RTA-OS

PPCe200/HighTec Port Guide

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Safety Notice

This ETAS product fulfills standard quality management requirements. If requirements of specific safety standards (e.g. IEC 61508, ISO 26262) need to be fulfilled, these requirements must be explicitly defined and ordered by the customer. Before use of the product, customer must verify the compliance with specific safety standards.

Contents

1 Introduction

RTA-OS is a small and fast real-time operating system that conforms to both the AUTOSAR OS (R3.0.1 -> R3.0.7, R3.1.1 -> R3.1.5, R3.2.1 -> R3.2.2, R4.0.1 -> R4.0.3 and R4.1.1 -> R4.1.3) and OSEK/VDX 2.2.3 standards. The operating system is configured and built on a PC, but runs on your target hardware.

This document describes the RTA-OS PPCe200/HighTec port plug-in that customizes the RTA-OS development tools for the Freescale/ST MPC5xxx/SPC56x with the HighTec compiler. It supplements the more general information you can find in the *User Guide* and the *Reference Guide*.

The document has two parts. Chapters 2 to 3 help you understand the PPCe200/HighTec port and cover:

- how to install the PPCe200/HighTec port plug-in;
- how to configure PPCe200/HighTec-specific attributes;
- how to build an example application to check that the PPCe200/HighTec port plug-in works.

Chapters 4 to 8 provide reference information including:

- the number of OS objects supported;
- required and recommended toolchain parameters;
- how RTA-OS interacts with the MPC5xxx/SPC56x, including required register settings, memory models and interrupt handling;
- memory consumption for each OS object;
- memory consumption of each API call;
- execution times for each API call.

For the best experience with RTA-OS it is essential that you read and understand this document.

1.1 About You

You are a trained embedded systems developer who wants to build real-time applications using a preemptive operating system. You should have knowledge of the C programming language, including the compilation, assembling and linking of C code for embedded applications with your chosen toolchain. Elementary knowledge about your target microcontroller, such as the start address, memory layout, location of peripherals and so on, is essential.

You should also be familiar with common use of the Microsoft Windows operating system, including installing software, selecting menu items, clicking buttons, navigating files and folders.

1.2 Document Conventions

The following conventions are used in this guide:

Choose **File > Open**.	Menu options appear in **bold, blue** characters.
Click **OK**.	Button labels appear in **bold** characters
Press <Enter>.	Key commands are enclosed in angle brackets.
The “Open file” dialog box appears	GUI element names, for example window titles, fields, etc. are enclosed in double quotes.
`Activate(Task1)`	Program code, header file names, C type names, C functions and API call names all appear in a `monospaced typeface`.
See Section 1.2.	Internal document hyperlinks are shown in blue letters.
	Functionality in RTA-OS that might not be portable to other implementations of AUTOSAR OS is marked with the RTA-OS icon.
	Important instructions that you must follow carefully to ensure RTA-OS works as expected are marked with a caution sign.

1.3 References

OSEK is a European automotive industry standards effort to produce open systems interfaces for vehicle electronics. For details of the OSEK standards, please refer to:

http://www.osek-vdx.org

AUTOSAR (AUTomotive Open System ARchitecture) is an open and standardized automotive software architecture, jointly developed by automobile manufacturers, suppliers and tool developers. For details of the AUTOSAR standards, please refer to:

http://www.autosar.org

2 Installing the RTA-OS Port Plug-in

2.1 Preparing to Install

RTA-OS port plug-ins are supplied as a downloadable electronic installation image which you obtain from the ETAS Web Portal. You will have been provided with access to the download when you bought the port. You may optionally have requested an installation CD which will have been shipped to you. In either case, the electronic image and the installation CD contain identical content.

Integration Guidance 2.1:*You must have installed the RTA-OS tools before installing the PPCe200/HighTec port plug-in. If you have not yet done this then please follow the instructions in the* Getting Started Guide*.*

2.1.1 Hardware Requirements

You should make sure that you are using at least the following hardware before installing and using RTA-OS on a host PC:

- 1GHz Pentium (or higher) IBM compatible PC.
- 512Mb RAM.
- 500Mb hard disk space.
- CD-ROM or DVD drive (Optional)
- Ethernet card.

2.1.2 Software Requirements

RTA-OS requires that your host PC has one of the following versions of Microsoft Windows installed:

- Windows 2000 (Service Pack 3 or later)
- Windows XP (Service Pack 2 or later)
- Windows Vista
- Windows 7

Integration Guidance 2.2:*The tools provided with RTA-OS require Microsoft's .NET Framework* v2.0 *and* v4.0 *to be installed. You should ensure that these have been installed before installing RTA-OS. The .NET framework is not supplied with RTA-OS but is freely available from* `http://www.microsoft.com/net/Download.aspx`*.*
The migration of the code from *v2.0* to *v4.0* will occur over a period of time for performance and maintenance reasons.

2.2 Installation

Target port plug-ins are installed in the same way as the tools:

1. Either
   - Double click the executable image; or
   - Insert the RTA-OS PPCe200/HighTec CD into your CD-ROM or DVD drive.

     If the installation program does not run automatically then you will need to start the installation manually. Navigate to the root directory of your CD/DVD drive and double click `autostart.exe` to start the setup.
2. Follow the on-screen instructions to install the PPCe200/HighTec port plug-in.

By default, ports are installed into `C:\ETAS\RTA-OS\Targets`. During the installation process, you will be given the option to change the folder to which RTA-OS ports are installed. You will normally want to ensure that you install the port plug-in in the same location that you have installed the RTA-OS tools. You can install different versions of the tools/targets into different directories and they will not interfere with each other.

Integration Guidance 2.3:*Port plug-ins can be installed into any location, but using a non-default directory requires the use of the `--target_include` argument to both* ***rtaosgen*** *and* ***rtaoscfg****. For example:*

```
rtaosgen --target_include:<target_directory>
```

2.2.1 Installation Directory

The installation will create a sub-directory under `Targets` with the name `PPCe200/HighTec_5.0.14`. This contains everything to do with the port plug-in.

Each version of the port installs in its own directory - the trailing `_5.0.14` is the port's version identifier. You can have multiple different versions of the same port installed at the same time and select a specific version in a project's configuration.

The port directory contains:

PPCe200/HighTec.dll - the port plug-in that is used by **rtaosgen** and **rtaoscfg**.

RTA-OS PPCe200/HighTec Port Guide.pdf - the documentation for the port (the document you are reading now).

RTA-OS PPCe200/HighTec Release Note.pdf - the release note for the port. This document provides information about the port plug-in release, including a list of changes from previous releases and a list of known limitations.

There may be other port-specific documentation supplied which you can also find in the root directory of the port installation. All user documentation is distributed in PDF format which can be read using Adobe Acrobat Reader. Adobe Acrobat Reader is not supplied with RTA-OS but is freely available from http://www.adobe.com.

2.3 Licensing

RTA-OS is protected by FLEXnet licensing technology. You will need a valid license key in order to use RTA-OS.

Licenses for the product are managed using the ETAS License Manager which keeps track of which licenses are installed and where to find them. The information about which features are required for RTA-OS and any port plug-ins is stored as license signature files that are stored in the folder `<install_folder>\bin\Licenses`.

The ETAS License Manager can also tell you key information about your licenses including:

- Which ETAS products are installed
- Which license features are required to use each product
- Which licenses are installed
- When licenses expire
- Whether you are using a local or a server-based license

Figure 2.1 shows the ETAS License Manager in operation.

2.3.1 Installing the ETAS License Manager

Integration Guidance 2.4:*The ETAS License Manager must be installed for RTA-OS to work. It is highly recommended that you install the ETAS License Manager during your installation of RTA-OS.*

The installer for the ETAS License Manager contains two components:

1. the ETAS License Manager itself;

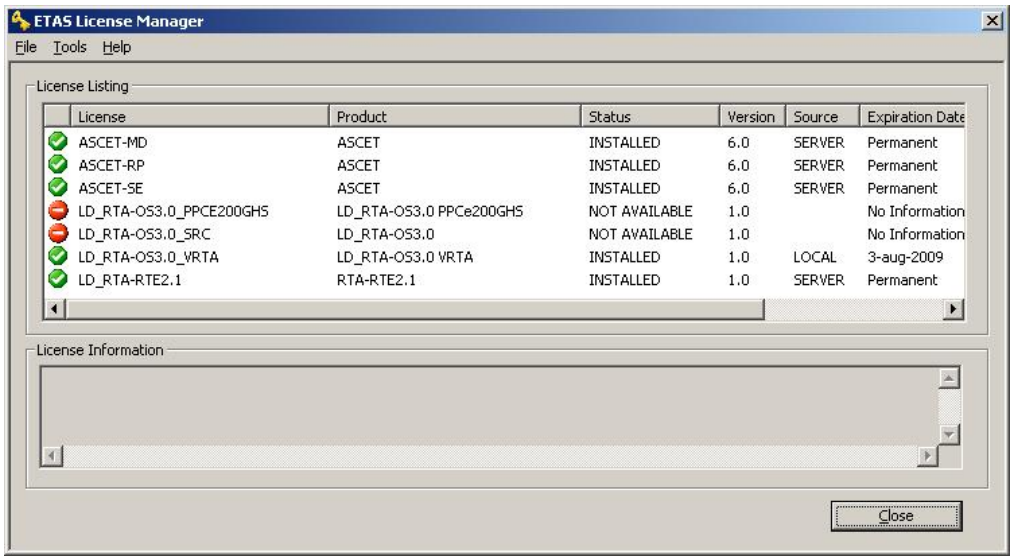

Figure 2.1: The ETAS License manager

2. a set of re-distributable FLEXnet utilities. The utilities include the software and instructions required to setup and run a FLEXnet license server manager if concurrent licenses are required (see Sections 2.3.2 and 2.3.3 for further details)

During the installation of RTA-OS you will be asked if you want to install the ETAS License Manager. If not, you can install it manually at a later time by running `<install_folder>\LicenseManager\LicensingStandaloneInstallation.exe`.

