Development Tools
for ARM-Powered Devices

MDK-ARM Microcontroller Development Kit
ULINK Adapters
Evaluation Boards

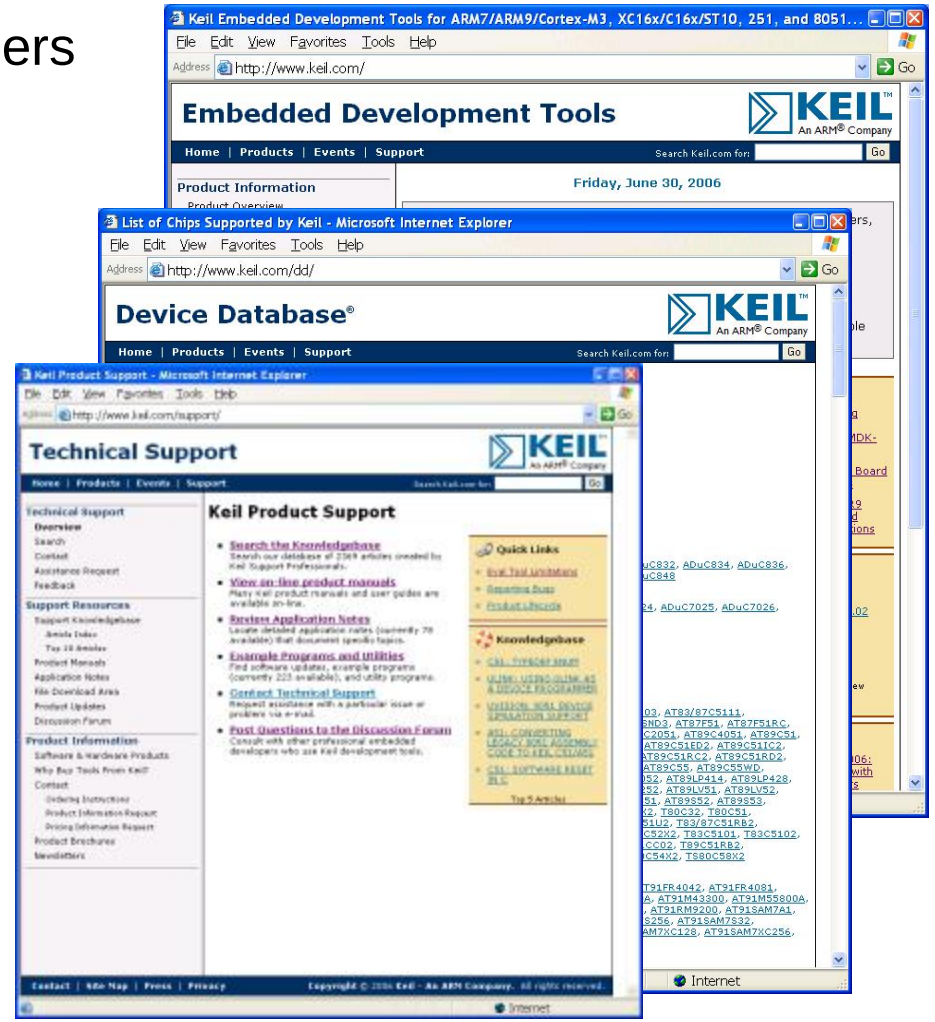
June 2009

Agenda

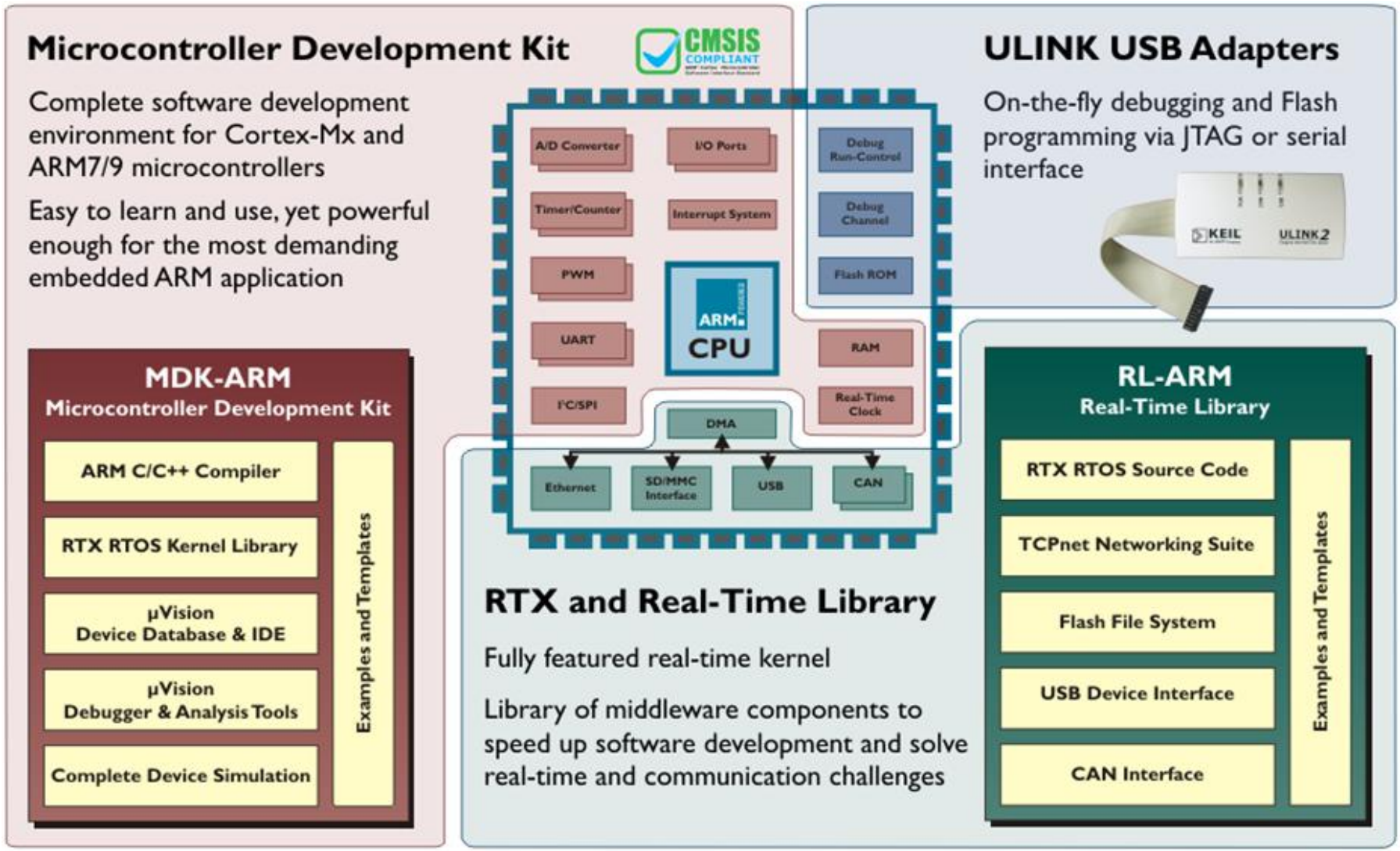
- Introduction and Overview
- Keil MDK-ARM Microcontroller Development Kit
  - µVision4 Integrated Development Environment
  - ARM Compilation Tools
  - Verification and Debug
    - Complete device simulation
    - Analysis tools
    - CoreSight Debug & Trace
- Hardware Components
  - ULINK USB-JTAG Adapters
  - Evaluation Boards

Keil Microcontroller Tools

- Leading supplier of MCU development tools
  - ANSI C/C++ compilers, Debuggers
  - Device simulation
  - Middleware components
- Extensive Device Database®
  - >1,600 8/16/32 bit MCUs
- Established support
  - Web support portal
  - User group structure
  - Global distribution network
- Huge installed base
  - 100K+ users world wide

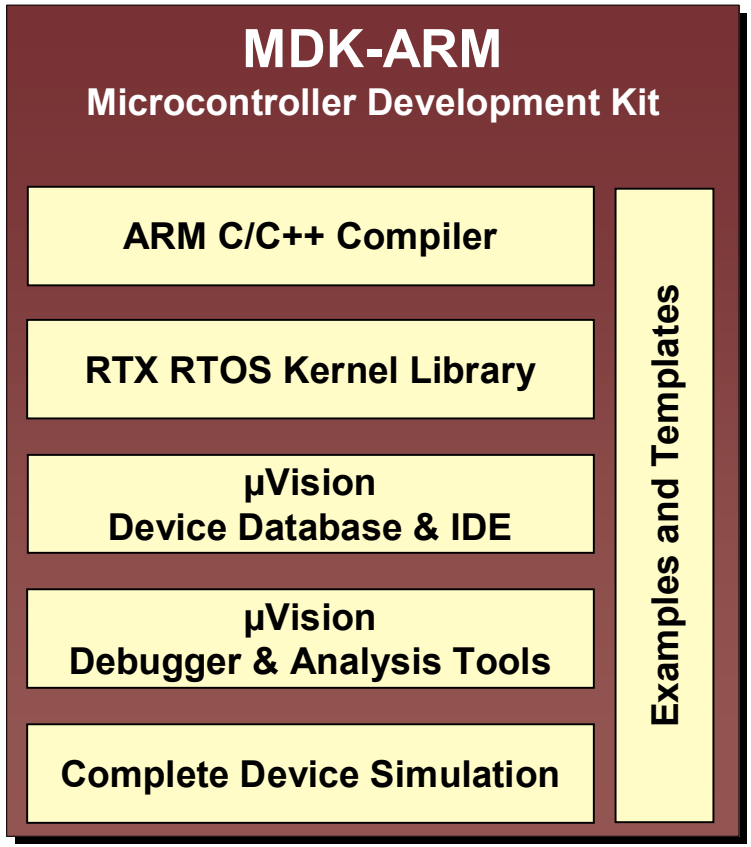


Software Development Tools



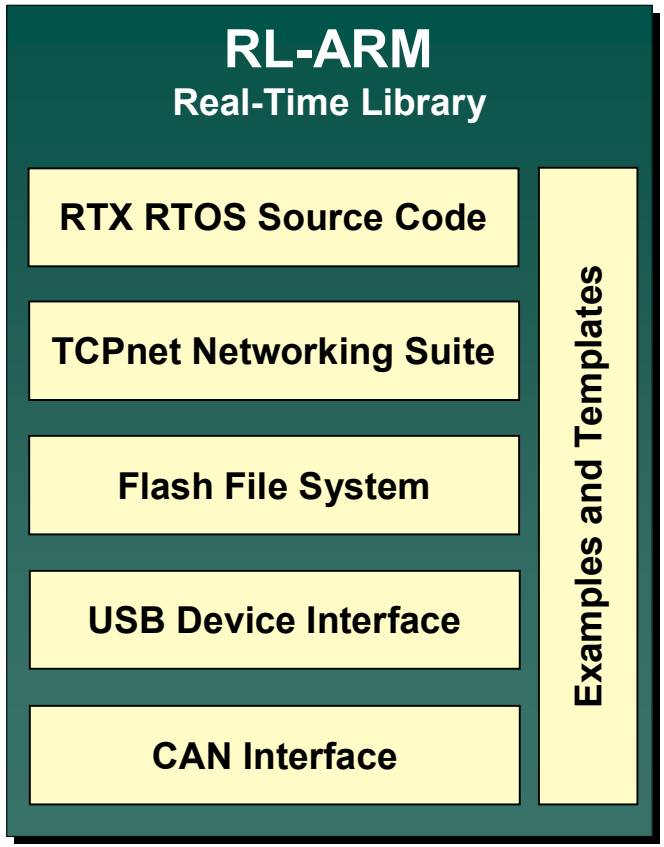
MDK-ARM

- Complete software development environment
  - For ARM7/9 and Cortex-Mx devices
  - Easy to learn and easy to use
- Industry leading technology
  - ARM Compiler
  - Keil µVision IDE / Debugger
- Complete device support
  - ARM7, ARM9, Cortex-Mx MCUs
  - Start-up code & Flash algorithms
  - Complete device simulation
  - Board support packages (BSPs)
- RTX Real-Time Kernel
  - Efficient RTOS Kernel for small systems



