Real-Time Operating System (Day 1 Lab)

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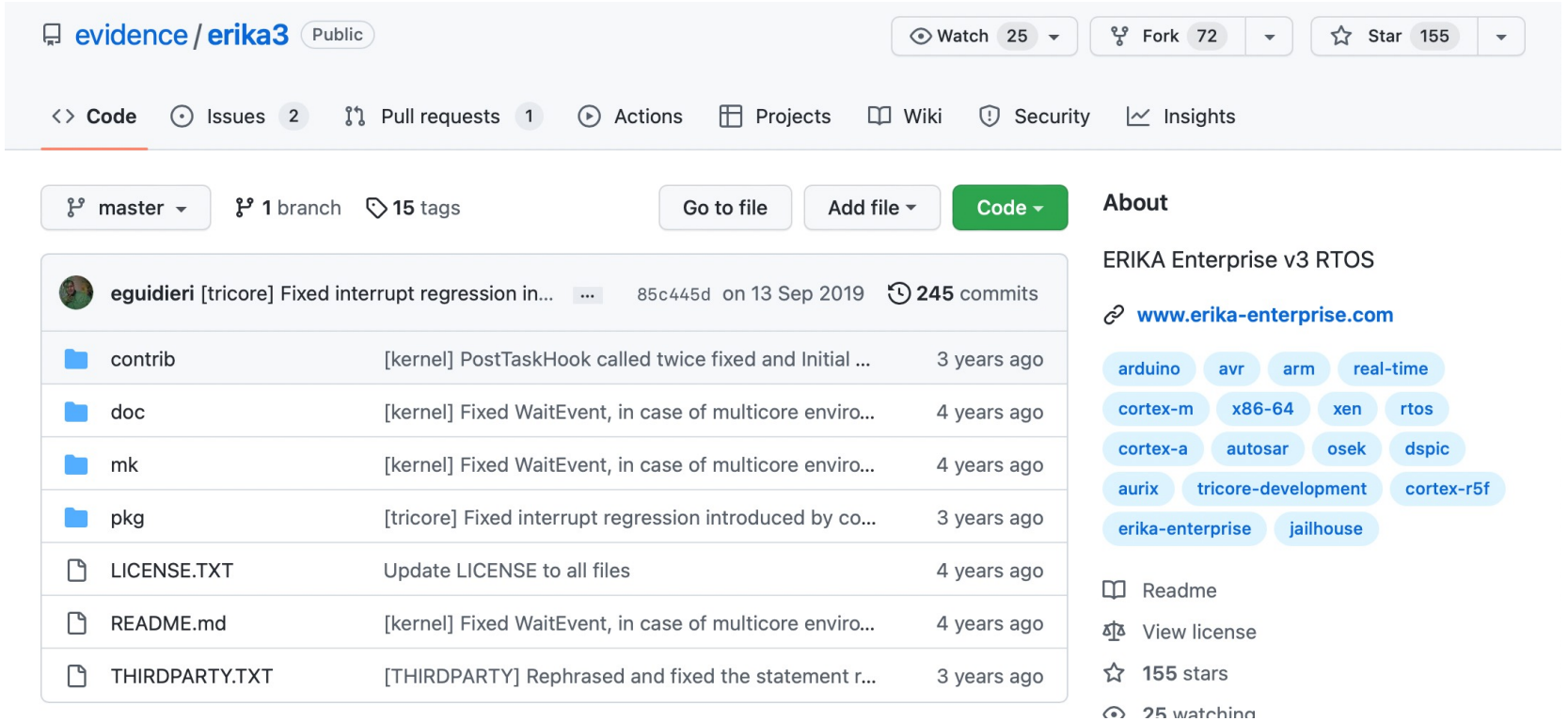
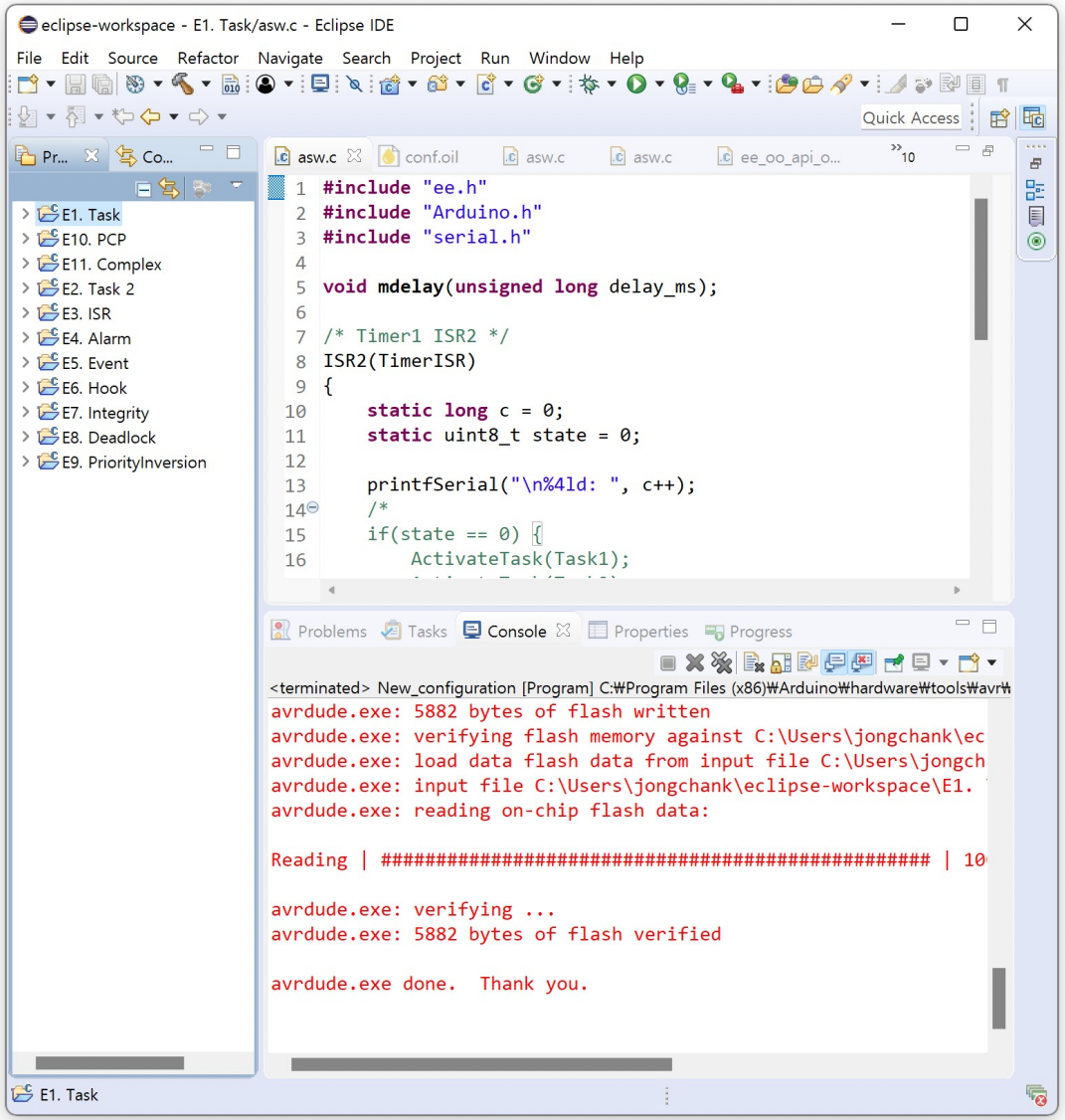
Erika Enterprise