Once the installation is complete, the ETAS License Manager can be found in `C:\Program Files\Common Files\ETAS\Licensing`.

After it is installed, a link to the ETAS License Manager can be found in the Windows Start menu under **Programs→ ETAS → License Management → ETAS License Manager**.

2.3.2 Licenses

When you install RTA-OS for the first time the ETAS License Manager will allow the software to be used in *grace mode* for seven days. Once the grace mode period has expired, a license key must be installed. If a license key is not available, please contact your local ETAS sales representative. Contact details can be found in Chapter 10.

You should identify which type of license you need and then provide ETAS with the appropriate information as follows:

Machine-named licenses allows RTA-OS to be used by any user logged onto the PC on which RTA-OS and the machine-named license is installed.

A machine-named license can be issued by ETAS when you provide the host ID (Ethernet MAC address) of the host PC

User-named licenses allow the named user (or users) to use RTA-OS on any PC in the network domain.

A user-named license can be issued by ETAS when you provide the Windows user-name for your network domain.

Concurrent licenses allow any user on any PC up to a specified number of users to use RTA-OS. Concurrent licenses are sometimes called *floating* licenses because the license can *float* between users.

A concurrent license can be issued by ETAS when you provide the following information:

1. The name of the server
2. The Host ID (MAC address) of the server.
3. The TCP/IP port over which your FLEXnet license server will serve licenses. A default installation of the FLEXnet license server uses port 27000.

You can use the ETAS License Manager to get the details that you must provide to ETAS when requesting a machine-named or user-named license and (optionally) store this information in a text file.

Open the ETAS License Manager and choose **Tools → Obtain License Info** from the menu. For machine-named licenses you can then select the network adaptor which provides the Host ID (MAC address) that you want to use as shown in Figure 2.2. For a user-based license, the ETAS License Manager automatically identifies the Windows username for the current user.

Selecting “Get License Info” tells you the Host ID and User information and lets you save this as a text file to a location of your choice.

2.3.3 Installing a Concurrent License Server

Concurrent licenses are allocated to client PCs by a FLEXnet license server manager working together with a vendor daemon. The vendor daemon for ETAS is called `ETAS.exe`. A copy of the vendor daemon is placed on disk when you install the ETAS License Manager and can be found in:

```
C:\Program Files\Common Files\ETAS\Licensing\Utility
```

Figure 2.2: Obtaining License Information

To work with an ETAS concurrent license, a license server must be configured which is accessible from the PCs wishing to use a license. The server must be configured with the following software:

- FLEXnet license server manager;
- ETAS vendor daemon (`ETAS.exe`);

It is also necessary to install your concurrent license on the license server.

In most organizations there will be a single FLEXnet license server manager that is administered by your IT department. You will need to ask your IT department to install the ETAS vendor daemon and the associated concurrent license.

If you do not already have a FLEXnet license server then you will need to arrange for one to be installed. A copy of the FLEXnet license server, the ETAS vendor daemon and the instructions for installing and using the server (`LicensingEndUserGuide.pdf`) are placed on disk when you install the ETAS License manager and can be found in:

```
C:\Program Files\Common Files\ETAS\Licensing\Utility
```

2.3.4 Using the ETAS License Manager

If you try to run RTA-OS without a valid license, you will be given the opportunity to start the ETAS License Manager and select a license.

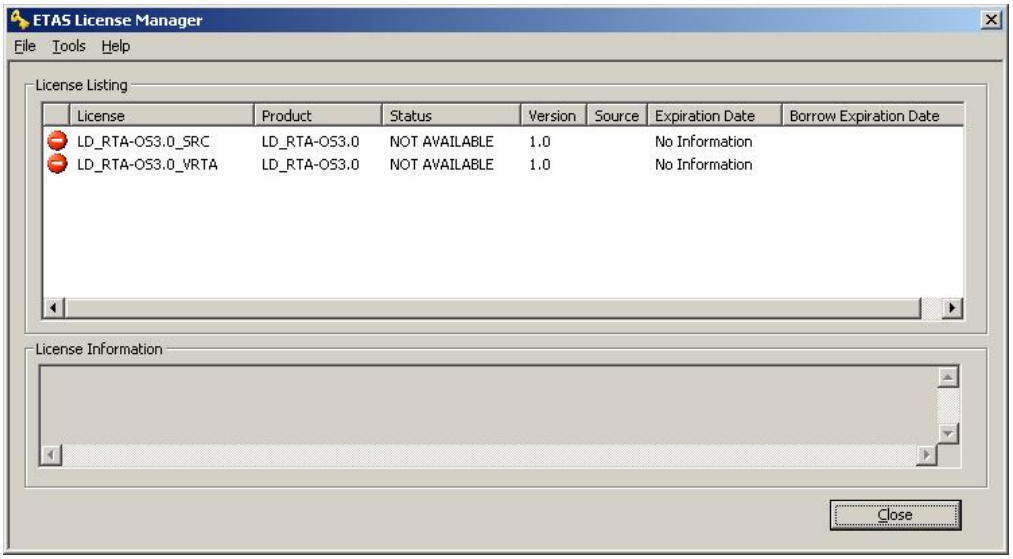

Figure 2.3: Unlicensed RTA-OS Installation

When the ETAS License Manager is launched, it will display the RTA-OS license state as `NOT AVAILABLE` and you will not be able to use any of the tools until a valid license is installed. This is shown in Figure 2.3.

License Key Installation

License keys are supplied in an ASCII text file, which will be sent to you on completion of a valid license agreement.

If you have a machine-based or user-based license key then you can simply install the license by opening the ETAS License Manager and selecting **File → Add License File** menu.

If you have a concurrent license key then you will need to create a license stub file that tells the client PC to look for a license on the FLEXnet server as follows:

1. create a copy of the concurrent license file
2. open the copy of the concurrent license file and delete every line *except* the one starting with SERVER
3. add a new line containing USE_SERVER
4. add a blank line
5. save the file

The file you create should look something like this:

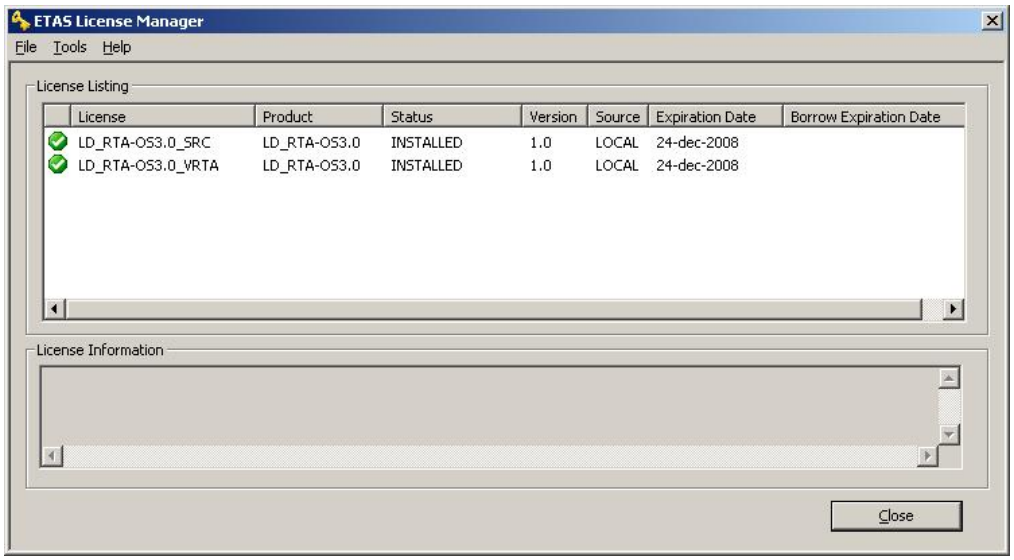

Figure 2.4: Licensed features for RTA-OS

```
SERVER <server name> <MAC address> <TCP/IP Port>¶
USE_SERVER¶
¶
```

Once you have create the license stub file you can install the license by opening the ETAS License Manager and selecting **File → Add License File** menu and choosing the license stub file.

License Key Status

When a valid license has been installed, the ETAS License Manager will display the license version, status, expiration date and source as shown in Figure 2.4.

When a license is installed by the ETAS License Manager it is placed in: `C:\Documents and Settings\All Users\Application Data\ETAS\FlexNet`

Borrowing a concurrent license

If you use a concurrent license and need to use RTA-OS on a PC that will be disconnected from the network (for example, you take a demonstration to a customer site), then the concurrent license will not be valid once you are disconnected.

To address this problem, the ETAS License Manager allows you to temporarily borrow a license from the license server.

To borrow a license:

1. Right click on the license feature you need to borrow.
2. Select “Borrow License”
3. From the calendar, choose the date that the borrowed license should expire.
4. Click “OK”

The license will automatically expire when the borrow date elapses. A borrowed license can also be returned before this date. To return a license:

1. Reconnect to the network;
2. Right-click on the license feature you have borrowed;
3. Select “Return License”.

2.3.5 Troubleshooting Licenses

RTA-OS tools will report an error if you try to use a feature for which a correct license key cannot be found. If you think that you should have a license for a feature but the RTA-OS tools appear not to work, then the following troubleshooting steps should be followed before contacting ETAS:

Can the ETAS License Manager see the license?

The ETAS License Manager must be able to see a valid license key for each product or product feature you are trying to use.

You can check what the ETAS License Manager can see by starting it from the **Help → License Manager. . .** menu option in **rtaoscfg** or directly from the Windows Start Menu - **Start → ETAS → License Management → ETAS License Manager**.

The ETAS License Manager lists all license features and their status. Valid licenses have status `INSTALLED`. Invalid licenses have status `NOT AVAILABLE`.

