



Real-Time Operating System (Day 2 Lab)

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09. ButtonISR (06 복사해서 수정)

- bsw.cpp 수정: 버튼 인터럽트 받을 수 있도록
- OIL 수정: ButtonISR 추가

```
...                                     bsw.c
#include <avr/io.h>
#include <avr/interrupt.h>
...
#define _BV(bit) (1 << (bit))
int main(void)
{
    PORTC = _BV(PC0);
    PCICR = _BV(PCIE1);
    PCMSK1 = _BV(PCINT8);
    EIFR = 0xff;
    sei();

    init();
}
```

```
ISR ButtonISR {
    CATEGORY = 2;
    SOURCE = "PCINT1";
};
```

09. ButtonISR

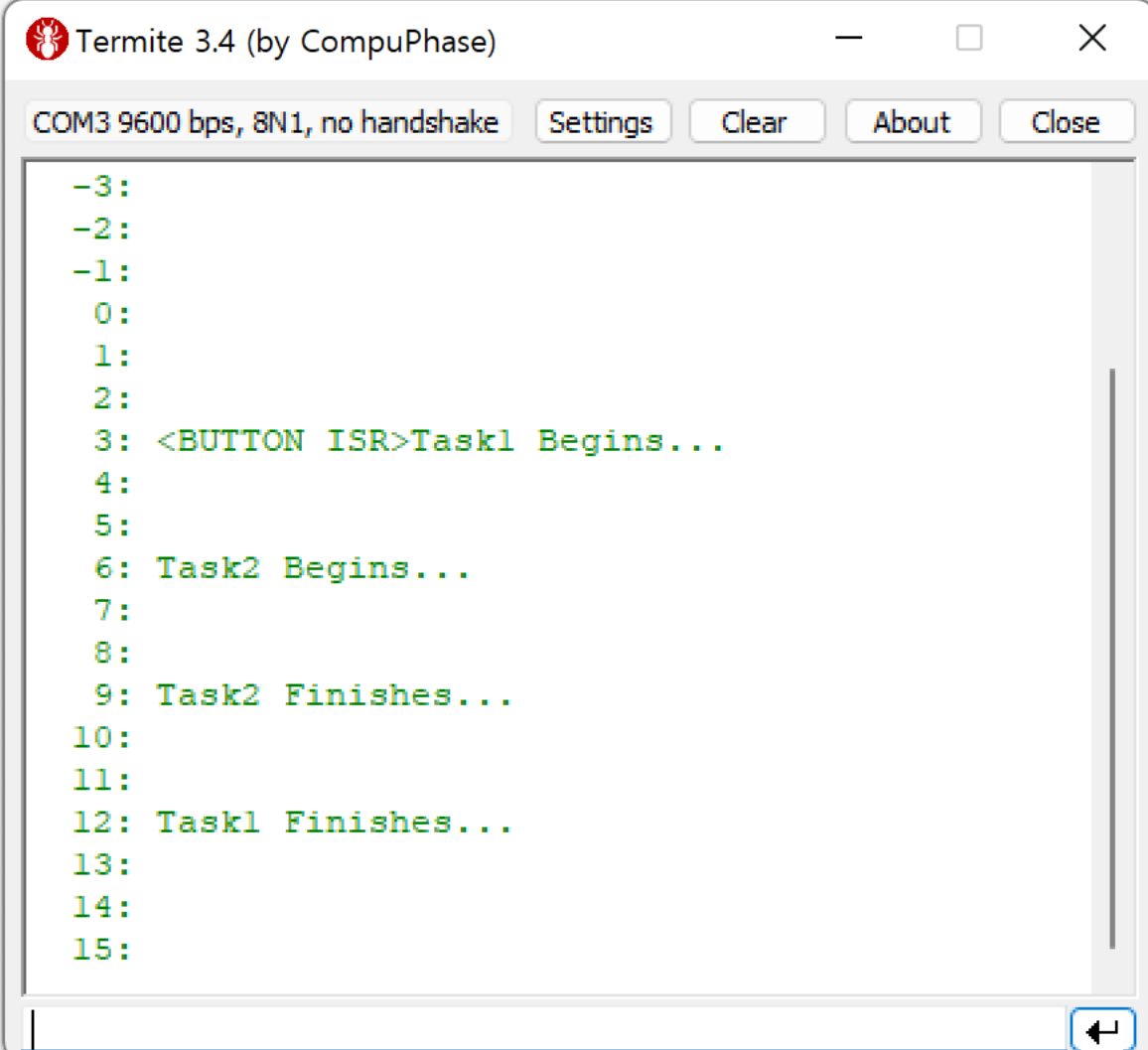
```
ISR2(TimerISR)
{
    static long c = -4;
    if (c == 0)
        ActivateTask(Task1);
    printfSerial("\n%4ld: ", c++);
}
```

```
ISR2(ButtonISR)
{
    int a0;
    DisableAllInterrupts();
    if ((PINC & 0x01) != 0) return;
    printfSerial("<BUTTON ISR>");
    a0 = analogRead(A0); // read ADC value
    if (a0 < 50) { // UP
        ActivateTask(Task1);
    } else if (a0 < 200) { // DOWN
        ActivateTask(Task2);
    } else if (a0 < 380) { // LEFT
        ;
    } else if (a0 < 520) { // RIGHT
        ;
    }
    EnableAllInterrupts();
}
```

asw.c

09. ButtonISR

- 중복 Activation의 경우?
 - ACTIVATION = 1; 수정 필요
- ISR에서 mdelay 실행하면?
- Nested Interrupt
 - ButtonISR 도중 TimerISR 실행



The screenshot shows a terminal window titled "Termite 3.4 (by CompuPhase)". The window has a menu bar with "COM3 9600 bps, 8N1, no handshake", "Settings", "Clear", "About", and "Close". The main text area displays a sequence of events, each preceded by a line number from -3 to 15. The events are as follows:

```
-3:
-2:
-1:
0:
1:
2:
3: <BUTTON ISR>Task1 Begins...
4:
5:
6: Task2 Begins...
7:
8:
9: Task2 Finishes...
10:
11:
12: Task1 Finishes...
13:
14:
15:
```

The text is displayed in a monospaced font, with the ISR event on line 3 and the task events on lines 6 and 12. The window has a scrollbar on the right side and a cursor at the bottom right.