- 이탈리아 EVIDENCE에서 개발된 오픈소스 OSEK/VDX RTOS
- 듀얼 라이센스 정책 (오픈소스 라이센스 + 상용 라이센스)
- RTOS 연구 및 교육에 널리 사용
- GitHub 리포

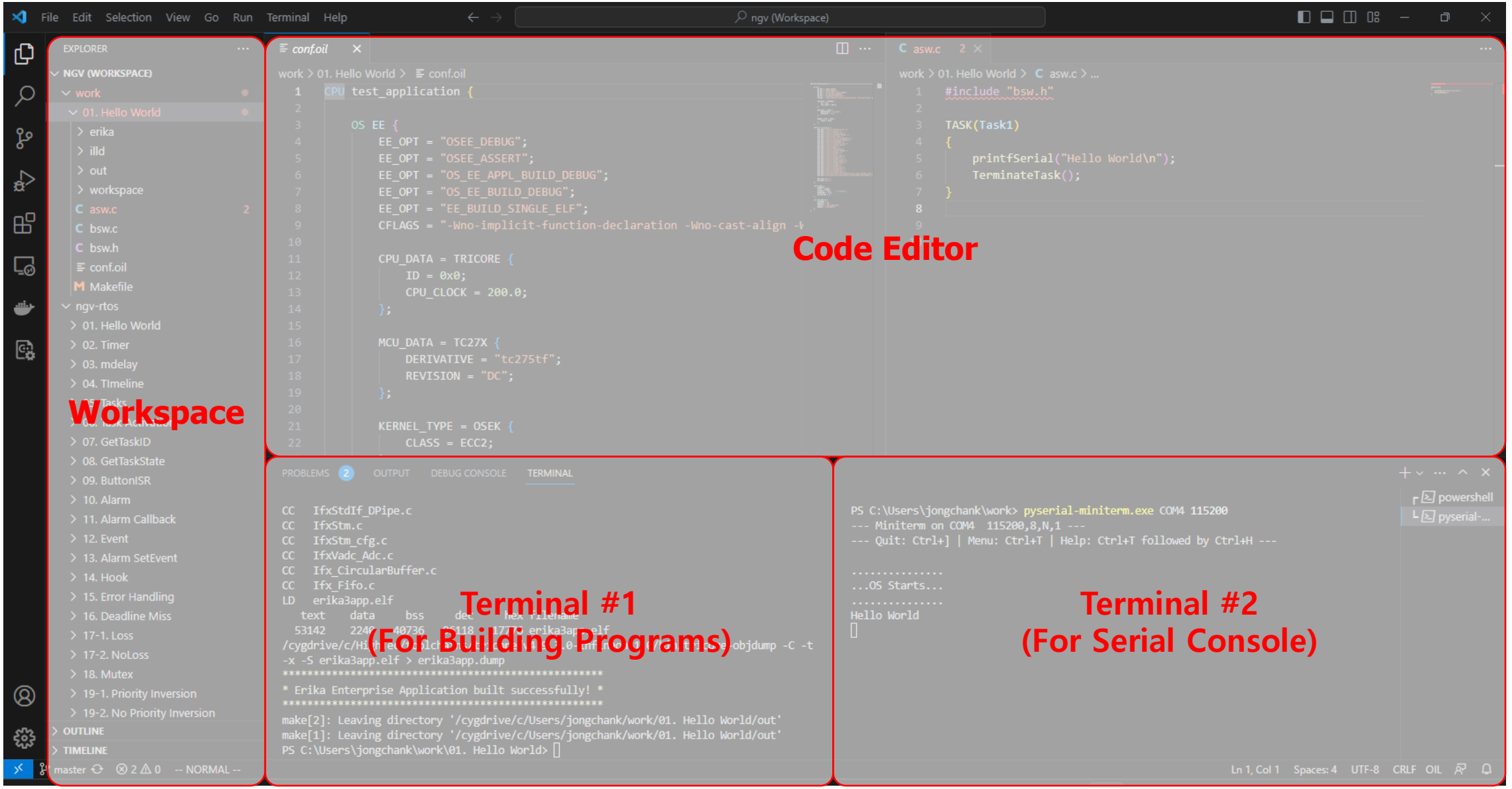


Eclipse 기반 IDE (old)

