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April 1st, 2010
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E30A Emulator for the R32C/100 Series
How to Use Trace and Section Time Measurement Events

Summary
The E30A emulator for the R32C/100 series incorporates two debug functions—the trace function and the section time measurement function. By selecting trace or time measurement for the event and then specifying access conditions in the event setup screen of High-performance Embedded Workshop (HEW), it is possible to perform a trace or section time measurement.

The results of trace and section time measurement can each be confirmed in the trace window and the time section measurement window of HEW.

The access conditions selectable for each event are listed below.

<table>
<thead>
<tr>
<th>Event</th>
<th>Access condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trace event (trace extraction event)</td>
<td>EXECUTION</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Trace event (trace start event/ trace end event)</td>
<td>BRANCH, READ, WRITE</td>
</tr>
<tr>
<td>Section time measurement event</td>
<td>EXECUTION, BRANCH</td>
</tr>
</tbody>
</table>

*1. Can be assigned to only events E0 and E4.

Limitations on access conditions of each event are shown below.

[Limitations of trace events]
If EXECUTION is specified for access condition of a trace, the emulator, owing to NSD specifications, may erroneously assume that the condition is met when the set address is prefetched *2 (prefetched in size of about 48 bytes). This will result in excessive trace information being acquired or a failure to acquire the intended trace information depending on trace measurement range (After or Before).

*2. Although it is possible to set an address for the trace event condition by taking prefetch into consideration, such is not a much practiced case because there are various factors such as interrupt process, branch process, loop process, or compiler optimization that make it difficult to identify the address.

[Limitations of section time measurement events]
Since the section time measurement is an operation to measure the execution time between data accesses based on trace information, the data access trace information (address, data, data size, read/write) is detected in the emulator as the measurement start event and measurement end event.

Therefore, it is only data access (READ, WRITE, or R/W) that can be specified for access condition, and in no case can such a time measurement that uses the start and end of a function as condition be performed (i.e., EXECUTION cannot be specified for access condition).

This application note explains the measures to be taken to cope with the above limitations.
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1. Environment

Microcomputers used: R32C/118 group (R5F64189PFB)
HEW: V.4.05.01.001
Emulator software: R32C/100 E30A Emulator Debugger V.1.00 Release 00
Compiler: R32C/100 Series C Compiler V.1.01 Release 00

2. Flow of This Document

The corrective measures are described below.

[Corrective measures for limitations on trace events]

• Embed a sequence in place that will have a data access (read process *) generated at the start position of a trace and specify the data access for access condition (alteration of the source required).

*3. If a write process is used for condition, because a trace event cannot have data comparison set for condition (e.g., a condition like the one that will cause a trace to start when variable ‘a’ = 1), a trace may erroneously be started at the time the data (variable) set for access condition is initialized (by writing “00”), making it impossible to trace the intended range.

(For details, see paragraph (4) in Section 3, “Frequently Asked Questions.”)

[Corrective measures for limitations on section time measurement events]

• Embed a sequence in place that will have a data access generated in a section of the program (start to end) in which a time measurement is to be performed and specify the data access for access condition (alteration of the source required).

The flow of this document is shown below.

```
Operation start

Trace based on data access

Section time measurement based on data access

End
```
2.1 Trace Based on Data Access

This section explains the method for performing a trace unaffected by prefetch by first embedding a global variable read process at the start position of a trace event and then specifying the global variable read process (data access) for the event’s access condition.

Shown here is an example in which a trace is started from the beginning of the `sort` function by using the Tutorial program included with the E30A emulator software.

1. Add global variables `point` and `trace_point` in the source file.

```c
13 long a[10];
14 struct Sample st;
15
16 char point;
17 char trace_point;
18
20 void main(void)
21 { FFFF0100
```

(2) Add `point = trace_point` at a place preceding the `sort` function. Perform a build after adding and then download the program.

```c
41 FFFF012B a[i] = j;
42
44 point = trace_point;
45
46 FFFF0136 sort(a); change(a);
```

Trace starts from here.