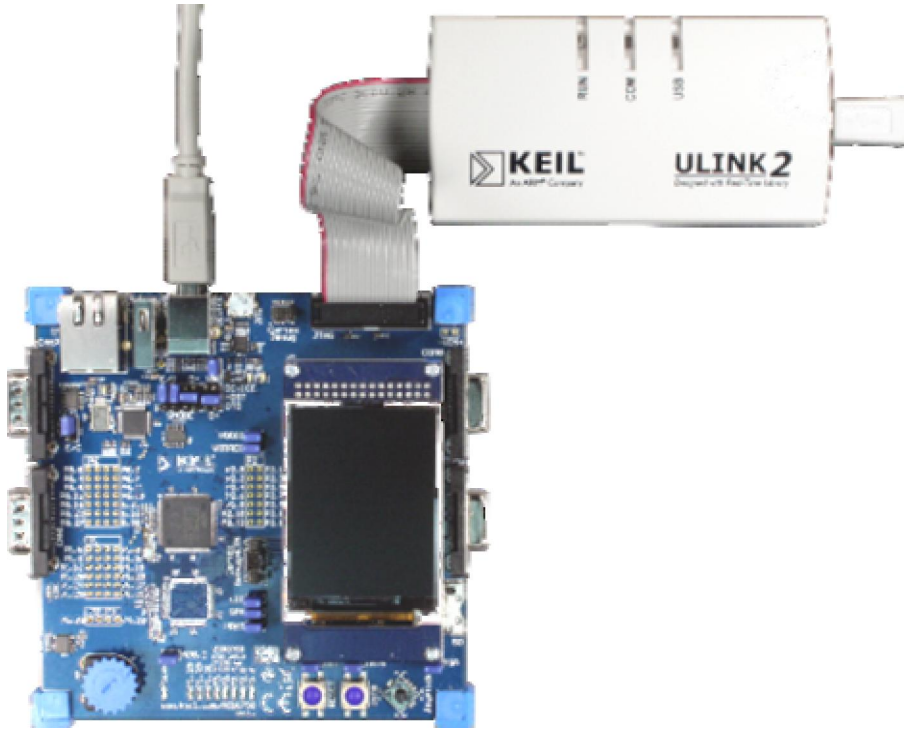
RL-ARM

- Extensive library of ready-to-use middleware components
  - Speed up software development
- Meets Embedded Developers' needs
  - Solves common embedded challenges
  - Real-Time Systems
  - Embedded communication & networking
  - Designed for use with MCU Devices
- Extensive Range of Examples
  - Easy to begin working
  - Can be used as building blocks
- Royalty Free
  - Includes RTX source code.
  - License – single user, multi project



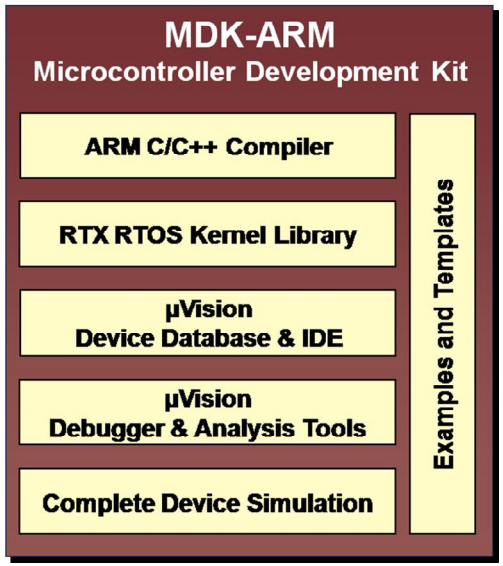
Hardware Components

- Range of evaluation boards and debug hardware
  - Verify application running on hardware target
- ULINK family of USB Adapters
  - Debug and Flash programming
  - JTAG and SWD support
  - Hi-Speed Streaming Trace
- Evaluation Boards
  - ARM7, ARM9, & Cortex-M3
  - Luminary, NXP, ST, & Toshiba



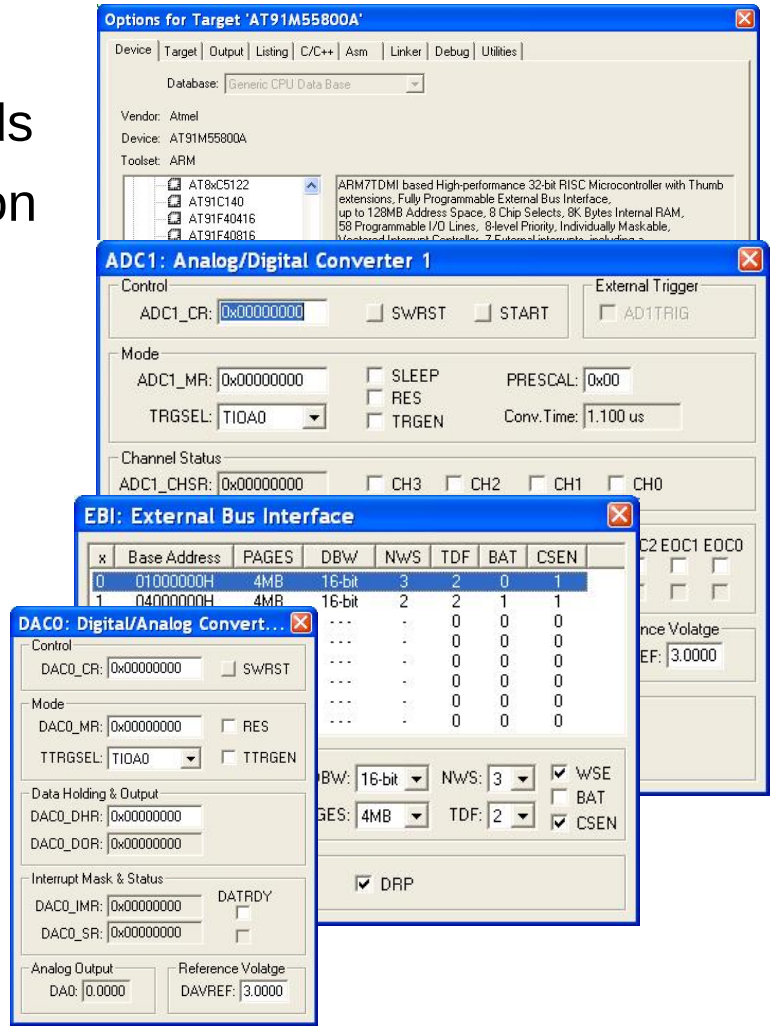
MDK-ARM

Microcontroller Development Kit



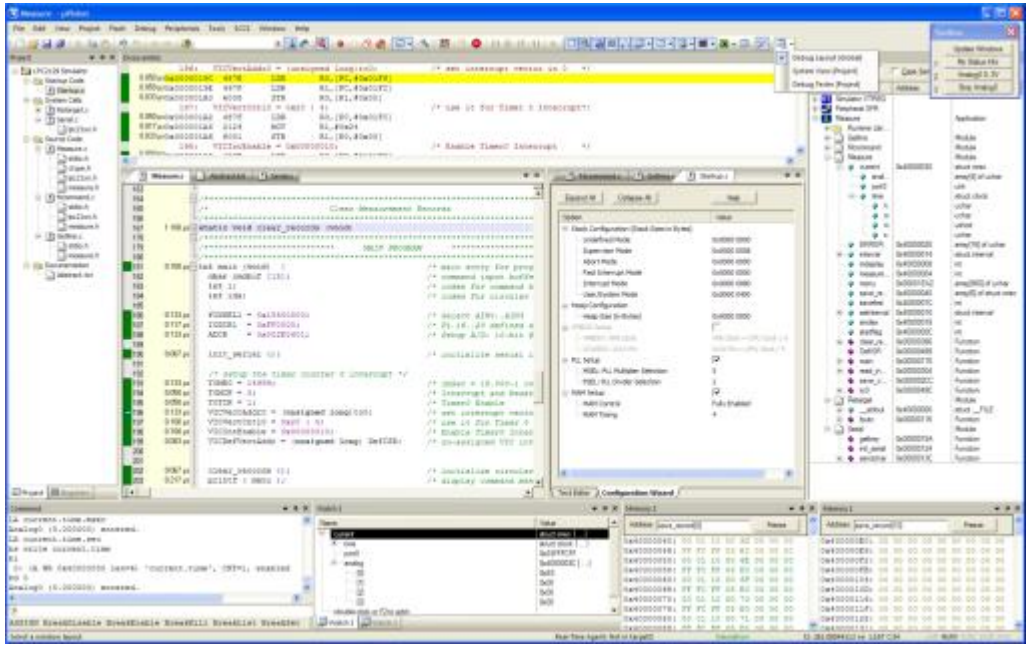
MDK-ARM supports MCUs

- Out-of-the-box support
  - >490 ARM MCUs
  - Start-up code and configuration wizards
  - Flash Algorithms and debug information
  - Examples and Templates
- Complete device simulation
  - Not only a processor simulator!
  - Includes On-Chip peripherals
  - External signals and I/O



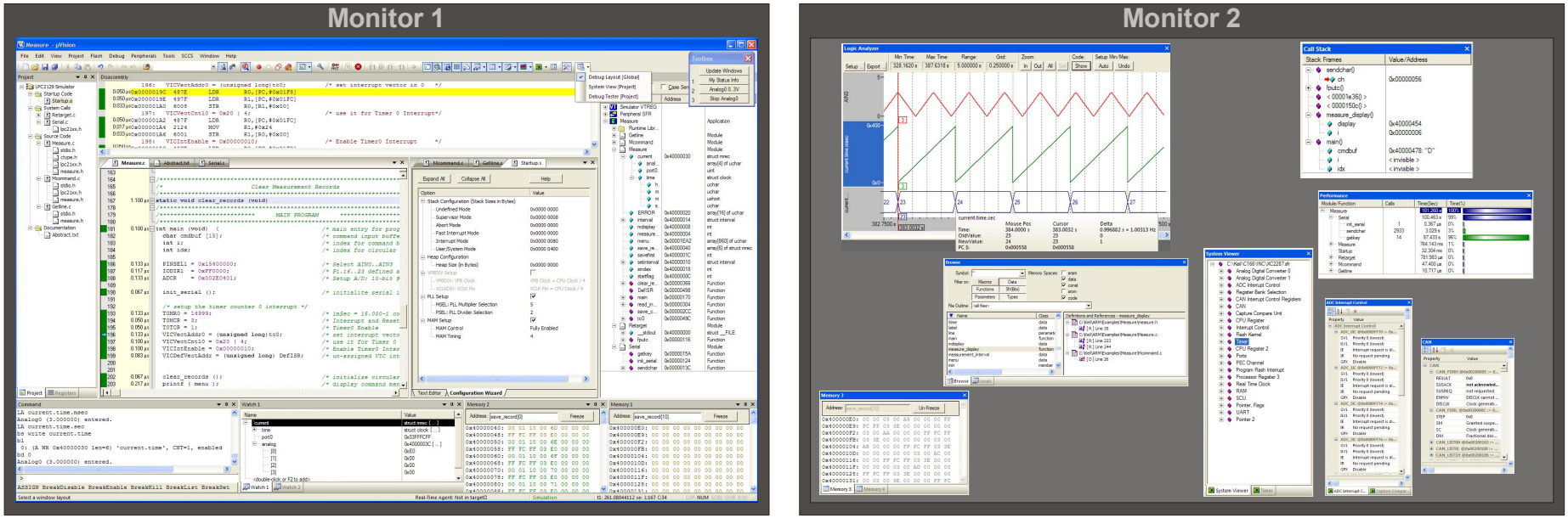
µVision4 IDE

- Industry-leading IDE for MCU and smartcard devices
  - Common to ARM, C166, and 8051 platforms
  - Includes target device configuration and Device Database
  - High speed simulation
    - Instruction Set
    - On-chip peripherals
  - Source code editor
  - Project debugging
  - Flash programming



