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OS Awareness Manual NORTi

MANUAL

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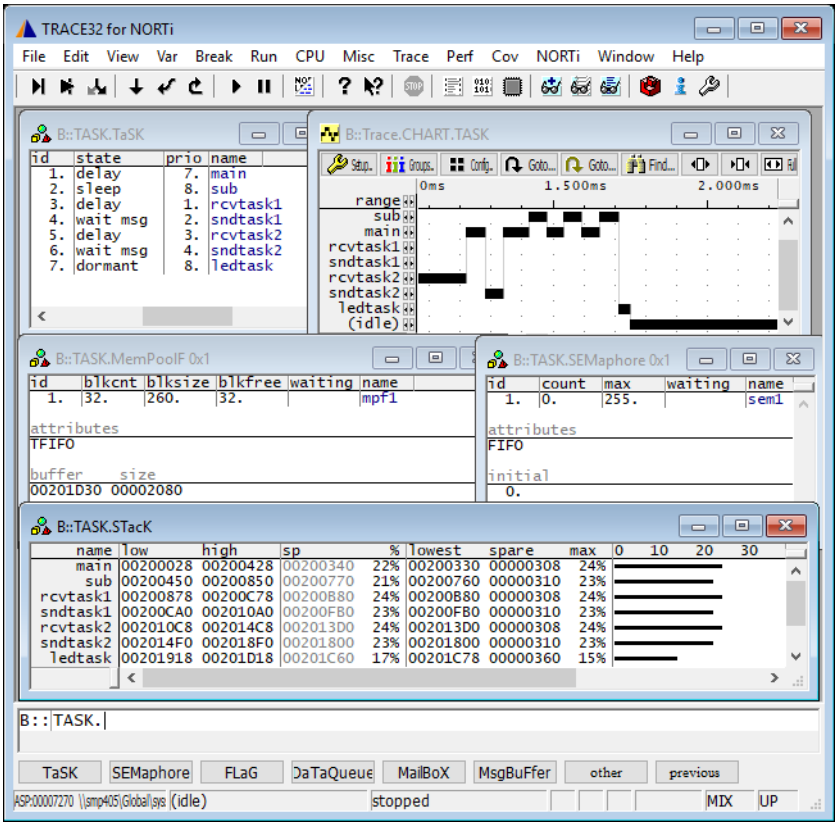
Version 06-Jun-2024

Overview



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

Brief Overview of Documents for New Users

Architecture-independent information:

- **"Training Basic Debugging"** (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.

Supported Versions

Currently NORTi is supported for the following versions:

- NORTi v4 version 4.12 for ARM, Nios II and PowerPC.

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

Automatic configuration tries to locate the NORTi internals automatically. For this purpose all symbol tables must be loaded and accessible at any time the OS Awareness is used.

If you want to have dual port access for the display functions (display “On The Fly”), you have to map emulation or shadow memory to the address space of all used system tables.

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 norti**

Quick Configuration Guide

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

1. Copy the files "`norti.t32`" and "`norti.men`" to your project directory

   (from TRACE32 directory "~~/demo/<*processor*>/kernel/norti").

2. Start the TRACE32 Debugger.

3. Load your application as normal.

4. Execute the command "`TASK.CONFIG norti`"

   (See "**Configuration**").

5. Execute the command "`MENU.ReProgram norti`"

   (See "**NORTi Specific Menu**").

6. Start your application.

Now you can access the NORTi extensions through the menu.

In case of any problems, please carefully read the previous configuration chapters.

Hooks & Internals in NORTi

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 NORTi kernel must be compiled with debug information.

Features

The OS Awareness for NORTi supports the following features.

Display of Kernel Resources

The extension defines new commands to display various kernel resources. Information on the following NORTi components can be displayed:

TASK.TaSK	Tasks
TASK.SEMaphore	Semaphores
TASK.FLaG	Event flags
TASK.DaTaQueue	Data queues
TASK.MailBoX	Mailboxes
TASK.MsgBuFfer	Message buffers
TASK.MuTeX	Mutexes
TASK.PORt	Rendezvous ports
TASK.MemPoolF	Fixed sized memory pools
TASK.MemPoolL	Variable sized memory pools
TASKCYClic	Cyclic handlers
TASK.ALarM	Alarm handlers
TASK.ISR	Interrupt service routines

For a description of the commands, refer to chapter "**NORTi Commands**".