10. Alarm

- OIL에 COUNTER와 ALARM 추가

```
COUNTER counter1 {  
    MINCYCLE = 1;  
    MAXALLOWEDVALUE = 127;  
    TICKSPERBASE = 1;  
};
```

```
ALARM alarm1 {  
    COUNTER = counter1;  
    ACTION = ACTIVATETASK {  
        TASK = Task1;  
    };  
    AUTOSTART = TRUE {  
        ALARMTIME = 5;  
        CYCLETIME = 10;  
    };  
};
```

```
ALARM alarm2 {  
    COUNTER = counter1;  
    ACTION = ACTIVATETASK {  
        TASK = Task2;  
    };  
    AUTOSTART = TRUE {  
        ALARMTIME = 5;  
        CYCLETIME = 20;  
    };  
};
```

10. Alarm

- TimerISR에서 counter1 증가

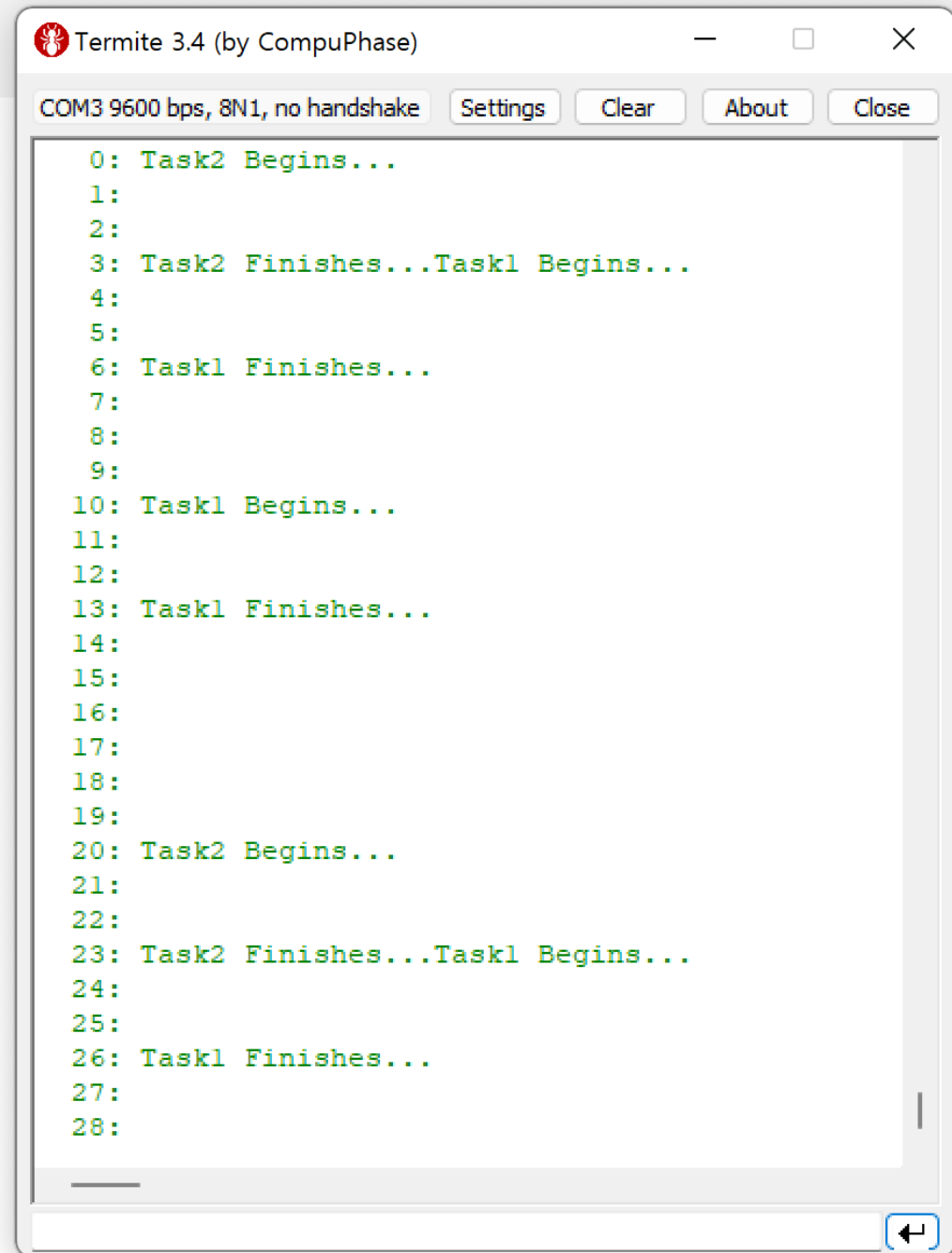
```
ISR2(TimerISR)
{
    static long c = -4;
    IncrementCounter(counter1);
    printfSerial("\n%4ld: ", c++);
}
```

```
TASK(Task1)
{
    printfSerial("Task1 Begins...");
    mdelay(3000);
    printfSerial("Task1 Finishes...");
    TerminateTask();
}
```

```
TASK(Task2)
{
    printfSerial("Task2 Begins...");
    mdelay(3000);
    printfSerial("Task2 Finishes...");
    TerminateTask();
}
```

