
Peripheral Power Consumption in Standby Mode for SAM L10/L11 Family of Devices

Introduction

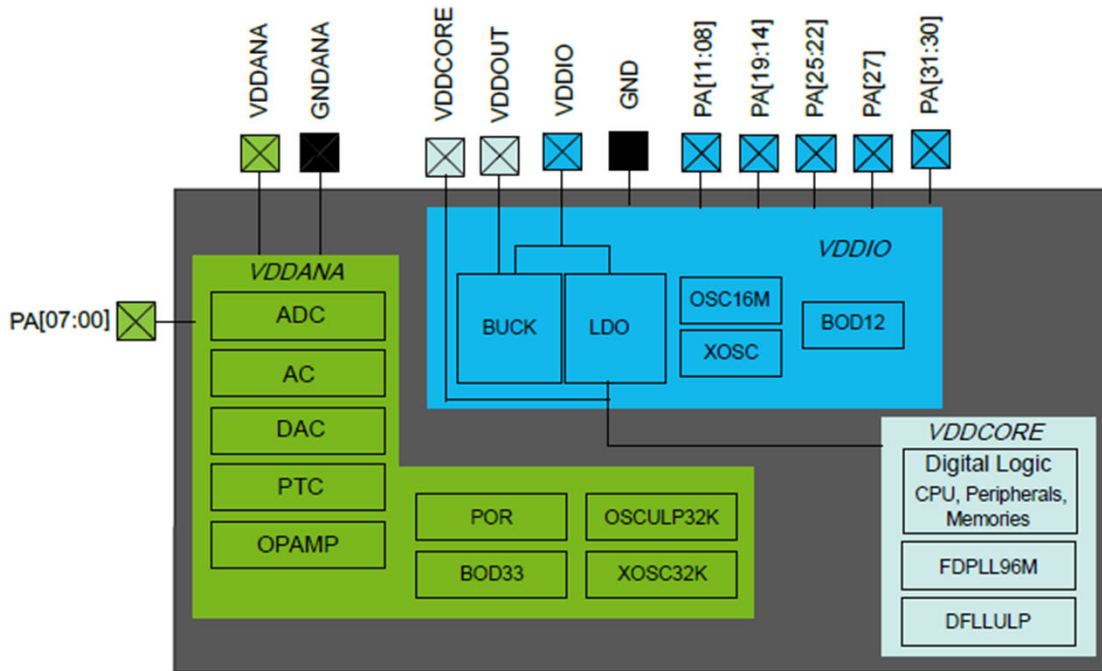
This document describes the usage of various peripherals in Standby Sleep mode for microcontrollers in the SAM L10/L11 family. The internal voltage regulator, which powers the VDDCORE on the SAM L10 device, can be operated in Low-Power mode when the device is in Standby Sleep mode. Since the current driving capacity of the regulator is lower in Low-Power mode than the normal operating mode, the peripherals must be configured hence the voltage regulator is not overloaded.

There are applications where the device must consume substantially low power while keeping a few peripherals running. In such cases, Standby Sleep mode can be used.

This document will help estimate the current consumed by peripherals from the VDDCORE power domain when the voltage regulator is operated in Low-Power mode. The measurements given in this document are taken on the SAM L10 devices. The current consumption from the internal voltage regulator by peripheral on the SAM L11 devices will be similar to the numbers provided in this document.

1. SAM L10 Power Domains and Low-Power Models

Figure 1-1. Power Domain Overview



The SAM L10 has three power supply pins: VDDIO, VDDOUT, and VDDANA. These pins must be connected and fed with a nominal voltage range: 3.3V, 1.62V to 3.63V. This common voltage is referred to as VDD. Even though the device is powered through a single supply, the device internally operates in two voltage domains. The core, memories, peripherals to core interfaces, DFLULP, and FDPLL96M are operated at a 0.9V to 1.2V range. I/Os are operated at the same voltage level as the VDD supply (nominal voltage range: 3.3V, 1.62V to 3.63V). An internal voltage regulator on the SAM L10 device gives a 1.2V supply to the core.

The SAM L10 device supports different sleep modes, such as Idle, Standby and Off to optimize for the Low-Power applications. For additional information, refer to the Power Considerations chapter in the "SAM L10 Data Sheet".