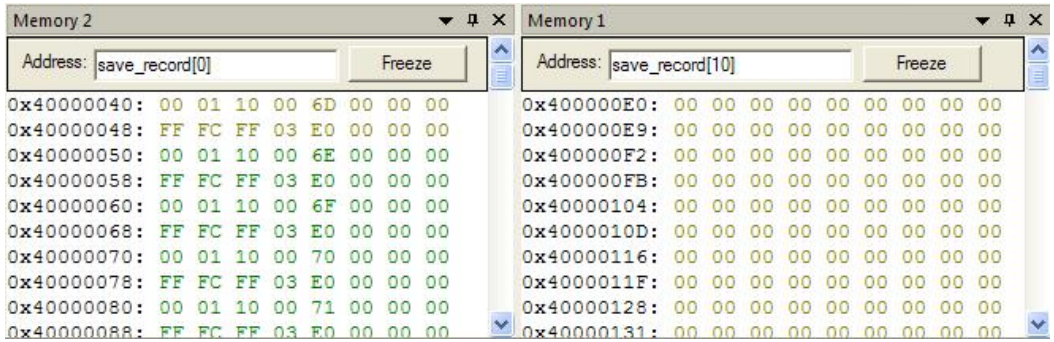
Multi-Monitor Support

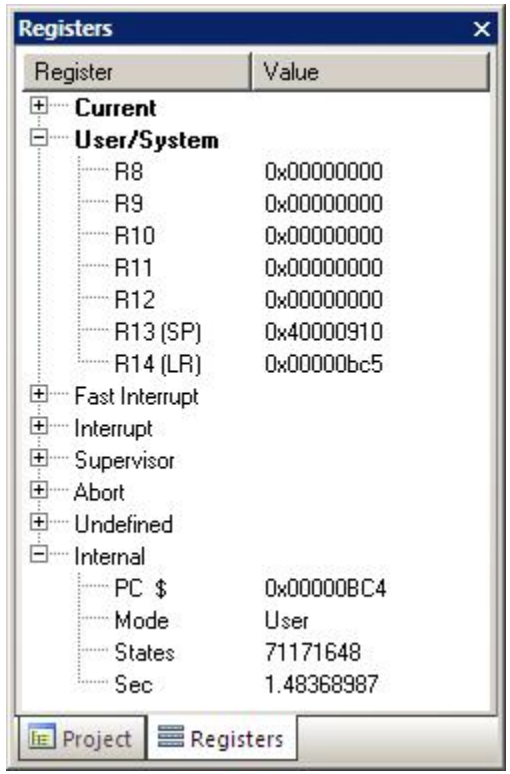
- Flexible windows management
  - Support for multiple monitors
  - Drag and drop windows anywhere on the work space
- Docking windows
  - Leave windows floating or docked to others



Flexible Windows Management

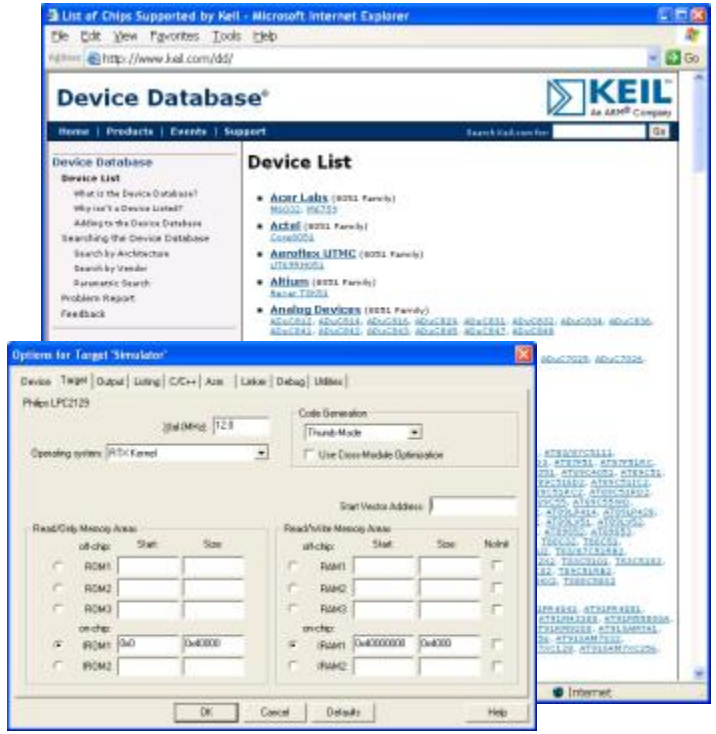
- Multiple windows
  - Open multiple versions of windows
  - Can be docked together or floated in workspace
- Tabbed groups
  - Group related windows together
  - Easy access and navigation





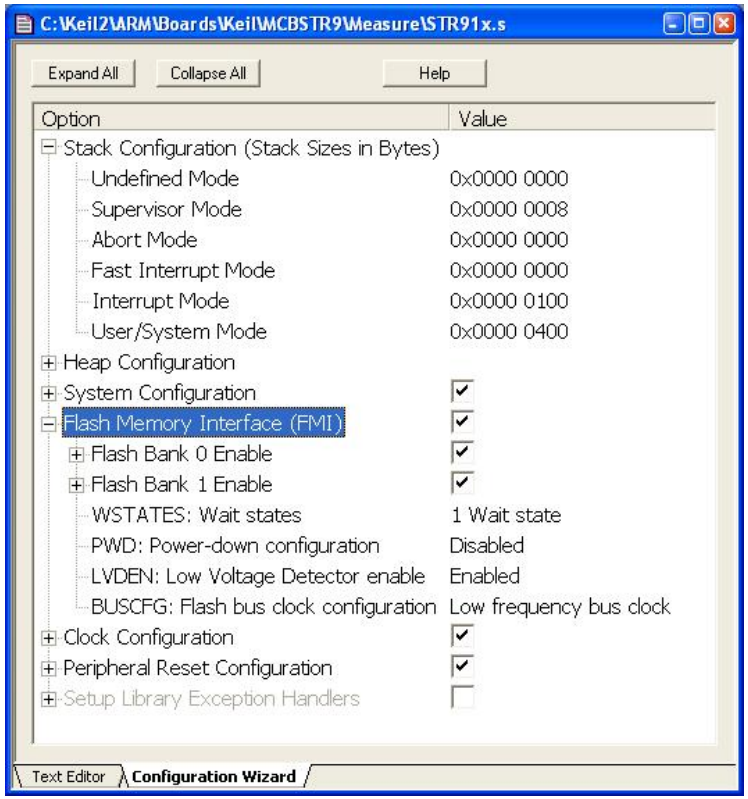
Device Database

- Enables quick selection of suitable device
- On-line
  - Includes Parametric Search
  - www.keil.com/dd
- µVision
  - Includes main parameters for device
  - Enables easy project creation
  - Fast device configuration



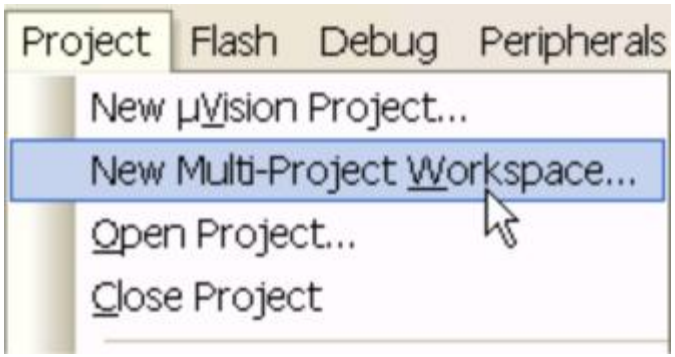
Device Configuration

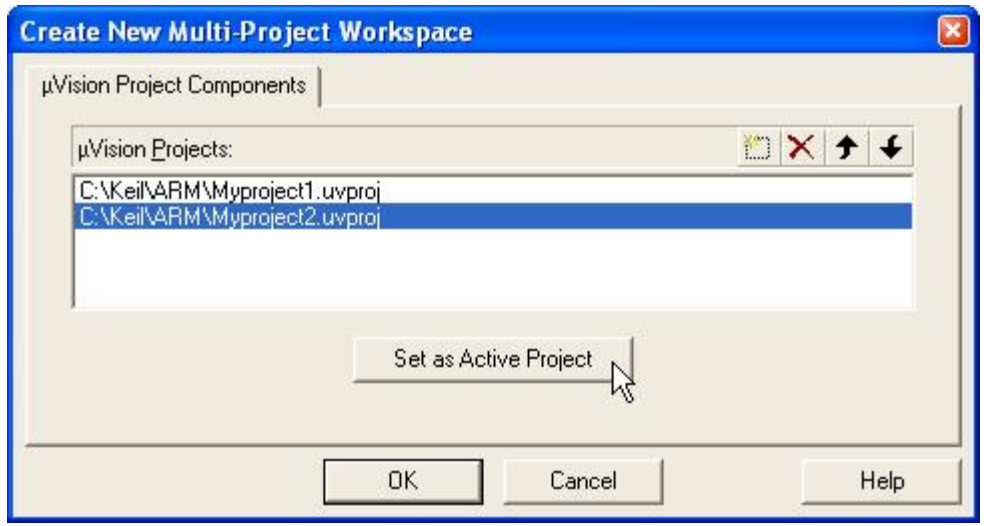
- Enables effortless device set-up
- Available for all devices
  - Included in Device Database
  - User configurable (text or wizard)
- Configuration Wizard
  - Main parameters for device
  - Drop-down selection or user entry
  - Enables stable device start-up