10. Alarm

- Alarm을 이용한 주기적 Task 실행



The screenshot shows a terminal window titled "Termite 3.4 (by CompuPhase)". The window has a menu bar with "COM3 9600 bps, 8N1, no handshake", "Settings", "Clear", "About", and "Close". The terminal displays a sequence of messages indicating the execution of two tasks, Task1 and Task2, over 28 lines. The messages are as follows:

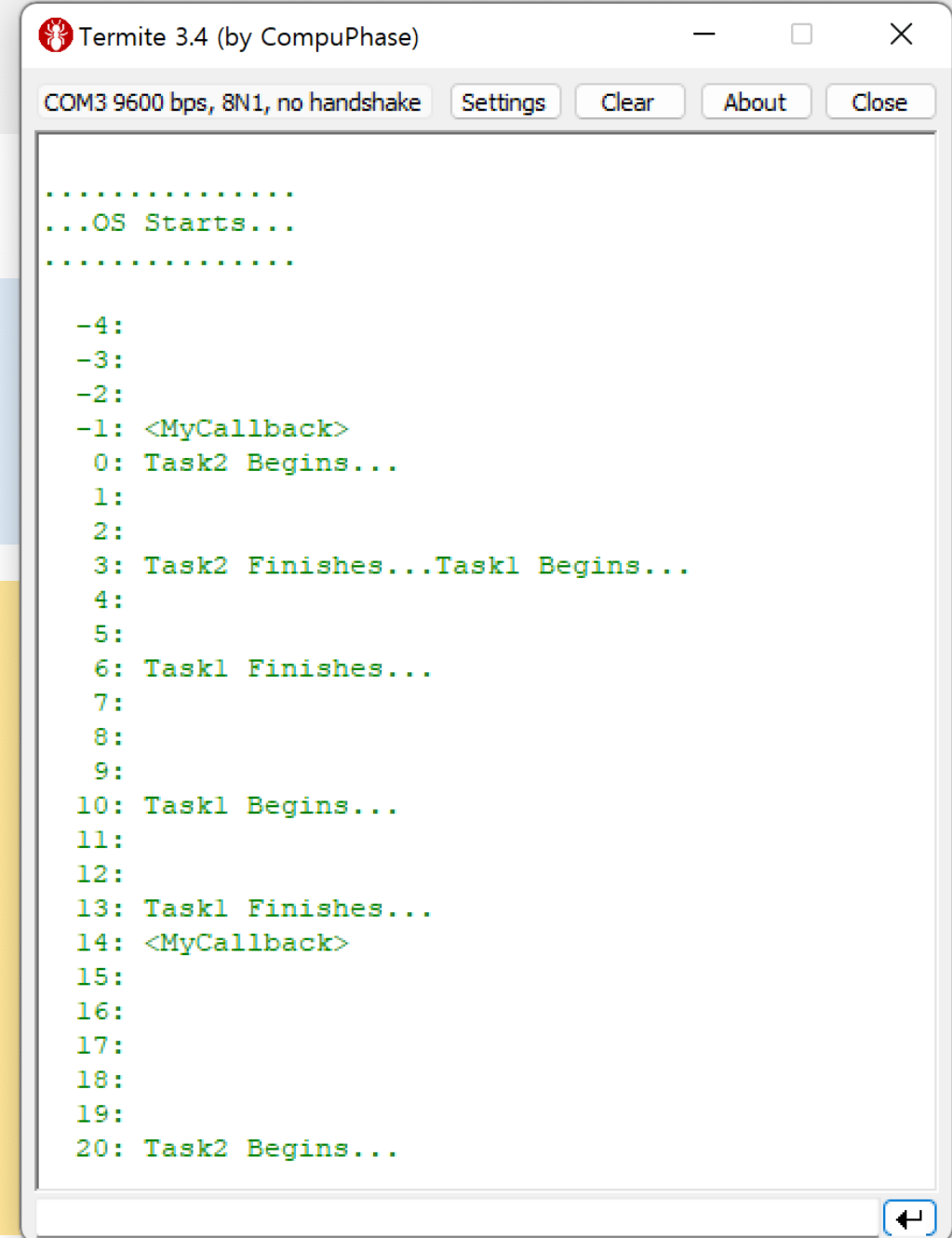
```
0: Task2 Begins...
1:
2:
3: Task2 Finishes...Task1 Begins...
4:
5:
6: Task1 Finishes...
7:
8:
9:
10: Task1 Begins...
11:
12:
13: Task1 Finishes...
14:
15:
16:
17:
18:
19:
20: Task2 Begins...
21:
22:
23: Task2 Finishes...Task1 Begins...
24:
25:
26: Task1 Finishes...
27:
28:
```

11. Alarm Callback

- 콜백 함수 등록

```
ALARMCALLBACK(MyCallback) {  
    printfSerial("MyCallback Begins...");  
    printfSerial("MyCallback Finishes...");  
}
```

```
ALARM alarm3 {  
    COUNTER = counter1;  
    ACTION = ALARMCALLBACK {  
        ALARMCALLBACKNAME = "MyCallback";  
    };  
    AUTOSTART = TRUE {  
        ALARMTIME = 5;  
        CYCLETIME = 15;  
    };  
};
```