2. Sleep Modes

Three main types of sleep modes are available on the SAM L1X product family: Idle, Standby, and Off.

Table 2-1. Sleep Mode Entry and Exit

Mode	Mode Entry	Wake-up Sources	Harmony PLIB API (4)
Idle	SLEEP_CFG.SLEEPMODE = IDLE_n	Synchronous (2) (APB, AHB), Asynchronous (1)	PM_IdleModeEnter()
Standby	SLEEP_CFG.SLEEPMODE = STANDBY	Synchronous (3), Asynchronous	PM_StandbyModeEnter()
Off	SLEEP_CFG.SLEEPMODE = OFF	External Reset	PM_OffModeEnter()

Notes:

1. Asynchronous: Interrupt is generated on the generic clock, external clock, or external event.
2. Synchronous: Interrupt is generated on the APB clock.
3. Synchronous interrupt only for peripherals configured to run in standby.
4. Users can call these MPLAB Harmony PLIB APIs in the application to enter the device into the respective sleep modes.

2.1 Idle Mode

The CPU is stopped, and the peripherals are still running. The synchronous clocks are stopped, except when requested. This mode allows power optimization with a fast wake-up time.

2.2 Standby Mode

All clock sources are stopped, except those where the RUNSTDBY (Run in Standby) bit for the module is set or has the ONDEMAND bit set to zero. By default, the regulator operates in Low-Power mode when using Standby Sleep mode and switches automatically to the normal mode in case of a sleepwalking task requiring more power. This mode allows the device to consume the lowest power with little overhead on wake-up time.

Note: : The FDPLL96M does not support ONDEMAND in Standby Sleep mode as the FDPLL96M On-Demand mode (DPLLCTRLA.ONDEMAND = 1) is not functional in Standby mode. Refer to the section 2.19.4. in the [SAML10 Errata](#).

2.3 Off Mode

The device is entirely powered off. This mode allows you to achieve the lowest power consumption. Since the device must be reset to recover from this mode, the wake-up time is longer.

3. Voltage Regulator Automatic Low-Power Mode

The embedded voltage regulator is used to provide VDDCORE to the device.

The SAM L10/L11 voltage regulator has the following modes:

- Linear (LDO) mode: The default mode after reset.
- Switching (BUCK) mode: The most power-efficient mode when the CPU and peripherals are running (Active mode).
Note: In Active mode, the voltage regulator can be selected on the fly between LDO (low-dropout) type regulator and Buck converter using the Supply Controller (SUPC).
- Low-Power mode (LPVREG): The default mode, used when the device is in Standby Sleep mode.

The Power Manager (PM) selects the main or the low-power voltage regulator in Standby mode to supply the VDDCORE. The low-power voltage regulator is used if the switchable power domain is in a retention state.

The main voltage regulator is used if a sleepwalking task is working on either asynchronous clocks (generic clocks) or synchronous clocks (APB/AHB clocks). This behavior can be changed by writing the Voltage Regulator Standby Mode bits in the Standby Configuration register (STDBYCFG.VREGSMOD). Users can configure these features using the PM peripheral module configuration in the MPLAB Code Configurator GUI.

Table 3-1.

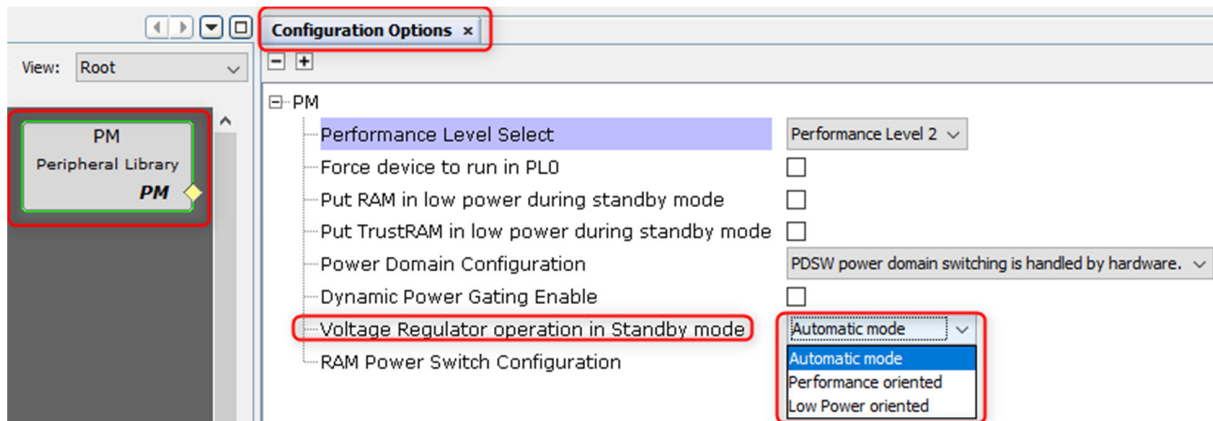
Sleep Modes	STDBYCFG.VREGSMOD	SleepWalking ⁽¹⁾	Regulator state for VDDCORE
Active	-	-	Main voltage regulator
Idle	-	-	Main voltage regulator
Standby (active)	0x0: AUTO	NO	Low-power regulator
		YES	Main voltage regulator
	0x1: PERFORMANCE		Main voltage regulator
	0x2: LP ⁽²⁾	- ⁽²⁾	Low-power regulator
Standby (retention)	-	-	Low-power regulator

