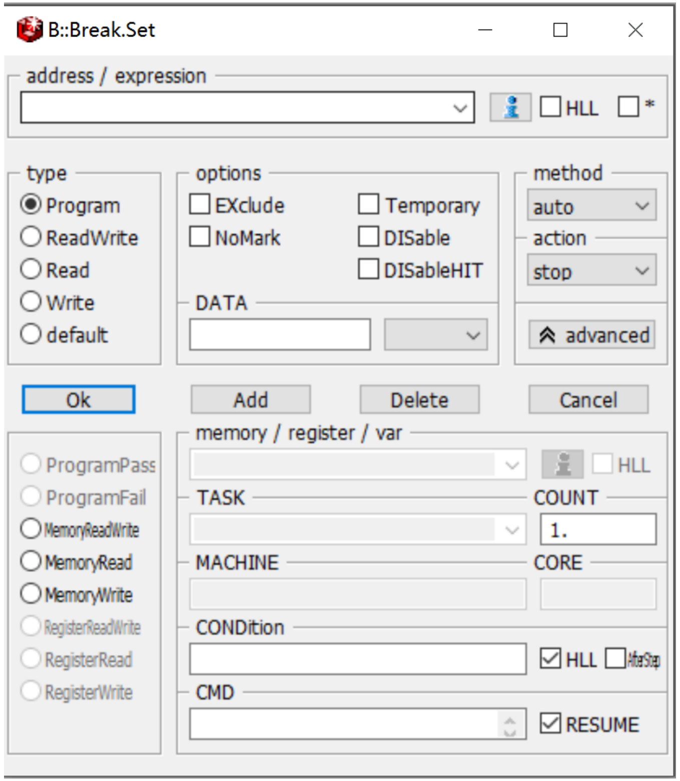


TRACE32®调试功能



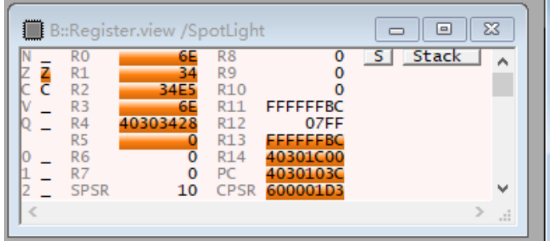
适合多种场景的断点功能

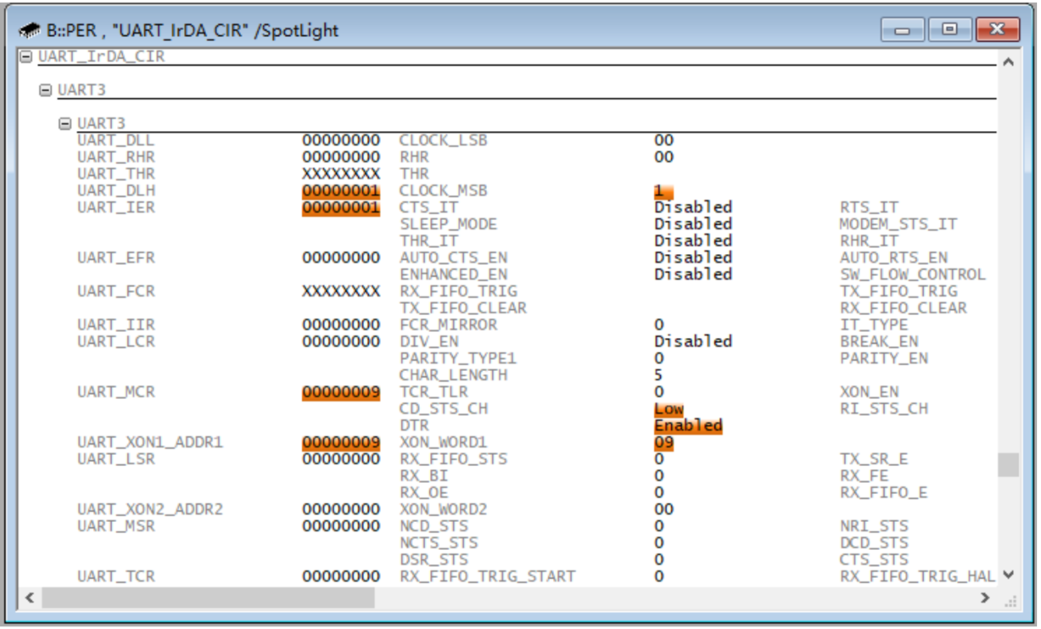
- **软件断点**， 需要设置多个断点
- **硬件断点**，适用于FLASH/ROM等区域
- **读写断点**，监控变量/内存是否被篡改
- **数据断点/位断点**
- **计数断点**，监控循环的次数
- **条件断点**，满足多种条件出发断点
- **组合断点**，多种定制化的调试场景



