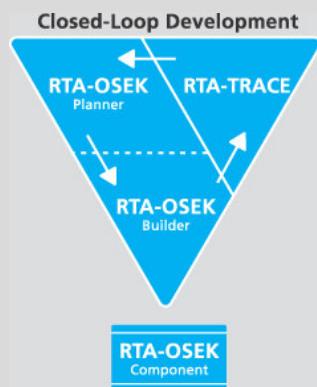


# RTA-OSEK

## STMicroelectronics ST7 with the Cosmic Compiler



### Features at a Glance

- OSEK/VDX OS version 2.2 certified OS
- RTOS overhead: 12 bytes RAM, 118 bytes ROM
- Category 2 interrupt latency: 182 CPU cycles
- Applications include: Automotive Body Electronics, Mechatronics and Industrial Process Control

### RTA-OSEK

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

This port data sheet discusses the STMicroelectronics ST7 family 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 LiveDevices.

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 using 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 optimized for greatest efficiency.

All tasks and ISRs in RTA-OSEK run on a single stack – even extended 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 overhead 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:

- Cosmic cxst7 Version 4.4d
- Cosmic cast7 Version 4.2r
- Cosmic clnk Version 4.3p

### Memory Model

The RTA-OSEK port to the ST7 with the Cosmic compiler supports a simple stack-based memory model. Subject to certain constraints that are necessary to ensure correct operation, the user is free to use a memory-based memory model (also called simulated stack) for support functions. RTA-OSEK places some key variables

in zero-page (@tiny) RAM to improve efficiency.

## ORTI Debugger Support

ORTI is the OSEK Run-Time Interface that is supported by RTA-OSEK for the following debuggers:

- Hitex HiTOP
- Cosmic Zap v3.7

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

## Hardware Environment

RTA-OSEK supports all variants of the STMicroelectronics ST7 family. Note that a single interrupt mask bit is used to control interrupts even on variants that support nested interrupts.

## Interrupt Model

One level of interrupts is supported.

## Floating Point Support

The STMicroelectronics ST7 uses software floating-point only. The kernel floating-point support routines are also used to preserve the context for 32-bit integer division. As a result, the majority of task switches are as fast as possible.

## Evaluation Board Support

RTA-OSEK for the STMicroelectronics ST7 can be used with any evaluation board. An example application is provided to run on the Hitex AX6811 emulator with the ST72561 evaluation 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 below table outlines the restrictions on the maximum number of operating system objects allowed by RTA-OSEK.

	BCC1	BCC2	ECC1	ECC2
Max no of tasks	16 plus an idle task			
Max tasks per priority	1	16	1	16
Max queued activations	1	255	1	255
Max events per task	n/a	n/a	8	8
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	255			

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 arrival-points is only limited by available hardware resources.

## Memory Usage

The memory overhead of RTA-OSEK is:

Memory type	Overhead (bytes)
RAM	12
ROM/Flash	118

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	17
BCC2 task	6	24
ECC1 task	8	27
ECC2 task	10	31
Category 1 ISR	0	0
Category 2 ISR	0	28
Resource	0	10
Internal Resource	0	0
Event	0	1
Alarm	5	36
Counter	2	37
Taskset (RW)	2	2
Taskset (RO)	0	2
Schedule	7	16
Arrivalpoint (RW)	6	6
Arrivalpoint (RO)	0	6

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 below table shows stack usage for these objects.

Object	Stack Bytes
Task priority level	11
Category 2 interrupt	9

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 44 more stack bytes per priority level than indicated in the table above.

## Performance

The following table gives the key kernel timings for operating sys-

tem behavior in CPU cycles.

Task Type	Basic	Extended	Ref
Category 1 ISR Latency	15	15	K
Category 2 ISR Latency	182	182	A
Normal Termination	222	548	D
ChainTask	640	1294	J
Pre-emption	598	1104	C
Triggered by alarm	1142	1646	F
Schedule	466	916	Q
ReleaseResource	556	1006	M
SetEvent	n/a	1706	S
Category 2 exit switch latency	354	802	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.

