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DEVELOPMENT TOOLS

OS Awareness Manual Zephyr

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MANUAL

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OS Awareness Manual Zephyr

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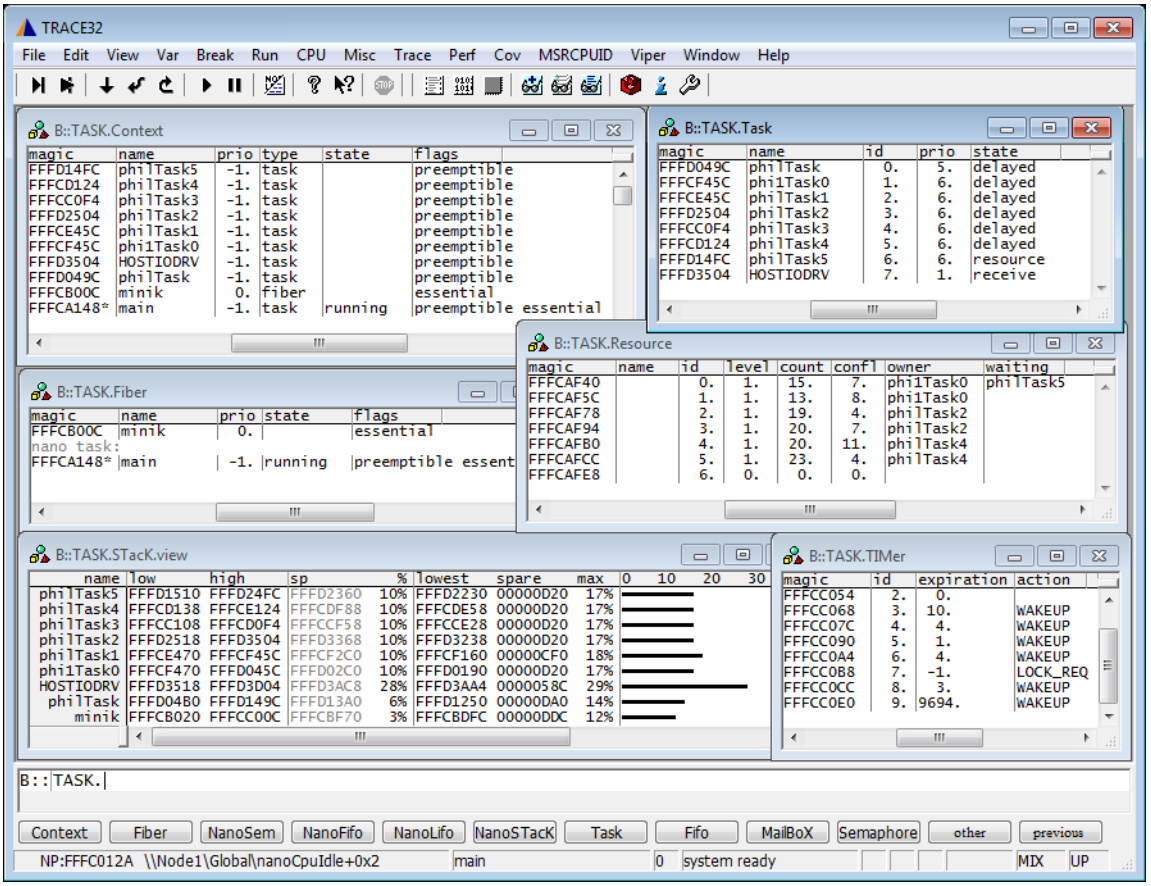
History

28-Aug-18 The title of the manual was changed from “RTOS Debugger for *<x>*” to “OS Awareness Manual *<x>*”.

Overview



The OS Awareness for Zephyr contains special extensions to the TRACE32 Debugger. This manual describes the additional features, such as additional commands and statistic evaluations.

Terminology

Zephyr v1.0 uses the terms “fibers” and “tasks”. If not otherwise specified, the TRACE32 term “task” corresponds to Zephyr fibers *and* tasks.

Zephyr v1.7 onwards uses the term “threads”. If not otherwise specified, the TRACE32 term “task” corresponds to Zephyr threads.