Is the license valid?

You may have been provided with a time-limited license (for example, for evaluation purposes) and the license may have expired. You can check that the Expiration Date for your licensed features to check that it has not elapsed using the ETAS License Manager.

If a license is due to expire within the next 30 days, the ETAS License Manager will use a warning triangle to indicate that you need to get a new license. Figure 2.5 shows that the license features `LD_RTA-OS3.0_VRTA` and `LD_RTA-OS3.0_SRC` are due to expire.

If your license has elapsed then please contact your local ETAS sales representative to discuss your options.

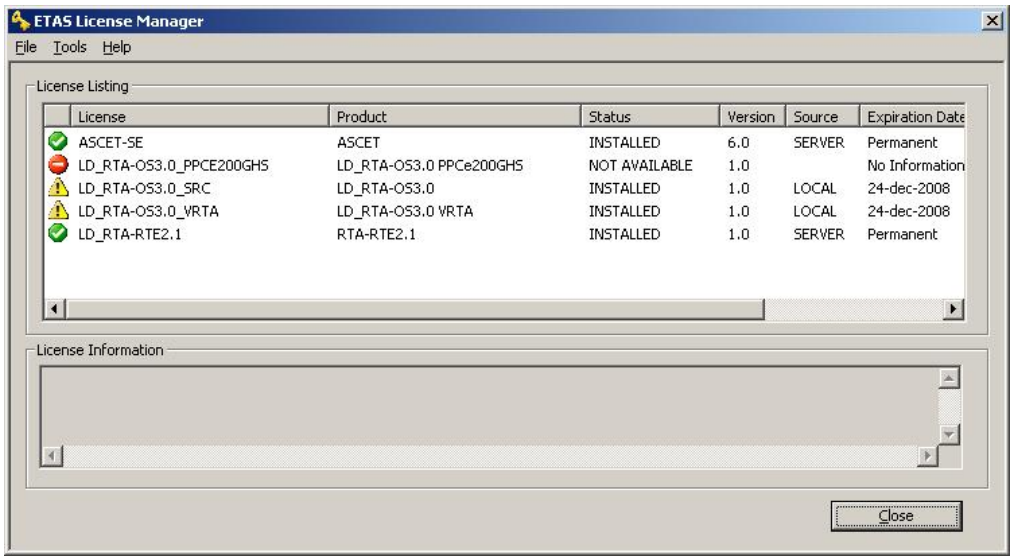

Figure 2.5: Licensed features that are due to expire

Does the Ethernet MAC address match the one specified?

If you have a machine based license then it is locked to a specific MAC address. You can find out the MAC address of your PC by using the ETAS License Manager (**Tools → Obtain License Info**) or using the Microsoft program **ipconfig /all** at a Windows Command Prompt.

You can check that the MAC address in your license file by opening your license file in a text editor and checking that the HOSTID matches the MAC address identified by the ETAS License Manager or the *Physical Address* reported by **ipconfig /all**.

If the HOSTID in the license file (or files) does not match your MAC address then you do not have a valid license for your PC. You should contact your local ETAS sales representative to discuss your options.

Is your Ethernet Controller enabled?

If you use a laptop and RTA-OS stops working when you disconnect from the network then you should check your hardware settings to ensure that your Ethernet controller is not turned off to save power when a network connection is not present. You can do this using Windows Control Panel. Select **System → Hardware → Device Manager** then select your Network Adapter. Right click to open **Properties** and check that the Ethernet controller is not configured for power saving in **Advanced** and/or **Power Management** settings.

Is the FlexNet License Server visible?

If your license is served by a FlexNet license server, then the ETAS License Manager will report the license as `NOT AVAILABLE` if the license server cannot be accessed.

You should contact your IT department to check that the server is working correctly.

Still not fixed?

If you have not resolved your issues, after confirming these points above, please contact ETAS technical support. The contact address is provided in Section 10.1. You must provide the contents and location of your license file and your Ethernet MAC address.

3 Verifying your Installation

Now that you have installed both the RTA-OS tools and a port plug-in and have obtained and installed a valid license key you can check that things are working.

3.1 Checking the Port

The first thing to check is that the RTA-OS tools can see the new port. You can do this in two ways:

1. use the **rtaosgen** tool

   You can run the command **rtaosgen --target:?** to get a list of available targets, the versions of each target and the variants supported, for example:

   ```
   RTA-OS Code Generator
   Version p.q.r.s, Copyright © ETAS nnnn
   Available targets:
    TriCoreHighTec_n.n.n [TC1797...]
    VRTA_n.n.n [MinGW,VS2005,VS2008,VS2010]
   ```

2. use the **rtaoscfg** tool

   The second way to check that the port plug-in can be seen is by starting **rtaoscfg** and selecting **Help → Information...** drop down menu. This will show information about your complete RTA-OS installation and license checks that have been performed.

Integration Guidance 3.1: *If the target port plug-ins have been installed to a non-default location, then the `--target_include` argument must be used to specify the target location.*

If the tools can see the port then you can move on to the next stage – checking that you can build an RTA-OS library and use this in a real program that will run on your target hardware.

3.2 Running the Sample Applications

Each RTA-OS port is supplied with a set of sample applications that allow you to check that things are running correctly. To generate the sample applications:

1. Create a new *working* directory in which to build the sample applications.

2. Open a Windows command prompt in the new directory.

3. Execute the command:

```
rtaosgen --target:<your target> --samples:[Applications]

e.g.

rtaosgen --target:[MPC5777Mv2]PPCe200HighTec_5.0.8
    --samples:[Applications]
```

You can then use the build.bat and run.bat files that get created for each sample application to build and run the sample. For example:

```
cd Samples\Applications\HelloWorld
build.bat
run.bat
```

Remember that your target toolchain must be accessible on the Windows PATH for the build to be able to run successfully.

Integration Guidance 3.2: *It is strongly recommended that you build and run at least the* Hello World *example in order to verify that RTA-OS can use your compiler toolchain to generate an OS kernel and that a simple application can run with that kernel.*

For further advice on building and running the sample applications, please consult your *Getting Started Guide*.

4 Port Characteristics

This chapter tells you about the characteristics of RTA-OS for the PPCe200/HighTec port.

4.1 Parameters of Implementation

To be a valid OSEK or AUTOSAR OS, an implementation must support a minimum number of OS objects. The following table specifies the *minimum* numbers of each object required by the standards and the *maximum* number of each object supported by RTA-OS for the PPCe200/HighTec port.

Parameter	Required	RTA-OS
Tasks	16	1024
Tasks not in SUSPENDED state	16	1024
Priorities	16	1024
Tasks per priority	-	1024
Queued activations per priority	-	4294967296
Events per task	8	32
Software Counters	8	4294967296
Hardware Counters	-	4294967296
Alarms	1	4294967296
Standard Resources	8	4294967296
Linked Resources	-	4294967296
Nested calls to `GetResource()`	-	4294967296
Internal Resources	2	no limit
Application Modes	1	4294967296
Schedule Tables	2	4294967296
Expiry Points per Schedule Table	-	4294967296
OS Applications	-	4294967295
Trusted functions	-	4294967295
Spinlocks (multicore)	-	4294967295
Register sets	-	4294967296

4.2 Configuration Parameters

Port-specific parameters are configured in the **General → Target** workspace of **rtaoscfg**, under the “Target-Specific” tab.

The following sections describe the port-specific configuration parameters for the PPCe200/HighTec port, the name of the parameter as it will appear in the XML configuration and the range of permitted values (where appropriate).

4.2.1 Stack used for C-startup

XML name SpPreStartOS

Description

The amount of stack already in use at the point that Os_StartOS() is called. This value is simply added to the total stack size that the OS needs to support all tasks and interrupts at run-time. Typically you use this to obtain the amount of stack that the linker must allocate. The value does not normally change if the OS configuration changes.

4.2.2 Stack used when idle

XML name SpStartOS

Description

The amount of stack used when the OS is in the idle state (typically inside Os_Cbk_Idle()). This is just the difference between the stack used at the point that Os_StartOS() is called and the stack used when no task or interrupt is running. This can be zero if Os_Cbk_Idle() is not used. The value does not normally change if the OS configuration changes.

4.2.3 Stack overheads for ISR activation

XML name SpIDisp

Description

The amount of stack needed to activate a task from within an ISR. If a task is activated within a Category 2 ISR, and that task has a higher priority than any currently running task, then the OS may need to use marginally more stack than if it activates a task that is of lower priority. This value is used in worst-case stack size calculations. The value may change if significant changes are made to the OS configuration. e.g. STANDARD/EXTENDED, SC1/2/3/4.

4.2.4 Stack overheads for ECC tasks

XML name SpECC

Description

The extra amount of stack needed to start an ECC task. ECC tasks need to save slightly more state on the stack when they are started than BCC tasks. This value contains the difference. The value may change if significant changes are made to the OS configuration. e.g. STANDARD/EXTENDED, SC1/2/3/4.

4.2.5 Stack overheads for ISR

XML name SpPreemption

Description

The amount of stack used to service a Category 2 ISR. When a Category 2 ISR interrupts a task, it usually places some data on the stack. If the ISR measures the stack to determine if the task has exceeded its stack budget, then it will overestimate the stack usage unless this value is subtracted from the measured size. The value is also used when calculating the worst-case stack usage of the system, assuming the maximum depth of preemption that can occur. Be careful to set this value accurately. If its value is too high then when the subtraction occurs, 32-bit underflow can occur and cause the OS to think that a budget overrun has occurred. The value may change if significant changes are made to the OS configuration. e.g. STANDARD/EXTENDED, SC1/2/3/4.

4.2.6 ORTI/Lauterbach

XML name Orti22Lauterbach

Description

Enables ORTI generation for Lauterbach debugger.

4.2.7 ORTI/winIDEA

XML name Orti21winIDEA

Description

Enables ORTI generation for winIDEA debugger.