When working with emulation memory or shadow memory, these resources can be displayed "On The Fly", i.e. while the target application is running, without any intrusion to the application. If using this dual port memory feature, be sure that emulation memory is mapped to all places, where NORTi holds its tables.

When working only with target memory, the information will only be displayed if the target application is stopped.

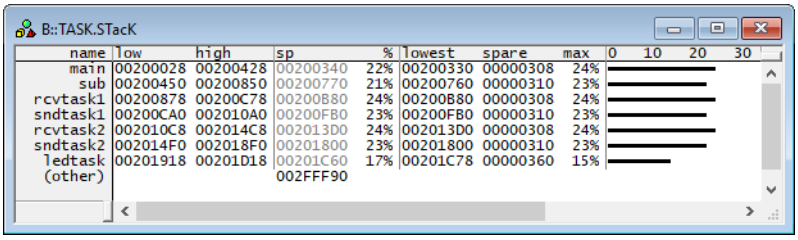
Task Stack Coverage

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.

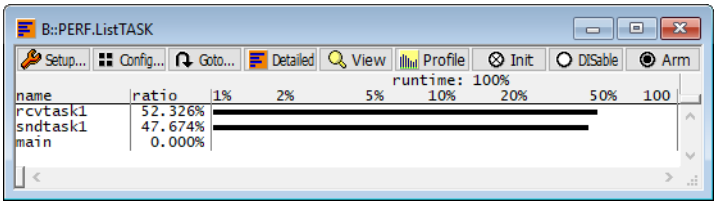
If you want to halt program execution as soon as a specific task is scheduled to run by the OS, you can use the **Break.SetTask** command.

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).



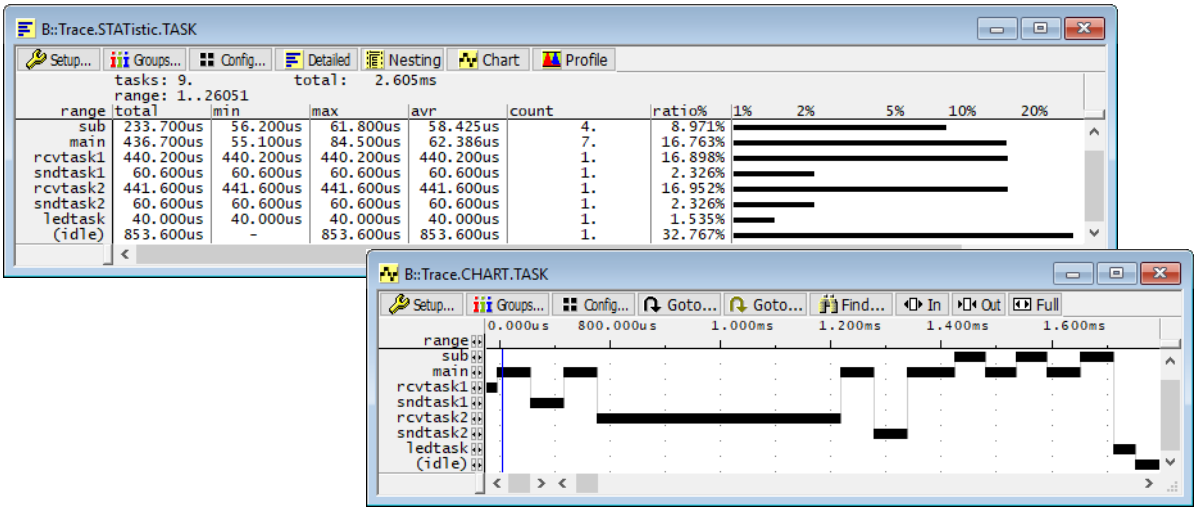
NOTE: This feature is *only* available, if your debug environment is able to trace task switches (program flow trace is not sufficient). It requires either an on-chip trace logic that is able to generate task information (eg. data trace), or a software instrumentation feeding one of TRACE32 software 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 and data accesses (program flow trace is not sufficient). It requires either an on-chip trace logic that is able to generate a 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).

The time different tasks are in a certain state (running, ready, suspended or waiting) can be evaluated statistically or displayed graphically.