Brief Overview of Documents for New Users

Architecture-independent information:

- **“Training - Debugger Basics”** (training_debugger.pdf): Get familiar with the basic features of a TRACE32 debugger.
- **“T32Start”** (app_t32start.pdf): T32Start assists you in starting TRACE32 PowerView instances for different configurations of the debugger. T32Start is only available for Windows.
- **“General Commands”** (general_ref_<*x*>.pdf): Alphabetic list of debug commands.

Architecture-specific information:

- **“Processor Architecture Manuals”**: These manuals describe commands that are specific for the processor architecture supported by your Debug Cable. To access the manual for your processor architecture, proceed as follows:

  - Choose **Help** menu > **Processor Architecture Manual**.

- **“OS Awareness Manuals”** (rtos_<*os*>.pdf): TRACE32 PowerView can be extended for operating system-aware debugging. The appropriate OS Awareness manual informs you how to enable the OS-aware debugging.

- **Linux Debugging Reference Card** (https://www.lauterbach.com/referencecards.html)

Supported Versions

Currently Zephyr is supported for the following versions:

- Zephyr 1.0 on ARM and x86.
- Zephyr 1.7 on ARM and x86. Special configuration options must be set to the kernel - see **Hooks & Internals**.
- Zephyr 1.14 on ARM and x86
- Zephyr 2.1 to 2.5 on ARM, RISC-V and x86
- Zephyr 2.6 to 2.7 on ARM, RISC-V and x86. Object tables other than threads are **not** supported, because the OS lacks the information for this.
- Zephyr 2.8 onwards on ARM, RISC-V and x86. Special configuration options must be set to the kernel - see **Hooks & Internals**.

Configuration

The **TASK.CONFIG** command loads an extension definition file called “zephyr.t32” (directory “~~/demo/<*arch*>/kernel/zephyr”). It contains all necessary extensions.

Automatic configuration tries to locate the Zephyr internals automatically. For this purpose all symbol tables must be loaded and accessible at any time the OS Awareness is used. Some Zephyr versions need special settings to allow automatic detection of object lists. Please see “**Hooks & Internals**”.

If you want to display the OS objects “On The Fly” while the target is running, you need to have access to memory while the target is running. In case of ICD, you have to enable **SYStem.MemAccess** or **SYStem.CpuAccess** (CPU dependent).

For system resource display, you can do an automatic configuration of the OS Awareness. For this purpose it is necessary that all system internal symbols are loaded and accessible at any time, the OS Awareness is used. Each of the **TASK.CONFIG** arguments can be substituted by '0', which means that this argument will be searched and configured automatically. For a fully automatic configuration omit all arguments:

Format:	**TASK.CONFIG zephyr**

See also “**Hooks & Internals**” for details on the used symbols and how to load object names.

Quick Configuration Guide

To get a quick access to the features of the OS Awareness for Zephyr with your application, follow the following roadmap:

1. Copy the files `zephyr.t32` and `zephyr.men` to your project directory
   (from TRACE32 directory "~~/demo/*/kernel/zephyr", where * stands for the architecture)
2. Start the TRACE32 Debugger.
3. Load your application as normal.
4. Execute the command `TASK.CONFIG zephyr`
   (See "**Configuration**").
5. Execute the command `MENU.ReProgram zephyr`
   (See "**Zephyr Specific Menu**").
6. Start your application.

Now you can access the Zephyr extensions through the menu.

In case of any problems, please carefully read the previous Configuration chapter.

Hooks & Internals in Zephyr

No hooks are used in the kernel.

For retrieving the kernel data structures, the OS Awareness uses the global kernel symbols and structure definitions. Ensure that access to those structures is possible every time when features of the OS Awareness are used. The Zephyr kernel must be compiled with debug information.

Zephyr v1.7:
To be able to support all features mentioned herein, the kernel must be configured with the following options:

```
CONFIG_THREAD_MONITOR=y
CONFIG_THREAD_STACK_INFO=y
CONFIG_OBJECT_TRACING=y
```

Zephyr v2.8:
To be able to support all features mentioned herein, the kernel must be configured with the following options:

```
CONFIG_THREAD_MONITOR=y
CONFIG_THREAD_STACK_INFO=y
CONFIG_INIT_STACKS=y
CONFIG_OBJECT_TRACING=y
CONFIG_TRACING_OBJECT_TRACKING
```

Features

The OS Awareness for Zephyr supports the following features.