Notes:

1. SleepWalking is running on a GCLK clock or synchronous clock. This is not related to XOSC32K or OSCULP32K clocks.
2. Must only be used when SleepWalking is running on the GCLK with a 32 kHz source.

Consumption details of various peripherals in Standby mode is described in the following section, along with measurement conditions.

Figure 3-1. SAM L10 Device Power Manager Peripheral Module Configuration in MPLAB Code Configurator GUI



4. Core Power Consumption Results

This section measures the power consumption for a few peripherals when the SAM L10 device is in Standby Sleep mode.

4.1 Clock Conditions Used for Measurements

The generic clock used by the peripherals are as follows:

- RTC: 1 kHz from ULP1K
- WDT: 1 kHz from ULP1K
- ADC: 1 MHz from OSC16M
- AC: 1 MHz from OSC16M
- TC: 1 kHz from XOSC32K
- EIC: 32 kHz from XOSC32K

4.2 Measurements at 25°C

Table 4-1. Measurements at 25°C

Peripheral	Current Consumption [nA]
None ⁽⁴⁾	671 ⁽¹⁾
RTC	685.9
TC	2025
ADC	696.7
WDT	1730
AC	694.9
EIC ⁽²⁾	696.3
EIC ⁽³⁾	2115

Notes:

1. Typical current consumption may be less than this value.
2. The Edge Detection clock is Asynchronously operated.
3. The Edge Detection clock is Synchronously operated.
4. 'None' in the peripheral column indicates the consumption from the internal voltage regulator when none of the peripherals are operated.

5. Usage Example for Standby Mode

An example of peripheral usage in Standby mode is described in this section. The application uses RTC and ADC. The ADC is used for periodically measuring the voltage on an input pin. The calculations below will help decide whether the internal voltage regulator needs to be operated in Normal mode or Low-Power mode.

When measured at 25°C, the current consumption from the internal voltage regulator by the RTC and ADC in Standby mode is:

- $RTC \geq 685.9 \text{ nA}$
- $ADC \geq 696.7 \text{ nA}$

The total current consumption by the two peripherals can be calculated as follows:

Total current consumption from the internal voltage regulator = Power consumption when no peripheral is operated + The sum of power consumption by each peripheral – (Power consumption when no peripheral is operated * Total number of peripherals running in Standby mode).

Note: The individual peripheral power consumption values mentioned in the Table 4-1 are included with the 'None' power consumption value.

Therefore, the value is $671 + (685.9 + 696.7) - (671 * 2) = 711.6 \text{ nA}$.

In this case, the RUNSTDBY bit for these two peripherals can be set to let them run in Standby Sleep mode and the internal voltage regulator can be configured to operate in Low-Power mode.

6. Conclusion

- Multiple peripherals can run in Standby mode. Power budgeting can be done based on typical values given in this document.
- When the GCLK frequency for a peripheral is higher than the clock conditions mentioned in [Clock Conditions Used for Measurements](#), the peripheral may consume more current from the internal voltage regulator than what is given in this document. In such cases, it is recommended to operate the core voltage regulator in Normal mode while the device is in Standby Sleep mode.