This feature requires that the following data accesses are recorded:

- All accesses to the status words of all tasks
- Accesses to the current task variable (= magic address)

Adjust your trace logic to record all data write accesses, or limit the recorded data to the area where all TCBs are located (plus the current task pointer).

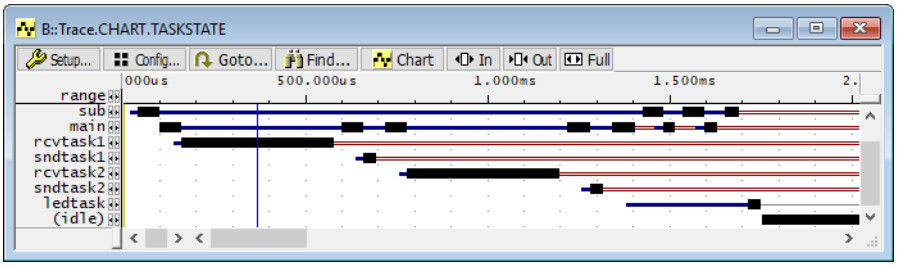
Example: This script assumes that the TCBs are located in an array named TCB_array and consequently limits the tracing to data write accesses on the TCBs and the task switch.

```
Break.Set Var.RANGE(TCB_array) /Write /TraceData
Break.Set TASK.CONFIG(magic) /Write /TraceData
```

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

Trace.STATistic.TASKState	Display task state statistic
Trace.Chart.TASKState	Display task state timechart