The screenshot shows the Termite 3.4 (by CompuPhase) window. The title bar includes a red bug icon, the text "Termite 3.4 (by CompuPhase)", and standard window controls. Below the title bar is a status bar showing "COM3 9600 bps, 8N1, no handshake" and buttons for "Settings", "Clear", "About", and "Close". The main area is a text field displaying a sequence of events in a green monospace font. The events are numbered from -4 to 20. The sequence starts with "...OS Starts..." at line -4, followed by a series of task execution and completion messages, including "Task2 Begins...", "Task1 Begins...", "Task2 Finishes...", "Task1 Finishes...", and "Task2 Begins..." at line 20. The window has a scrollbar on the right side.

```
.....  
...OS Starts...  
.....  
  
-4:  
-3:  
-2:  
-1: <MyCallback>  
  0: Task2 Begins...  
  1:  
  2:  
  3: Task2 Finishes...Task1 Begins...  
  4:  
  5:  
  6: Task1 Finishes...  
  7:  
  8:  
  9:  
 10: Task1 Begins...  
 11:  
 12:  
 13: Task1 Finishes...  
 14: <MyCallback>  
 15:  
 16:  
 17:  
 18:  
 19:  
 20: Task2 Begins...
```


12. Event

```
TASK(Task2)
{
    EventMaskType mask;
    printfSerial("Task2 Begins...");
    printfSerial("Task2 Waits...");
    WaitEvent(Event1 | Event2 | Event3);
    printfSerial("Task2 Wakes Up...");
    GetEvent(Task2, &mask);
    if (mask & Event1) {
        printfSerial("[Event1]");
        ClearEvent(Event1);
    }
    if (mask & Event2) {
        printfSerial("[Event2]");
        ClearEvent(Event2);
    }
}
```

```
    if (mask & Event3) {
        printfSerial("[Event3]");
        ClearEvent(Event3);
    }
    printfSerial("Task2 Finishes...");
    TerminateTask();
}
```

12. Event

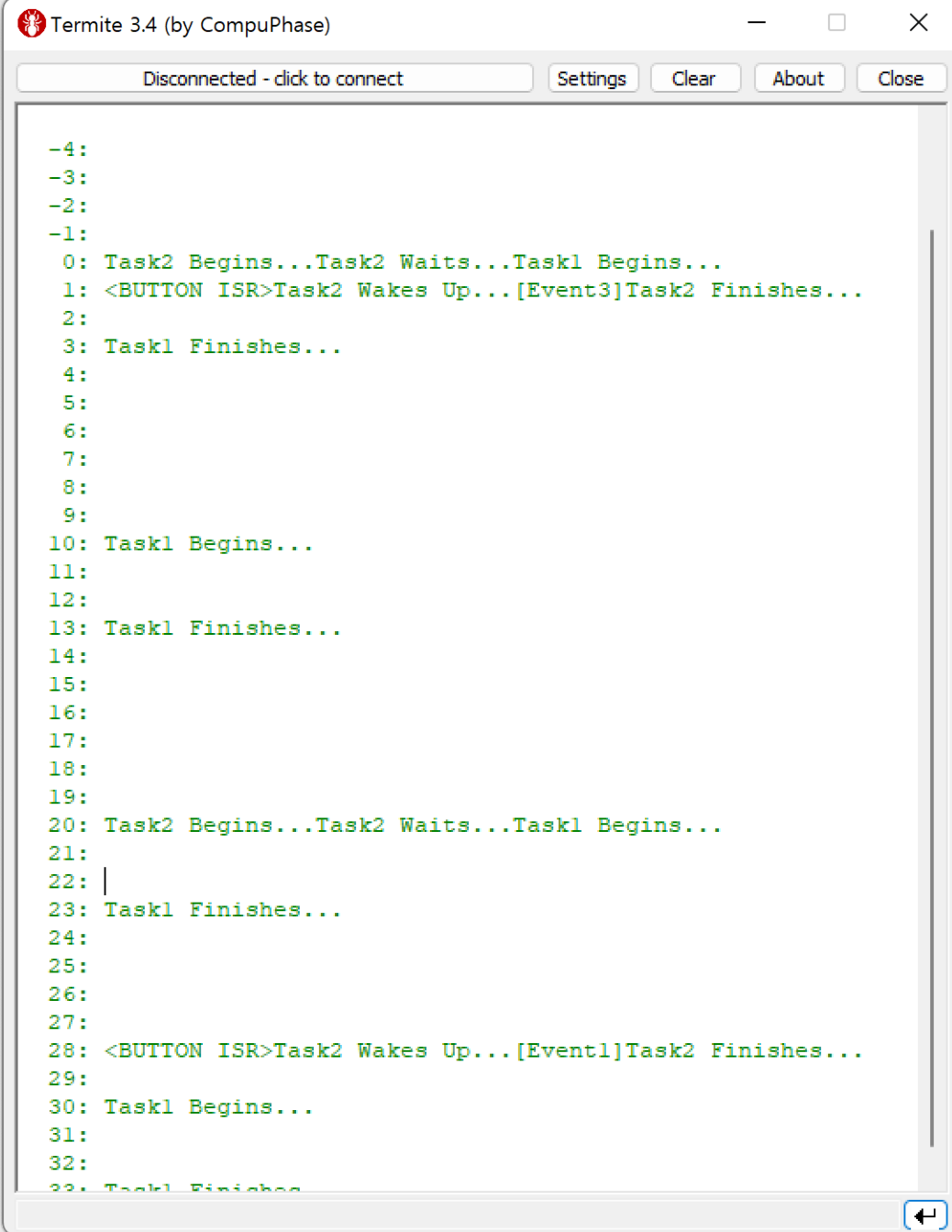
```
ISR2(ButtonISR)
{
    int a0;
    DisableAllInterrupts();
    if ((PINC & 0x01) != 0) return;
    printfSerial("<BUTTON ISR>");
    a0 = analogRead(A0); // read ADC value
    if (a0 < 50) { // UP
        SetEvent(Task2, Event1);
    } else if (a0 < 200) { // DOWN
        SetEvent(Task2, Event2);
    } else if (a0 < 380) { // LEFT
        ;
    } else if (a0 < 520) { // RIGHT
        ;
    }
    EnableAllInterrupts();
}
```

```
...
CPU_DATA = AVR8 {
    MULTI_STACK = TRUE;
};
...
EVENT Event1 { MASK = AUTO; };
EVENT Event2 { MASK = AUTO; };
...
TASK Task2 {
    PRIORITY = 2;
    STACK = PRIVATE {
        SIZE = 512;
    };
    SCHEDULE = FULL;
    EVENT = Event1;
    EVENT = Event1;
...