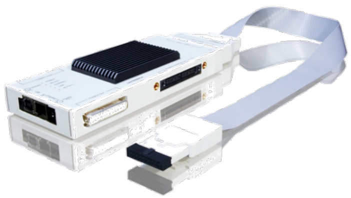
TRACE32®调试功能

寄存器观察

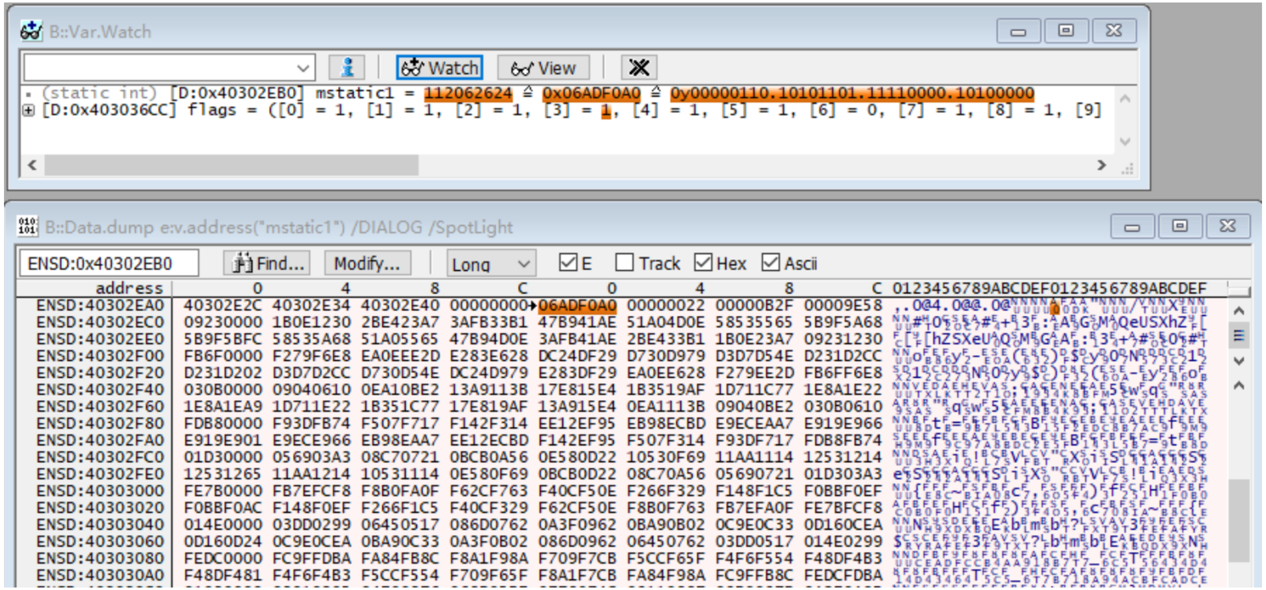




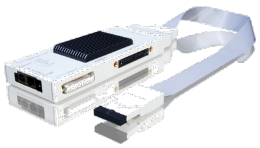
TRACE32®调试功能



内存分析、变量观察



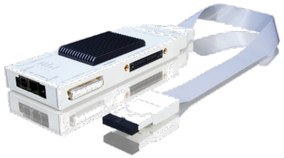
TRACE32®调试功能



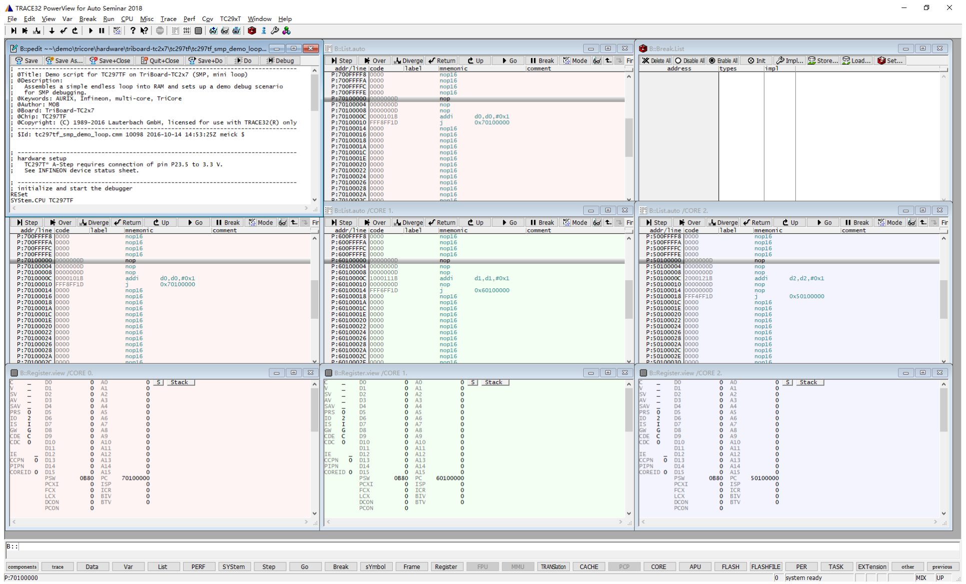
- 支持多种Flash编程（内置脚本/内置命令/内置模板）

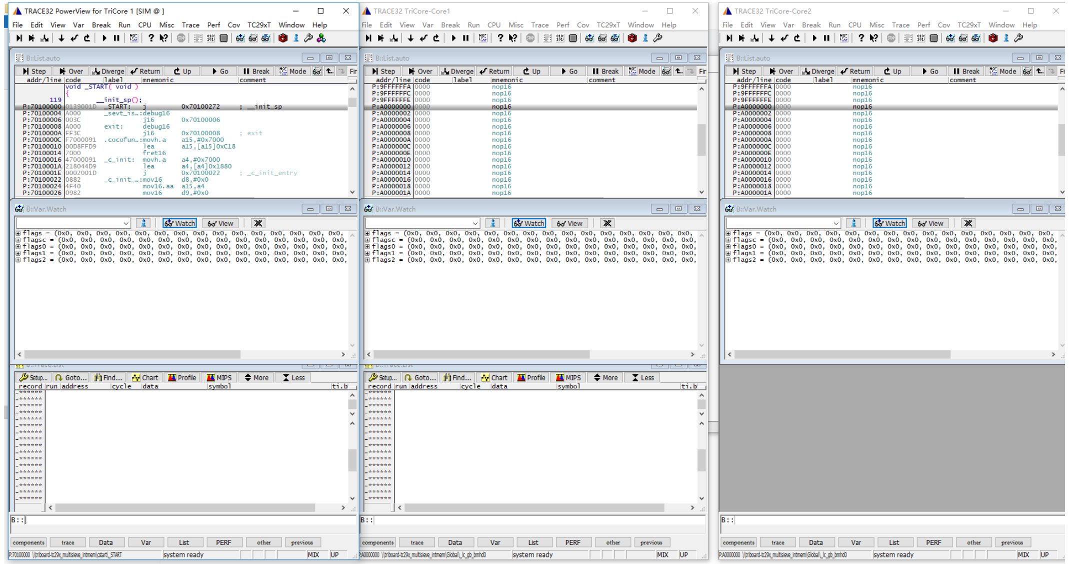
<table>
<tr><td>Cell type</td><td colspan="5">NOR</td><td colspan="2">NAND</td></tr>
<tr><td>Physical connection
CPU ↔ FLASH</td><td colspan="2">Parallel</td><td colspan="3">Serial</td><td colspan="2">Serial</td></tr>
<tr><td>Position on
the Chip</td><td>Internal</td><td>External</td><td colspan="3">External</td><td colspan="2">External</td></tr>
<tr><td rowspan="2">TRACE32 Naming</td><td rowspan="2">Internal/
On-chip</td><td rowspan="2">NOR
FLASH</td><td rowspan="2">Hyper
Flash</td><td colspan="2">SPI FLASH</td><td rowspan="2">NAND</td><td rowspan="2">EMMC</td></tr>
<tr><td>QSPI</td><td>SPI</td></tr>