Display of Kernel Resources

The extension defines new commands to display various kernel resources.

NOTE:	The display command listed here apply only for Zephyr 1.0. Zephyr 1.7 uses different objects and commands which are not yet documented.

In Zephyr 1.0, information on the following components can be displayed:

TASK.Context	Contexts
TASK.Event	Microkernel Events
TASK.Fiber	Nanokernel Fibers
TASK.FIFO	Microkernel Fifos
TASK.MailBoX	Microkernel Mailboxes
TASK.Map	Microkernel Memory Maps
TASK.NanoFifo	Nanokernel Fifos
TASK.NanoLifo	Nanokernel Lifos
TASK.NanoSem	Nanokernel Semaphores
TASK.NanoSTacK	Nanokernel Stacks
TASK.PIPE	Microkernel Pipes
TASK.Pool	Microkernel Memory Pools
TASK.Semaphore	Microkernel Semaphores
TASK.Task	Microkernel Tasks
TASK.TIMer	Microkernel Timers

For a description of the commands, refer to chapter "**Zephyr Commands v1.0**".

In Zephyr 1.7 onwards, information on the following components can be displayed:

TASK.ALERT	Alerts
TASK.MailBOX	Mailboxes
TASK.MEMSLAB	Memory Slabs
TASK.MSGQ	Message Queues
TASK.MUTEX	Mutexes

TASK.SEMaphore	Semaphores
TASK.THREAD	Threads
TASK.TIMER	Timers
TASK.PIPE	Pipes
TASK.QUEUE	Queues
TASK.ZSTACK	Zephyr Stacks

For a description of the commands, refer to chapter "**Zephyr Commands v1.7**".

If your hardware allows memory access while the target is running, these resources can be displayed "On The Fly", i.e. while the application is running, without any intrusion to the application.

Without this capability, the information will only be displayed if the target application is stopped.

Task Stack Coverage

For stack usage coverage of tasks, you can use the **TASK.STacK** command. Without any parameter, this command will open a window displaying with all active tasks. If you specify only a task magic number as parameter, the stack area of this task will be automatically calculated.

To use the calculation of the maximum stack usage, a stack pattern must be defined with the command **TASK.STacK.PATtern** (default value is zero).

To add/remove one task to/from the task stack coverage, you can either call the **TASK.STacK.ADD** or **TASK.STacK.ReMove** commands with the task magic number as the parameter, or omit the parameter and select the task from the **TASK.STacK.*** window.

It is recommended to display only the tasks you are interested in because the evaluation of the used stack space is very time consuming and slows down the debugger display.

Task-Related Breakpoints

Any breakpoint set in the debugger can be restricted to fire only if a specific task hits that breakpoint. This is especially useful when debugging code which is shared between several tasks. To set a task-related breakpoint, use the command:

Break.Set *<address>*|*<range>* [**/***<option>*] **/TASK** *<task>*	Set task-related breakpoint.

- Use a magic number, task ID, or task name for *<task>*. For information about the parameters, see **"What to know about the Task Parameters"** (general_ref_t.pdf).
- For a general description of the **Break.Set** command, please see its documentation.

By default, the task-related breakpoint will be implemented by a conditional breakpoint inside the debugger. This means that the target will *always* halt at that breakpoint, but the debugger immediately resumes execution if the current running task is not equal to the specified task.

NOTE:	Task-related breakpoints impact the real-time behavior of the application.

On some architectures, however, it is possible to set a task-related breakpoint with *on-chip* debug logic that is less intrusive. To do this, include the option **/Onchip** in the **Break.Set** command. The debugger then uses the on-chip resources to reduce the number of breaks to the minimum by pre-filtering the tasks.

For example, on ARM architectures: *If* the RTOS serves the Context ID register at task switches, and *if* the debug logic provides the Context ID comparison, you may use Context ID register for less intrusive task-related breakpoints:

Break.CONFIG.UseContextID ON	Enables the comparison to the whole Context ID register.
Break.CONFIG.MatchASID ON	Enables the comparison to the ASID part only.
TASK.List.tasks	If **TASK.List.tasks** provides a trace ID (**traceid** column), the debugger will use this ID for comparison. Without the trace ID, it uses the magic number (**magic** column) for comparison.