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
```

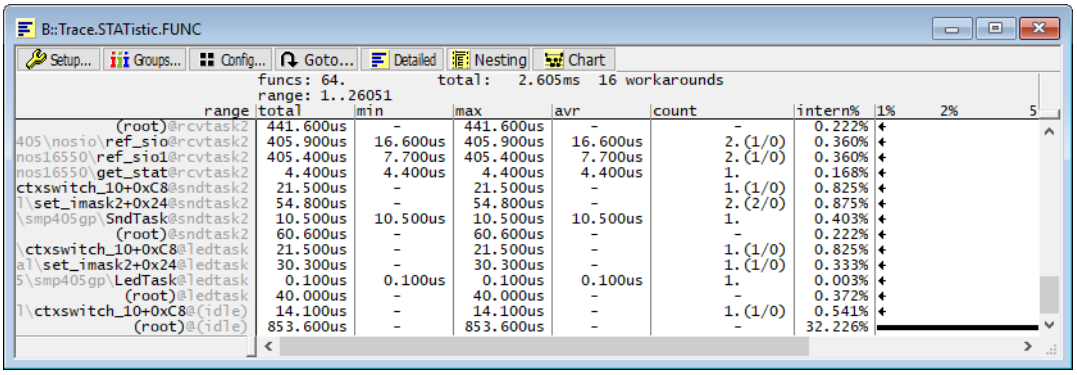
To do a selective recording on task-related function runtimes, based on the Arm Context ID, use the following command:

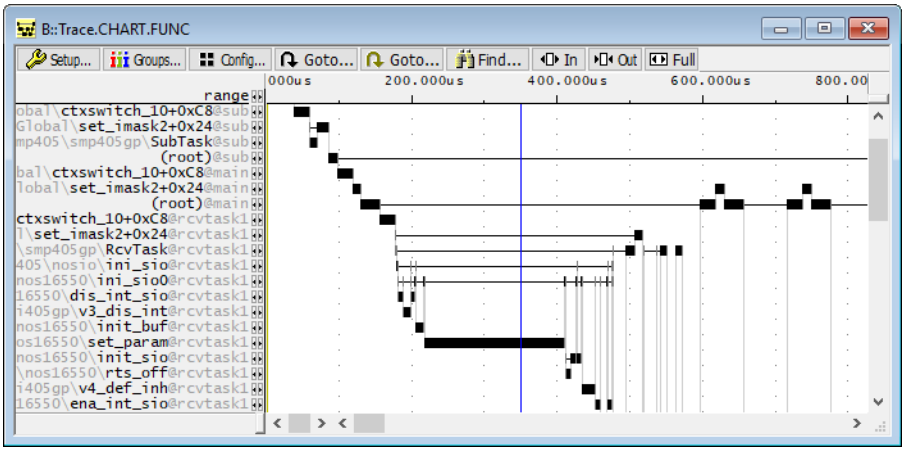
```
; Enable flow trace with Arm Context ID (e.g. 32bit)
ETM.ContextID 32
```

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)".

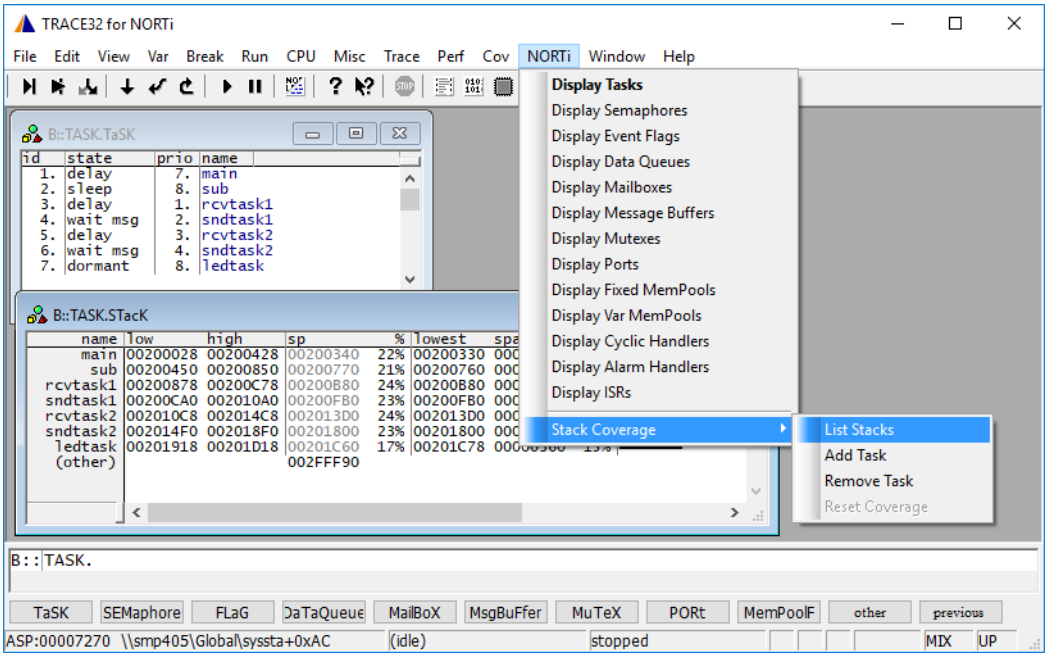

B::Trace.STATistic.FUNC
Setup...
Groups...
Config...
Goto...
Detailed
Nesting
Chart
funcs: 64.
total: 2.605ms 16 workarounds
range: 1..26051
range total min max avr count intern% 1% 2% 5
(root)@rcvtask2 441.600us - 441.600us - - 0.222%
405\nosio\ref_sio@rcvtask2 405.900us 16.600us 405.900us 16.600us 2.(1/0) 0.360%
nos16550\ref_sio1@rcvtask2 405.400us 7.700us 405.400us 7.700us 2.(1/0) 0.360%
nos16550\get_stat@rcvtask2 4.400us 4.400us 4.400us 4.400us 1. 0.168%
ctxswitch_10+0xC8@sndtask2 21.500us - 21.500us - 1.(1/0) 0.825%
l\set_imask2+0x24@sndtask2 54.800us - 54.800us - 2.(2/0) 0.875%
\smp405gp\SndTask@sndtask2 10.500us 10.500us 10.500us 10.500us 1. 0.403%
(root)@sndtask2 60.600us - 60.600us - - 0.222%
\ctxswitch_10+0xC8@ledtask 21.500us - 21.500us - 1.(1/0) 0.825%
al\set_imask2+0x24@ledtask 30.300us - 30.300us - 1.(1/0) 0.333%
5\smp405gp\LedTask@ledtask 0.100us 0.100us 0.100us 0.100us 1. 0.003%
(root)@ledtask 40.000us - 40.000us - - 0.372%
l\ctxswitch_10+0xC8@(idle) 14.100us - 14.100us - 1.(1/0) 0.541%
(root)@(idle) 853.600us - 853.600us - - 32.226%


B::Trace.CHART.FUNC
Setup...
Groups...
Config...
Goto...
Goto...
Find...
In
Out
Full
000us
200.000us
400.000us
600.000us
800.00
range
obal\ctxswitch_10+0xC8@sub
Global\set_imask2+0x24@sub
mp405\smp405gp\SubTask@sub
(root)@sub
bal\ctxswitch_10+0xC8@main
lobal\set_imask2+0x24@main
(root)@main
ctxswitch_10+0xC8@rcvtask1
l\set_imask2+0x24@rcvtask1
\smp405gp\RcvTask@rcvtask1
405\nosio\ini_sio@rcvtask1
nos16550\ini_sio0@rcvtask1
16550\dis_int_sio@rcvtask1
i405gp\v3_dis_int@rcvtask1
nos16550\init_buf@rcvtask1
os16550\set_param@rcvtask1
nos16550\init_sio@rcvtask1
\nos16550\rts_off@rcvtask1
i405gp\v4_def_inh@rcvtask1
16550\ena_int_sio@rcvtask1

NORTi specific Menu

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

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



- The **Display** menu items launch the kernel resource display windows.
- The **Stack Coverage** submenu starts and resets the NORTi 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.ALarM — Display alarm handlers

Format: **TASK.ALarM**

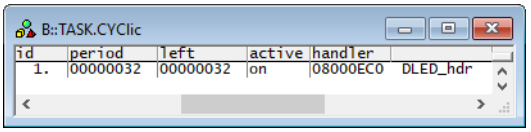
Displays the table of installed alarm handlers.

The fields “id” and “handler” are mouse sensitive. Double-clicking on them open appropriate windows. Right clicking on them will show local menu.

TASK.CYClic — Display cyclic handlers

Format: **TASK.CYClic**

Displays the table of installed cyclic handlers.