4.2.8 ORTI Stack Fill

XML name OrtiStackFill

Description

Expands ORTI information to cover stack address, size and fill pattern details to support debugger stack usage monitoring.

4.2.9 Support winIDEA Analyzer

XML name winIDEAAnalyzer

Description

Adds support for the winIDEA profiler to track ORTI items. Context switches take a few cycles longer as additional code is inserted to support this feature.

4.2.10 Link Type

XML name OSLinkMemModel

Description

Select the type of map used in linker samples.

Settings

Value	Description
IntRAM	Code/data in internal RAM (default)
IntFLASH	Code in internal flash, data in internal RAM

4.2.11 SDA RAM Threshold

XML name sda_value

Description

Sets the value used for small data objects when compiling. Defaults to undefined.

4.2.12 SDA ROM Threshold

XML name sda_value_const

Description

Sets the value used for small const objects when compiling. Defaults to undefined.

4.2.13 MultiCore Lock

XML name MC_Locker

Description

Select hardware used for Spinlock implementation. Software option is only applicable to MPC57xx variants.

4.2.14 OS Locks disable Cat1

XML name OSLockDisableAll

Description

Specify whether all interrupts are disabled while internal OS spinlocks are held. This does not affect spinlocks accessed using the GetSpinlock or TryToGetSpinlock APIs

Settings

Value	Description
TRUE	Disable all interrupts
FALSE	Do not disable interrupts (default)

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4.2.15 MultiCore interrupts

XML name MC_Interrupt

Description

Select the first software interrupt to use for multi-core implementation. The OS will use the appropriate number of consecutive interrupts.

Settings

Value	Description
0	INTC0 (default)
1	INTC1
2	INTC2
3	INTC3
4	INTC4
5	INTC5
6	INTC6

4.2.16 Preserve SPE

XML name preserve_spe

Description

Select whether SPE related registers are preserved across TASK and Category 2 ISR preemptions

Settings

Value	Description
TRUE	Preserve SPE related registers
FALSE	Do not preserve SPE related registers (default)

4.2.17 Enable stack repositioning

XML name AlignUntrustedStacks

Description

Use to support realignment of the stack for untrusted code when there are MPU protection region granularity issues. Refer to the documentation for Os_Cbk_SetMemoryAccess

Settings

Value	Description
TRUE	Support repositioning
FALSE	Normal behavior (default)

4.2.18 Enable untrusted stack check

XML name DistrustStacks

Description

Extra code can be placed in interrupt handlers to detect when untrusted code has an illegal stack pointer value. Also exception handlers run on a private stack (Refer to the documentation for Os_Cbk_GetAbortStack). This has a small performance overhead, so is made optional.

Settings

Value	Description
TRUE	Perform the checks (default)
FALSE	Do not check

4.2.19 Use software vectoring

XML name SoftwareVectoring

Description

Select software-based dispatching of interrupts. RTA-OS will provide the software dispatching code unless you specify your own dispatcher by configuring an interrupt on IVOR 4.

Settings

Value	Description
TRUE	Software vectoring
FALSE	Hardware vectoring (default)

4.2.20 Block default interrupt

XML name block_default_interrupt

Description

Where a default interrupt is specified, it will normally execute if a spurious interrupt fires. You can block this behavior using this option. The option affects the priority assigned to unused interrupt sources.

Settings

Value	Description
TRUE	Block the default interrupt
FALSE	Allow the default interrupt handler to run if a spurious interrupt fires (default)

4.2.21 Generate Cat1 EOIR

XML name GenerateEOIR

Description

Select whether code is emitted to write to the EOIR in Cat 1 interrupts.

Settings

Value	Description
TRUE	Code is emitted to write to the EOIR
FALSE	Code is not emitted to write to the EOIR (default)

4.2.22 Cache CoreID

XML name Cache_CoreID

Description

Select a register to cache the Core ID into. This can improve performance, especially where there is untrusted code. If this option has a value, the OS will initialize and use this register where it can to read the Core ID. It must not be modified.

Settings

Value	Description
SPRG4	SPRG4
SPRG5	SPRG5
SPRG6	SPRG6
SPRG7	SPRG7
PMGC0	PMGC0
*	Test Only

4.2.23 Emit stack usage

XML name emit_stack_usage

Description

Generate stack usage files using the -fstack-usage compiler option.

Settings

Value	Description
TRUE	Emit stack usage files
FALSE	Do not emit stack usage files (default)

4.3 Generated Files

The following table lists the files that are generated by **rtaosgen** for all ports:

Filename	Contents
`Os.h`	The main include file for the OS.
`Os_Cfg.h`	Declarations of the objects you have configured. This is included by `Os.h`.
`Os_MemMap.h`	AUTOSAR memory mapping configuration used by RTA-OS to merge with the system-wide `MemMap.h` file.
`RTAOS.<lib>`	The RTA-OS library for your application. The extension `<lib>` depends on your target.
`RTAOS.<lib>.sig`	A signature file for the library for your application. This is used by **rtaosgen** to work out which parts of the kernel library need to be rebuilt if the configuration has changed. The extension `<lib>` depends on your target.
`<projectname>.log`	A log file that contains a copy of the text that the tool and compiler sent to the screen during the build process.

5 Port-Specific API

The following sections list the port-specific aspects of the RTA-OS programmers reference for the PPCe200/HighTec port that are provided either as:

- additions to the material that is documented in the *Reference Guide*; or
- overrides for the material that is documented in the *Reference Guide*. When a definition is provided by both the *Reference Guide* and this document, the definition provided in this document takes precedence.

5.1 API Calls

5.1.1 Os_InitializeVectorTable

Initialize the interrupt hardware and vector table(s).

Syntax

```
void Os_InitializeVectorTable(void)
```

Description

Os_InitializeVectorTable() initializes the CPU and INTC interrupts according to the requirements of the project configuration. In particular, it sets IVPR, IVOR registers and INTC priorities. It sets hardware or software vectoring mode based on whether IVOR_4 has been assigned to an ISR.

Os_InitializeVectorTable() should be called before StartOS(). It should be called even if 'Suppress Vector Table Generation' is set to TRUE.

Example

```
Os_InitializeVectorTable();
```

See Also

StartOS

5.2 Callbacks

5.2.1 Os_Cbk_GetAbortStack

Callback routine to provide the start address of the stack to use to handle exceptions.

Syntax

```
FUNC(void *, {memclass}) Os_Cbk_GetAbortStack(void)
```

Return Values

The call returns values of type **void** *.

Description

Untrusted code can misbehave and cause a protection exception. When this happens, AUTOSAR requires that ProtectionHook is called and the task, ISR or OS Application must be terminated.

It is possible that at the time of the fault the untrusted code's stack pointer is invalid.

For this reason, if 'Enable untrusted stack check' is configured, RTA-OS will call Os_Cbk_GetAbortStack to get the address of a safe area of memory that it should use for the stack while it performs this processing.

Maskable interrupts will be disabled during this process so the stack only needs to be large enough to get to and execute ProtectionHook.

A default implementation of Os_Cbk_GetAbortStack is supplied in the RTA-OS library, but you can implement your own version to override its behaviour.

In systems that use the Os_Cbk_SetMemoryAccess callback, the return value is the last stack location returned in ApplicationContext from Os_Cbk_SetMemoryAccess.

This is to avoid having to reserve memory. Note that this relies on Os_Cbk_SetMemoryAccess having been called at least once on that core otherwise zero will be returned. (The stack will not get adjusted if zero is returned.)

Otherwise the default implementation returns the address of an area of static memory that is reserved for sole use by the abort stack.

Note: memclass is OS_APPL_CODE for AUTOSAR 3.x, OS_CALLOUT_CODE for AUTOSAR 4.0, OS_OS_CBK_GETABORTSTACK_CODE for AUTOSAR 4.1.

Example

```
FUNC(void *, {memclass}) Os_Cbk_GetAbortStack(void) {
  /* NOTE The last location of the array is treated as the
      previous stack frame where the LR would be stored. */
  static uint32 abortstack[40U];
  return &abortstack[38U];
}
```

Required when

The callback must be present if 'Enable untrusted stack check' is configured and there are untrusted OS Applications.

5.2.2 Os_Cbk_StartCore

Callback routine used to start a non master core on a multicore variant.

Syntax

```
FUNC(StatusType, {memclass})Os_Cbk_StartCore(
    uint16 CoreID
)
```

Return Values

The call returns values of type StatusType.

Value	Build	Description
E_OK	all	No error.
E_OS_ID	all	The core does not exist or can not be started.

Description

In a multi-core application, the StartCore and StartNonAutosarCore OS APIs have to be called prior to StartOS for each core that is to run.

For this target port, these APIs make a call to Os_Cbk_StartCore which is responsible for starting the specified core and causing it to enter OS_MAIN.

RTA-OS provides a default implementation of Os_Cbk_StartCore that sets the core reset vector to 'os_example_init_core' and then releases the core.

Os_Cbk_StartCore does not get called for core 0, because core 0 must start first.

Note: memclass is OS_APPL_CODE for AUTOSAR 3.x, OS_CALLOUT_CODE for AUTOSAR 4.0, OS_OS_CBK_STARTCORE_CODE for AUTOSAR 4.1.

Example

```
FUNC(StatusType, {memclass}) Os_Cbk_StartCore(uint16 CoreID) {
  SET_CORE_RSTVEC(CoreID);
  RELEASE_CORE(CoreID);
}
```

Required when

Required for non master cores that will be started.

See Also

StartCore
StartNonAutosarCore
StartOS

5.3 Macros

5.3.1 CAT1_ISR

Macro that should be used to create a Category 1 ISR entry function. This macro exists to help make your code portable between targets.