```

12. Event

- ClearEvent는 왜 필요한가?
- 우선순위 반대의 경우 스케줄링



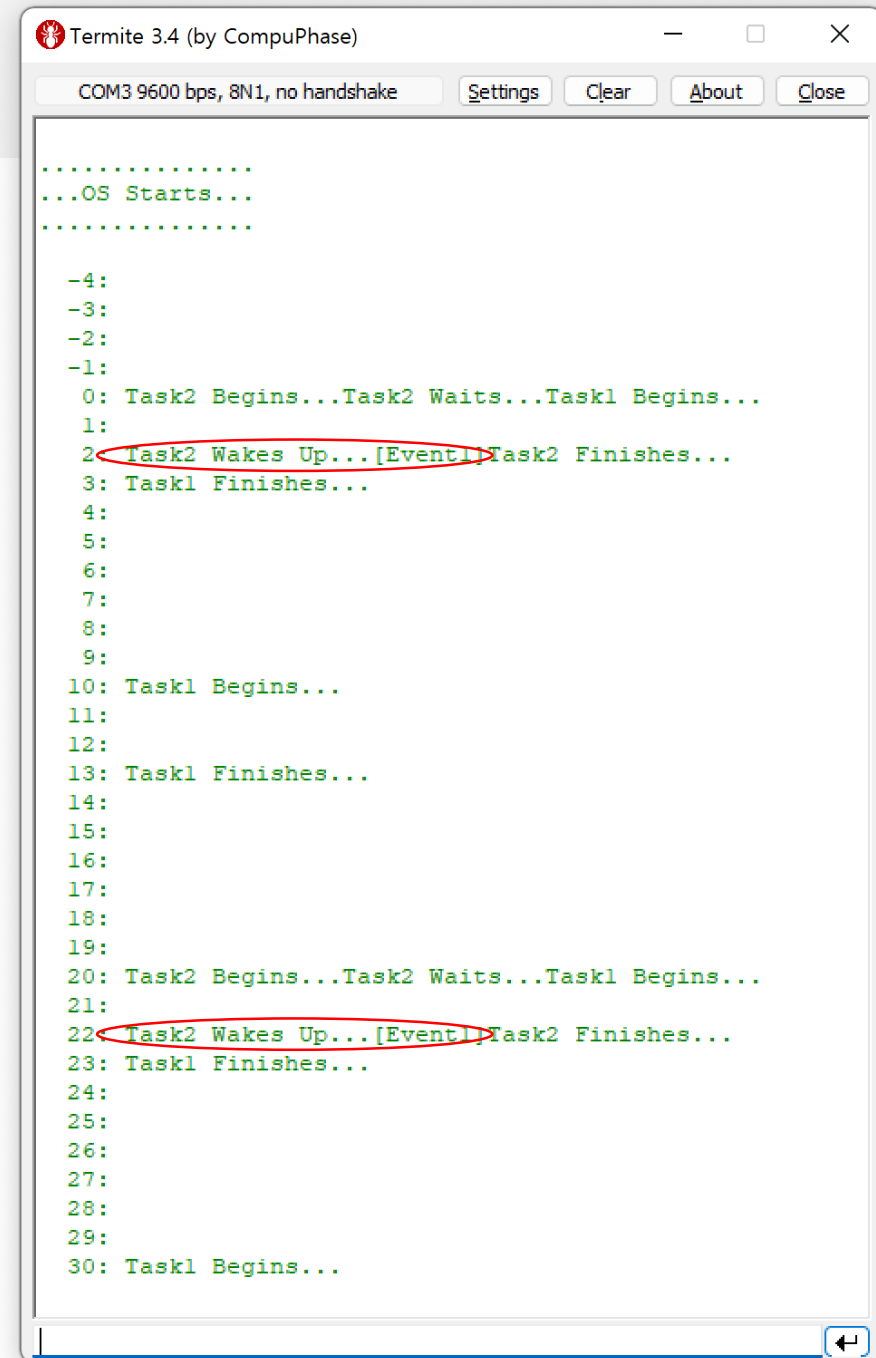
The screenshot shows a window titled "Termite 3.4 (by CompuPhase)". At the top, there is a status bar that says "Disconnected - click to connect" and four buttons: "Settings", "Clear", "About", and "Close". The main area of the window is a text log displaying a sequence of events. The events are numbered from -4 to 33. The log shows the execution of two tasks, Task1 and Task2, with various states like "Begins...", "Waits...", "Wakes Up...", and "Finishes...". The events are as follows:

```
-4:
-3:
-2:
-1:
 0: Task2 Begins...Task2 Waits...Task1 Begins...
 1: <BUTTON ISR>Task2 Wakes Up...[Event3]Task2 Finishes...
 2:
 3: Task1 Finishes...
 4:
 5:
 6:
 7:
 8:
 9:
10: Task1 Begins...
11:
12:
13: Task1 Finishes...
14:
15:
16:
17:
18:
19:
20: Task2 Begins...Task2 Waits...Task1 Begins...
21:
22: |
23: Task1 Finishes...
24:
25:
26:
27:
28: <BUTTON ISR>Task2 Wakes Up...[Event1]Task2 Finishes...
29:
30: Task1 Begins...
31:
32:
33: Task1 Finishes...
```