Multi project workspace

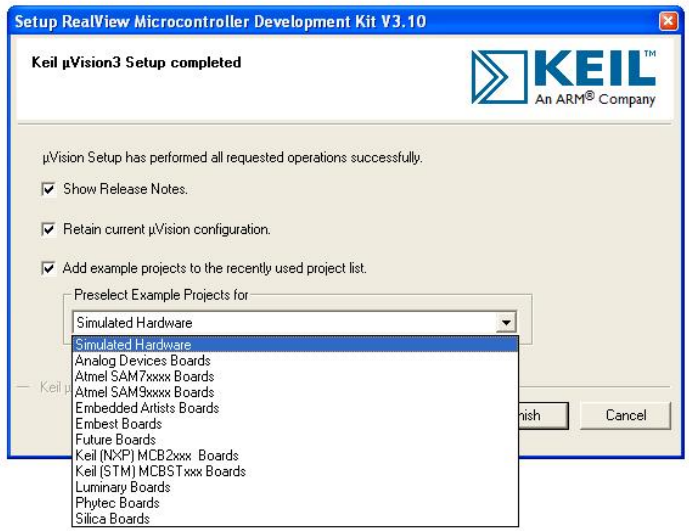
- Often need to work on more than one project at same time
  - Develop application and bootloader
- Multi-project workspace
  - Define a group of projects as a Multi-Project Workspace file (.MPW)
  - Work on them in one project workspace





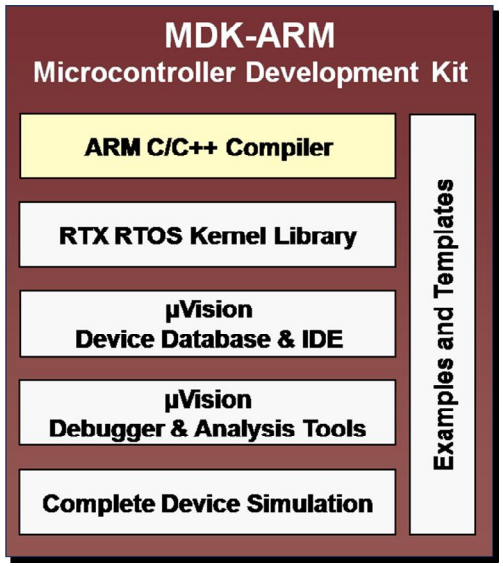
Examples and Templates

- Board Support Packages
  - Examples and BSPs provided for numerous evaluation boards from many vendors
  - Examples work on target hardware or simulation
- Templates
  - Enable base for user projects
- Fast out-of-box experience
  - Included in MDK-ARM and RL-ARM



MDK-ARM

Compilation Tools

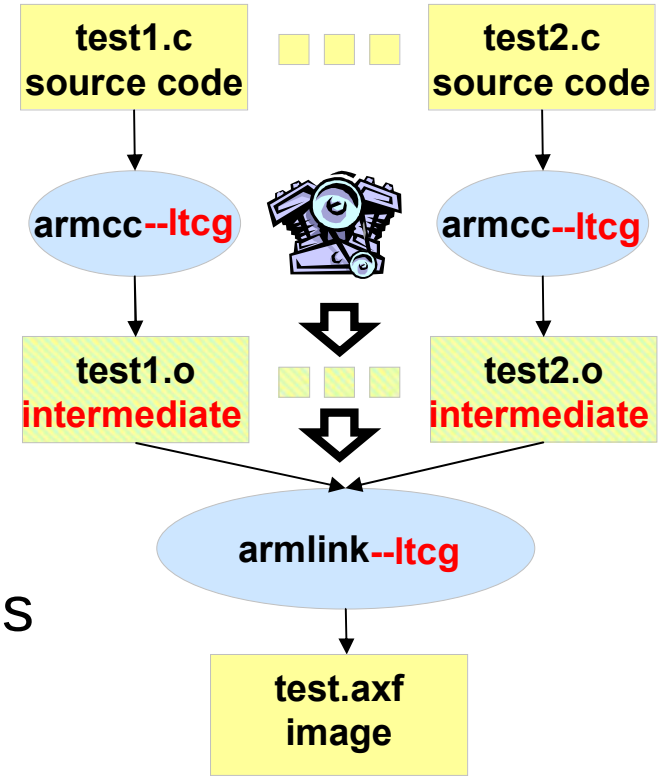


ARM Compilation Tools

- Best-in-class compilation tools
  - Enables applications to run faster
  - Reduces system cost
- The ARM Compilation tools contain:
  - Highly-optimizing ISO C/C++ compiler
  - Supports ARM, Thumb and Thumb2 Instruction sets including FPU
  - Full C and C++ run-time library support
- The ARM Compiler Advantage
  - Smaller, Faster Code

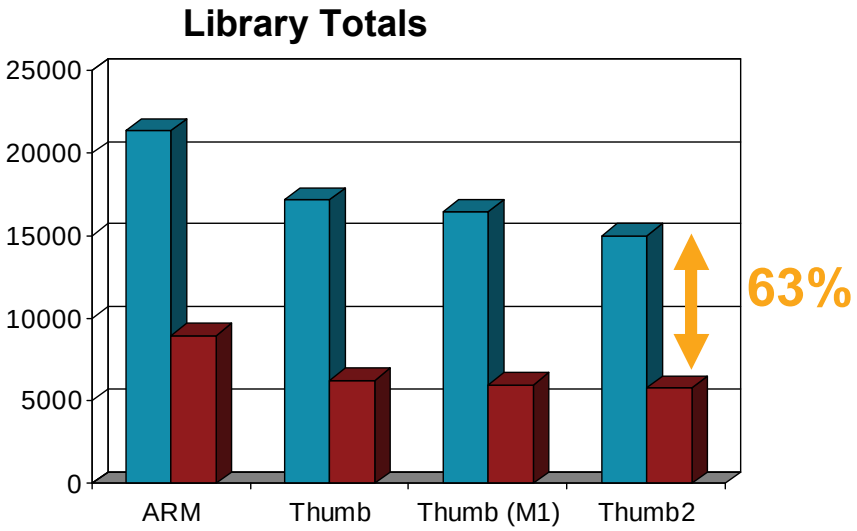
ARM Compilation Tools v4.0

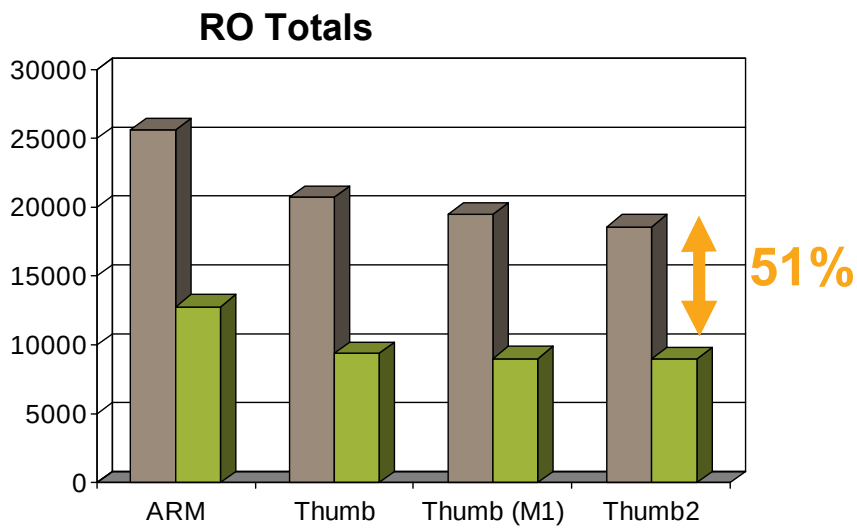
- New link-time code generation
  - Compilation of code at link time
  - Applies optimizations across files
    - In-lining, shared literals, cross-jumping
  - Fits into normal build process
    - Just add --ltcg command line option
  - 5% better code size and performance
- Includes MicroLib optimized C Libraries
  - Superset of standard ARM C Library
  - Optimized for embedded applications
    - Minimal overhead for un-used OS functionality
    - Un-used functions removed from memory footprint
  - Faster system bring-up
    - Most functions initialized at point of use



MicroLib – Optimized for Embedded

- Reduces system code size by 50% to 90%



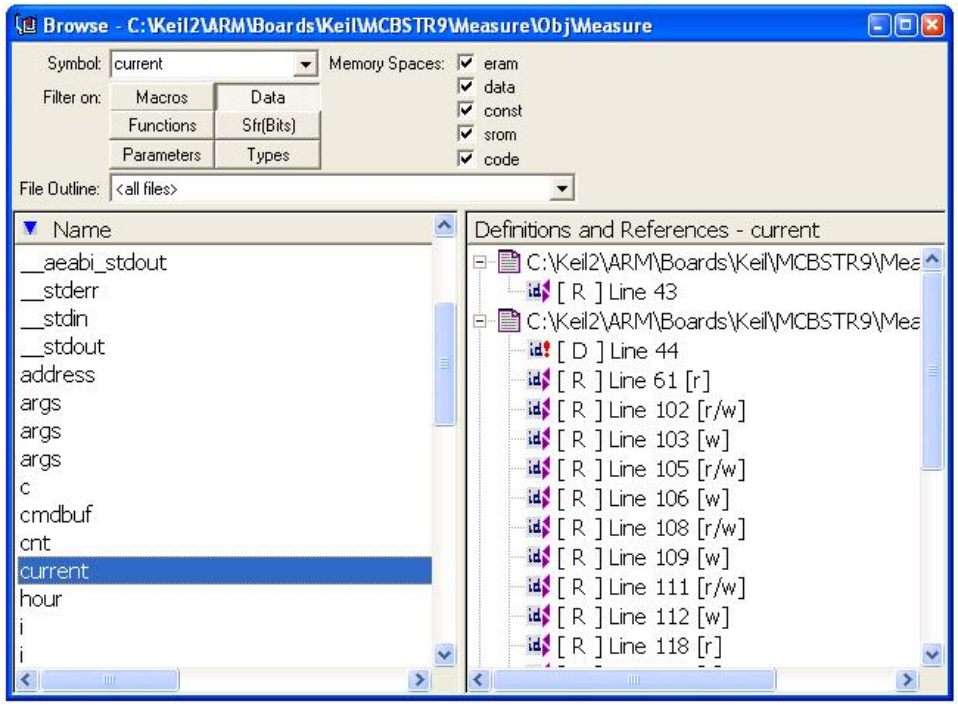


Processor	Object		Standard	MicroLib	% saving
ARM7TDMI	ARM	Library Total	21,352	8,980	61%
		RO Total	25,608	12,816	51%
ARM7TDMI	Thumb	Library Total	17,156	6,244	57%
		RO Total	20,129	9,348	50%
Cortex-M1	Thumb	Library Total	16,452	5,996	64%
		RO Total	19,472	9,016	54%
Cortex-M3	Thumb-2	Library Total	15,018	5,796	63%
		RO Total	18,616	8,976	54%

Based on Dhrystone 2.1 Benchmark

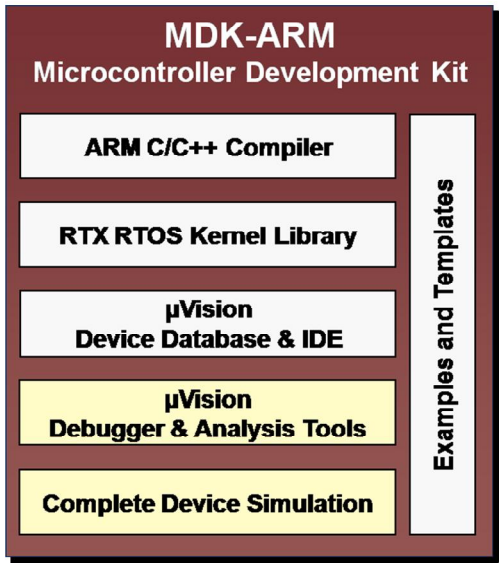
Source Browser

- Displays variable and function definitions
  - Use F12 key to display definition
  - View all instances throughout your application