<tr><td>Document</td><td colspan="2">norflash.pdf</td><td colspan="3">serialflash.pdf</td><td>nandflash.pdf</td><td>emmcflash.pdf</td></tr>
<tr><td>Memory-Mapping</td><td colspan="2">Memory-Mapped</td><td colspan="3">Memory-Mapped
Or
Non Memory Mapped</td><td colspan="2">Non Memory-Mapped
(if not fully memory mapped)</td></tr>
<tr><td>Commands</td><td colspan="2">FLASH.*</td><td colspan="3">FLASH.*
Or FLASHFILE.*
(Depends on the Memory Mapping)</td><td colspan="2">FLASHFILE.*</td></tr>
</table>

TRACE32®调试功能

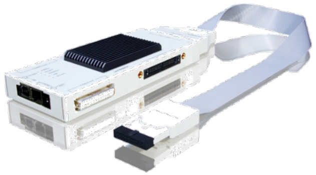


支持多核调试（同构/异构）

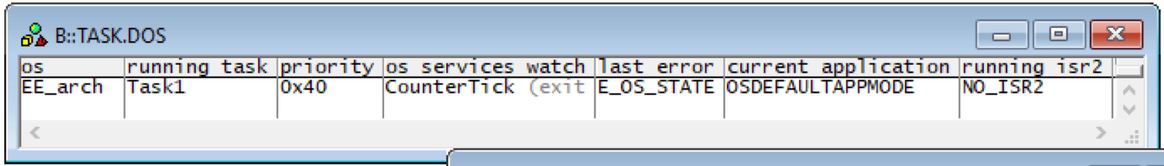




TRACE32®调试功能

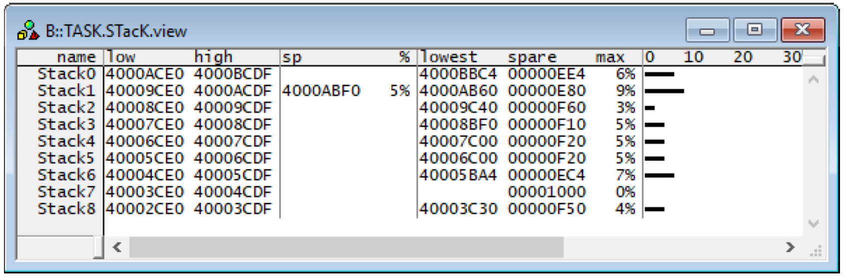


- 支持操作系统调试（Linux，AUTOSAR，FreeRTOS，等等）



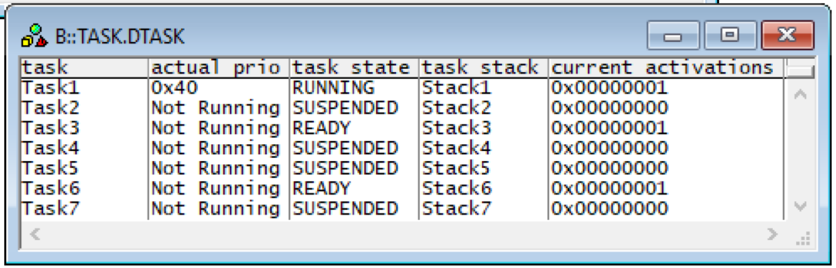
B::TASK.DOS

os	running task	priority	os services watch	last error	current application	running isr2
EE_arch	Task1	0x40	CounterTick (exit	E_OS_STATE	OSDEFAULTAPPMODE	NO_ISR2