7. FAQs

- **Is it possible to perform such measurement on a SAM L10 Xplained Pro?**

This can be done on a SAM L10 Xplained Pro since the values are measured on the SAM L10 Xplained Pro. To measure the SAM L10 MCU power consumption, the user can use the "XAM Configuration" setup mentioned in the *SAM L10/L11 Xplained Pro User Guide*.

Refer to the "SAML10/L11 Xplained Pro Kit User's Guide" available for [download](http://www.microchip.com/en-us/development-tool/dm320204#Documentation) at www.microchip.com/en-us/development-tool/dm320204#Documentation.

- **Are the measurements given in this document applicable to other SAM L1X devices?**

The measurements given in this Technical Brief are measured with SAM L10 devices. The consumption numbers on SAM L11 will be similar to or lower than the numbers provided in this document.

- **If the GCLK frequency for a peripheral is reduced by half, what will be the effect on current consumption from the internal voltage regulator?**

The resulting current consumption will be approximately the same as the original value or a little less.

8. References

The following documents are used as reference. For additional information, visit the Microchip [Website](#), or contact a local Microchip sales representative.

- [SAML10 Data Sheet](#)
- [Low-Power Features of SAM L Series Devices](#)
- [Create a new MPLAB Harmony v3 project using MCC](#)
- [Update and Configure an Existing MHC-based MPLAB Harmony v3 Project to MCC-based Project](#)
- [Getting Started with MPLAB Harmony v3 Using MPLAB Code Configurator](#)
- [MPLAB® Code Configurator Content Manager for MPLAB Harmony v3 Projects](#)

Microchip Information

The Microchip Website

Microchip provides online support via our website at www.microchip.com/. This website is used to make files and information easily available to customers. Some of the content available includes:

- **Product Support** – Data sheets and errata, application notes and sample programs, design resources, user's guides and hardware support documents, latest software releases and archived software
- **General Technical Support** – Frequently Asked Questions (FAQs), technical support requests, online discussion groups, Microchip design partner program member listing
- **Business of Microchip** – Product selector and ordering guides, latest Microchip press releases, listing of seminars and events, listings of Microchip sales offices, distributors and factory representatives

Product Change Notification Service

Microchip's product change notification service helps keep customers current on Microchip products. Subscribers will receive email notification whenever there are changes, updates, revisions or errata related to a specified product family or development tool of interest.

To register, go to www.microchip.com/pcn and follow the registration instructions.

Customer Support

Users of Microchip products can receive assistance through several channels:

- Distributor or Representative
- Local Sales Office
- Embedded Solutions Engineer (ESE)
- Technical Support

Customers should contact their distributor, representative or ESE for support. Local sales offices are also available to help customers. A listing of sales offices and locations is included in this document.

Technical support is available through the website at: www.microchip.com/support

Microchip Devices Code Protection Feature

Note the following details of the code protection feature on Microchip products:

- Microchip products meet the specifications contained in their particular Microchip Data Sheet.
- Microchip believes that its family of products is secure when used in the intended manner, within operating specifications, and under normal conditions.
- Microchip values and aggressively protects its intellectual property rights. Attempts to breach the code protection features of Microchip product is strictly prohibited and may violate the Digital Millennium Copyright Act.
- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of its code. Code protection does not mean that we are guaranteeing the product is "unbreakable". Code protection is constantly evolving. Microchip is committed to continuously improving the code protection features of our products.

Legal Notice

This publication and the information herein may be used only with Microchip products, including to design, test, and integrate Microchip products with your application. Use of this information in any other manner violates these terms. Information regarding device applications is provided only for your convenience and may be superseded

by updates. It is your responsibility to ensure that your application meets with your specifications. Contact your local Microchip sales office for additional support or, obtain additional support at www.microchip.com/en-us/support/design-help/client-support-services.

THIS INFORMATION IS PROVIDED BY MICROCHIP "AS IS". MICROCHIP MAKES NO REPRESENTATIONS OR WARRANTIES OF ANY KIND WHETHER EXPRESS OR IMPLIED, WRITTEN OR ORAL, STATUTORY OR OTHERWISE, RELATED TO THE INFORMATION INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTIES OF NON-INFRINGEMENT, MERCHANTABILITY, AND FITNESS FOR A PARTICULAR PURPOSE, OR WARRANTIES RELATED TO ITS CONDITION, QUALITY, OR PERFORMANCE.

