RTA-OSEK

Analog Devices Blackfin® with the Analog Devices Compiler

Closed-Loop Development
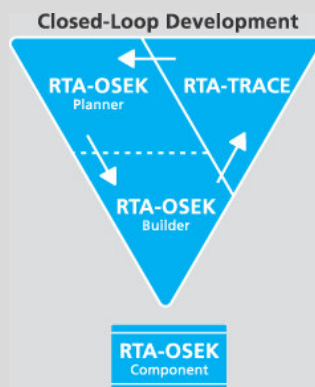
Features at a Glance

- OSEK/VDX OS version 2.2 certified OS
- RTOS overhead: 28 bytes RAM, 166 bytes ROM
- Category 2 interrupt latency: 156 CPU cycles
- Applications include: Multi-media and convergence applications

RTA-OSEK

RTA-OSEK provides an application design environment that com-bines the smallest and fastest OSEK RTOS with an unique timing analysis tool.

This port data sheet discusses the Analog Devices Blackfin® port of the RTA-OSEK kernel alone and should be read in conjunction with the Technical Product Overview "*Developing Embedded Real-Time Applications with RTA-OSEK*" available from LiveDevic-es.

The kernel element of RTA-OSEK is a fixed priority, pre-emptive real-time operating system that is compliant to the OSEK/VDX OS standard version 2.2 for all four conformance classes (BCC1, BCC2, ECC1 and ECC2) and intra processor communication us-ing OSEK COM Conformance Classes A and B (CCCA and CCCB).

All CPU overheads of the kernel have low worst case bounds and little variability in execution time. The kernel is particularly suited to systems with very tight constraints on hardware costs and where run-time performance must be guaranteed.

The kernel is configured using an offline tool provided with RTA-OSEK. Determining in advance which features are used allows memory requirements to be minimized and API calls to be opti-mized for greatest efficiency.

All tasks and ISRs in RTA-OSEK run on a single stack – even ex-tended tasks. This allows dramatic reductions in application stack space requirements.

The RTA-OSEK kernel is designed to be scalable. When a task uses queued activation or waits on events, the additional RTOS over-head required to support these features is paid by the task rather than by the system. This means that a basic single activation task uses the same resources in a BCC1 system as it does in an ECC2 system.

Compiler/Assembler/Linker

The libraries containing the code for the RTA-OSEK kernel have been built using the following tools:

- Analog Devices C/C++ compiler 6.3.0
- Analog Devices Assembler version 2.2.4.1
- Analog Devices linker version 2.8.8.2

Memory Model

RTA-OSEK for the Analog Devices Blackfin® supports a flat 32-bit memory model provided by the Analog Devices compiler.

ORTI Debugger Support

ORTI is the OSEK Run-Time Interface. Currently there are no ORTI compatible debuggers supported by RTA-OSEK for this target.

Further information about ORTI for RTA-OSEK can be found in the ORTI Guide.

Hardware Environment

RTA-OSEK supports all variants of the Analog Devices Blackfin family ADSP_BF531, ADSP-BF532, ADSP-BF533 and ADSP-DM102.

Interrupt Model

RTA-OSEK can configure the following 9 interrupts as sources for either Category 1 or 2 Interrupt Service Routines (ISRs): General Purpose Interrupts 7 to 13 (IVG7 to IVG13), Core timer (IVTMR) and Hardware Exception (IVHW). Additionally, the NMI and Exception interrupts can be configured for use with Category 1 ISRs. The two lowest priority General Purpose Interrupts (IVG14 and IVG15) are reserved for use by RTA-OSEK. RTA-OSEK does not make use of the Blackfin® Core user mode.

Floating Point Support

RTA-OSEK for the Analog Devices Blackfin® uses software floating point. The libraries supplied with the toolchain are fully reentrant. This allows floating point to be used in RTA-OSEK tasks and ISRs with out the need to save and restore any additional context.