When single stepping, the debugger halts at the next instruction, regardless of which task hits this breakpoint. When debugging shared code, stepping over an OS function may cause a task switch and coming back to the same place - but with a different task. If you want to restrict debugging to the current task, you can set up the debugger with **SETUP.StepWithinTask ON** to use task-related breakpoints for single stepping. In this case, single stepping will always stay within the current task. Other tasks using the same code will not be halted on these breakpoints.

If you want to halt program execution as soon as a specific task is scheduled to run by the OS, you can use the **Break.SetTask** command.

Dynamic Task Performance Measurement

The debugger can execute a dynamic performance measurement by evaluating the current running task in changing time intervals. Start the measurement with the commands **PERF.Mode TASK** and **PERF.Arm**, and view the contents with **PERF.ListTASK**. The evaluation is done by reading the 'magic' location (= current running task) in memory. This memory read may be non-intrusive or intrusive, depending on the **PERF.METHOD** used.

If **PERF** collects the PC for function profiling of processes in MMU-based operating systems (**SYStem.Option.MMUSPACES ON**), then you need to set **PERF.MMUSPACES**, too.

For a general description of the **PERF** command group, refer to **"General Commands Reference Guide P"** (general_ref_p.pdf).

Task Runtime Statistics

NOTE:	This feature is *only* available, if your debug environment is able to trace task switches (program flow trace is not sufficient). It requires either an on-chip trace logic that is able to generate task information (eg. data trace), or a software instrumentation feeding one of TRACE32 software based traces (e.g. **FDX** or **Logger**). For details, refer to **"OS-aware Tracing"** (glossary.pdf).

Based on the recordings made by the **Trace** (if available), the debugger is able to evaluate the time spent in a task and display it statistically and graphically.

To evaluate the contents of the trace buffer, use these commands:

Trace.List List.TASK DEFault	Display trace buffer and task switches
Trace.STATistic.TASK	Display task runtime statistic evaluation
Trace.Chart.TASK	Display task runtime timechart
Trace.PROfileSTATistic.TASK	Display task runtime within fixed time intervals statistically
Trace.PROfileChart.TASK	Display task runtime within fixed time intervals as colored graph
Trace.FindAll Address TASK.CONFIG(magic)	Display all data access records to the "magic" location
Trace.FindAll CYcle owner OR CYcle context	Display all context ID records

The start of the recording time, when the calculation doesn't know which task is running, is calculated as "(unknown)".

NOTE:	This feature is *only* available, if your debug environment is able to trace task switches (program flow trace is not sufficient). It requires either an on-chip trace logic that is able to generate task information (eg. data trace), or a software instrumentation feeding one of TRACE32 software based traces (e.g. **FDX** or **Logger**). For details, refer to **"OS-aware Tracing"** (glossary.pdf).

All function-related statistic and time chart evaluations can be used with task-specific information. The function timings will be calculated dependent on the task that called this function. To do this, in addition to the function entries and exits, the task switches must be recorded.

To do a selective recording on task-related function runtimes based on the data accesses, use the following command:

```
; Enable flow trace and accesses to the magic location
Break.Set TASK.CONFIG(magic) /TraceData
```

To do a selective recording on task-related function runtimes, based on the Arm Context ID, use the following command:

```
; Enable flow trace with Arm Context ID (e.g. 32bit)
ETM.ContextID 32
```

To evaluate the contents of the trace buffer, use these commands:

Trace.ListNesting	Display function nesting
Trace.STATistic.Func	Display function runtime statistic
Trace.STATistic.TREE	Display functions as call tree
Trace.STATistic.sYmbol /SplitTASK	Display flat runtime analysis
Trace.Chart.Func	Display function timechart
Trace.Chart.sYmbol /SplitTASK	Display flat runtime timechart

The start of the recording time, when the calculation doesn't know which task is running, is calculated as "(unknown)".

Zephyr specific Menu

The menu file “zephyr.men” contains a menu with Zephyr specific menu items. Load this menu with the **MENU.ReProgram** command.

You will find a new menu called **Zephyr**.

- The **Display** menu items launch the kernel resource display windows.
- The **Stack Coverage** submenu starts and resets the Zephyr specific stack coverage and provides an easy way to add or remove tasks from the stack coverage window.