B::TASK.STacK.view

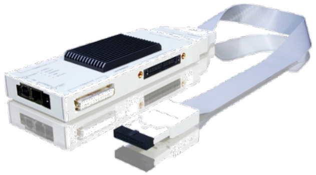
name	low	high	sp	%	lowest	spare	max	0 10 20 30
Stack0	4000ACE0	4000BCDF			4000BBC4	00000EE4	6%	
Stack1	40009CE0	4000ACDF	4000ABF0	5%	4000AB60	00000E80	9%	
Stack2	40008CE0	40009CDF			40009C40	00000F60	3%	
Stack3	40007CE0	40008CDF			40008BF0	00000F10	5%	
Stack4	40006CE0	40007CDF			40007C00	00000F20	5%	
Stack5	40005CE0	40006CDF			40006C00	00000F20	5%	
Stack6	40004CE0	40005CDF			40005BA4	00000EC4	7%	
Stack7	40003CE0	40004CDF				00001000	0%	
Stack8	40002CE0	40003CDF			40003C30	00000F50	4%	



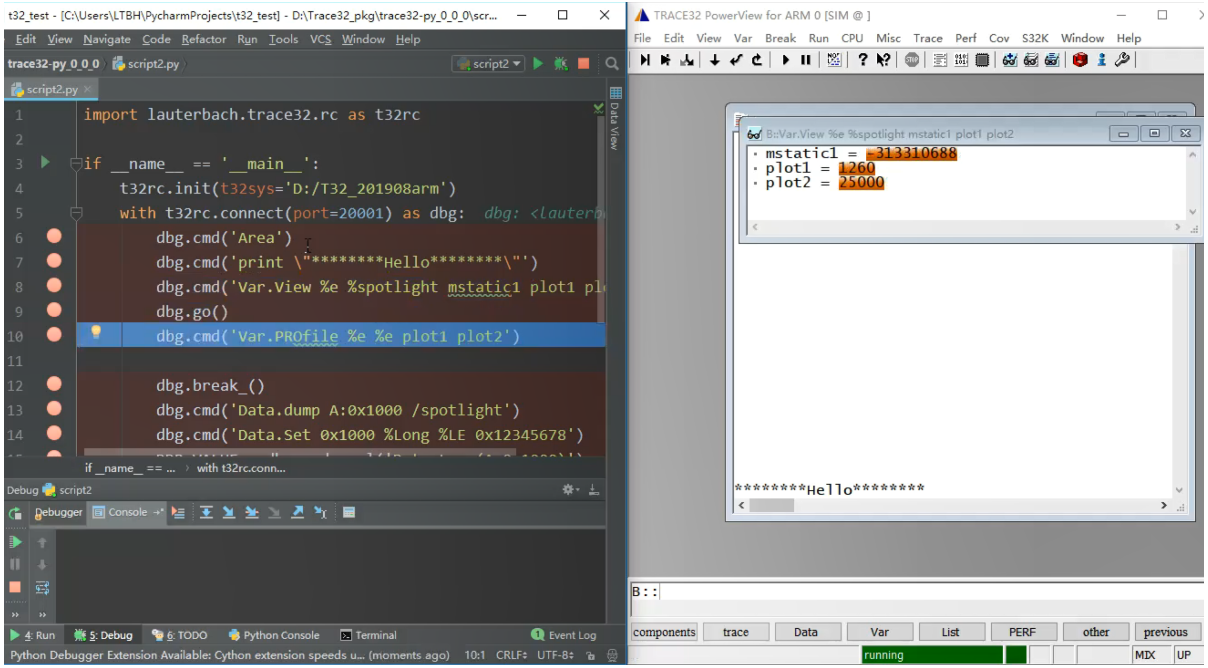
B::TASK.DTASK

task	actual prio	task state	task stack	current activations
Task1	0x40	RUNNING	Stack1	0x00000001
Task2	Not Running	SUSPENDED	Stack2	0x00000000
Task3	Not Running	READY	Stack3	0x00000001
Task4	Not Running	SUSPENDED	Stack4	0x00000000
Task5	Not Running	SUSPENDED	Stack5	0x00000000
Task6	Not Running	READY	Stack6	0x00000001
Task7	Not Running	SUSPENDED	Stack7	0x00000000