The fields “id” and “handler” are mouse sensitive. Double-clicking on them open appropriate windows. Right clicking on them will show local menu.

TASK.DaTaQueue — Display data queues

Format: **TASK.DaTaQueue** [<*queue*>]

Displays the data queue table of NORTi or detailed information about one specific data queue.

Without any arguments, a table with all created data queues will be shown.
Specify a data queue ID or name to display detailed information on that data queue.

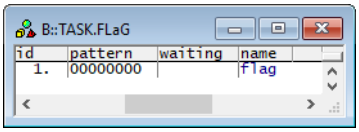
The “waiting” column shows the task IDs waiting.

The field “id” is mouse sensitive. Double-clicking on it opens an appropriate window. Right clicking on it will show a local menu.

Format: **TASK.FLaG** [<*flag*>]

Displays the event flag table of NORTi or detailed information about one specific event flag.

Without any arguments, a table with all created event flags will be shown. Specify a flag ID or name to display detailed information on that flag.



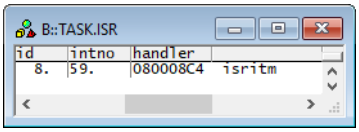
The “waiting” column shows the task IDs waiting.

The field “id” is mouse sensitive. Double-clicking on it opens an appropriate window. Right clicking on it will show a local menu.

TASK.ISR Display interrupt service routines

Format: **TASK.ISR**

Displays the table of installed interrupt service routines.



The fields “id” and “handler” are mouse sensitive. Double-clicking on them open appropriate windows. Right clicking on them will show local menu.

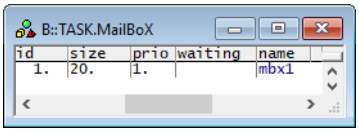
TASK.MailBoX Display mailboxes

Format: **TASK.MailBoX** [<*mailbox*>]

Displays the mailbox table of NORTi or detailed information about one specific mailbox.

Without any arguments, a table with all created mailboxes will be shown.

Specify a mailbox ID or name to display detailed information on that mailbox.



The “waiting” column shows the task IDs waiting.

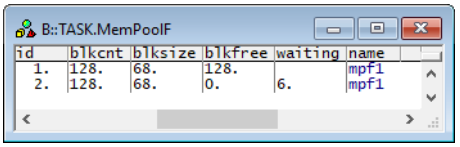
The field “id” is mouse sensitive. Double-clicking on it opens an appropriate window. Right clicking on it will show a local menu.

TASK.MemPoolF Display fixed memory pools

Format: **TASK.MemPoolF** [<*mempool*>]

Displays the fixed size memory pool table of NORTi or detailed information about one specific memory pool.

Without any arguments, a table with all created memory pools will be shown.
Specify a pool ID or name to display detailed information on that memory pool.



The “waiting” column shows the task IDs waiting.

The field “id” is mouse sensitive. Double-clicking on it opens an appropriate window. Right clicking on it will show a local menu.

TASK.MemPoolL Display variable memory pools

Format: **TASK.MemPoolL** [<*mempool*>]

Displays the variable size memory pool table of NORTi or detailed information about one specific memory pool.

Without any arguments, a table with all created memory pools will be shown.
Specify a pool ID or name to display detailed information on that memory pool.