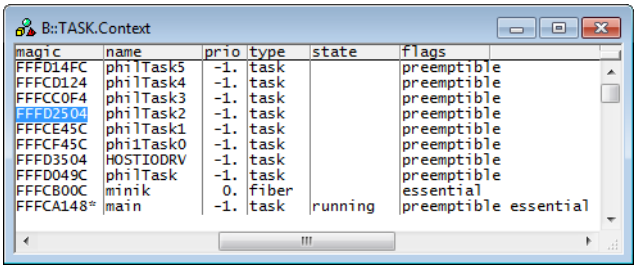
In addition, the menu file (*.men) modifies these menus on the TRACE32 main menu bar:

- The **Trace** menu is extended. In the **List** submenu, you can choose if you want a trace list window to show only task switches (if any) or task switches together with the default display.
- The **Perf** menu contains additional submenus for task runtime statistics.

TASK.Context — Display contexts

Format: **TASK.Context**

Displays the context table of Zephyr.



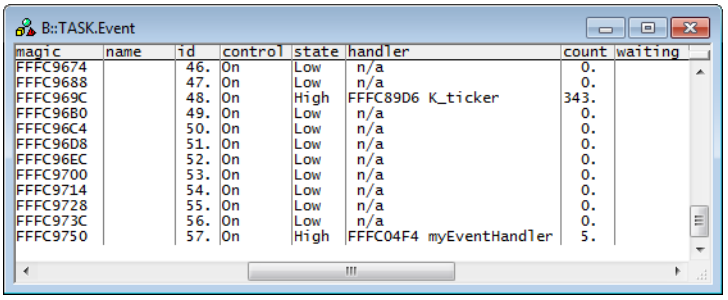
“magic” is a unique ID, used by the OS Awareness to identify a specific context (address of the context control structure).

The field “magic” is mouse sensitive, double clicking on it opens an appropriate window. Right clicking on it will show a local menu.

TASK.Event — Display microkernel events

Format: **TASK.Event**

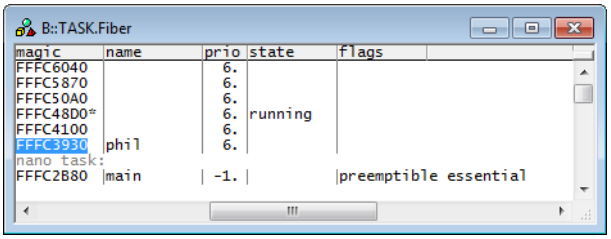
Displays the event table of Zephyr Microkernel.



“magic” is a unique ID, used by the OS Awareness to identify a specific event (address of the event control structure). The field “magic” is mouse sensitive, double clicking on it opens an appropriate window. Right clicking on it will show a local menu.

Format: **TASK.Fiber**

Displays the fiber table of Zephyr.



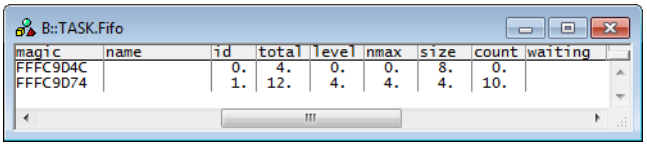
“magic” is a unique ID, used by the OS Awareness to identify a specific fiber (address of the fiber control structure).

The field “magic” is mouse sensitive, double clicking on it opens an appropriate window. Right clicking on it will show a local menu.

TASK.FIFO Display microkernel FIFOs

Format: **TASK.FIFO**

Displays the FIFO table of Zephyr Microkernel.

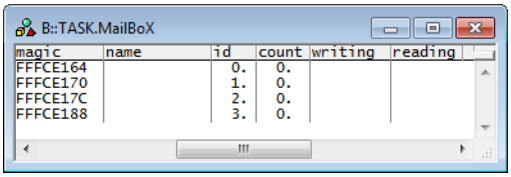


“magic” is a unique ID, used by the OS Awareness to identify a specific FIFO (address of the FIFO control structure).

The field “magic” is mouse sensitive, double clicking on it opens an appropriate window. Right clicking on it will show a local menu.

Format: **TASK.MailBoX**

Displays the mailbox table of Zephyr Microkernel.



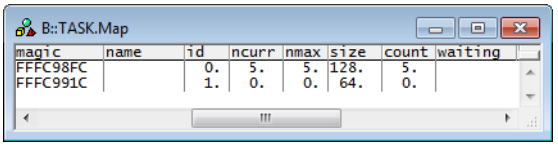
"magic" is a unique ID, used by the OS Awareness to identify a specific mailbox (address of the mailbox control structure).