- 프로젝트 생성
- OIL 파일, C/C++ 파일 편집
- 프로젝트 빌드
- 실행파일 다운로드
- …

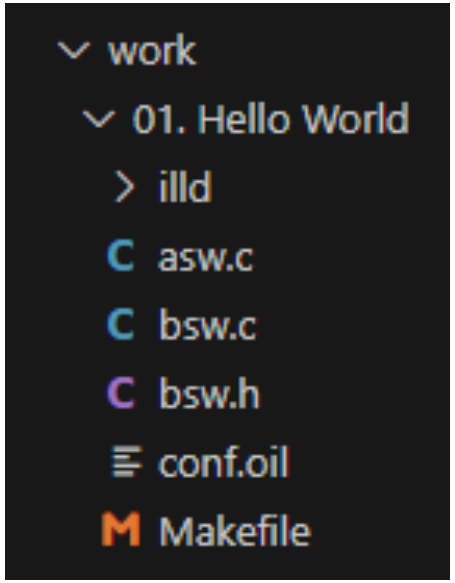


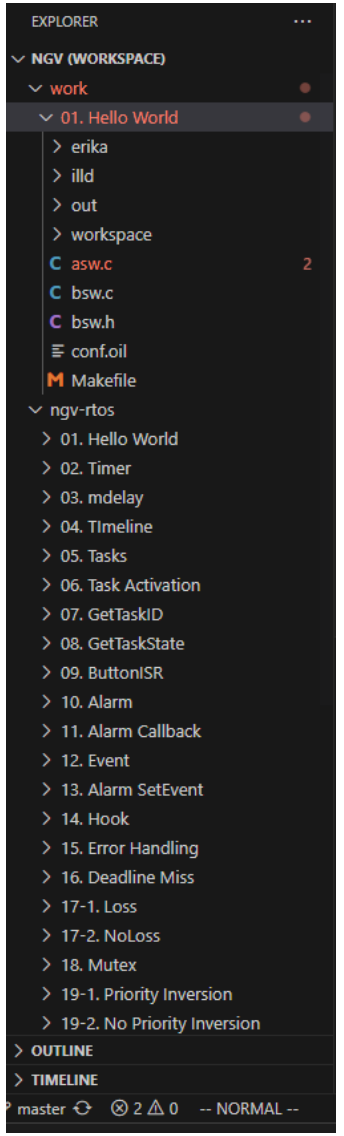
Visual Studio Code 기반 개발환경 (new)



Workspace

- Workspace File
  - `C:\Users\user\ngv.code-workspace`
- Imported Directories
  - `C:\Users\user\work`: working directory
  - `C:\Users\user\ngv-rtos`: example projects Git Repository
- Example Projects Directory Structure
  - `illd/`: Infineon Low Level Driver
  - `asw.c`: Application SW code
  - `bsw.c`: Basic SW code
  - `bsw.h`: Basic SW header
  - `conf.oil`: OIL configuration file
  - `Makefile`: Top-level Makefile