(3) Choose Trace from the View menu and then select Trace Point.
(4) The Event Settings dialog box is displayed. Double-click in the Event Status column.

(5) The Set Event Status dialog box is displayed. Select Trace for Event Type, AFTER for Trace Measurement Range, trace_point for Start Address, and READ for Access Condition. Then click the OK button.
(6) The contents you've set are displayed in the Event Settings dialog box. Click the Set button to make the changes take effect.

(7) Choose Trace from the View menu and then select Trace.
(8) The Trace window is displayed.

(9) Run the program and stop, and the result of a trace will be displayed. Although one event has just been used in the global variable process (data access) specified for access condition, a trace can be started from the beginning of the sort function.
2.2 Section Time Measurement Based on Data Access

This section explains the method for measuring the execution time (from start to end) of a function by embedding a global variable write process at the start and end positions of a section time measurement event and then specifying the global variable write process (data access) for the event's access condition.

Shown here is an example in which measurement is made of the execution time of the sort function by using the Tutorial program included with the E30A emulator software.

(1) Add global variables `time_start` and `time_stop` in the source file.

```c
13 14 15 16
long a[10];
struct SampleSt;
17 18 19 20
char time_start;
char time_stop;
21

void main(void)
{
    ...
}
```

(2) Add `time_start = 1` and `time_stop = 1` before and after the `sort` function. Perform a build after adding and then download the program.

```c
49 50 51
FFFF0138 time_start = 1;
FFFF013C sort(a);
FFFF0144 time_stop = 1;
FFFF014C change(a);
```

(3) Choose Trace from the View menu and then select Section Time Measurement.
(4) The Section Time Measurement dialog box is displayed. Double-click in the Event Status column.

(5) The Set Event Status dialog box is displayed. Select Time Measurement for Event Type, check the Section Time Measurement and the Data Comparison check boxes and uncheck the Execution Time Measurement check box. Select _time_start for Address and WRITE for Access Condition and set Data to “00000001.” Then click the OK button.
In the same way, complete the dialog box by selecting _time_stop for Address etc. as shown below, and then click the OK button.

(6) The contents you’ve set are displayed in the Section Time Measurement dialog box. At this time, check to see if _time_start and _time_stop are set for events E1 and E2, respectively. Next, select MP1 in the Measurement Points column and double-click in it.
(7) The Set Measurement Point: MP1 dialog box is displayed. Select E1 for Start and E2 for End, and then click the OK button. This setting causes a measurement to be made from when event E1 occurs till when E2 occurs.

(8) The contents you’ve set are displayed in the Measurement Points column of the Section Time Measurement dialog box. Click the Set button to make the changes take effect.
(9) Run the program and stop, and the result of a section time measurement will be displayed. That way, it is possible to measure the execution time of the sort function.
3. Frequency Asked Questions

(1) Are there any precautions to take when using the trace function and the section time measurement function?

[Precautions to taken when using the trace function]

- The trace function can only be used when the trace mode is selected on the operation mode tab of the Init dialog.
- In the Before and the After modes, the trace events that occurred in the trace rage, as well as the trace start events that occurred during that time, are recorded. Note, however, that trace end events are not recorded.
- In a conditional branch trace, display for the disassemble mode and source mode of the trace window may take time.
- If MCU execution priority is selected for the trace mode, the trace range becomes 512 cycles. If a trace range of 8M cycles is desired, select trace priority for the trace mode. In the trace priority mode, trace data output has priority and MCU execution is delayed. Program processing requires a longer timer than in the MCU execution priority mode. Note that for a conditional branch trace, the trace priority mode is the default mode of trace.
- Even when a function is specified when selecting the file to be displayed in the SRC mode, if the specified function exists in the currently displayed file, it is always the top of the file that is displayed.
- When a trace result is saved in text form, there is a possibility of the header and data strings getting their vertical positions displaced. Select “save in tab separated text” when saving a trace result and open it in spreadsheet software etc. to get correct display.
- Displaying each cycle in time (hours, minutes, and seconds) is not supported.
- The trace image files (*.rtt files) saved with the M3T-PDxx debugger cannot be loaded. Nor can the trace image files saved with other targets be loaded.
- The word data (16-bit) located beginning with an odd-numbered address or longword data (32-bit) not located at 4-byte boundaries cannot be traced normally.
- Data access events by DMA are not detected.
- If a runtime debug, RAM monitor, or data comparison break is used in a branch trace to record jump addresses, branch information (debug monitor program processing address) that is unlikely to occur in the user program may be included. So be careful.