The field "magic" is mouse sensitive, double clicking on it opens an appropriate window. Right clicking on it will show a local menu.

TASK.Map Display microkernel maps

Format: **TASK.Map**

Displays the memory map table of Zephyr Microkernel.



"magic" is a unique ID, used by the OS Awareness to identify a specific memory map (address of the map control structure).

The field "magic" is mouse sensitive, double clicking on it opens an appropriate window. Right clicking on it will show a local menu.

Format: **TASK.MuTeX**

Displays the mutex table of Zephyr Microkernel.

“magic” is a unique ID, used by the OS Awareness to identify a specific mutex (address of the mutex control structure).

The field “magic” is mouse sensitive, double clicking on it opens an appropriate window. Right clicking on it will show a local menu.

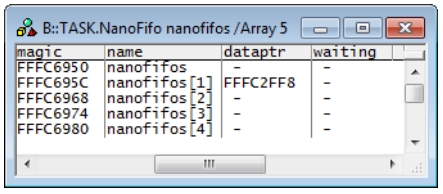
TASK.NanoFifo Display nanokernel FIFOs

Format: **TASK.NanoFifo** *<symbol>* [**/Struct** | **/Ptr** | **/Array** *<size>*]

Displays FIFOs of Zephyr Nanokernel. Specify the symbol name of a FIFO to display its contents.

Optional Parameters:

Struct	*<symbol>* refers to a variable holding a NANO_FIFO structure (default)
Ptr	*<symbol>* is a pointer to a NANO_FIFO structure
Array *<size>*	*<symbol>* is an array with *<size>* NANO_FIFO entries



“magic” is a unique ID, used by the OS Awareness to identify a specific FIFO (address of the FIFO control structure).

The field “magic” is mouse sensitive, double clicking on it opens an appropriate window. Right clicking on it will show a local menu.

Format: **TASK.NanoLifo** *<symbol>* [**/Struct** | **/Ptr** | **/Array** *<size>*]

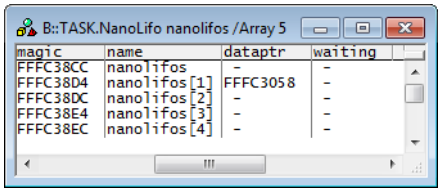
Displays LIFOs of Zephyr Nanokernel. Specify the symbol name of a LIFO to display its contents.

Optional Parameters:

Struct *<symbol>* refers to a variable holding a NANO_LIFO structure (default)

Ptr *<symbol>* is a pointer to a NANO_LIFO structure

Array *<size>* *<symbol>* is an array with *<size>* NANO_LIFO entries



“magic” is a unique ID, used by the OS Awareness to identify a specific LIFO (address of the LIFO control structure).

The field “magic” is mouse sensitive, double clicking on it opens an appropriate window. Right clicking on it will show a local menu.

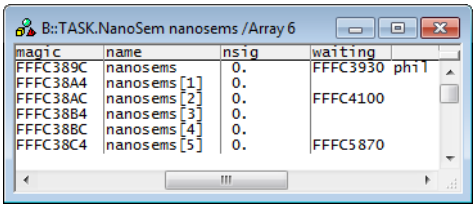
TASK.NanoSem Display nanokernel semaphores

Format: **TASK.NanoSem** *<symbol>* [**/Struct** | **/Ptr** | **/Array** *<size>*]

Displays semaphores of Zephyr Nanokernel. Specify the symbol name of a semaphore to display its contents.

Optional Parameters:

Struct	<*symbol*> refers to a variable holding a NANO_SEM structure (default)
Ptr	<*symbol*> is a pointer to a NANO_SEM structure
Array <*size*>	<*symbol*> is an array with <*size*> NANO_SEM entries



“magic” is a unique ID, used by the OS Awareness to identify a specific semaphore (address of the semaphore control structure).

The field “magic” is mouse sensitive, double clicking on it opens an appropriate window. Right clicking on it will show a local menu.