Example

```
CAT1_ISR(MyISR) {...}
```

5.3.2 Os_DisableAllConfiguredInterrupts

The Os_DisableAllConfiguredInterrupts macro will disable all configured INTC interrupts by adjusting the INTC PSR settings. You will need to #include the file "Os_DisableInterrupts.h" if you want to use this macro. It may not be used by untrusted code.

Example

```
Os_DisableAllConfiguredInterrupts()
Os_Enable_Millisecond()
```

5.3.3 Os_Disable_x

The Os_Disable_x macro will disable the named INTC interrupt vector by adjusting its INTC PSR settings. The macro can be called using either the INTC vector name or the RTA-OS configured vector name. In the example, this is Os_Disable_eMIOS_Channel_0() and Os_Disable_Millisecond() respectively. You will need to #include the file "Os_DisableInterrupts.h" if you want to use this macro. It may not be used by untrusted code.

Example

```
Os_Disable_eMIOS_Channel_0()
Os_Disable_Millisecond()
```

5.3.4 Os_EnableAllConfiguredInterrupts

The Os_EnableAllConfiguredInterrupts macro will enable all configured INTC interrupts by adjusting the INTC PSR settings. You will need to #include the file "Os_DisableInterrupts.h" if you want to use this macro. It may not be used by untrusted code.

Example

```
Os_DisableAllConfiguredInterrupts()
...
Os_EnableAllConfiguredInterrupts()
```

5.3.5 Os_Enable_x

The Os_Enable_x macro will re-enable the named INTC interrupt vector at the priority it was configured with by adjusting its INTC PSR settings. The macro can be called using either the INTC vector name or the RTA-OS configured vector name. In the example, this is Os_Enable_eMIOS_Channel_0() and Os_Enable_Millisecond() respectively. You will need to #include the file "Os_DisableInterrupts.h" if you want to use this macro. It may not be used by untrusted code.

Example

```
Os_Enable_eMIOS_Channel_0()
Os_Enable_Millisecond()
```

5.3.6 Os_IntChannel_x

The Os_IntChannel_x macro can be used to get the vector number associated with the named INTC interrupt (0, 1, 2...). The macro can be called using either the INTC vector name or the RTA-OS configured vector name. In the example, this is Os_IntChannel_eMIOS_Channel_0 and Os_IntChannel_Millisecond respectively. You will need to #include the file "Os_DisableInterrupts.h" if you want to use this macro.

Example

```
trigger_interrupt(Os_IntChannel_eMIOS_Channel_0);
trigger_interrupt(Os_IntChannel_Millisecond);
```

5.4 Type Definitions

5.4.1 Os_StackSizeType

An unsigned value representing an amount of stack in bytes.

Example

```
Os_StackSizeType stack_size;
stack_size = Os_GetStackSize(start_position, end_position);
```

5.4.2 Os_StackValueType

An unsigned value representing the position of the stack pointer (ESP).

Example

```
Os_StackValueType start_position;
start_position = Os_GetStackValue();
```

6 Toolchain

This chapter contains important details about RTA-OS and the HighTec toolchain. A port of RTA-OS is specific to both the target hardware and a specific version of the compiler toolchain. You must make sure that you build your application with the supported toolchain.

In addition to the version of the toolchain, RTA-OS may use specific tool options (switches). The options are divided into three classes:

kernel options are those used by **rtaosgen** to build the RTA-OS kernel.

mandatory options must be used to build application code so that it will work with the RTA-OS kernel.

forbidden options must not be used to build application code.

Any options that are not explicitly forbidden can be used by application code providing that they do not conflict with the kernel and mandatory options for RTA-OS.

Integration Guidance 6.1:*ETAS has developed and tested RTA-OS using the tool versions and options indicated in the following sections. Correct operation of RTA-OS is only covered by the warranty in the terms and conditions of your deployment license agreement when using identical versions and options. If you choose to use a different version of the toolchain or an alternative set of options then it is your responsibility to check that the system works correctly. If you require a statement that RTA-OS works correctly with your chosen tool version and options then please contact ETAS to discuss validation possibilities.*

6.1 Compiler

Name ppc-vle-gcc.exe
Version ppc-vle-gcc.exe (HighTec Release v4.6.5.0) 4.6.4 build on 2014-09-22

Options

Kernel Options

The following options were used to build the RTA-OS kernel for the configuration that was used to generate the performance figures in this document. If you select different target options, then the values used to build the kernel might change. You can run a Configuration Summary report to check the values used for your configuration.

-mcpu=MCU_JDP_UC1 Generate code for target processor. This option is used for all variants with an _JDP suffix

-fno-builtin No built-in functions

-fno-common No common block

-W Enable additional warnings

-Wall Enable common warnings

-Wbad-function-cast Warn for function cast to a non-matching type

-Werror-implicit-function-declaration Error if function is used before being declared

-Winline Warn if inline function cannot be inlined

-Wmissing-prototypes Warn if a global function is defined without a prototype

-Wnested-externs Warn about extern in a function

-Wpointer-arith Warn for arithmetic using size of function or void

-Wredundant-decls Warn about multiple redundant declarations

-Wstrict-prototypes Warn if type and number of arguments for a function are not declared

-Wundef Warn about undefined macro in #if

-Wfloat-equal Warn if floats are used in equality tests

-Wno-sign-conversion Do not warn about conversions between signed and unsigned integers

-Wno-unused-parameter Do not warn about unused function parameters that are declared but not used

-Wno-unused-variable Do not warn about unused variables that are declared but not used

-Os Optimize for size

-gdwarf-2 Generate DWARF v2 debugging information

-mno-regnames No register names directly in asm

-mvle Compile for VLE encoding

-mfixed-sda Treat r14-r17 as fixed registers

-fomit-frame-pointer Do not keep frame pointer in a register unless needed

-mno-spe Disable SPE instructions

-msdata=eabi Use r2 for .sdata2, r13 for .sdata

-fno-section-anchors Do not use common anchors

-Werror Treat all warnings as errors

-ffunction-sections Functions normally in a .text section are placed in their own individual sections.

-fdata-sections Items normally in a .data section are placed in their own individual sections.

-mpragma-data-sections Pragma data sections are placed in their own individual sections.

Mandatory Options for Application Code

The following options were mandatory for application code used with the configuration that was used to generate the performance figures in this document. If you select different target options, then the values required by application code might change. You can run a Configuration Summary report to check the values used for your configuration.

-msmall-data=8 SDA RAM threshold (value set by target option)

Forbidden Options for Application Code

The following options were forbidden for application code used with the configuration that was used to generate the performance figures in this document. If you select different target options, then the forbidden values might change. You can run a Configuration Summary report to check the values used for your configuration.

- Any options that conflict with kernel options

6.2 Assembler

Name ppc-vle-gcc.exe
Version ppc-vle-gcc.exe (HighTec Release v4.6.5.0) 4.6.4 build on 2014-09-22

Kernel Options

The following options were used to build the RTA-OS kernel for the configuration that was used to generate the performance figures in this document. If you select different target options, then the values used to build the kernel might change. You can run a Configuration Summary report to check the values used for your configuration.

- The same options as for compilation

Mandatory Options for Application Code

The following options were mandatory for application code used with the configuration that was used to generate the performance figures in this document. If you select different target options, then the values required by application code might change. You can run a Configuration Summary report to check the values used for your configuration.

- The same options as for compilation

Forbidden Options for Application Code

The following options were forbidden for application code used with the configuration that was used to generate the performance figures in this document. If you select different target options, then the forbidden values might change. You can run a Configuration Summary report to check the values used for your configuration.

- Any options that conflict with kernel options

6.3 Librarian

Name	ppc-vle-ar.exe
Version	ar (HighTec Release v4.6.5.0) build on 2014-09-22 (GNU Binutils) 2.20

6.4 Linker

Name	ppc-vle-g++.exe
Version	ppc-vle-g++.exe (HighTec Release v4.6.5.0) 4.6.4 build on 2014-09-22

Kernel Options

The following options were used to build the RTA-OS kernel for the configuration that was used to generate the performance figures in this document. If you select different target options, then the values used to build the kernel might change. You can run a Configuration Summary report to check the values used for your configuration.

-Wl,-warn-orphan Warn if there is no dedicated mapping between an input section and an output section

-nodefaultlibs No standard libraries

-mvle Compile for VLE encoding

-Wl,-cref Generate cross reference table

-Wl,-no-demangle Do not demangle symbol names

-Wl,-relax Relax branches

-Wl,-warn-once Only warn once about each undefined symbol

Mandatory Options for Application Code

The following options were mandatory for application code used with the configuration that was used to generate the performance figures in this document. If you select different target options, then the values required by application code might change. You can run a Configuration Summary report to check the values used for your configuration.

- The same options as for compilation

Forbidden Options for Application Code

The following options were forbidden for application code used with the configuration that was used to generate the performance figures in this document. If you select different target options, then the forbidden values might change. You can run a Configuration Summary report to check the values used for your configuration.

- Any options that conflict with kernel options

6.5 Debugger

Name Lauterbach TRACE32
Version Build 45520 or later

Notes

Supports .elf files and ORTI files.

Notes on using ORTI with the debugger

ORTI with the Lauterbach debugger

When ORTI information for the Trace32 debugger is enabled entry and exit times for Category 1 interrupts are increased by a few cycles to support tracking of Category 1 interrupts by the debugger.

ORTI Stack Fill with the Lauterbach debugger

The 'ORTI Stack Fill' target option is provided to extend the ORTI support to allow evaluation of unused stack space. The Task.Stack.View command can then be used in the Trace32 debugger. The following must also be added to an application to ensure correct operation (as demonstrated in the sample applications):

The linker file must create labels holding the start address and stack size for each stack (one per core). For a single core system (i.e. core 0 only) the labels are:

```
OS_STACK0_BASE = _stackcore0_addr;
OS_STACK0_SIZE = _stackcore0_size;
```

where _stackcore0 is the section containing the Core 0 stack.