IN NO EVENT WILL MICROCHIP BE LIABLE FOR ANY INDIRECT, SPECIAL, PUNITIVE, INCIDENTAL, OR CONSEQUENTIAL LOSS, DAMAGE, COST, OR EXPENSE OF ANY KIND WHATSOEVER RELATED TO THE INFORMATION OR ITS USE, HOWEVER CAUSED, EVEN IF MICROCHIP HAS BEEN ADVISED OF THE POSSIBILITY OR THE DAMAGES ARE FORESEEABLE. TO THE FULLEST EXTENT ALLOWED BY LAW, MICROCHIP'S TOTAL LIABILITY ON ALL CLAIMS IN ANY WAY RELATED TO THE INFORMATION OR ITS USE WILL NOT EXCEED THE AMOUNT OF FEES, IF ANY, THAT YOU HAVE PAID DIRECTLY TO MICROCHIP FOR THE INFORMATION.

Use of Microchip devices in life support and/or safety applications is entirely at the buyer's risk, and the buyer agrees to defend, indemnify and hold harmless Microchip from any and all damages, claims, suits, or expenses resulting from such use. No licenses are conveyed, implicitly or otherwise, under any Microchip intellectual property rights unless otherwise stated.

Trademarks

The Microchip name and logo, the Microchip logo, Adaptec, AVR, AVR logo, AVR Freaks, BesTime, BitCloud, CryptoMemory, CryptoRF, dsPIC, flexPWR, HELDO, IGLOO, JukeBlox, KeeLoq, Kleer, LANCheck, LinkMD, maXStylus, maXTouch, MediaLB, megaAVR, Microsemi, Microsemi logo, MOST, MOST logo, MPLAB, OptoLyzer, PIC, picoPower, PICSTART, PIC32 logo, PolarFire, Prochip Designer, QTouch, SAM-BA, SenGenuity, SpyNIC, SST, SST Logo, SuperFlash, Symmetricom, SyncServer, Tachyon, TimeSource, tinyAVR, UNI/O, Vectron, and XMEGA are registered trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

AgileSwitch, APT, ClockWorks, The Embedded Control Solutions Company, EtherSynch, Flashtec, Hyper Speed Control, HyperLight Load, Libero, motorBench, mTouch, Powermite 3, Precision Edge, ProASIC, ProASIC Plus, ProASIC Plus logo, Quiet- Wire, SmartFusion, SyncWorld, Temux, TimeCesium, TimeHub, TimePicta, TimeProvider, TrueTime, and ZL are registered trademarks of Microchip Technology Incorporated in the U.S.A.

Adjacent Key Suppression, AKS, Analog-for-the-Digital Age, Any Capacitor, AnyIn, AnyOut, Augmented Switching, BlueSky, BodyCom, Clockstudio, CodeGuard, CryptoAuthentication, CryptoAutomotive, CryptoCompanion, CryptoController, dsPICDEM, dsPICDEM.net, Dynamic Average Matching, DAM, ECAN, Espresso T1S, EtherGREEN, GridTime, IdealBridge, In-Circuit Serial Programming, ICSP, INICnet, Intelligent Paralleling, IntelliMOS, Inter-Chip Connectivity, JitterBlocker, Knob-on-Display, KoD, maxCrypto, maxView, memBrain, Mindi, MiWi, MPASM, MPF, MPLAB Certified logo, MPLIB, MPLINK, MultiTRAK, NetDetach, Omniscient Code Generation, PICDEM, PICDEM.net, PICkit, PICtail, PowerSmart, PureSilicon, QMatrix, REAL ICE, Ripple Blocker, RTAX, RTG4, SAM-ICE, Serial Quad I/O, simpleMAP, SimpliPHY, SmartBuffer, SmartHLS, SMART-I.S., storClad, SQL, SuperSwitcher, SuperSwitcher II, Switchtec, SynchroPHY, Total Endurance, Trusted Time, TSHARC, USBCheck, VariSense, VectorBlox, VeriPHY, ViewSpan, WiperLock, XpressConnect, and ZENA are trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

SQTP is a service mark of Microchip Technology Incorporated in the U.S.A.

The Adaptec logo, Frequency on Demand, Silicon Storage Technology, and Symmcom are registered trademarks of Microchip Technology Inc. in other countries.