TRACE32®调试功能

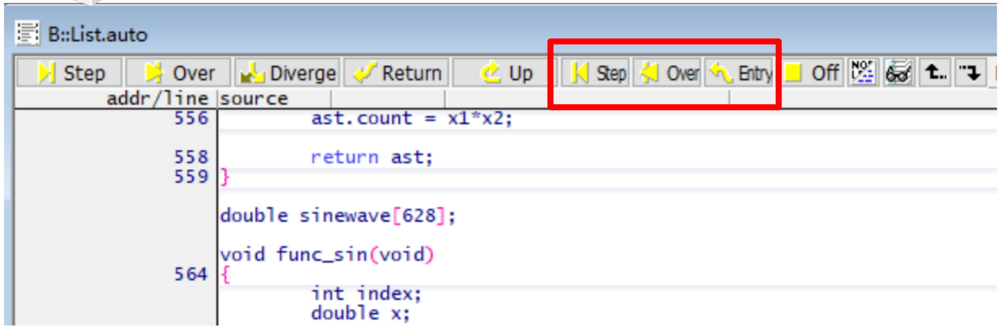


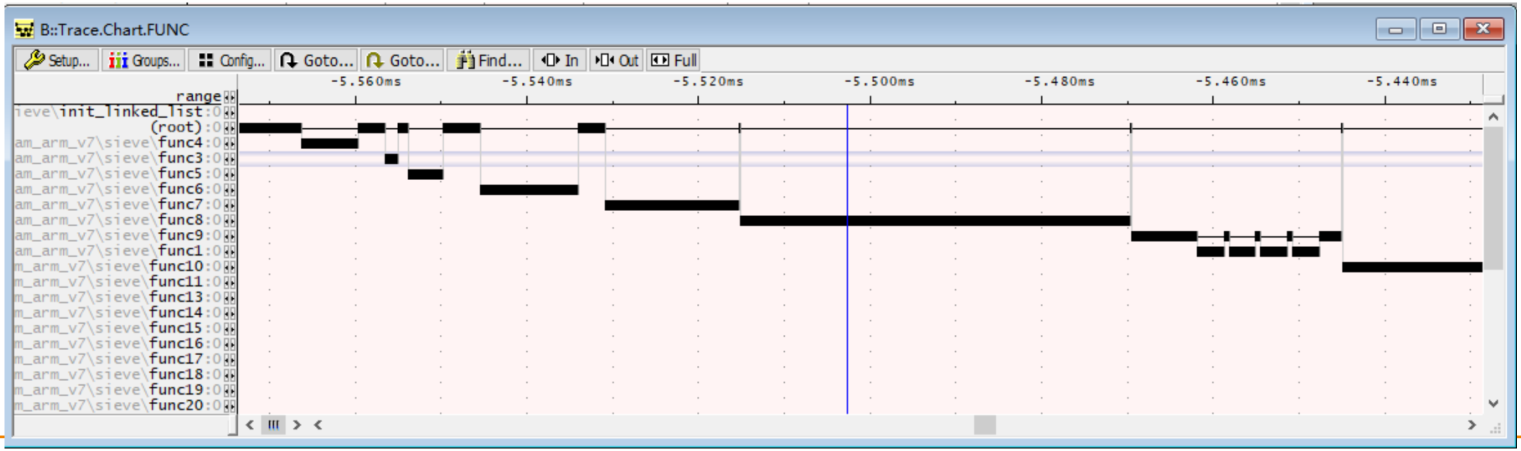
- 支持开放的API 接口



TRACE32® 跟踪功能

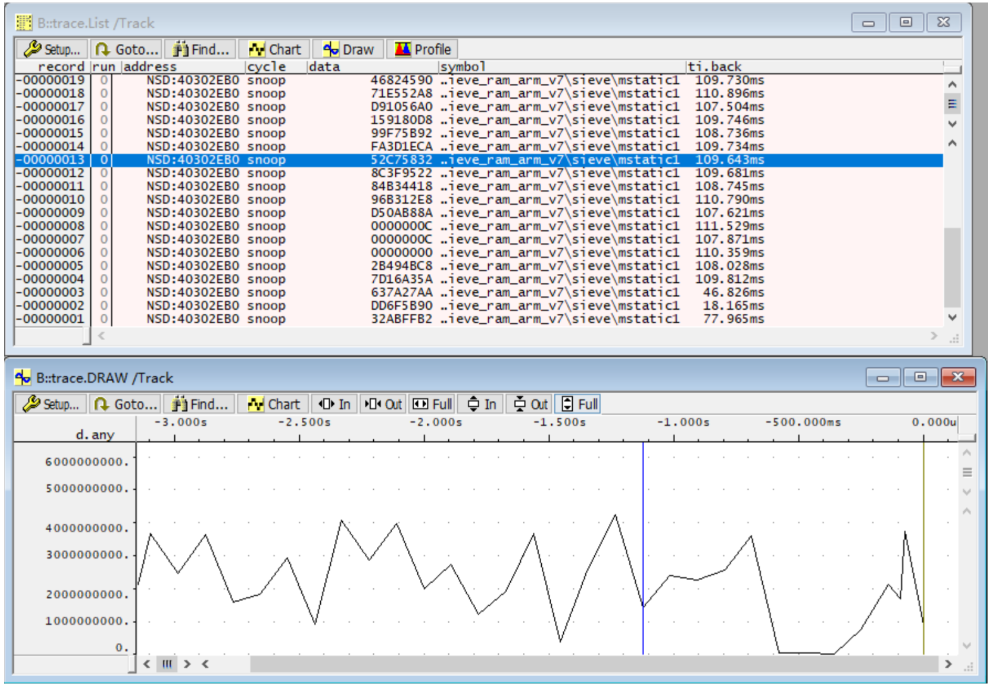
- 程序流记录，历史程序代码回溯





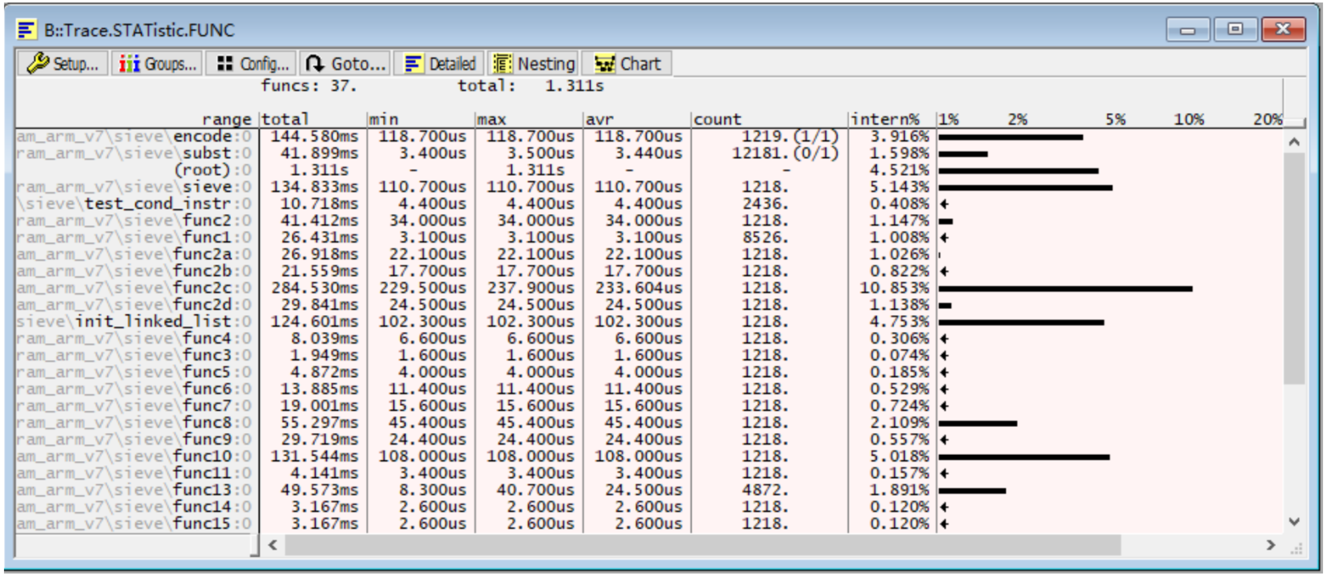
TRACE32® 跟踪功能

- 数据流记录



TRACE32® 跟踪功能

- 性能分析



B::Trace.STATistic.FUNC

Setup... | Groups... | Config... | Goto... | Detailed | Nesting | Chart

funcs: 37. total: 1.311s

range	total	min	max	avr	count	intern%
am_arm_v7\sieve\encode:0	144.580ms	118.700us	118.700us	118.700us	1219. (1/1)	3.916%
ram_arm_v7\sieve\subst:0	41.899ms	3.400us	3.500us	3.440us	12181. (0/1)	1.598%
(root):0	1.311s	-	1.311s	-	-	4.521%
ram_arm_v7\sieve\sieve:0	134.833ms	110.700us	110.700us	110.700us	1218.	5.143%
\sieve\test_cond_instr:0	10.718ms	4.400us	4.400us	4.400us	2436.	0.408%
ram_arm_v7\sieve\func2:0	41.412ms	34.000us	34.000us	34.000us	1218.	1.147%
ram_arm_v7\sieve\func1:0	26.431ms	3.100us	3.100us	3.100us	8526.	1.008%
am_arm_v7\sieve\func2a:0	26.918ms	22.100us	22.100us	22.100us	1218.	1.026%
am_arm_v7\sieve\func2b:0	21.559ms	17.700us	17.700us	17.700us	1218.	0.822%