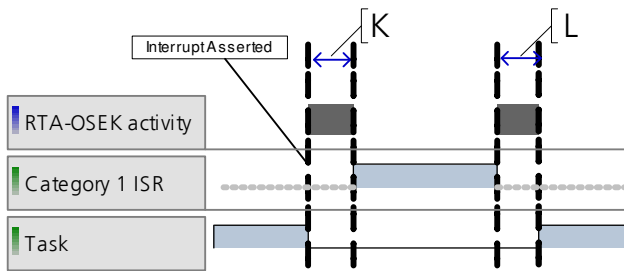


Figure 1 - Category 1 interrupt with return to interrupted task

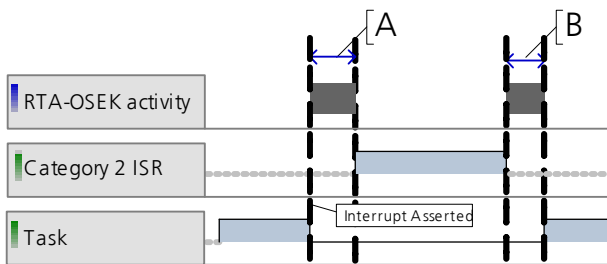


Figure 2 - Category 2 interrupt with return to interrupted task

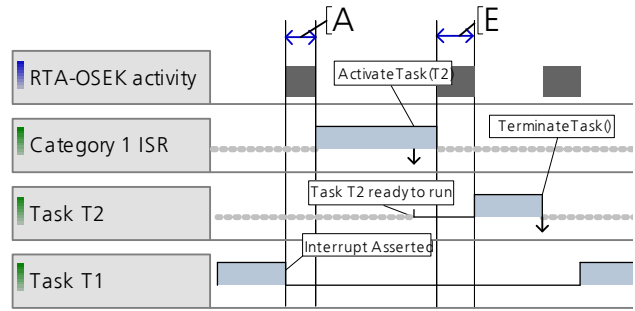


Figure 3 - Category 2 interrupt activates a higher priority task

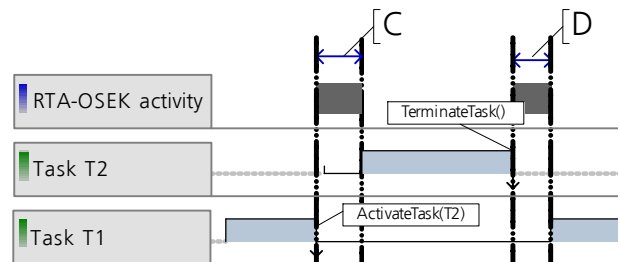


Figure 4 - Task activates a higher priority task

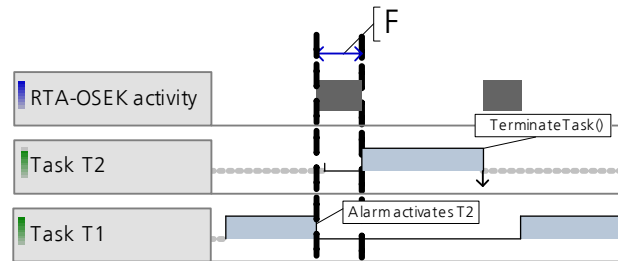


Figure 5 - Alarm activates task

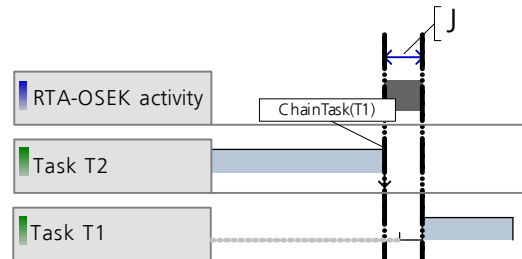


Figure 6 - Task chaining

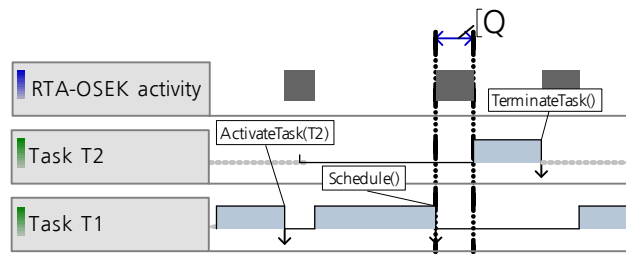


Figure 7 - Schedule() call

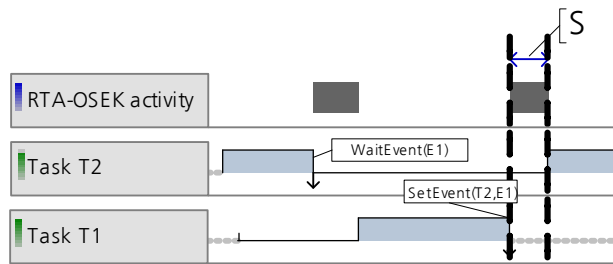


Figure 8 - Activation by SetEvent()

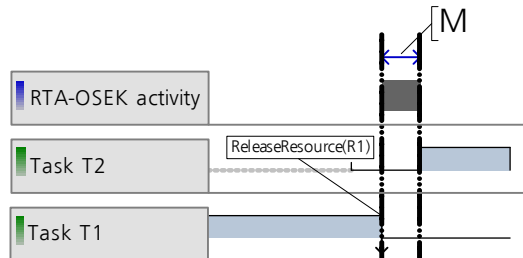


Figure 9 - ReleaseResource()

## 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	1843
OS RAM	198
comprising RAM data	54
comprising RAM stack	144

## 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	2337
OS RAM	199
comprising RAM data	53
comprising RAM stack	146

## 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
<b>OS ROM</b>	<b>2996</b>
<b>OS RAM</b>	<b>207</b>
comprising RAM data	62
comprising RAM stack	145

## 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
<b>OS ROM</b>	<b>4912</b>
<b>OS RAM</b>	<b>246</b>
comprising RAM data	78
comprising RAM stack	168

## 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)	BCC 1	BCC 2	ECC 1	ECC 2
<b>Non-optimized</b>	<b>524</b>	<b>526</b>	<b>525</b>	<b>548</b>