GestIC is a registered trademark of Microchip Technology Germany II GmbH & Co. KG, a subsidiary of Microchip Technology Inc., in other countries.

All other trademarks mentioned herein are property of their respective companies.

© 2022, Microchip Technology Incorporated and its subsidiaries. All Rights Reserved.

ISBN: 978-1-6683-0767-0

Quality Management System

For information regarding Microchip's Quality Management Systems, please visit www.microchip.com/quality.

Worldwide Sales and Service

AMERICAS	ASIA/PACIFIC	ASIA/PACIFIC	EUROPE
Corporate Office 2355 West Chandler Blvd. Chandler, AZ 85224-6199 Tel: 480-792-7200 Fax: 480-792-7277 Technical Support: www.microchip.com/support Web Address: www.microchip.com	Australia - Sydney Tel: 61-2-9868-6733 China - Beijing Tel: 86-10-8569-7000 China - Chengdu Tel: 86-28-8665-5511 China - Chongqing Tel: 86-23-8980-9588 China - Dongguan Tel: 86-769-8702-9880 China - Guangzhou Tel: 86-20-8755-8029 China - Hangzhou Tel: 86-571-8792-8115 China - Hong Kong SAR Tel: 852-2943-5100 China - Nanjing Tel: 86-25-8473-2460 China - Qingdao Tel: 86-532-8502-7355 China - Shanghai Tel: 86-21-3326-8000 China - Shenyang Tel: 86-24-2334-2829 China - Shenzhen Tel: 86-755-8864-2200 China - Suzhou Tel: 86-186-6233-1526 China - Wuhan Tel: 86-27-5980-5300 China - Xian Tel: 86-29-8833-7252 China - Xiamen Tel: 86-592-2388138 China - Zhuhai Tel: 86-756-3210040	India - Bangalore Tel: 91-80-3090-4444 India - New Delhi Tel: 91-11-4160-8631 India - Pune Tel: 91-20-4121-0141 Japan - Osaka Tel: 81-6-6152-7160 Japan - Tokyo Tel: 81-3-6880-3770 Korea - Daegu Tel: 82-53-744-4301 Korea - Seoul Tel: 82-2-554-7200 Malaysia - Kuala Lumpur Tel: 60-3-7651-7906 Malaysia - Penang Tel: 60-4-227-8870 Philippines - Manila Tel: 63-2-634-9065 Singapore Tel: 65-6334-8870 Taiwan - Hsin Chu Tel: 886-3-577-8366 Taiwan - Kaohsiung Tel: 886-7-213-7830 Taiwan - Taipei Tel: 886-2-2508-8600 Thailand - Bangkok Tel: 66-2-694-1351 Vietnam - Ho Chi Minh Tel: 84-28-5448-2100	Austria - Wels Tel: 43-7242-2244-39 Fax: 43-7242-2244-393 Denmark - Copenhagen Tel: 45-4485-5910 Fax: 45-4485-2829 Finland - Espoo Tel: 358-9-4520-820 France - Paris Tel: 33-1-69-53-63-20 Fax: 33-1-69-30-90-79 Germany - Garching Tel: 49-8931-9700 Germany - Haan Tel: 49-2129-3766400 Germany - Heilbronn Tel: 49-7131-72400 Germany - Karlsruhe Tel: 49-721-625370 Germany - Munich Tel: 49-89-627-144-0 Fax: 49-89-627-144-44 Germany - Rosenheim Tel: 49-8031-354-560 Israel - Ra'anana Tel: 972-9-744-7705 Italy - Milan Tel: 39-0331-742611 Fax: 39-0331-466781 Italy - Padova Tel: 39-049-7625286 Netherlands - Drunen Tel: 31-416-690399 Fax: 31-416-690340 Norway - Trondheim Tel: 47-72884388 Poland - Warsaw Tel: 48-22-3325737 Romania - Bucharest Tel: 40-21-407-87-50 Spain - Madrid Tel: 34-91-708-08-90 Fax: 34-91-708-08-91 Sweden - Gothenberg Tel: 46-31-704-60-40 Sweden - Stockholm Tel: 46-8-5090-4654 UK - Wokingham Tel: 44-118-921-5800 Fax: 44-118-921-5820