am_arm_v7\sieve\func2c:0	284.530ms	229.500us	237.900us	233.604us	1218.	10.853%
am_arm_v7\sieve\func2d:0	29.841ms	24.500us	24.500us	24.500us	1218.	1.138%
sieve\init_linked_list:0	124.601ms	102.300us	102.300us	102.300us	1218.	4.753%
ram_arm_v7\sieve\func4:0	8.039ms	6.600us	6.600us	6.600us	1218.	0.306%
ram_arm_v7\sieve\func3:0	1.949ms	1.600us	1.600us	1.600us	1218.	0.074%
ram_arm_v7\sieve\func5:0	4.872ms	4.000us	4.000us	4.000us	1218.	0.185%
ram_arm_v7\sieve\func6:0	13.885ms	11.400us	11.400us	11.400us	1218.	0.529%
ram_arm_v7\sieve\func7:0	19.001ms	15.600us	15.600us	15.600us	1218.	0.724%
ram_arm_v7\sieve\func8:0	55.297ms	45.400us	45.400us	45.400us	1218.	2.109%
ram_arm_v7\sieve\func9:0	29.719ms	24.400us	24.400us	24.400us	1218.	0.557%
am_arm_v7\sieve\func10:0	131.544ms	108.000us	108.000us	108.000us	1218.	5.018%
am_arm_v7\sieve\func11:0	4.141ms	3.400us	3.400us	3.400us	1218.	0.157%
am_arm_v7\sieve\func13:0	49.573ms	8.300us	40.700us	24.500us	4872.	1.891%
am_arm_v7\sieve\func14:0	3.167ms	2.600us	2.600us	2.600us	1218.	0.120%
am_arm_v7\sieve\func15:0	3.167ms	2.600us	2.600us	2.600us	1218.	0.120%