13. Alarm SetEvent

- Alarm의 SetEvent Action

```
ALARM alarm3 {  
    COUNTER = counter1;  
    ACTION = SETEVENT {  
        TASK = Task2;  
        EVENT = Event1;  
    };  
    AUTOSTART = TRUE {  
        ALARMTIME = 7;  
        CYCLETIME = 20;  
    };  
};
```



```
Termite 3.4 (by CompuPhase)  
COM3 9600 bps, 8N1, no handshake Settings Clear About Close  
.....  
...OS Starts...  
.....  
-4:  
-3:  
-2:  
-1:  
0: Task2 Begins...Task2 Waits...Task1 Begins...  
1:  
2: Task2 Wakes Up...[Event1] Task2 Finishes...  
3: Task1 Finishes...  
4:  
5:  
6:  
7:  
8:  
9:  
10: Task1 Begins...  
11:  
12:  
13: Task1 Finishes...  
14:  
15:  
16:  
17:  
18:  
19:  
20: Task2 Begins...Task2 Waits...Task1 Begins...  
21:  
22: Task2 Wakes Up...[Event1] Task2 Finishes...  
23: Task1 Finishes...  
24:  
25:  
26:  
27:  
28:  
29:  
30: Task1 Begins...
```

14. Hook

- OIL 파일 Hook 설정
- Alarm3 삭제
- 8번 예제의 printState() 추가

```
...  
    KERNEL_TYPE = OSEK {  
        CLASS = ECC2; // Default  
    };  
    STARTUPHOOK = TRUE;  
    SHUTDOWNHOOK = TRUE;  
    PRETASKHOOK = TRUE;  
    POSTTASKHOOK = TRUE;  
};  
...
```

14. Hook

- Task2 변경
- 8번 예제의 printState() 사용. 추가

```
TASK(Task2)
{
    printfSerial("Task2 Begins...");
    mdelay(3000);
    printfSerial("Task2 Finishes...");
    TerminateTask();
}
```

14. Hook

- StartupHook
- ShutdownHook

```
void StartupHook(void)
{
    printfSerial("..StartupHook..\n");
}

void ShutdownHook(StatusType Error)
{
    printfSerial("ShutdownHook...\n");
    printState(Task1);
    printState(Task2);
}
```