OS Overhead	144	146	145	168
Application Overhead	380	380	380	380
<b>Optimized</b>	<b>269</b>	<b>269</b>	<b>270</b>	<b>270</b>
OS Overhead	89	89	90	90
Application Overhead	180	180	180	180

### Contact addresses:

LiveDevices Ltd.  
 Atlas House  
 Link Business Park  
 Osbaldwick Link Road  
 Osbaldwick  
 York YO10 3JB, Great Britain  
 Phone +44 (1904) 56 25 80  
 Fax +44 (1904) 56 25 81  
 info@livedevices.com  
 www.livedevices.com

ETAS GmbH  
 Borsigstraße 14  
 70469 Stuttgart, Germany  
 Phone +49 (711) 8 96 61-102  
 Fax +49 (711) 8 96 61-106  
 sales@etas.de  
 www.etas.de

ETAS Inc.  
 3021 Miller Road  
 Ann Arbor, MI 48103, USA  
 Phone +1 (888) ETAS INC  
 Fax +1 (734) 997-9449  
 sales@etas.us  
 www.etas.us

ETAS K.K.  
 Queen's Tower C-17F  
 2-3-5, Minatomirai  
 Nishi-ku  
 Yokohama 220-6217, Japan  
 Phone +81 (45) 222-0900  
 Fax +81 (45) 222-0956  
 sales@etas.co.jp  
 www.etas.co.jp

ETAS S.A.S.  
 1, place des Etats-Unis  
 SILIC 307  
 94588 Rungis Cedex, France  
 Phone +33 (1) 56 70 00 50  
 Fax +33 (1) 56 70 00 51  
 sales@etas.fr  
 www.etas.fr

ETAS Korea Co., Ltd.  
 4F, 705 Bldg. 70-5  
 Yangjae-dong, Seocho-gu  
 Seoul 137-889, Korea  
 Phone +82 (2) 57 47-016  
 Fax +82 (2) 57 47-120  
 sales@etas.co.kr  
 www.etas.co.kr

www.etasgroup.com

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