TRACE32® 跟踪功能

- 代码覆盖率统计

Navigation: Application ▶ Module: sieve — *TRACE32© Code-Coverage Report*

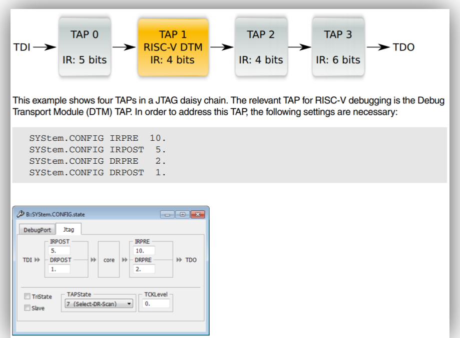
P:403004F8--40300587	func2d	stmt	100.000%		7	7	144	144
P:40300588--403005A3	func3	stmt	100.000%		3	3	28	28
P:403005A4--403005FB	func4	stmt	100.000%		4	4	88	88
P:403005FC--4030063B	func5	stmt	100.000%		3	3	64	64
P:4030063C--403006B7	func6	stmt	100.000%		7	7	124	124
P:403006B8--40300753	func7	stmt	100.000%		7	7	156	156
P:40300754--40300A57	func8	stmt	100.000%		38	38	772	772
P:40300A58--40300AEF	func9	stmt	100.000%		13	13	152	152
P:40300AF0--40300E2B	func10	stmt	100.000%		104	104	828	828
P:40300E2C--40300EF7	func11	incomplete	35.714%		14	5	180	56
P:40300EF8--40300F1F	func12	incomplete	0.000%		3	0	40	0
P:40300F20--40300FC3	func13	stmt	100.000%		8	8	164	164
P:40300FC4--40300FEF	func14	stmt	100.000%		3	3	44	44
P:40300FF0--4030101B	func15	stmt	100.000%		3	3	44	44
P:4030101C--40301043	func16	stmt	100.000%		3	3	40	40
P:40301044--4030107B	func17	stmt	100.000%		3	3	56	56
P:4030107C--403010AF	func18	stmt	100.000%		3	3	52	52
P:403010B0--403010E3	func19	stmt	100.000%		3	3	52	52
P:403010E4--40301123	func20	stmt	100.000%		3	3	64	64
P:40301124--40301163	func21	stmt	100.000%		3	3	64	64
P:40301164--403011A3	func22	stmt	100.000%		3	3	64	64
P:403011A4--403011E3	func23	stmt	100.000%		3	3	64	64
P:403011E4--403011FF	func24	stmt	100.000%		3	3	28	28
P:40301200--4030121F	func25	stmt	100.000%		3	3	32	32
P:40301220--4030123F	func26	stmt	100.000%		3	3	32	32
P:40301240--403012A3	func27	incomplete	0.000%		4	0	100	0
P:403012A4--403012EB	test_cond_instr	stmt	100.000%		4	4	72	72
P:403012EC--403013DB	int_sin	incomplete	0.000%		9	0	240	0
P:403013DC--4030146B	func_sin	incomplete	0.000%		5	0	144	0
P:4030146C--4030164F	init_linked_list	stmt	100.000%		14	14	484	484
P:40301650--40301707	subst	stmt	100.000%		9	9	100	100
P:40301708--403017DB	encode	stmt	100.000%		12	12	212	212
P:403017DC--4030184B	func28	stmt	100.000%		5	5	112	112
P:4030184C--40301E1F	main	incomplete	91.025%		78	71	1492	1420
P:40301E20--40301ECF	sieve	stmt	100.000%		15	15	176	176
P:40301ED0--40301F5F	background	incomplete	0.000%		8	0	184	0
	total	incomplete	89.427%		454	406	7492	6564

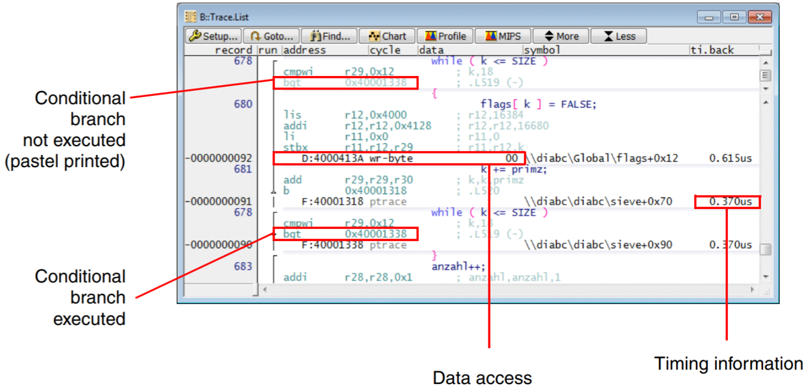
议题

- LAUTERBACH公司介绍
- TRACE32®工具RISC-V 的调试跟踪解决方案
- RISC-V 调试相关的文档/培训/支持

TRACE32® 调试RISC-V相关文档

- https://www2.lauterbach.com/pdf/debugger_riscv.pdf
- https://www2.lauterbach.com/pdf/training_nexus.pdf
- https://www.lauterbach.com/manual.html 下更多内容