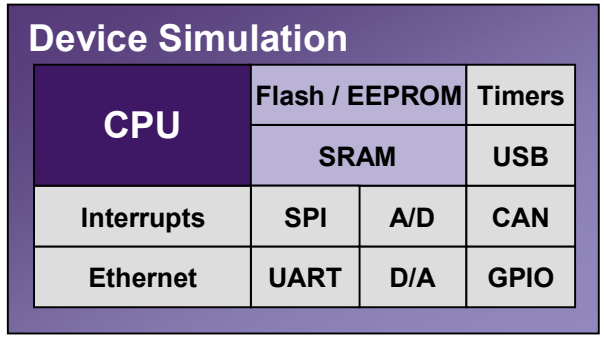
MDK-ARM

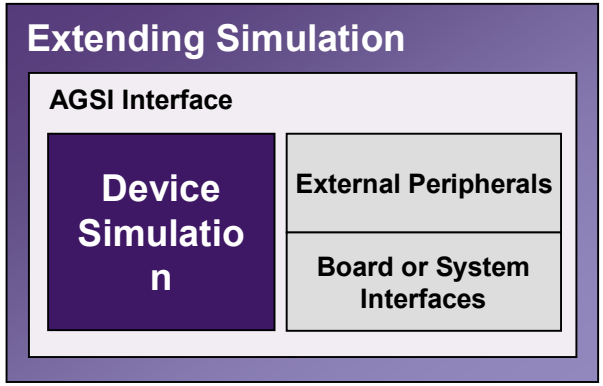
Verification and Debug



µVision Device Simulation

- All components of target device are simulated
  - Code can be run on entire device
  - Complete simulation of target
- Fast Instruction Set Simulation (ISS)
  - On-chip peripherals
  - ADC, DAC, EBI, Timers
  - UART, CAN, I2C, Interrupts, etc.
  - Includes external signals and I/O
- Dialog Boxes
  - Complete access to peripherals
  - Read and write



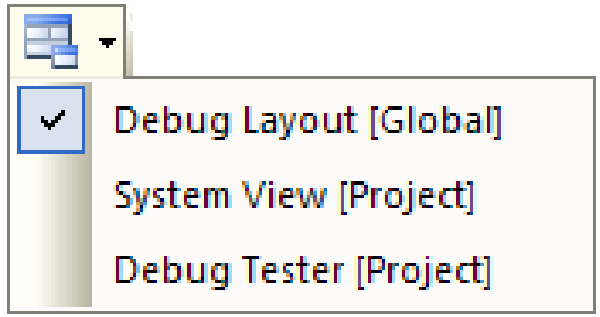


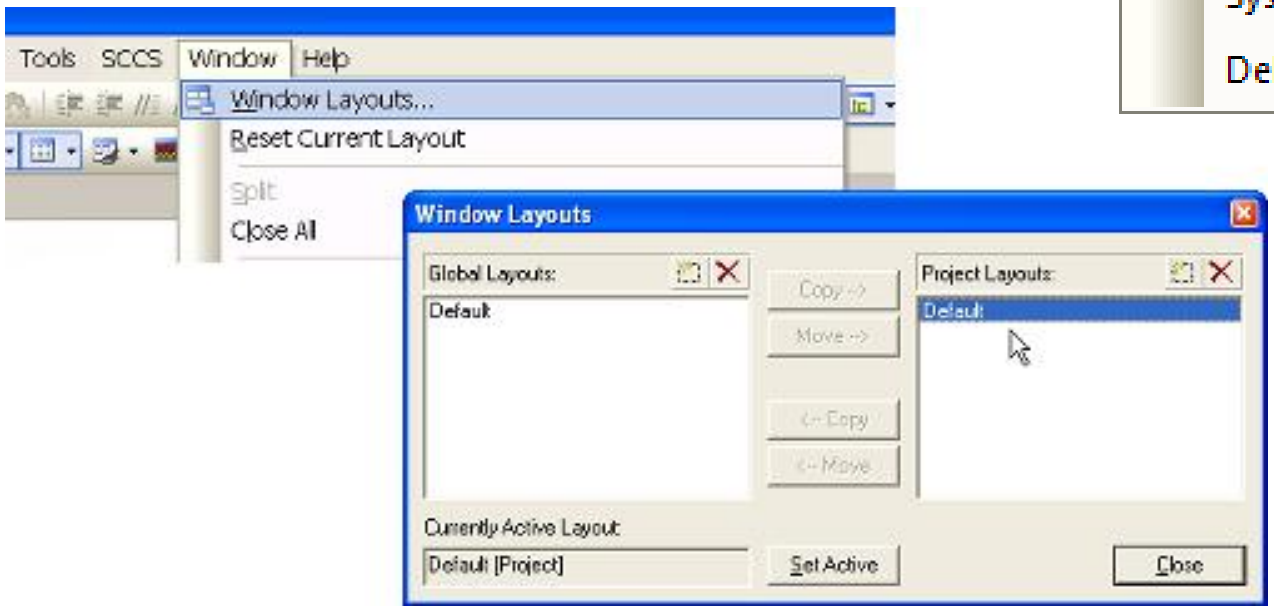
CPU and Peripheral Control

- Simulation offers synchronization of all components
- Halt Stops Peripherals
  - Whole system stops, including external signals
  - Breakpoint and Single-Stepping
- Complete System Analysis
  - Test can be reproduced
  - Executes from a ‘known’ state
- Full Power-Down Control
  - Debug in all MCU states
  - Timing analysis of power-down activity

Debug Restore views

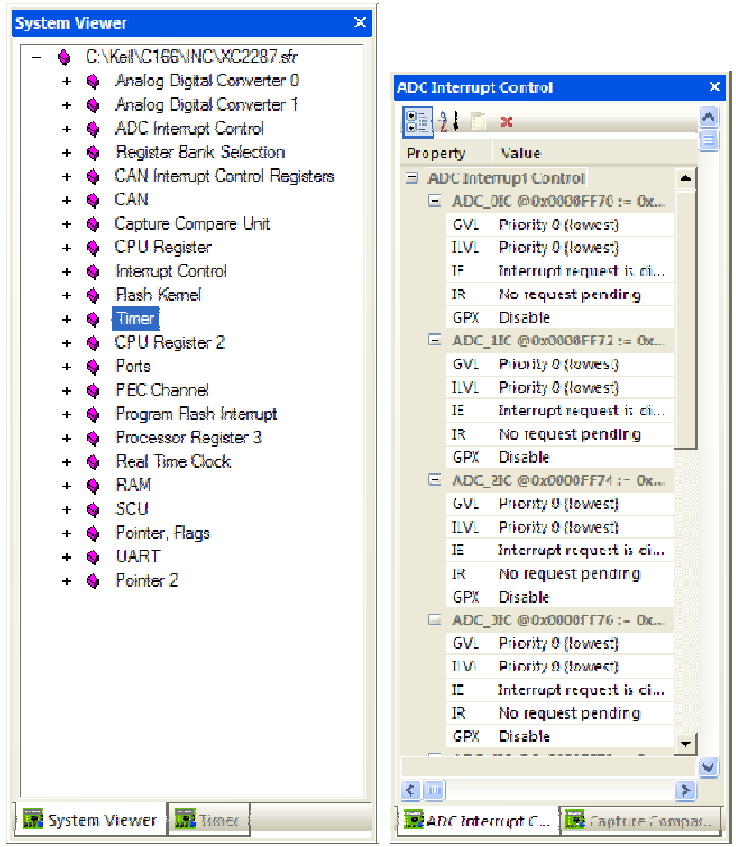
- Save multiple debug window layouts
  - Customize view to suit application being debugged
  - Save multiple views for a project
  - Save a view globally or locally





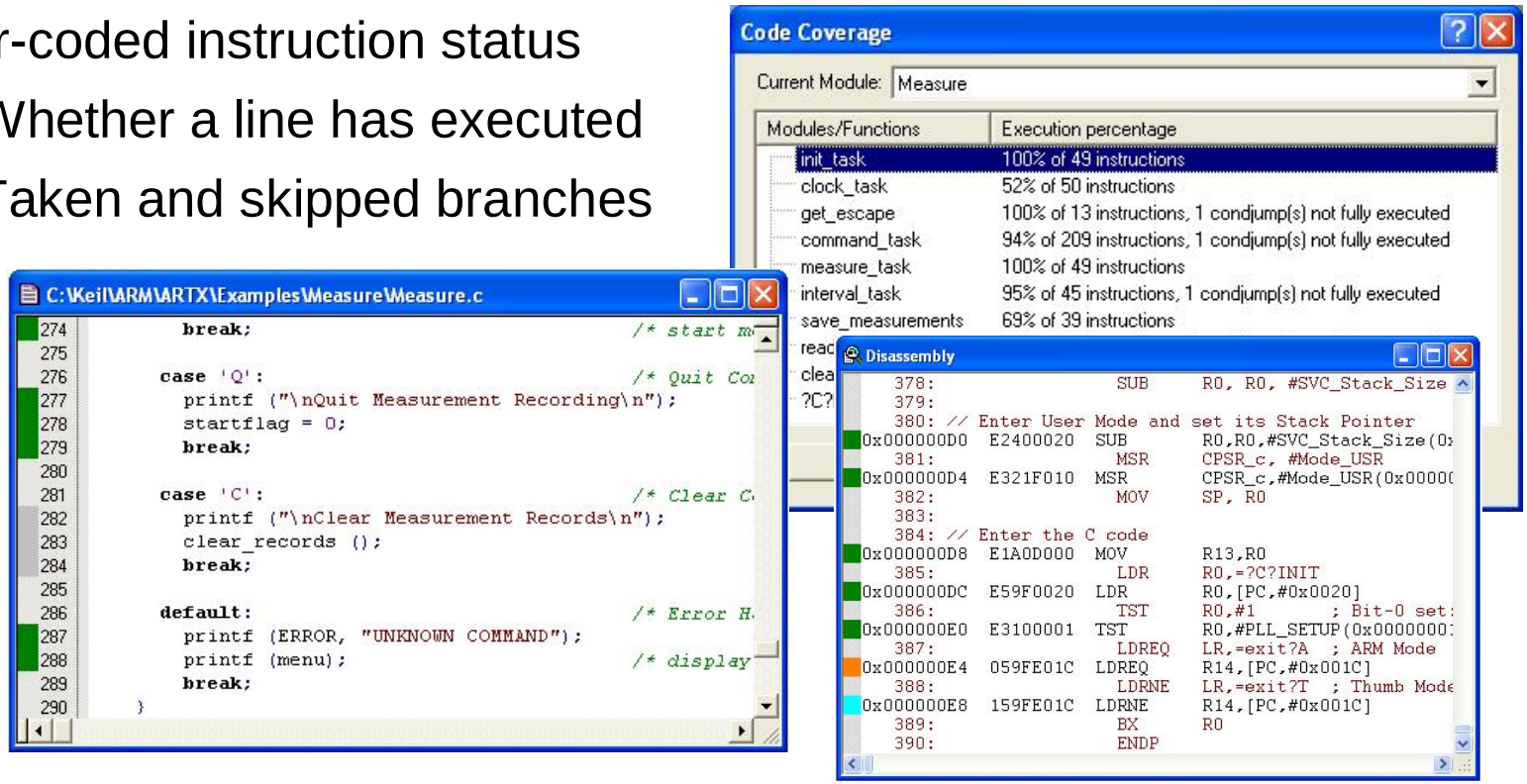
System Viewer Windows

- Displays contents of device's peripheral registers
  - Detailed status information is available
  - Change register values directly from the window
- Flexible views
  - Window can show registers from one or multiple peripherals
  - Can open multiple windows during a debug session