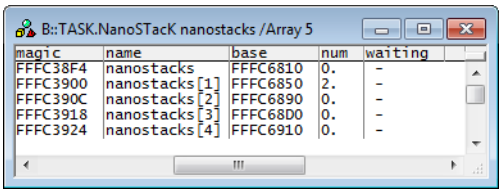
TASK.NanoSTacK Display nanokernel stacks

Format: **TASK.NanoSTacK** <*symbol*> [**/Struct** | **/Ptr** | **/Array** <*size*>]

Displays stacks of Zephyr Nanokernel. Specify the symbol name of a stack to display its contents.

Optional Parameters:

Struct	<*symbol*> refers to a variable holding a NANO_STACK structure (default)
Ptr	<*symbol*> is a pointer to a NANO_STACK structure
Array <*size*>	<*symbol*> is an array with <*size*> NANO_STACK entries



“magic” is a unique ID, used by the OS Awareness to identify a specific stack (address of the stack control structure).

The fields “magic”and “base” are mouse sensitive. Double-clicking on them opens appropriate windows. Right clicking on them will show a local menu.

TASK.PIPE Display microkernel pipes

Format: **TASK.PIPE**

Displays the pipe table of Zephyr Microkernel.

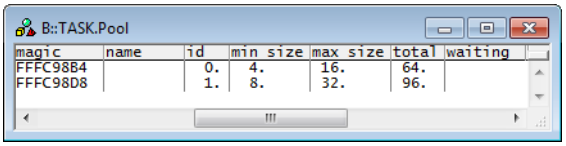
“magic” is a unique ID, used by the OS Awareness to identify a specific pipe (address of the pipe control structure).

The field “magic” is mouse sensitive, double clicking on it opens an appropriate window. Right clicking on it will show a local menu.

TASK.Pool Display microkernel pools

Format: **TASK.Pool**

Displays the memory pool table of Zephyr Microkernel.

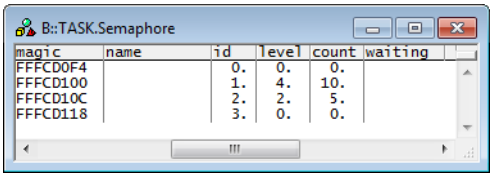


“magic” is a unique ID, used by the OS Awareness to identify a specific pool (address of the pool control structure).

The field “magic” is mouse sensitive, double clicking on it opens an appropriate window. Right clicking on it will show a local menu.

Format: **TASK.Semaphore**

Displays the semaphore table of Zephyr Microkernel.



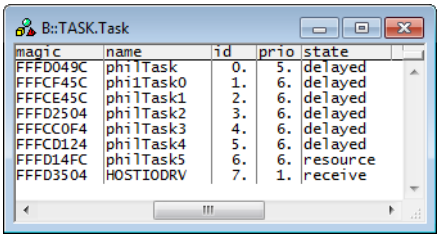
“magic” is a unique ID, used by the OS Awareness to identify a specific semaphore (address of the semaphore control structure).

The field “magic” is mouse sensitive, double clicking on it opens an appropriate window. Right clicking on it will show a local menu.

TASK.Task Display tasks

Format: **TASK.Task**

Displays the task table of Zephyr.

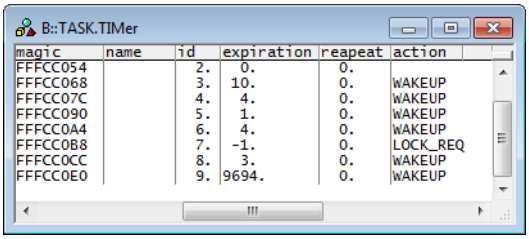


“magic” is a unique ID, used by the OS Awareness to identify a specific task (address of the task control structure).

The field “magic” is mouse sensitive, double clicking on it opens an appropriate window. Right clicking on it will show a local menu.

Format: **TASK.TIMer**

Displays the timer table of Zephyr Microkernel.



“magic” is a unique ID, used by the OS Awareness to identify a specific timer (address of the timer control structure).

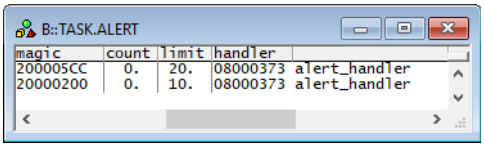
The field “magic” is mouse sensitive, double clicking on it opens an appropriate window. Right clicking on it will show a local menu.