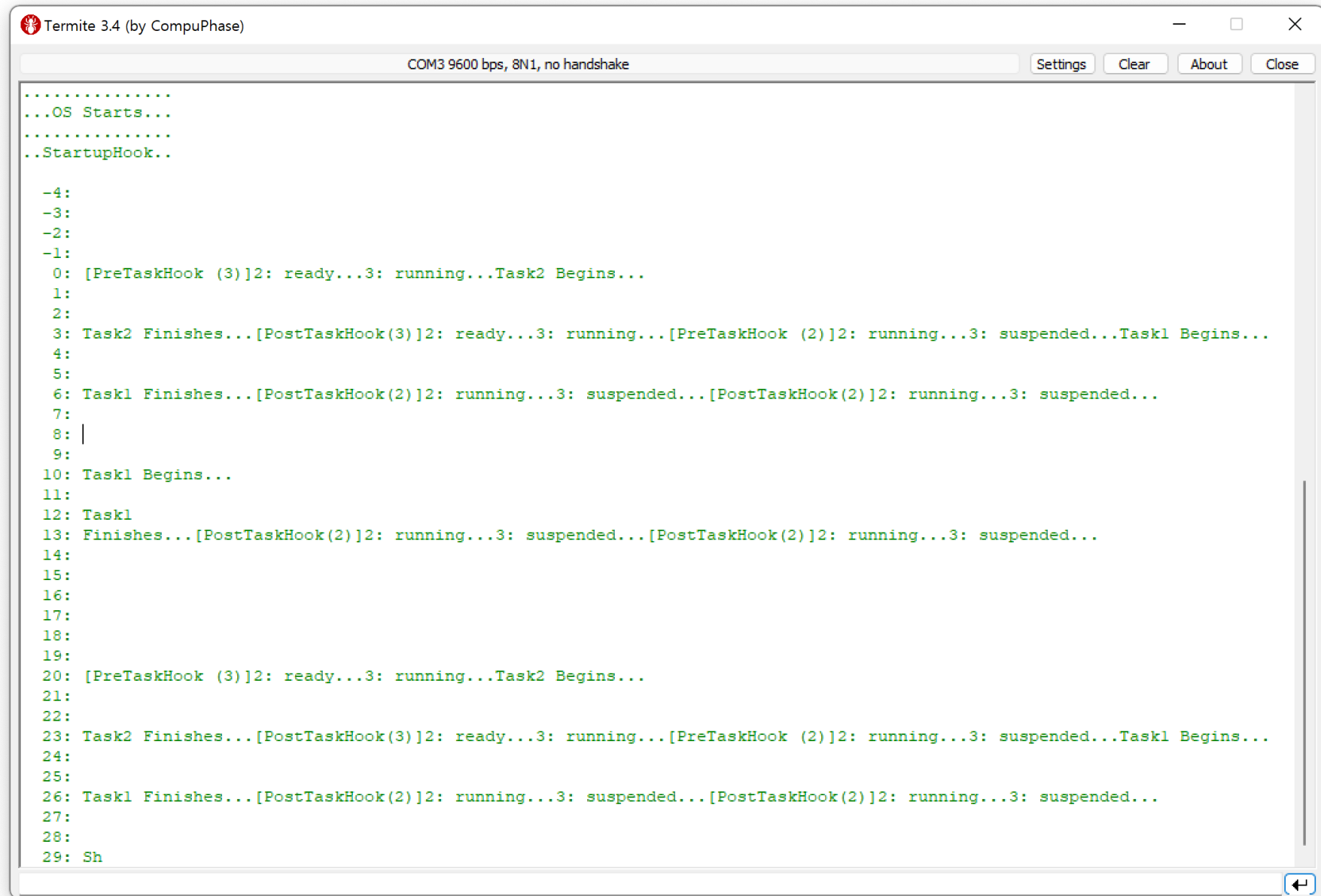
14. Hook

- PreTaskHook
- PostTaskHook

```
void PreTaskHook(void)
{
    TaskType id;
    GetTaskID(&id);
    printfSerial("[PreTaskHook(%d)]", id);
    printState(Task1);
    printState(Task2);
}

void PostTaskHook(void)
{
    TaskType id;
    GetTaskID(&id);
    printfSerial("[PostTaskHook(%d)]", id);
    printState(Task1);
    printState(Task2);
}
```


14. Hook



The screenshot shows a window titled "Termit 3.4 (by CompuPhase)" with a status bar indicating "COM3 9600 bps, 8N1, no handshake". The window contains a text area with the following text:

```
.....  
...OS Starts...  
.....  
..StartupHook..  
  
-4:  
-3:  
-2:  
-1:  
 0: [PreTaskHook (3)]2: ready...3: running...Task2 Begins...  
 1:  
 2:  
 3: Task2 Finishes...[PostTaskHook(3)]2: ready...3: running...[PreTaskHook (2)]2: running...3: suspended...Task1 Begins...  
 4:  
 5:  
 6: Task1 Finishes...[PostTaskHook(2)]2: running...3: suspended...[PostTaskHook(2)]2: running...3: suspended...  
 7:  
 8: |  
 9:  
10: Task1 Begins...  
11:  
12: Task1  
13: Finishes...[PostTaskHook(2)]2: running...3: suspended...[PostTaskHook(2)]2: running...3: suspended...  
14:  
15:  
16:  
17:  
18:  
19:  
20: [PreTaskHook (3)]2: ready...3: running...Task2 Begins...  
21:  
22:  
23: Task2 Finishes...[PostTaskHook(3)]2: ready...3: running...[PreTaskHook (2)]2: running...3: suspended...Task1 Begins...  
24:  
25:  
26: Task1 Finishes...[PostTaskHook(2)]2: running...3: suspended...[PostTaskHook(2)]2: running...3: suspended...  
27:  
28:  
29: Sh
```

15. Error Handling

- OIL 파일 설정

오류가 발생한 Service ID와
Parameter 정보 접근

```
...  
    KERNEL_TYPE = OSEK {  
        CLASS = ECC2; // Default  
    };  
    STARTUPHOOK = FALSE;  
    SHUTDOWNHOOK = FALSE;  
    PRETASKHOOK = FALSE;  
    POSTTASKHOOK = FALSE;  
    ERRORHOOK = TRUE;  
    USEGETSERVICEID = TRUE;  
    USEPARAMETERACCESS = TRUE;  
};  
...
```

15. Error Handling

```
ISR2(TimerISR)
{
    static long c = -4;
    TaskStateType s;
    if (c == 5) {
        GetTaskState(30, &s);
    }
    IncrementCounter(counter1);
    printfSerial("\n%4ld: ", c++);
}
```

```
void ErrorHook(StatusType error)
{
    printfSerial("[ErrorHook: error = %d, service = %d, TaskID = %d]",
        error,
        OSErrorGetServiceId(),
        OSError_GetTaskState_TaskID());
}
```

Parameter 정보 접근 매크로
(ee_oo_api_osek.h)

15. Error Handling

```
E_OK,                /* ((StatusType)0) */
E_OS_ACCESS,         /* ((StatusType)1) */
E_OS_CALLEVEL,       /* ((StatusType)2) */
E_OS_ID,             /* ((StatusType)3) */
E_OS_LIMIT,          /* ((StatusType)4) */
E_OS_NOFUNC,         /* ((StatusType)5) */
E_OS_RESOURCE,       /* ((StatusType)6) */
E_OS_STATE,          /* ((StatusType)7) */
E_OS_VALUE,          /* ((StatusType)8) */
E_OS_SERVICEID,      /* ((StatusType)9) */
E_OS_ILLEGAL_ADDRESS, /* ((StatusType)10) */
...
```

ee_api_types.h

```
OSServiceId_ActivateTask      = (0),
OSServiceId_TerminateTask     = (2),
OSServiceId_ChainTask         = (4),
OSServiceId_Schedule          = (6),
OSServiceId_GetTaskID         = (8),
OSServiceId_GetTaskState      = (10)
,
OSServiceId_DisableAllInterrupts = (12)
,
OSServiceId_EnableAllInterrupts = (14)
,
OSServiceId_SuspendAllInterrupts = (16)
,
OSServiceId_ResumeAllInterrupts = (18)
,
OSServiceId_SuspendOSInterrupts = (20)
,
OSServiceId_ResumeOSInterrupts = (22)
...
```

15. Error Handling

```
/**
 * \brief This macro returns the TaskID parameter passed to ActivateTask().
 * \ingroup primitives-hook
 */
#define OSErrror_ActivateTask_TaskID()\
    ((TaskType)osEE_get_api_param1().num_param)

/**
 * \brief This macro returns the TaskID parameter passed to ChainTask().
 * \ingroup primitives-hook
 */
#define OSErrror_ChainTask_TaskID()\
    ((TaskType)osEE_get_api_param1().num_param)

/**
 * \brief This macro returns the TaskID parameter passed to GetTaskID().
 * \ingroup primitives-hook
 */
#define OSErrror_GetTaskID_TaskID()\
    ((TaskRefType)osEE_get_api_param1().p_param)
```