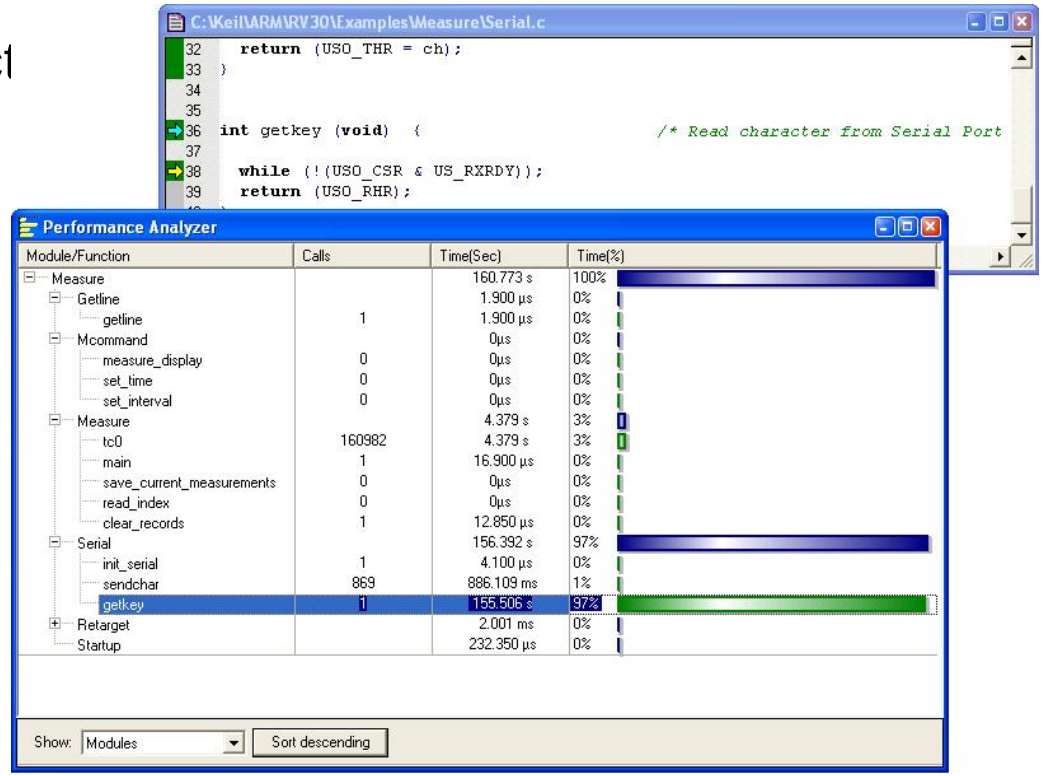
Code Coverage

- Execution Statistics
  - Always active for complete project
  - Multi-session coverage
    - Compare coverage results from different tests
  - Color-coded instruction status
    - Whether a line has executed
    - Taken and skipped branches



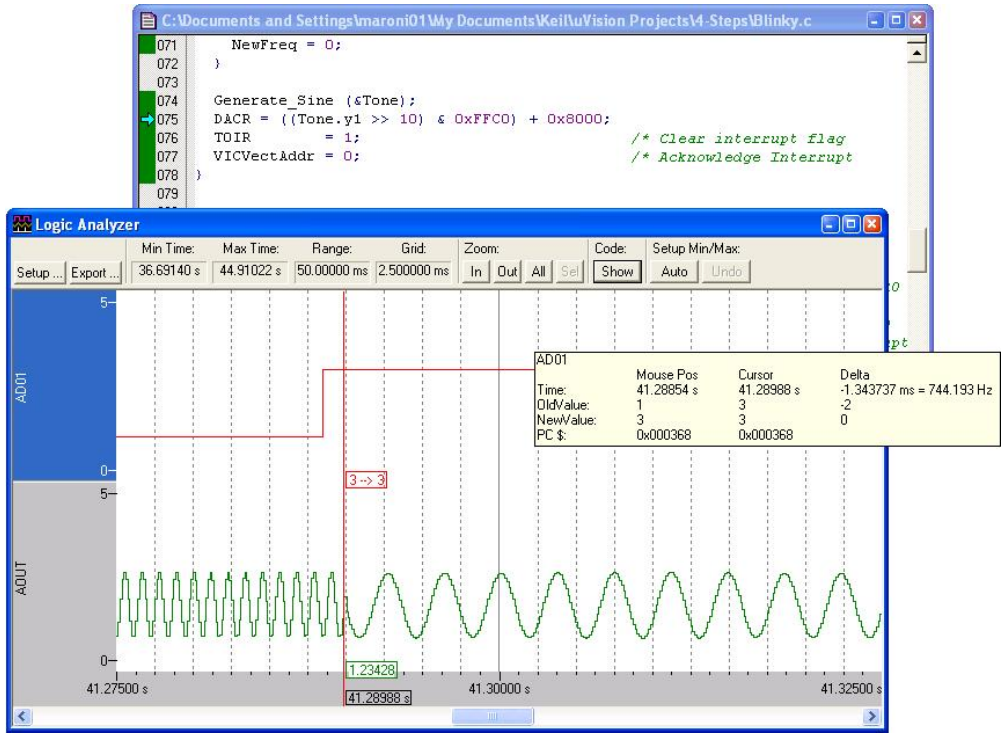
Execution Profiling

- Simulation provides exact CPU timing
  - Analyze program execution with different parameters
- Detailed Timing Statistics
  - Active for Complete Project
    - Execution Time
    - Number of Executions
  - Flexible Views
    - Source
    - Disassembler
    - Compete Overview



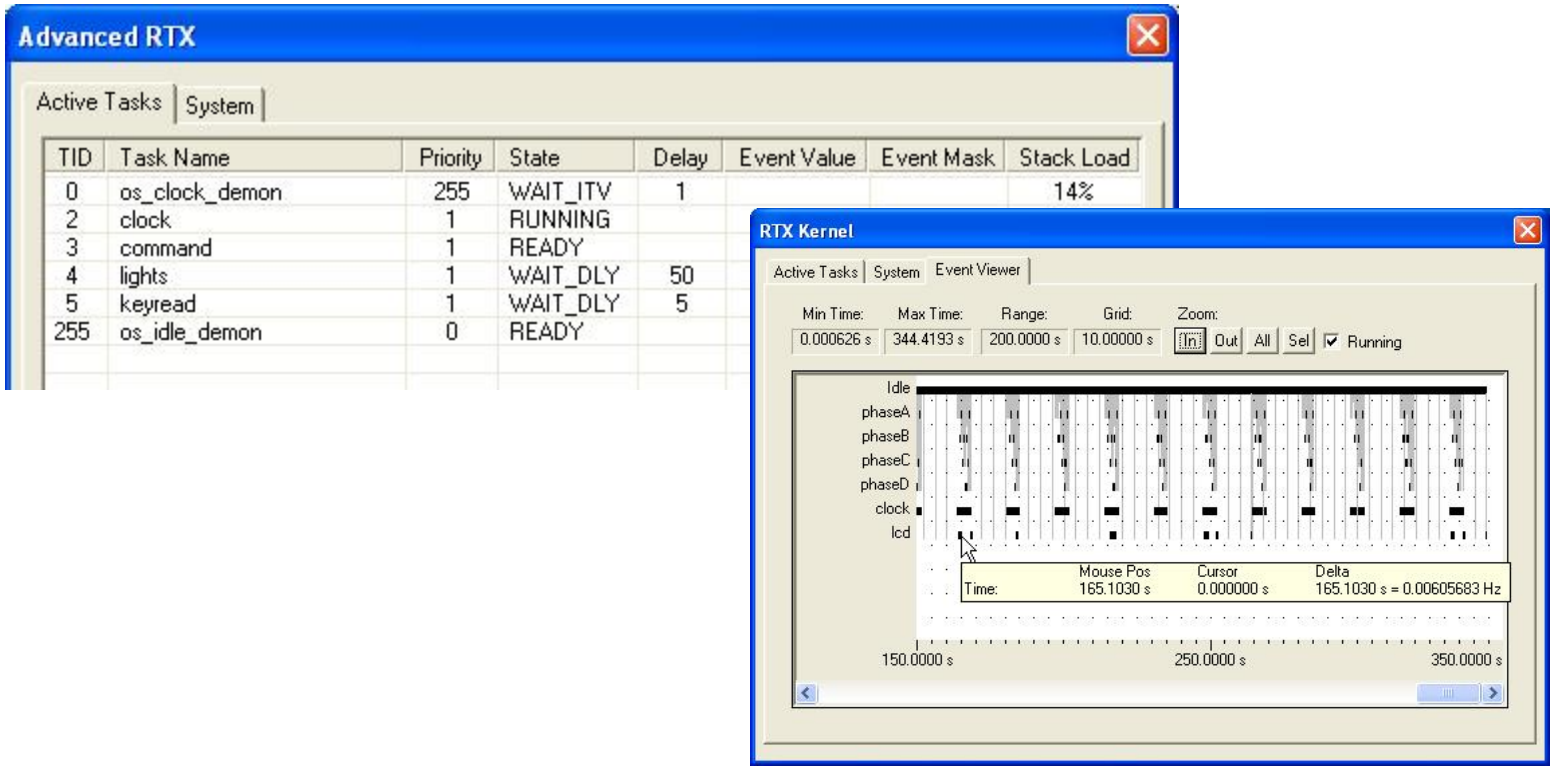
Logic Analyzer

- Allows signals to be monitored graphically
- Timing analysis of
  - Analog & digital I/O pins and signals
  - Internal variables
- Exact timing
  - View delta changes from cursor to current location
- Direct code analysis
  - From Analyzer window
  - View instruction that caused variable change



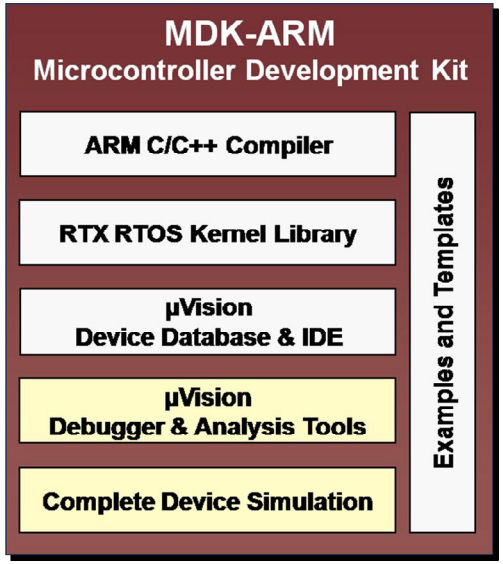
Kernel-Aware Debugging

- Enabled by tight integration of RTX and µVision
  - Tasks and Event analysis
  - Resource Loading
    - Allowing resource optimisation