OS Awareness Manuals

OS Awareness Manual AMX	rtos_amx.pdf
OS Awareness Manual ARTK	rtos_artk.pdf
OS Awareness Manual Atomthreads	rtos_atomthreads.pdf
OS Awareness Manual ARTX-166	rtos_rtxartx166.pdf
OS Awareness Manual ChibiOS/RT	rtos_chibios.pdf
OS Awareness Manual Chorus Classic	rtos_chorus_classic.pdf
OS Awareness Manual Chorus Micro	rtos_chorus_micro.pdf
OS Awareness Manual Cmicro	rtos_cmicro.pdf
OS Awareness Manual CMX	rtos_cmx.pdf
OS Awareness Manual CMX-TINY+	rtos_cmx_tiny.pdf
OS Awareness Manual DSP/BIOS	rtos_bios.pdf
OS Awareness Manual eCos	rtos_ecos.pdf
OS Awareness Manual embOS	rtos_embos.pdf
OS Awareness Manual FAMOS	rtos_famos.pdf
OS Awareness Manual FreeRTOS	rtos_freertos.pdf
OS Awareness Manual HI7000	rtos_hi7000.pdf
OS Awareness and Run Mode Debugging for Linux	
Run Mode Debugging Manual Linux	rtos_linux_run.pdf
OS Awareness Manual Linux	rtos_linux_stop.pdf
Training Linux Debugging	training_rtos_linux.pdf
OS Awareness Manual LiteOS	rtos_liteos.pdf
OS Awareness Manual LynxOS	rtos_lynx.pdf
OS Awareness Manual MicroC/OS-II	rtos_ucos.pdf
OS Awareness Manual MicroC/OS-III	rtos_ucos3.pdf
OS Awareness Manual MicroC3/Compact	rtos_uc3cmp.pdf
OS Awareness Manual MicroC3/Standard	rtos_uc3std.pdf
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OS Awareness Manual OKL4	rtos_okl4.pdf
OS Awareness Manual OS21	rtos_os21.pdf
OS Awareness Manual OS-9	rtos_os9.pdf
OS Awareness Manual OSE Classic	rtos_ose_classic.pdf
OS Awareness Manual OSE Delta	rtos_ose_delta.pdf
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OS Awareness for OSEK/ORTI	
OS Awareness Manual OSEK/ORTI	rtos_orti.pdf
Application Note for OSEK/ORTI	
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OS Awareness Manual PrKERNEL	rtos_prkernel.pdf
OS Awareness Manual pSOS+	rtos_psos.pdf
OS Awareness Manual PXROS	rtos_pxros.pdf

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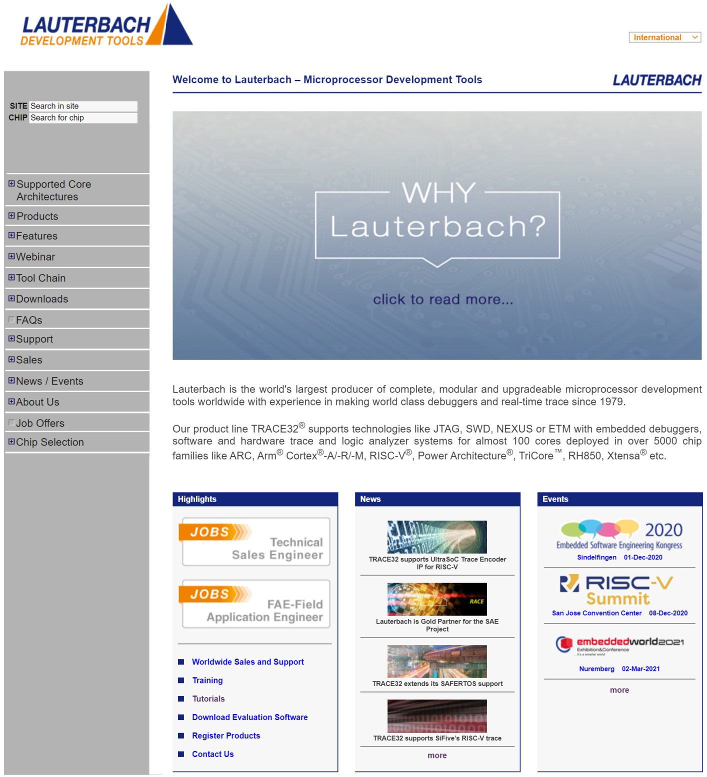
Debugging Linux with a TRACE32 JTAG Debugger by Wiem Benayed

- **TRACE32 Linux Debugging (ca. 10 min)**



TRACE32® 微信公众号资源

- 更新新的芯片的支持情况
- 分享RISCV调试技巧视频
- 经典实用案例文章

LAUTERBACH 本地技术支持

- 电话
- 邮件
- 远程协助 （Skype, Zoom…）
- 苏州培训学院（免费）
- 定制的上门支持和培训服务（收费）

QUESTIONS?

THANK YOU!

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