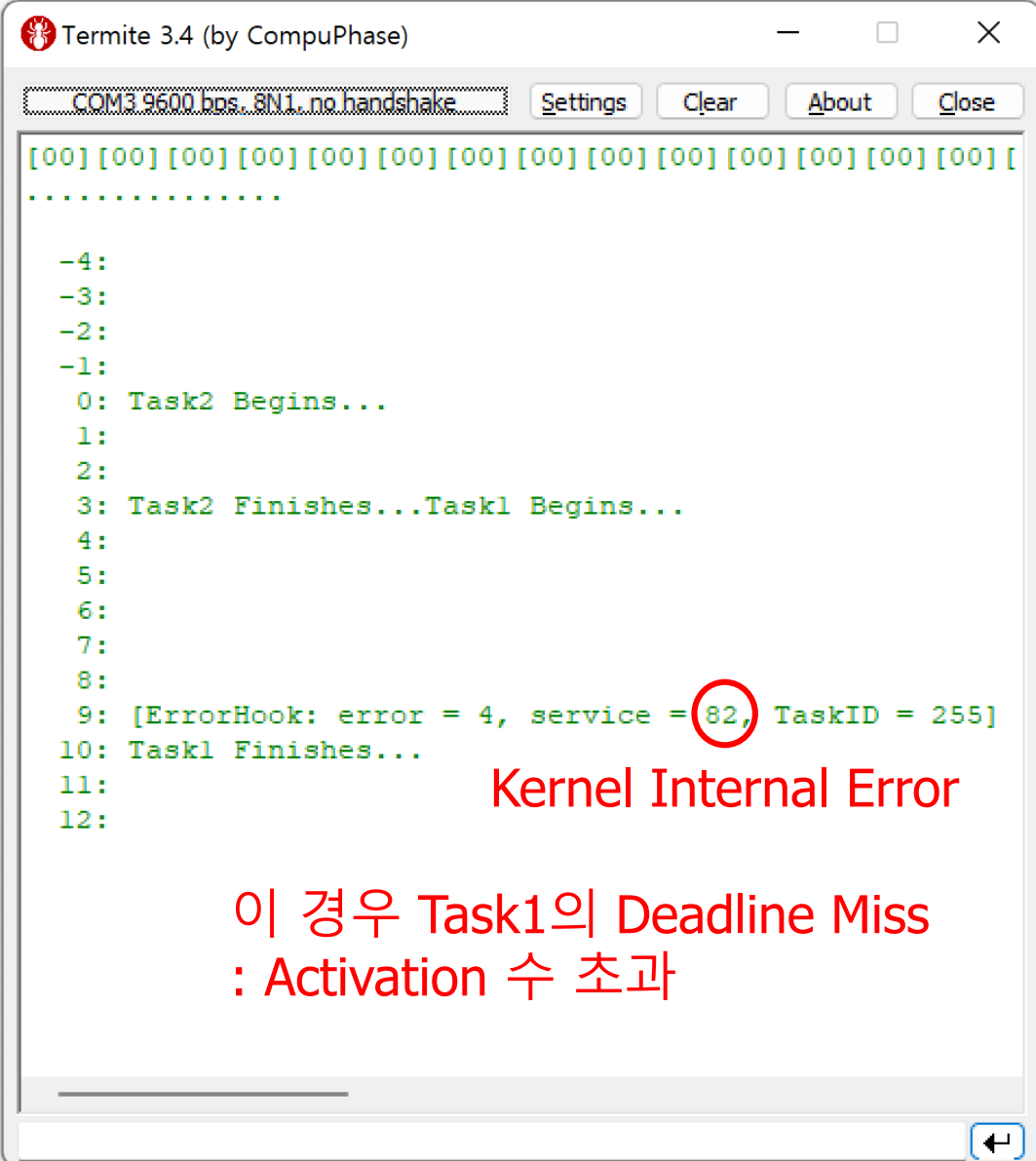
ee_oo_api_osek.h

16. Deadline Miss

```
ISR2(TimerISR)
{
    static long c = -4;

    IncrementCounter(counter1);
    printfSerial("\n%4ld: ", c++);
}

TASK(Task1)
{
    TaskType id;
    printfSerial("Task1 Begins...");
    mdelay(7000);
    printfSerial("Task1 Finishes...");
    TerminateTask();
}
```



The screenshot shows the Termite 3.4 serial terminal window. The title bar reads "Termite 3.4 (by CompuPhase)". The status bar at the top indicates "COM3 9600 bps, 8N1, no handshake". The main display area shows a sequence of events: lines -4 through -1 show a counter incrementing from -4 to -1; line 0 says "Task2 Begins..."; line 1 is blank; line 2 is blank; line 3 says "Task2 Finishes...Task1 Begins..."; line 4 is blank; line 5 is blank; line 6 is blank; line 7 is blank; line 8 is blank; line 9 shows an error: "[ErrorHook: error = 4, service = 82, TaskID = 255]"; line 10 says "Task1 Finishes..."; line 11 is blank; line 12 is blank. The value "82" in the error message is circled in red. Below the terminal window, there is red Korean text: "이 경우 Task1의 Deadline Miss : Activation 수 초과".

```
COM3 9600 bps, 8N1, no handshake Settings Clear About Close

[00] [00] [00] [00] [00] [00] [00] [00] [00] [00] [00] [00] [00] [00] [
.....

-4:
-3:
-2:
-1:
 0: Task2 Begins...
 1:
 2:
 3: Task2 Finishes...Task1 Begins...
 4:
 5:
 6:
 7:
 8:
 9: [ErrorHook: error = 4, service = 82, TaskID = 255]
10: Task1 Finishes...
11:
12:
```

이 경우 Task1의 Deadline Miss
: Activation 수 초과

Questions