[Precautions to taken when using the section time measurement function]

- The event setting window and the section time measurement window share the same resource of the emulator. If an event is changed in the section time measurement window, the contents set in the event setting window are also changed.
- In a section time measurement performed, the data access trace information output from the MCU is compared in the emulator to detect the start and end events. If a large number of data access times is specified, trace output will take a lot of time, leading to errors in section time measurement or affecting execution of the MCU.

For the case where Xin = 8 MHz, PLL = 128 MHz (× 16), and BASE = 64 MHz, for example, it takes 5 µs to output the data access trace information. If a data access of less than 5 µs occurs, a trace output time-dependent error will occur. Furthermore, if such a short data access occurs frequently, execution of the MCU will be delayed.

We recommend write-only settings with least possible events.
(2) Why is it impossible to select Trace or Time Measurement for Event Type in the Set Event Status dialog box?

Trace or Time Measurement cannot be selected.

E30A uses the same internal resource of the emulator for trace, time measurement, and RAM monitor, so that to use the respective functions, it is necessary to change operation modes.

Choose Emulator from the Basic Settings menu of HEW and then select System to open the Init dialog box.

On the Operation Mode tab of the Init dialog box, select Trace to use the trace function or Time Measurement to use the section time measurement function.
(3) Although a trace was executed, no results are displayed in the trace window. Why?

No trace results are displayed.

This is because the operation mode is set to other than trace (time measurement or RAM monitor). Check to see if Trace is selected on the Operation Mode tab of the Init dialog box.

(For details on how to set the operation mode, see paragraph (2) in this section.)

(4) Although a data access (write process) is embedded for the access condition of a trace event, the intended range cannot be traced. Why?

Example: To trace the sort function, embed a process for write to a global variable `trace_point = 1` in front of the sort function and perform a trace with a data access (`trace_point` write process) specified as access condition.

Define the global variable `trace_point`.

```
13 int a[18];
14 struct Sample st;
15
16 char trace_point;
17
18 void main(void)
19 {
20     FFFF0100
```

Embed `trace_point = 1` in front of the `sort` function and, after performing a build, download the program.

```
41 }
42  
43 FFFF0136 trace_point = 1;
44
45 FFFF0134 sort(a);
46 FFFF0132 change(2);
```
In the Set Event Status dialog box, set an event that will cause a trace to start upon WRITE to trace_point. And then perform a trace.

Check the trace result in the trace window after program execution, and it will be found that a trace was started by a process trace_point = 00, and that the main function, not the sort function, was traced.

This is because initialization was performed (by writing “00”) at the time the global variable trace_point was declared, by which a trace was erroneously started.

To set a data access for the access condition of a trace event, we recommend using a read process for the condition.
4. Related Documents

The E30A emulator and HEW have many other useful functions than those presented in this application note. Along with this application note, please see the following related documents also, in which you'll find detailed specifications of each product, as well as technical information, limitations, and other helpful information.

[E30A emulator related documents]
- E30A Emulator User’s Manual
- R32C/100 E30A Emulator Debugger V.1.00 User’s Manual
- R32C/100 E30A Emulator Debugger V.1.00.00 Release Notes

[High-performance Embedded Workshop related documents]
- High-performance Embedded Workshop Release Notes

[CPU related documents]
- R32C/118 Group Short Sheet
- R32C/100 Series Software Manual

[R32C/100 series C compiler package related documents]
- R32C/100 Series C Compiler Package V.1.01 C Compiler User’s Manual
- R32C/100 Series C Compiler Package V.1.01 Release 00 Release Notes
- R32C/100 Series C Compiler Package V.1.01 Assembler User’s Manual

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