Evaluation Board Support

RTA-OSEK for the Analog Devices Blackfin® can be used with any evaluation board. An example application is provided to run on the LH02234, VDM project phase II development board. This application can be adapted for other target boards by adjusting the linker command file (to alter the RAM locations) and one source file (if alternative output pins are required).

Functionality

The table below outlines the restrictions on the maximum number of operating system objects allowed by RTA-OSEK.

	BCC1	BCC2	ECC1	ECC2
Max no of tasks	32 plus an idle task			
Max tasks per priority	1	32	1	32
Max queued activations	1	255	1	255
Max events per task	n/a	n/a	32	32
Max nested resources	255			
Max alarms	not limited by RTA-OSEK			
Max standard resources	255			
Max internal resources	not limited by RTA-OSEK			
Max application modes	4294967295			

Note that OSEK specifies that queued activations in an ECC2 system are only possible for basic tasks. Where tasks share a priority level, the maximum number of queued activations per priority level is 255.

The number of alarms, tasksets, schedules and schedule arrivalpoints is only limited by available hardware resources.

Memory Usage

The memory overhead of RTA-OSEK is:

Memory type	Overhead (bytes)
RAM	28
ROM/Flash	166

In addition to the RTOS overhead, each object used by an application has the following memory requirements:

Object	RAM Bytes	ROM Bytes
BCC1 task	0	36
BCC2 task	10	52
ECC1 task	176	60
ECC2 task	178	68
Category 1 ISR	0	0
Category 2 ISR	0	76
Resource	0	20
Internal Resource	0	0
Event	0	4
Alarm	12	42
Counter	4	48
Taskset (RW)	4	4
Taskset (RO)	0	4
Schedule	16	36
Arrivalpoint (RW)	12	12
Arrivalpoint (RO)	0	12

In addition to these static memory requirements each task priority and Category 2 interrupt has a stack overhead (in addition to application stack usage). The single stack model means that this overhead applies to each priority level rather than to each task. Similarly, for Category 2 interrupts this overhead applies for each unique interrupt priority. The table below shows stack usage for these objects.

Object	Stack Bytes
Task priority level	204
Category 2 interrupt	164

RTA-OSEK provides an optimization for task termination if the user can guarantee that tasks only terminate from their entry function. Tasks that terminate from elsewhere are not eligible for this optimization and duly require 188 more stack bytes per priority level than indicated in the table above.

Performance

The following table gives the key kernel timings for operating system behavior in CPU cycles.

Task Type	Basic	Extended	Ref
Category 1 ISR Latency	80	80	K
Category 2 ISR Latency	156	156	A

Task Type	Basic	Extended	Ref
Normal Termination	36	124	D
ChainTask	92	235	J
Pre-emption	57	162	C
Triggered by alarm	91	195	F
Schedule	52	155	Q
ReleaseResource	58	160	M
SetEvent	n/a	339	S
Category 2 exit switch latency	63	166	E

All performance figures are for the non-optimized interface to RTA-OSEK. Using the optimized interface will result in shorter execution times for some operations. All tasks use lightweight termination and no pre or post task hooks were specified.