The “waiting” column shows the task IDs waiting.

The field “id” is mouse sensitive. Double-clicking on it opens an appropriate window. Right clicking on it will show a local menu.

TASK.MsgBuFfer — Display message buffers

Format: **TASK.MsgBuFfer** [<*msgbuffer*>]

Displays the message buffer table of NORTi or detailed information about one specific message buffer.

Without any arguments, a table with all created message buffers will be shown.
Specify a message buffer ID or name to display detailed information on that message buffer.

The “waiting” column shows the task IDs waiting.

The field “id” is mouse sensitive. Double-clicking on it opens an appropriate window. Right clicking on it will show a local menu.

Format: **TASK.MuTeX** [<*mutex*>]

Displays the mutex table of NORTi or detailed information about one specific mutex.

Without any arguments, a table with all created mutexes will be shown.
Specify a mutex ID or name to display detailed information on that mutex.

“locked” shows the task ID that locked this mutex.

The field “id” is mouse sensitive. Double-clicking on it opens an appropriate window. Right clicking on it will show a local menu.

TASK.PORt Display rendezvous ports

Format: **TASK.PORt** [<*port*>]

Displays the rendezvous port table of NORTi or detailed information about one specific port.

Without any arguments, a table with all created port will be shown.
Specify a port ID or name to display detailed information on that port.

“accept” shows the task ID that is waiting for accepting this rendezvous.

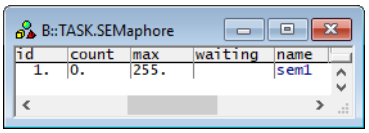
The “call” column shows the task IDs waiting for calling the rendezvous.

The field “id” is mouse sensitive. Double-clicking on it opens an appropriate window. Right clicking on it will show a local menu.

Format: **TASK.SEMaphore** [<*semaphore*>]

Displays the semaphore table of NORTi or detailed information about one specific semaphore.

Without any arguments, a table with all created semaphores will be shown. Specify a semaphore ID or name to display detailed information on that semaphore.



The “waiting” column shows the task IDs waiting.

The field “id” is mouse sensitive. Double-clicking on it opens an appropriate window. Right clicking on it will show a local menu.

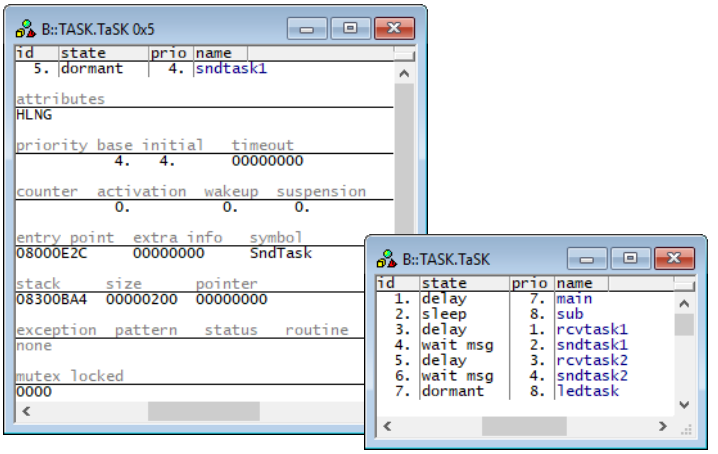
TASK.TaSK Display tasks

Format: **TASK.TaSK** [<*task*>]

Displays the task table of NORTi or detailed information about one specific task.

Without any arguments, a table with all created tasks will be shown.

Specify a task ID or name to display detailed information on that task.



The fields “id” and “entry” are mouse sensitive, double clicking on them opens appropriate windows. Right clicking on them will show a local menu.

NORTi PRACTICE Functions

There are special definitions for NORTi 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.