TASK.ALERT

Display alerts

Format: **TASK.ALERT**

Displays the alert table of Zephyr.

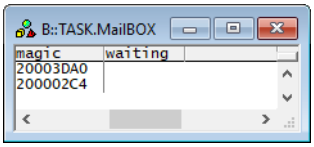


TASK.MailBOX

Display mailboxes

Format: **TASK.MailBOX**

Displays the mailbox table of Zephyr.

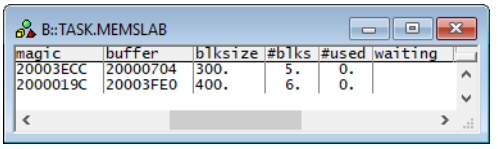


TASK.MEMSLAB

Display memslabs

Format: **TASK.MEMSLAB**

Displays the memory slab table of Zephyr.

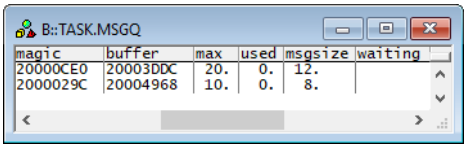


TASK.MSGQ

Display msgqs

Format: **TASK.MSGQ**

Displays the message queue table of Zephyr.

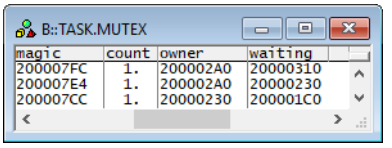


TASK.MUTEX

Display mutexes

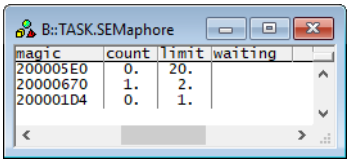
Format: **TASK.MUTEX**

Displays the mutex table of Zephyr.



Format: **TASK.SEMaphore**

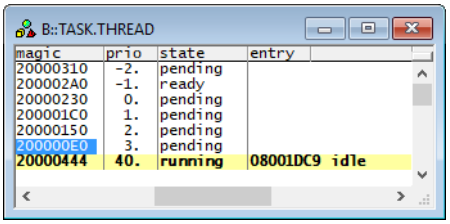
Displays the semaphore table of Zephyr.



TASK.THREAD Display threads

Format: **TASK.THREAD**

Displays the thread table of Zephyr.

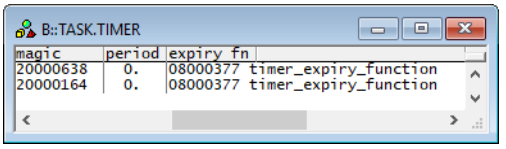


TASK.TIMER

Display timers

Format: **TASK.TIMER**

Displays the timer table of Zephyr.

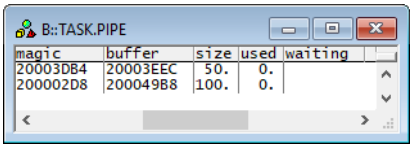


TASK.PIPE

Display pipes

Format: **TASK.PIPE**

Displays the pipe table of Zephyr.

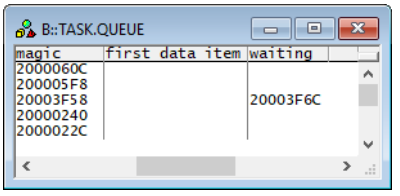


TASK.QUEUE

Display queues

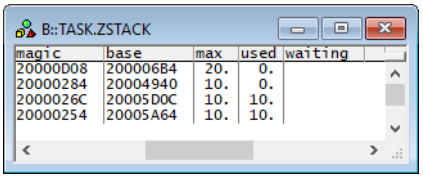
Format: **TASK.QUEUE**

Displays the queue table of Zephyr.



Format: **TASK.ZSTACK**

Displays the Zephyr stack table.



Zephyr PRACTICE Functions

There are special definitions for Zephyr specific PRACTICE functions.

TASK.CONFIG() OS Awareness configuration information

Syntax: **TASK.CONFIG(magic | magicsize)**

Parameter and Description:

magic	**Parameter Type**: String (***without*** quotation marks). Returns the magic address, which is the location that contains the currently running task (i.e. its task magic number).
magicsize	**Parameter Type**: String (***without*** quotation marks). Returns the size of the task magic number (1, 2 or 4).

Return Value Type: Hex value.