The execution time for every kernel API call is available on request from LiveDevices.
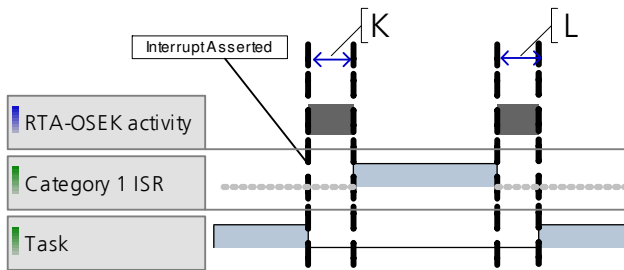
Figure 1 - Category 1 interrupt with return to interrupted task
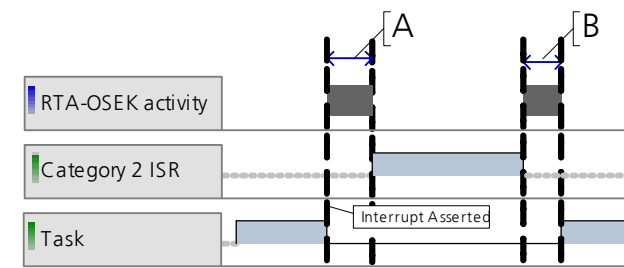
Figure 2 - Category 2 interrupt with return to interrupted task
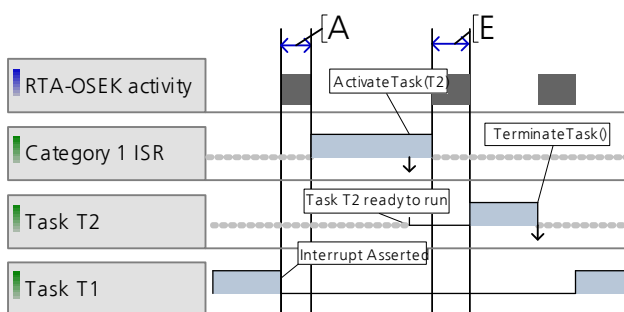
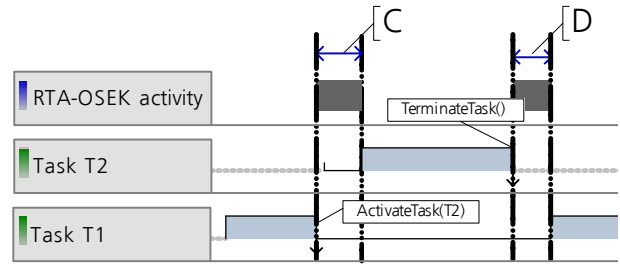Figure 3 - Category 2 interrupt activates a higher priority task

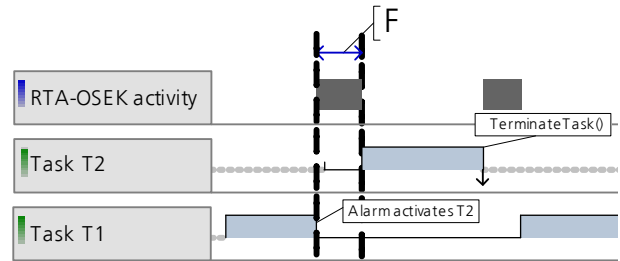Figure 4 - Task activates a higher priority task
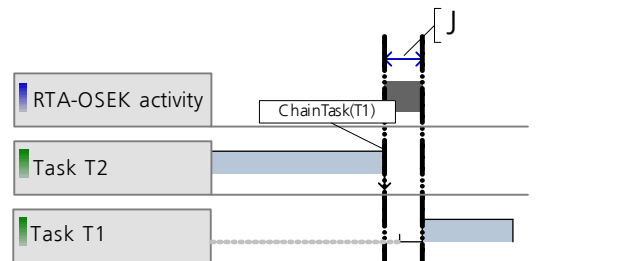