The fill pattern used by the debugger must be contained with in a 32 bit constant `OS_STACK_FILL` (i.e. for a fill pattern `0xCAFEF00D`).

```
const uint32 OS_STACK_FILL = 0xCAFEF00D;
```

The stack must also be initialized with this fill pattern either in the application start-up routines or during debugger initialization.

ORTI with the winIDEA debugger

When ORTI information for the winIDEA debugger is enabled entry and exit times for Category 1 interrupts are increased by a few cycles to allow tracking of Category 1 interrupts by the debugger.

ORTI Stack Fill with the winIDEA debugger

Again the 'ORTI Stack Fill' target option is provided to extend the ORTI support to allow evaluation of unused stack space. The stack use is then displayed in the 'Operating System' window in addition to the other ORTI information. The following must also be added to an application to ensure correct operation (as demonstrated in the sample applications):

The linker file must create labels holding the start address and stack size for each stack (one per core). For a single core system (i.e. core 0 only) the labels are:

```
OS_STACK0_BASE = _stackcore0_addr;
OS_STACK0_SIZE = _stackcore0_size;
```

where _stackcore0 is the section containing the Core 0 stack.

The application must contain 32 bit constant values referencing these labels to allow the debugger to visualize these.

```
extern const uint32 OS_STACK0_BASE;
extern const uint32 OS_STACK0_SIZE;
const uint32 Os_Stack0_Start = (const uint32)&OS_STACK0_BASE;
const uint32 Os_Stack0_Size = (const uint32)&OS_STACK0_SIZE;
```

The fill pattern used by the debugger is set to 0xCAFEF00D by default in the ORTI file. If a different fill pattern is required then the ORTI file must be edited.

The stack must also be initialized with the fill pattern either in the c start-up code or during debugger initialization.

Using the winIDEA Analyzer

When profiler analyzer support for the winIDEA debugger is enabled the entry and exit times for Tasks and Category 2 interrupts are increased by a few cycles to allow measurement of these objects.

7 Hardware

7.1 Supported Devices

This port of RTA-OS has been developed to work with the following target:

Name: Freescale/ST
Device: MPC5xxx/SPC56x

The following variants of the MPC5xxx/SPC56x are supported:

- MPC5534
- MPC5561
- MPC5565
- MPC5566
- MPC5567
- MPC5604B
- MPC5604C
- MPC5604S
- MPC5605B
- MPC5606B
- MPC5607B
- MPC5633
- MPC5642A
- MPC5643L
- MPC5644B
- MPC5644C
- MPC5645B
- MPC5645C
- MPC5645S
- MPC5646B
- MPC5646C
- MPC5673F

- MPC5673Fv2
- MPC5674F
- MPC5674Fv2
- MPC5675K
- MPC5676R
- MPC5726L
- MPC5726L_JDP
- MPC5744K
- MPC5744K_JDP
- MPC5744Kv2
- MPC5744Kv2_JDP
- MPC5744P
- MPC5746M
- MPC5746M_JDP
- MPC5746Mv2
- MPC5746Mv2_JDP
- MPC5746R
- MPC5748GCompatibility
- MPC5748Gv2
- MPC5777C
- MPC5777M
- MPC5777M_JDP
- MPC5777Mv2
- MPC5777Mv2_JDP
- SPC560B40
- SPC560B44
- SPC560B50

- SPC560B54
- SPC560B60
- SPC560B64
- SPC560C
- SPC560P
- SPC560S
- SPC563M
- SPC572L64
- SPC572L64_JDP
- SPC574K72
- SPC574K72_JDP
- SPC574K72v2
- SPC574K72v2_JDP
- SPC582B
- SPC584B
- SPC584C
- SPC58xx84
- SPC58xx84_JDP

If you require support for a variant of MPC5xxx/SPC56x not listed above, please contact ETAS.

7.2 Register Usage

7.2.1 Initialization

RTA-OS requires the following registers to be initialized to the indicated values before `StartOS()` is called.

Register	Setting
CCU	Multicore: The Cache Coherency Unit must be enabled (when present).
INTC_PSRx	The INTC priorities have to be set to the values declared in the configuration. This can be done by calling Os_InitializeVectorTable().
IVORx	The IVOR vectors have to be set correctly based on the configuration. This can be done by calling Os_InitializeVectorTable().
IVPR	The interrupt base address has to be set to the start of Os_InterruptVectorTable or Os_CPU_vectors depending on the target variant and vectoring mode. This can be done by calling Os_InitializeVectorTable().
L1CSR	Multicore: The instruction cache may be enabled. The data cache must be set to write-through if enabled.
MSR	MSR[EE] should be set, MSR[SPE] must be set and MSR[PR] must be reset.
TLB	The INTC must be cache-inhibited and guarded (where appropriate).
XBAR	Multicore: Round-robin scheduling is needed for core accesses to ROM and RAM

7.2.2 Modification

The following registers must not be modified by user code after the call to `StartOS()`:

Register	Notes
INTC_BCR	INTC configuration register. (Or equivalent for Multicore.)
INTC_CPR	INTC priority register. (Or equivalent for Multicore.)
INTC_EOIR	INTC end of interrupt register. (Or equivalent for Multicore.)
INTC_IACKR	INTC acknowledge register. (Or equivalent for Multicore.)
INTC_PSRx	INTC priority select register.
IVPR	Interrupt vector base address register.
MSR	Machine Status Register EE, SPE and PR bits.
SEMA4_Gatexx	(Multicore only) 1 SEMA4 gate is reserved for use by the OS. Default is Gate 0. It must be cache-inhibited and guarded. There is no reservation if the software semaphore option is used.

7.3 Interrupts

This section explains the implementation of RTA-OS's interrupt model on the MPC5xxx/SPC56x.

7.3.1 Interrupt Priority Levels

Interrupts execute at an interrupt priority level (IPL). RTA-OS standardizes IPLs across all targets. IPL 0 indicates task level. IPL 1 and higher indicate an interrupt priority. It is important that you don't confuse IPLs with task priorities. An IPL of 1 is higher than the highest task priority used in your application.

The IPL is a target-independent description of the interrupt priority on your target hardware. The following table shows how IPLs are mapped onto the hardware interrupt priorities of the MPC5xxx/SPC56x:

IPL	INTC_CPR	Description
0	EE=1, INTC_CPR=0	User (task) level
1-15/63	EE=1, INTC_CPR=1-15/63	Category 1 and 2 level (Max value depends upon target)
16/64	EE=0, INTC_CPR=x	Category 1 only (Max value depends upon target)

Even though a particular mapping is permitted, all Category 1 ISRs must have equal or higher IPL than all of your Category 2 ISRs.

7.3.2 Allocation of ISRs to Interrupt Vectors

The following restrictions apply for the allocation of Category 1 and Category 2 interrupt service routines (ISRs) to interrupt vectors on the MPC5xxx/SPC56x. A ✓ indicates that the mapping is permitted and a ✗ indicates that it is not permitted:

Address	Category 1	Category 2
INTC_0 to the highest INTC interrupt. Multi-core operation uses software interrupts for cross-core communication (By default these are allocated from INTC_0).	✓	✓
IVOR_0 to the highest IVOR interrupt. Note: RTA-OS only preserves the SRR0/SRR1 registers for the External, Decrementer and Fixed Interval Timer interrupts.	✓	✗

RTA-OS normally selects hardware vectoring mode when there are INTC interrupts and it will ensure that the INTC vector table is configured correctly. You can alternatively use a target option to select software vectoring mode, in which case a CAT1 ISR attached to IVOR_4 performs the dispatching of INTC interrupts based. The Os_INTC_vectors table changes in software vectoring mode to contain pointers to void functions that take a single uint32 argument containing the vector number 0, 1, ... RTA-OS will supply the dispatcher unless you place a Category 1 ISR on IVOR_4 (External Interrupt). In this case your code can perform the dispatching. The function

to call for a Category 1 ISR 'name' is 'void <name>(vector)'. The function to call for a Category 2 ISR is void 'Os_ISRWrapper(vector)' for single core, 'Os_ISRWrapper<corenum>(vector)' for multi core.

Note that your CAT1_ISR handler code is entered with all necessary CPU registers saved, but no others. In particular, you may need to deal with EOIR in the interrupt controller.

7.3.3 Vector Table

rtaosgen normally generates an interrupt vector table for you automatically. You can configure "Suppress Vector Table Generation" as TRUE to stop RTA-OS from generating the interrupt vector table.

Depending upon your target, you may be responsible for locating the generated vector table at the correct base address. The following table shows the section (or sections) that need to be located and the associated valid base address:

Section	Valid Addresses
Os_intvec	Contains the INTC vectors. The linker/locater must ensure that alignment is appropriate for the target variant.
Os_cpuvec	Contains the CPU vectors/initializers. The linker/locater must ensure that alignment is appropriate for the target variant.

When 'Suppress Vector Table Generation' is configured as TRUE, no CPU or INTC vector tables will be generated. You are then responsible for providing them. You should still call Os_InitializeVectorTable() to ensure that interrupt priorities are correctly configured. Where there are multiple cores, each core must call Os_InitializeVectorTable().

7.3.4 Writing Category 1 Interrupt Handlers

Raw Category 1 interrupt service routines (ISRs) must correctly handle the interrupt context themselves. RTA-OS provides an optional helper macro `CAT1_ISR` that can be used to make code more portable. Depending on the target, this may cause the selection of an appropriate interrupt control directive to indicate to the compiler that a function requires additional code to save and restore the interrupt context.

A Category 1 ISR therefore has the same structure as a Category 2 ISR, as shown below.

```
CAT1_ISR(Category1Handler) {
  /* Handler routine */
}
```

7.3.5 Writing Category 2 Interrupt Handlers

Category 2 ISRs are provided with a C function context by RTA-OS, since the RTA-OS kernel handles the interrupt context itself. The handlers are written using the `ISR()` macro as shown below:

```
#include <Os.h>
ISR(MyISR) {
  /* Handler routine */
}
```

You must not insert a return from interrupt instruction in such a function. The return is handled automatically by RTA-OS.