MDK-ARM

CoreSight Debug and Trace



CoreSight Introduction

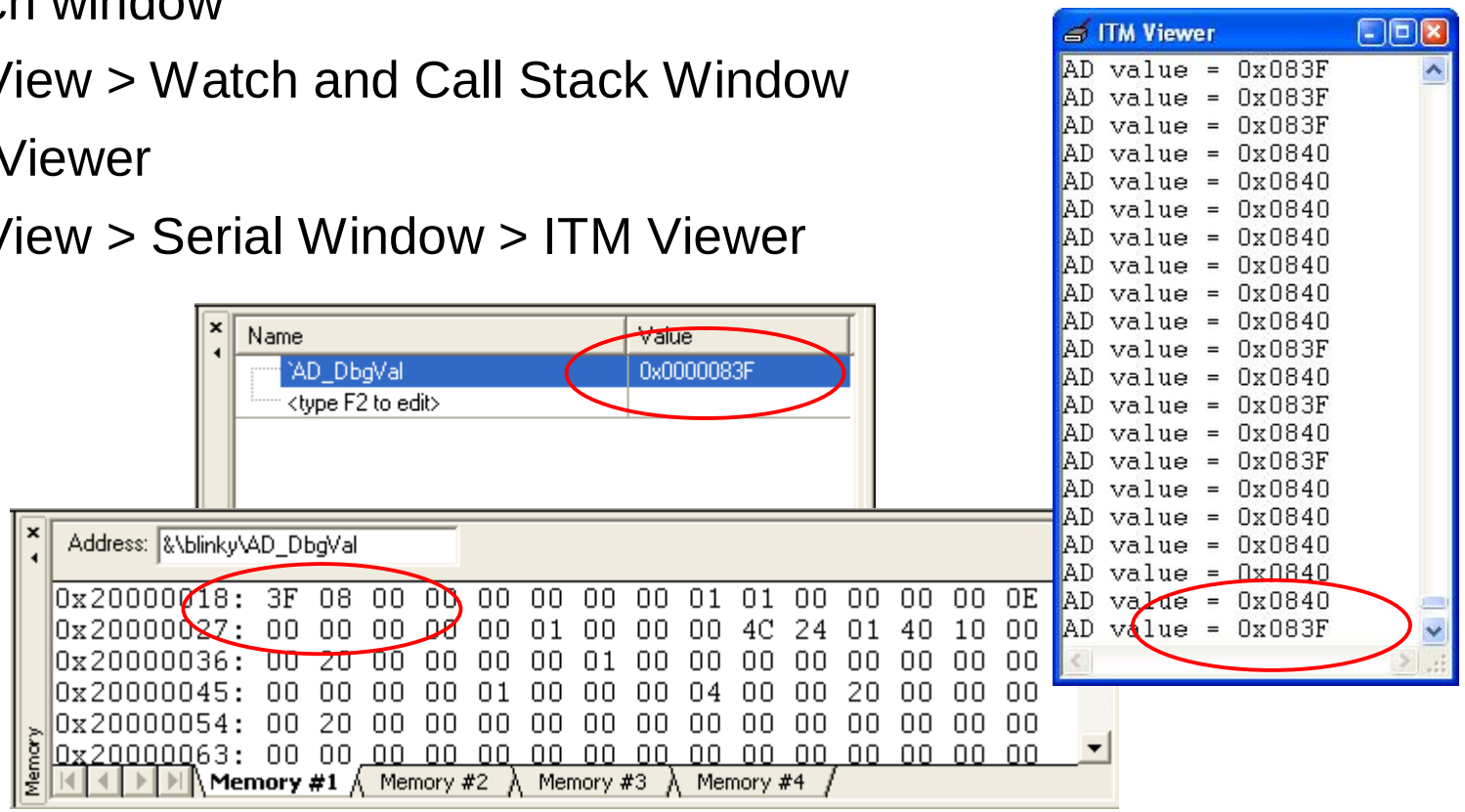
- Debug and trace technology in Cortex-Mx devices
- On-the-fly debugging
  - Debug application while the processor is running
    - Set breakpoints, read/write memory locations
  - Direct access to memory, no need to go through processor
  - Increased number of watchpoints
- Flexible trace options
  - Integrated Data Trace (Cortex-M3)
  - Optional Instruction Trace (ETM)
- Reduced pin count interface
  - 2-pin Serial Wire Debug (SWD)
  - 1-pin Serial Wire Viewer (SWV)
  - Uses standard JTAG connectors
- Supported in MDK-ARM and ULINK family of adapters

Data Trace (SWV)

- Fully supported in MDK-ARM
  - No additional software or hardware required
  - Serial Wire interface supported by all ULINK adapters

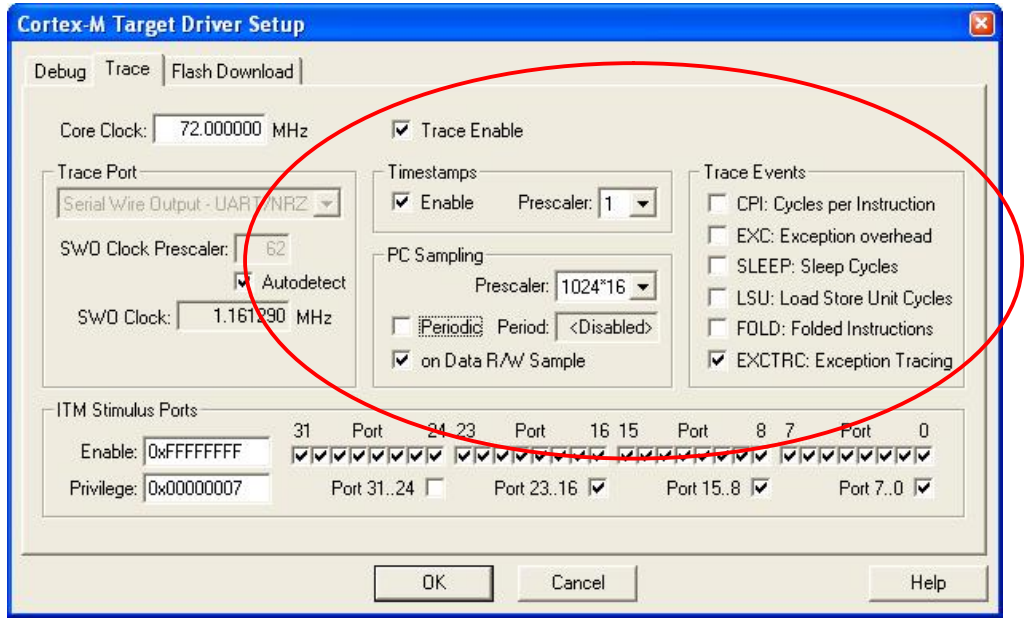
View the SWV output

- µVision provides 3 different ways to view variables
  - Memory Window
    - View > Memory Window
  - Watch window
    - View > Watch and Call Stack Window
  - ITM Viewer
    - View > Serial Window > ITM Viewer



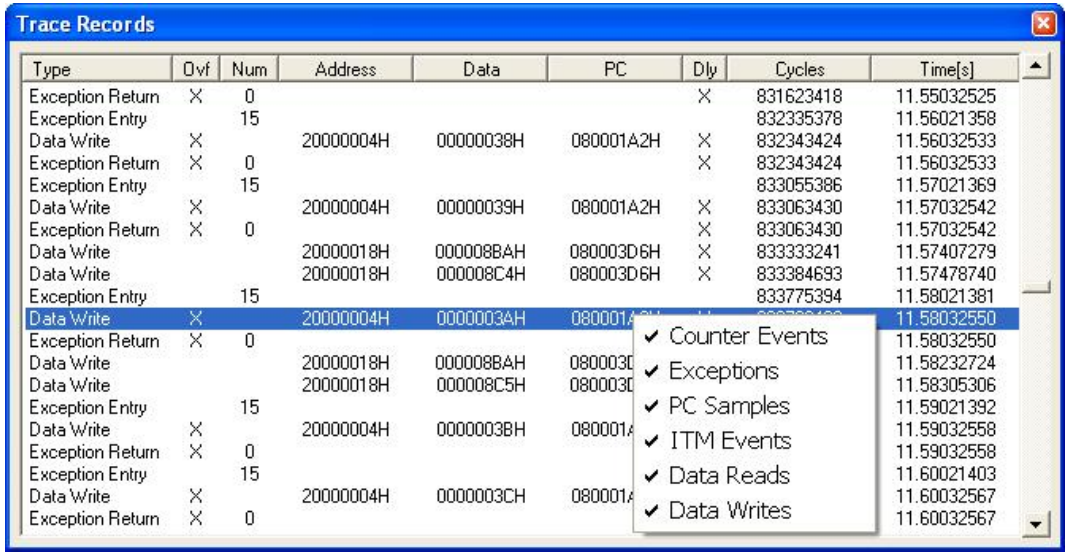
Trace Configuration

- Easy configuration
  - Cortex-Mx Target Driver Setup window
- MDK-ARM displays trace information
  - Four Trace Views:
  - Trace Records
  - Exception Trace
  - Event Counters
  - Logic Analyzer



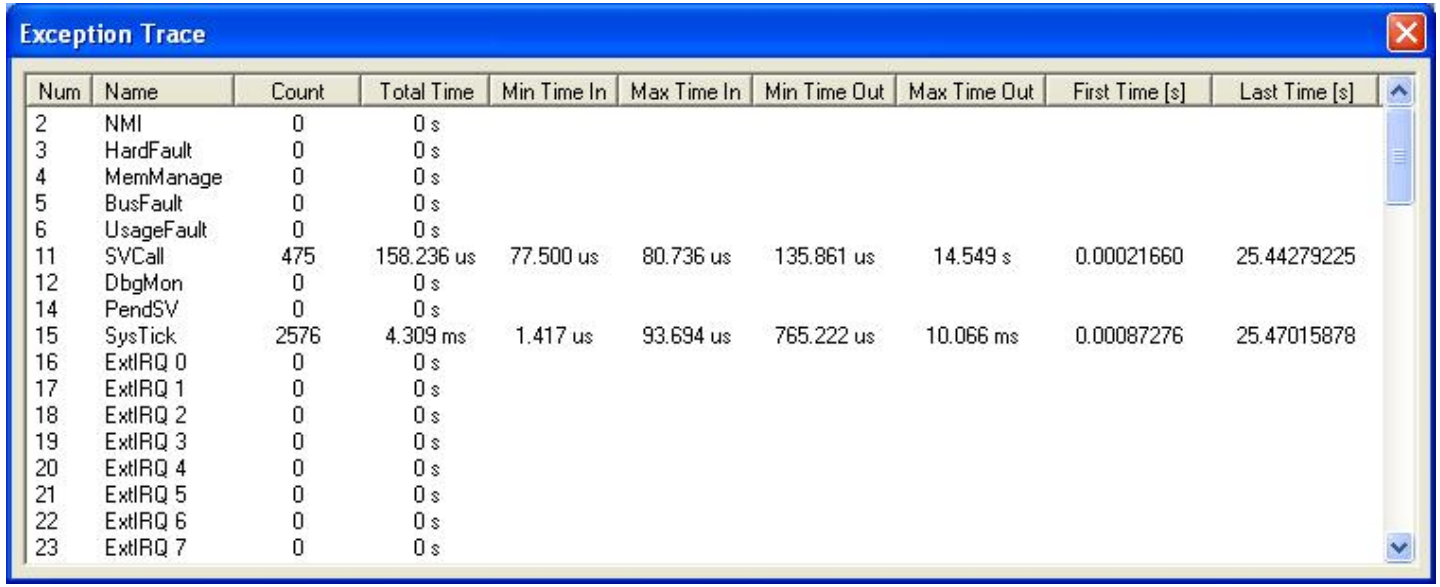
Trace Records

- Trace Records display program flow
  - Capture timestamp, PC sample, Read/Write accesses
  - Time delay and lost cycles are noted
- Raw trace data from all trace sources
  - Filter window to refine the view
  - Can be updated while CPU is running