Figure 5 - Alarm activates task
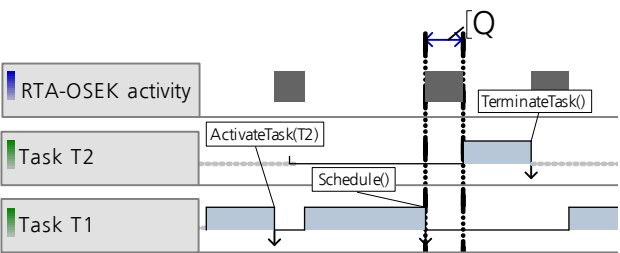

Figure 6 - Task chaining
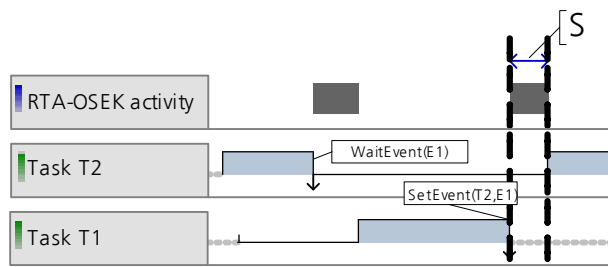

Figure 7 - Schedule() call
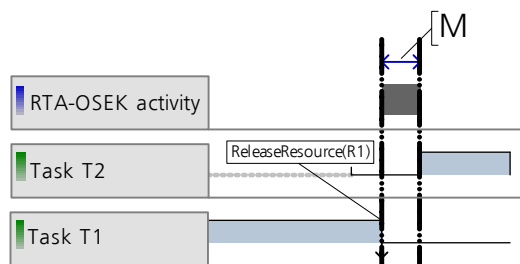
Figure 8 - Activation by SetEvent()

Figure 9 - ReleaseResource()

Benchmarks

The following sections shows benchmarks for RTA-OSEK memory usage for BCC1, BCC2, ECC1 and ECC2 conformant applications. The applications have the following framework:

- 8 tasks plus the idle task
- All basic tasks are lightweight tasks
- 1 Category 2 ISR with a 10ms minimum inter-arrival time
- 1 Counter
- 7 or 8 alarms, all attached to the same counter
- No resources or internal resources
- No hooks
- No schedules
- No tasksets
- Built using standard status

The following table shows the task priority configuration for each benchmark application:

Task/ISR	Stack (bytes)	Period (ms)	BCC1	BCC2	ECC1	ECC2
ISR1	10	10	IPL1	IPL1	IPL1	IPL1
A	10	10	8	8	8	8
B	20	20	7	7	7	7
C	30	20	6	6	6	6
D	40	30	5	5	5	5
E	50	50	4	4	4	4
F	60	80	3	3	3	3
G	70	100	2	2	2	2
H	80	150	1	1	1	2
Idle	10	-	idle	idle	idle	idle

The overhead figures give the ROM and RAM required for RTA-OSEK in addition to that required by the application. The RAM figure is shown split into RAM data and RAM stack.

BCC1

The BCC1 application uses 8 basic tasks with unique priorities.

This application has the following overheads:

Memory usage	Bytes
OS ROM	**2120**
OS RAM	**1964**
comprising RAM data	128
comprising RAM stack	1836

BCC2

The BCC2 application uses 8 basic tasks with unique priorities.

Tasks A-G are attached to 7 alarms. Task H is activated multiple times from Task A and has maximum queued activation count of 255.

This application has the following overheads:

Memory usage	Bytes
OS ROM	**2346**
OS RAM	**1980**
comprising RAM data	124
comprising RAM stack	1856

ECC1

The ECC1 application uses 7 basic tasks and 1 extended task with unique priorities. Task H is the extended task and it waits on a single event that is set by basic tasks A-G.

This application has the following overheads:

Memory usage	Bytes
OS ROM	**2868**
OS RAM	**2380**
comprising RAM data	304
comprising RAM stack	2076

ECC2

The ECC2 application uses 6 basic tasks and 2 extended tasks. Tasks G and H are the extended tasks and share a priority. The extended tasks wait on a single event that is set by tasks A-F.

This application has the following overheads:

Memory usage	Bytes
OS ROM	**3484**
OS RAM	**2934**
comprising RAM data	490
comprising RAM stack	2444

Stack Optimization

Using stack optimization with the benchmark example identifies that the following tasks can share internal resources:

"Tasks A, B and C

"Tasks D, E and F

"Tasks G and H

The benefit of this optimization is shown in the following table:

Total Stack Space (bytes)	BCC1	BCC2	ECC1	ECC2
Non-optimized	**2216**	**2236**	**2453**	**2824**
OS Overhead	1836	1856	2076	2444
Application Overhead	380	380	380	380
Optimized	**996**	**996**	**1236**	**1236**
OS Overhead	816	816	1056	1056
Application Overhead	180	180	180	180