7.3.6 Default Interrupt

The 'default interrupt' is intended to be used to catch all unexpected interrupts. All unused interrupts have their interrupt vectors directed to the named routine that you specify. The routine you provide is not handled by RTA-OS and must correctly handle the interrupt context itself. The handler must use the `CAT1_ISR` macro in the same way as a Category 1 ISR (see Section 7.3.4 for further details).

7.4 Memory Model

The following memory models are supported:

Model	Description
Flat 32 bit address space	The SDA threshold defaults to undefined, preventing small data/const access. This can be changed via a target option.

7.5 Processor Modes

RTA-OS can run in the following processor modes:

Mode	Notes
Supervisor	All OS and "trusted" code runs in supervisor mode.
User	All "untrusted" code runs in user mode.

7.6 Stack Handling

RTA-OS uses a single stack for all tasks and ISRs.

RTA-OS uses the stack in use when the OS starts (register R1). Where there are multiple cores, each core must use different stack areas.

8 Performance

This chapter provides detailed information on the functionality, performance and memory demands of the RTA-OS kernel. RTA-OS is highly scalable. As a result, different figures will be obtained when your application uses different sets of features. The figures presented in this chapter are representative for the PPCe200/HighTec port based on the following configuration:

- There are 32 tasks in the system
- Standard build is used
- Stack monitoring is disabled
- Time monitoring is disabled
- There are no calls to any hooks
- Tasks have unique priorities
- Tasks are not queued (i.e. tasks are BCC1 or ECC1)
- All tasks terminate/wait in their entry function
- Tasks and ISRs do not save any auxiliary registers (for example, floating point registers)
- Resources are shared by tasks only
- The generation of the resource `RES_SCHEDULER` is disabled

8.1 Measurement Environment

The following hardware environment was used to take the measurements in this chapter:

Device	MPC5746Mv2_JDP on Bosch MDG1
CPU Clock Speed	16.0MHz
Stopwatch Speed	16.0MHz

8.2 RAM and ROM Usage for OS Objects

Each OS object requires some ROM and/or RAM. The OS objects are generated by **rtaosgen** and placed in the RTA-OS library. In the main:

- `Os_Cfg_Counters` includes data for counters, alarms and schedule tables.
- `Os_Cfg` contains the data for most other OS objects.

8.2.1 Single Core

The following table gives the ROM and/or RAM requirements (in bytes) for each OS object in a simple single-core configuration. Note that object sizes will vary depending on the project configuration and compiler packing issues.

Object	ROM	RAM
Alarm	2	12
Cat 2 ISR	8	0
Counter	20	4
CounterCallback	4	0
ExpiryPoint	3.5	0
OS Overheads (max)	0	69
OS-Application	0	0
Resource	8	4
ScheduleTable	16	16
Task	16	0

8.2.2 Multi Core

The following table gives the ROM and/or RAM requirements (in bytes) for each OS object in a simple multi-core configuration. Note that object sizes will vary depending on the project configuration and compiler packing issues.

Object	ROM	RAM
Alarm	8	12
Cat 2 ISR	16	0
Core Overheads (each OS core)	0	56
Core Overheads (each processor core)	40	28
Counter	32	4
CounterCallback	4	0
ExpiryPoint	3.5	0
OS Overheads (max)	0	20
OS-Application	8	0
Resource	24	8
ScheduleTable	20	16
Task	40	0

8.3 Stack Usage

The amount of stack used by each Task/ISR in RTA-OS is equal to the stack used in the Task/ISR body plus the context saved by RTA-OS. The size of the run-time context saved by RTA-OS depends on the Task/ISR type and the exact system configuration. The only reliable way to get the correct value for Task/ISR stack usage is to call the `Os_GetStackUsage()` API function.

Note that because RTA-OS uses a single-stack architecture, the run-time contexts of all tasks reside on the same stack and are recovered when the task terminates. As a result, run-time contexts of mutually exclusive tasks (for example, those that share an internal resource) are effectively overlaid. This means that the worst case stack usage can be significantly less than the sum of the worst cases of each object on the system. The RTA-OS tools automatically calculate the total worst case stack usage for you and present this as part of the configuration report.

8.4 Library Module Sizes

8.4.1 Single Core

The RTA-OS kernel is demand linked. This means that each API call is placed into a separately linkable module. The following table lists the section sizes for each API module (in bytes) for the simple single-core configuration in standard status.

Library Module	Os_Cat1_vle	Os_cpuvec	Os_intvec	Os_text_vle	bss	rodata	sbss	text_vle
ActivateTask								172
AdvanceCounter								4
CallTrustedFunction								32
CancelAlarm								148
ChainTask								156
CheckISRMemoryAccess								62
CheckObjectAccess								130
CheckObjectOwnership								120
CheckTaskMemoryAccess								62
ClearEvent								84
ControlIdle							4	100
DisableAllInterrupts							8	58
DispatchTask								182
ElapsedTime								428
EnableAllInterrupts								66
GetActiveApplicationMode								6
GetAlarm								206
GetAlarmBase								48
GetApplicationID								26
GetCounterValue								90
GetElapsedCounterValue								112
GetEvent								84

Library Module	Os_Cat1_vle	Os_cpuvec	Os_intvec	Os_text_vle	bss	rodata	sbss	text_vle
GetExecutionTime								84
GetISRID								6
GetIsrMaxExecutionTime								84
GetIsrMaxStackUsage								84
GetResource								114
GetScheduleTableStatus								90
GetStackSize								4
GetStackUsage								84
GetStackValue								10
GetTaskID								10
GetTaskMaxExecutionTime								84
GetTaskMaxStackUsage								84
GetTaskState								30
GetVersionInfo								26
Idle								4
InShutdown								2
IncrementCounter								24
NextScheduleTable								162
Os_Cat1	46							
Os_Cfg					592	648	29	322
Os_Cfg_Counters						728		4574
Os_Vectors		406	38					
Os_Wrapper								142
Os_setjmp				160				
Os_vec_init						12		126
ProtectionSupport								108
ReleaseResource								134
ResetIsrMaxExecutionTime								84
ResetIsrMaxStackUsage								84
ResetTaskMaxExecutionTime								84
ResetTaskMaxStackUsage								84
ResumeAllInterrupts								66
ResumeOSInterrupts								66
Schedule								140
SetAbsAlarm								162
SetEvent								84
SetRelAlarm								214
SetScheduleTableAsync								120
ShutdownOS								60

Library Module	Os_Cat1_vle	Os_cpuvec	Os_intvec	Os_text_vle	bss	rodata	sbss	text_vle
StackOverrunHook								6
StartOS								152
StartScheduleTableAbs								164
StartScheduleTableRel								156
StartScheduleTableSynchron								120
StopScheduleTable								132
SuspendAllInterrupts							8	58
SuspendOSInterrupts							8	146
SyncScheduleTable								120
SyncScheduleTableRel								120
TerminateTask								12
ValidateCounter								48
ValidateISR								20
ValidateResource								40
ValidateScheduleTable								40
ValidateTask								40
WaitEvent								84

8.4.2 Multi Core

The RTA-OS kernel is demand linked. This means that each API call is placed into a separately linkable module. The following table lists the section sizes for each API module (in bytes) for the simple multi-core configuration in standard status.

Library Module	Os_Cat1_vle	Os_cpuvec	Os_intvec	Os_text_vle	bss	rodata	sbss	text_vle
ActivateTask								312
AdvanceCounter								4
CallTrustedFunction								32
CancelAlarm								186
ChainTask								236
CheckISRMemoryAccess								62
CheckObjectAccess								210
CheckObjectOwnership								178
CheckTaskMemoryAccess								62

Library Module	Os_Cat1_vle	Os_cpuvec	Os_intvec	Os_text_vle	bss	rodata	sbss	text_vle
ClearEvent								90
ControlIdle							8	116
CrossCore								20
DisableAllInterrupts								64
DispatchTask								394
ElapsedTime								458
EnableAllInterrupts								74
GetActiveApplicationMode								6
GetAlarm								212
GetAlarmBase								44
GetApplicationID								46
GetCounterValue								96
GetElapsedCounterValue								124
GetEvent								90
GetExecutionTime								90
GetISRID								24
GetIsrMaxExecutionTime								90
GetIsrMaxStackUsage								90
GetNumberOfActivatedCores								36
GetResource								154
GetScheduleTableStatus								142
GetSpinlock								4
GetStackSize								4
GetStackUsage								90
GetStackValue								28
GetTaskID								28
GetTaskMaxExecutionTime								90
GetTaskMaxStackUsage								90
GetTaskState								60
GetVersionInfo								26
Idle								4
InShutdown								2
IncrementCounter								24
MultiCoreInit				112				
NextScheduleTable								204
Os_Cat1	138							
Os_Cfg					800	1824	29	386
Os_Cfg_Counters						1080		6044
Os_CoreLocks								64

Library Module	Os_Cat1_vle	Os_cpuvec	Os_intvec	Os_text_vle	bss	rodata	sbss	text_vle
Os_CrossCore								432
Os_ScheduleQ								66
Os_StartCores								148
Os_Vectors		570	38					
Os_Wrapper								388
Os_setjmp				160				
Os_vec_init						12		178
ProtectionSupport								114
ReleaseResource								180
ReleaseSpinlock								4
ResetIsrMaxExecutionTime								90
ResetIsrMaxStackUsage								90
ResetTaskMaxExecutionTime								90
ResetTaskMaxStackUsage								90
ResumeAllInterrupts								74
ResumeOSInterrupts								74
Schedule								172
SetAbsAlarm								200
SetEvent								90
SetRelAlarm								252
SetScheduleTableAsync								126
ShutdownAllCores								64
ShutdownOS								106
StackOverrunHook								6
StartCore								80
StartNonAutosarCore								80
StartOS								352
StartScheduleTableAbs								206
StartScheduleTableRel								192
StartScheduleTableSynchron								126
StopScheduleTable								170
SuspendAllInterrupts								64
SuspendOSInterrupts								134
SyncScheduleTable								126
SyncScheduleTableRel								126
TerminateTask								32
TryToGetSpinlock								8
ValidateCounter								40
ValidateISR								20