Exception and Interrupt Trace

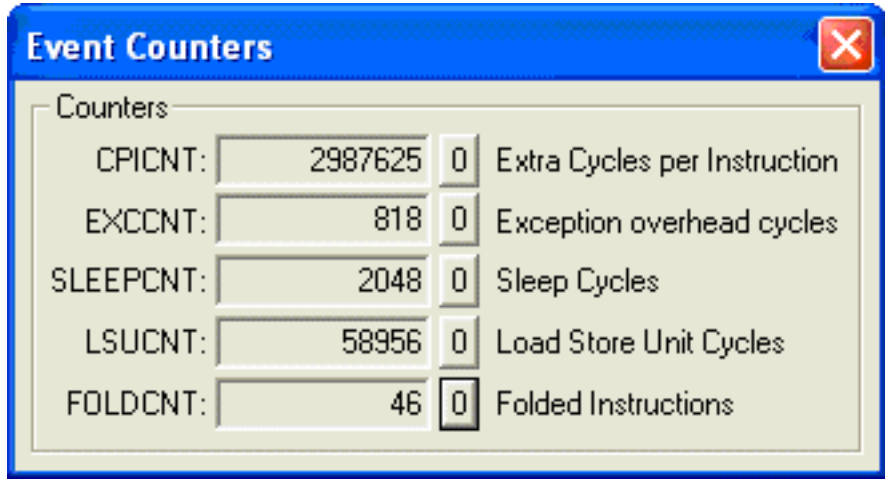
- Statistical information about exceptions and interrupts
- Captures detailed information
  - Name and number of exception; number of time entered
  - Max and Min time spent in and out of exceptions



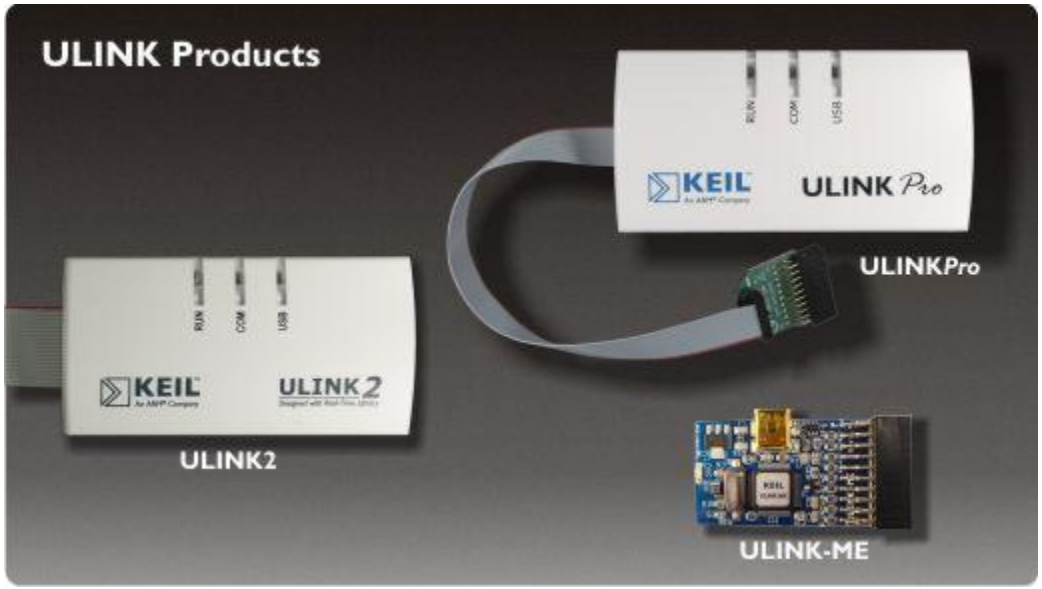
Num	Name	Count	Total Time	Min Time In	Max Time In	Min Time Out	Max Time Out	First Time [s]	Last Time [s]
2	NMI	0	0 s						
3	HardFault	0	0 s						
4	MemManage	0	0 s						
5	BusFault	0	0 s						
6	UsageFault	0	0 s						
11	SVCall	475	158.236 us	77.500 us	80.736 us	135.861 us	14.549 s	0.00021660	25.44279225
12	DbgMon	0	0 s						
14	PendSV	0	0 s						
15	SysTick	2576	4.309 ms	1.417 us	93.694 us	765.222 us	10.066 ms	0.00087276	25.47015878
16	ExtIRQ 0	0	0 s						
17	ExtIRQ 1	0	0 s						
18	ExtIRQ 2	0	0 s						
19	ExtIRQ 3	0	0 s						
20	ExtIRQ 4	0	0 s						
21	ExtIRQ 5	0	0 s						
22	ExtIRQ 6	0	0 s						
23	ExtIRQ 7	0	0 s						

Event Counters

- Display real-time values of specific event counters
- Provide performance indications
  - Extra cycles taken to execute instructions
    - May be due to memory contentions (Flash waitstates)
  - Cycles of overhead caused by handling exceptions
  - Cycles spent in sleep mode
  - Number of cycles spent performing memory accesses
  - Number of folded branch instructions



Debug and Trace Units

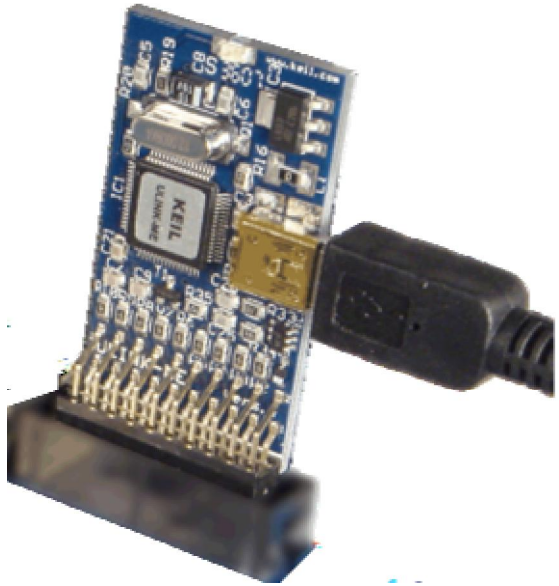


ULINK2 Adapter

- Easy-to-use USB run-control adapter
  - Supports program debugging and Flash programming
- Features
  - Cortex-M3 Serial Wire Debug and Trace
  - Plug and Play USB Installation
  - On-the-fly debugging with Real-Time Agent
- Program Debugging
  - Single Stepping & Real-Time Execution
  - Flash and Software Breakpoints
  - Memory Access Breakpoints
- Flash Programming
  - Download, Verify, and Execute

ULINK-ME

- Low-cost adapter
  - For evaluation and starter kits
  - Same functionality as ULINK2
- Features
  - Cortex-M3 Serial Wire Debug and Trace
  - Plug-and-play USB installation
  - On-the-fly debugging with Real-Time Agent
  - Target power via ULINK-ME
  - Mini USB connector
  - ARM 20-pin (0.1”) connector only
  - Small size: 28 x 80mm (1 ¼” x 3 ¼”)



ULINK*Pro* Debug and Trace Unit

- Features
  - Debug via JTAG interface for ARM7/9 and Cortex-Mx
  - Serial Wire Debug (SWD) for Cortex-M3
  - Serial Wire Viewer (SWV) data trace for Cortex-M3
  - Instruction trace (via ETM) for Cortex-M3
  - Data streaming direct to host PC
  - Cortex-Mx processors running up to 200MHz
  - Connectors: 10-pin (0.05"), 20-pin (0.10"), and 20-pin (0.05")
- Performance
  - 50MHz JTAG clock speed
  - 1MB/s memory read/write
  - 480bits/s USB 2.0 connection
- Available - September 2009

ULINK*Pro* Benefits

- Real-Time Trace for Cortex-M3 devices
  - ETM instruction trace captures detailed program execution
  - Non-intrusive software verification of a running system
  - Improves code coverage accuracy
  - Enables dynamic analysis of running applications
- Data streaming via USB 2.0 interface
  - No buffer, no trace overflow resulting in data loss
  - Enables code coverage and performance analysis on target
  - Supports targets running up to 200MHz
- Support for multiple target connectors
  - Flexibility and compatibility

Comparison of debug and trace units

	ULINK-ME	ULINK2	ULINK*Pro*
JTAG interface	✓	✓	✓
Serial Wire Debug interface	✓	✓	✓
Data trace via SWV	✓	✓	✓
ETM Instruction Trace	✗	✗	✓
JTAG Clock	10MHz	10MHz	50MHz
Memory read/write	28KB/s	28KB/s	1MB/s
Data Streaming	1Mb/s	1Mb/s	100Mb/s
Logic Analyzer	✓	✓	✓
Performance Analyzer	✗	✗	✓
Execution Profiling	✗	✗	✓
Code Coverage	✗	✗	✓

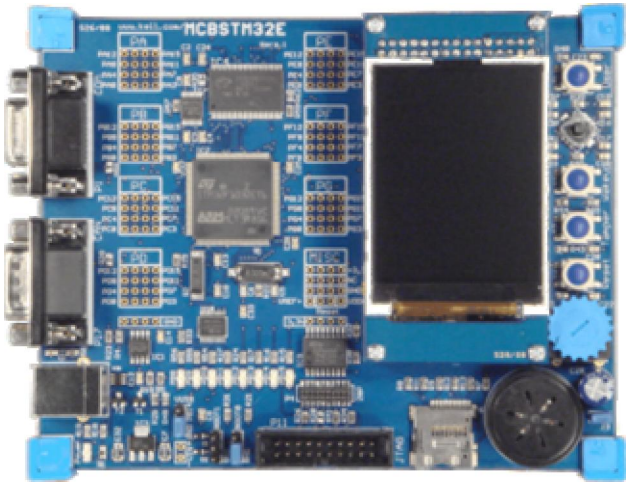
Starter Kits

Evaluation Boards

- Proven hardware for quick development and debug
  - Designed for easy set-up
  - Extensive program examples
  - Available as starter kits
    - Evaluation version of MDK-ARM
    - ULINK adapter

Toshiba TMPM330

STM32E



LPC1700

Get More Information

- Customers use www.keil.com on a daily basis to obtain
  - Program examples
  - Latest technical information
  - Application Notes
  - Program Examples
  - Device Database
  - Support Knowledgebase
  - Discussion Forum

Summary

- Out-of-box user experience
  - Easy to learn and use
  - Device Database and Startup code
- Industry-leading tools
  - µVision IDE
  - ARM Compilation tools
- Advanced verification and debug
  - Complete device simulation
  - Sophisticated analysis tools
  - Support for CoreSight debug and trace technology
- Hardware components
  - Complete the testing cycle by running on target hardware
- Total solution for developing embedded applications