Library Module	Os_Cat1_vle	Os_cpuvec	Os_intvec	Os_text_vle	bss	rodata	sbss	text_vle
ValidateResource								48
ValidateScheduleTable								48
ValidateTask								48
WaitEvent								90

8.5 Execution Time

The following tables give the execution times in CPU cycles, i.e. in terms of ticks of the processor's program counter. These figures will normally be independent of the frequency at which you clock the CPU. To convert between CPU cycles and SI time units the following formula can be used:

Time in microseconds = Time in cycles / CPU Clock rate in MHz

For example, an operation that takes 50 CPU cycles would be:

- at 20MHz = 50/20 = 2.5μs
- at 80MHz = 50/80 = 0.625μs
- at 150MHz = 50/150 = 0.333μs

While every effort is made to measure execution times using a stopwatch running at the same rate as the CPU clock, this is not always possible on the target hardware. If the stopwatch runs slower than the CPU clock, then when RTA-OS reads the stopwatch, there is a possibility that the time read is less than the actual amount of time that has elapsed due to the difference in resolution between the CPU clock and the stopwatch (the *User Guide* provides further details on the issue of uncertainty in execution time measurement).

The figures presented in Section 8.5.1 have an uncertainty of 0 CPU cycle(s).

Values are given for single-core operation only. Timings for cross-core activations, though interesting, are variable because of the nature of multi-core operation. Minimum values cannot be given, because timings are dependent on the activity on the core that receives the activation.

8.5.1 Context Switching Time

Task switching time is the time between the last instruction of the previous task and the first instruction of the next task. The switching time differs depending on the switching contexts (e.g. an `ActivateTask()` versus a `ChainTask()`).

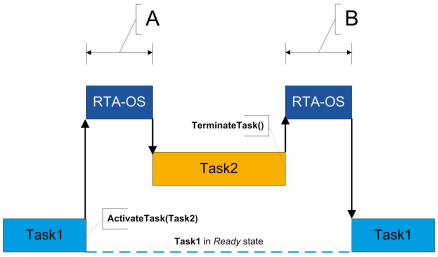
Interrupt latency is the time between an interrupt request being recognized by the target hardware and the execution of the first instruction of the user provided handler function:

For Category 1 ISRs this is the time required for the hardware to recognize the interrupt.

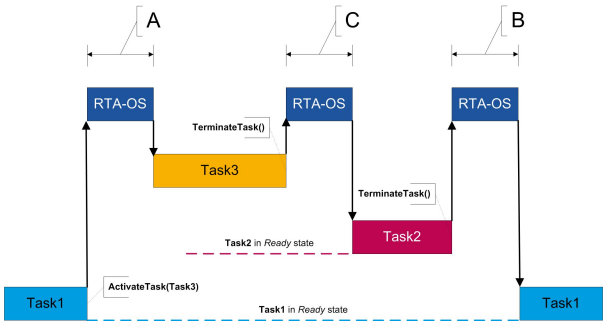
For Category 2 ISRs this is the time required for the hardware to recognize the interrupt plus the time required by RTA-OS to set-up the context in which the ISR runs.

Figure 8.1 shows the measured context switch times for RTA-OS.

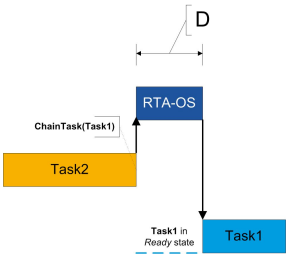
Switch	Key	CPU Cycles	Actual Time
Task activation	A	158	9.88us
Task termination with resume	B	98	6.12us
Task termination with switch to new task	C	119	7.44us
Chaining a task	D	218	13.6us
Waiting for an event resulting in transition to the WAITING state	E	490	30.6us
Setting an event results in task switch	F	650	40.6us
Non-preemptive task offers a preemption point (co-operative scheduling)	G	153	9.56us
Releasing a resource results in a task switch	H	149	9.31us
Entering a Category 2 ISR	I	77	4.81us
Exiting a Category 2 ISR and resuming the interrupted task	J	150	9.38us
Exiting a Category 2 ISR and switching to a new task	K	181	11.3us
Entering a Category 1 ISR	L	35	2.19us



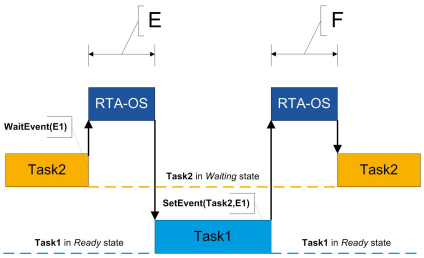
(a) Task activated. Termination resumes preempted task.



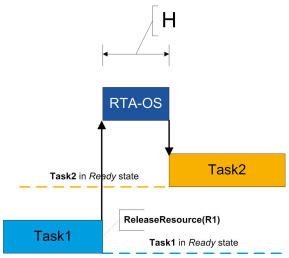
(b) Task activated. Termination switches into new task.



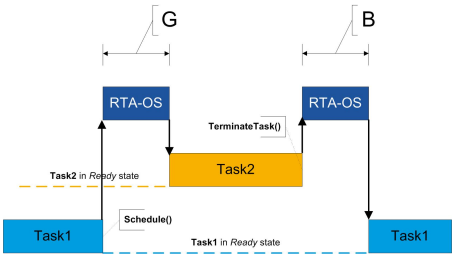
(c) Task chained.



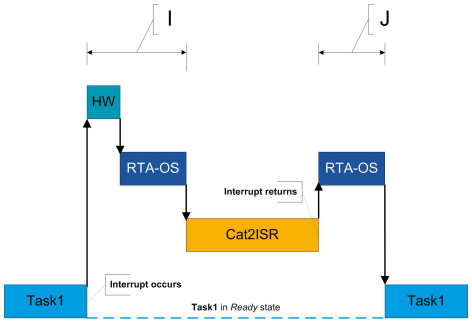
(d) Task waits. Task is resumed when event set.



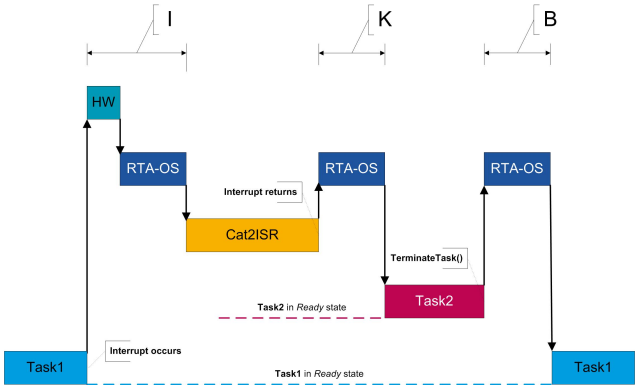
(e) Task switch when resource is released.



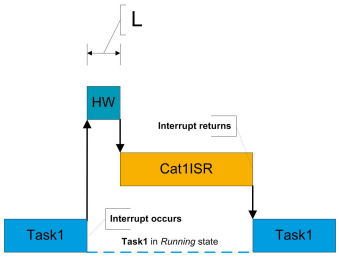
(f) Request for scheduling made by non-preemptive task.



(g) Category 2 interrupt entry. Interrupted task resumed on exit.



(h) Category 2 interrupt entry. Switch to new task on exit.



(i) Category 1 interrupt entry.

Figure 8.1: Context Switching

9 Finding Out More

Additional information about PPCe200/HighTec-specific parts of RTA-OS can be found in the following manuals:

***PPCe200/HighTec Release Note*.** This document provides information about the PPCe200/HighTec port plug-in release, including a list of changes from previous releases and a list of known limitations.

Information about the port-independent parts of RTA-OS can be found in the following manuals:

***Getting Started Guide*.** This document explains how to install RTA-OS tools and describes the underlying principles of the operating system

***Reference Guide*.** This guide provides a complete reference to the API, programming conventions and tool operation for RTA-OS.

***User Guide*.** This guide shows you how to use RTA-OS to build real-time applications.

10 Contacting ETAS

10.1 Technical Support

Technical support is available to all users with a valid support contract. If you do not have a valid support contract, please contact your regional sales office (see Section 10.2.2).

The best way to get technical support is by email. Any problems or questions about the use of the product should be sent to:

rta.hotline.uk@etas.com

If you prefer to discuss your problem with the technical support team, you call the support hotline on:

+44 (0)1904 562624.

The hotline is available during normal office hours (0900-1730 GMT/BST).

In either case, it is helpful if you can provide technical support with the following information:

- Your support contract number
- Your `.xml`, `.arxml`, `.rtaos` and/or `.stc` files
- The command line which caused the error
- The version of the ETAS tools you are using
- The version of the compiler tool chain you are using
- The error message you received (if any)
- The file `Diagnostic.dmp` if it was generated

10.2 General Enquiries

10.2.1 ETAS Global Headquarters

ETAS GmbH

Borsigstrasse 14	Phone:	+49 711 3423-0
70469 Stuttgart	Fax:	+49 711 3423-2106
Germany	WWW:	www.etas.com

10.2.2 ETAS Local Sales & Support Offices

Contact details for your local sales office and local technical support team (where available) can be found on the ETAS web site:

ETAS subsidiaries	www.etas.com/en/contact.php
ETAS technical support	www.etas.com/en/hotlines.php

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