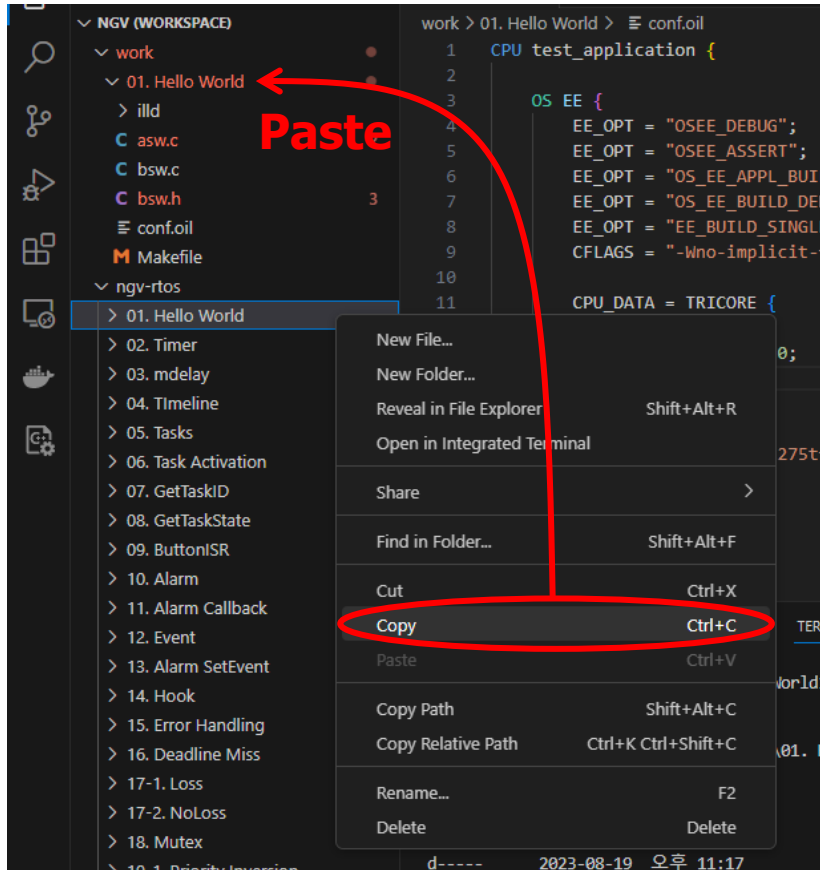


Working

Examples

Workflow

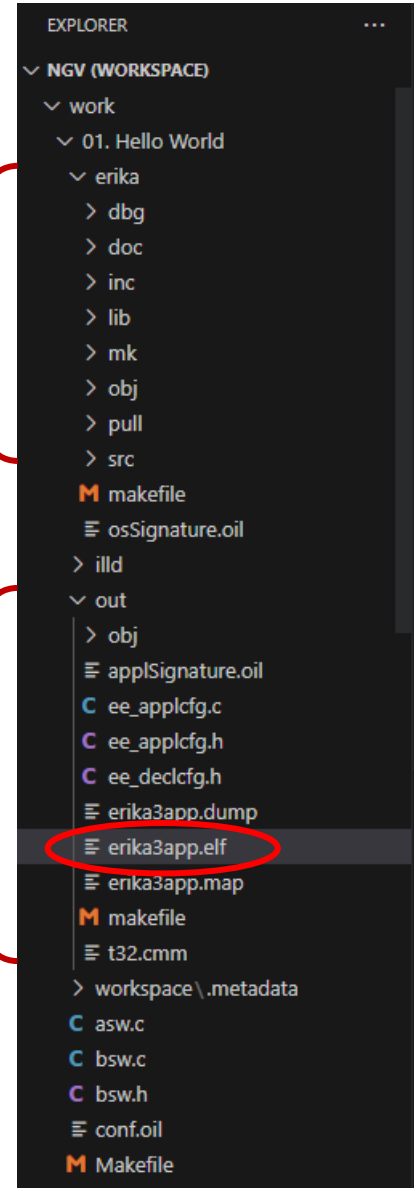
- Basic Workflow
  1) Copy a project (e.g., 01. Hello World) from ngv-rtos to work
  2) Edit source files (.C or .H) and OIL files
  3) Build
- Build Process (in Terminal #1)
  1) `cd work/01. Hello World`
  2) `make config`
     - Generate OS kernel files from conf.oil
  3) `Make`
     - Generate an executable file



Generated Files

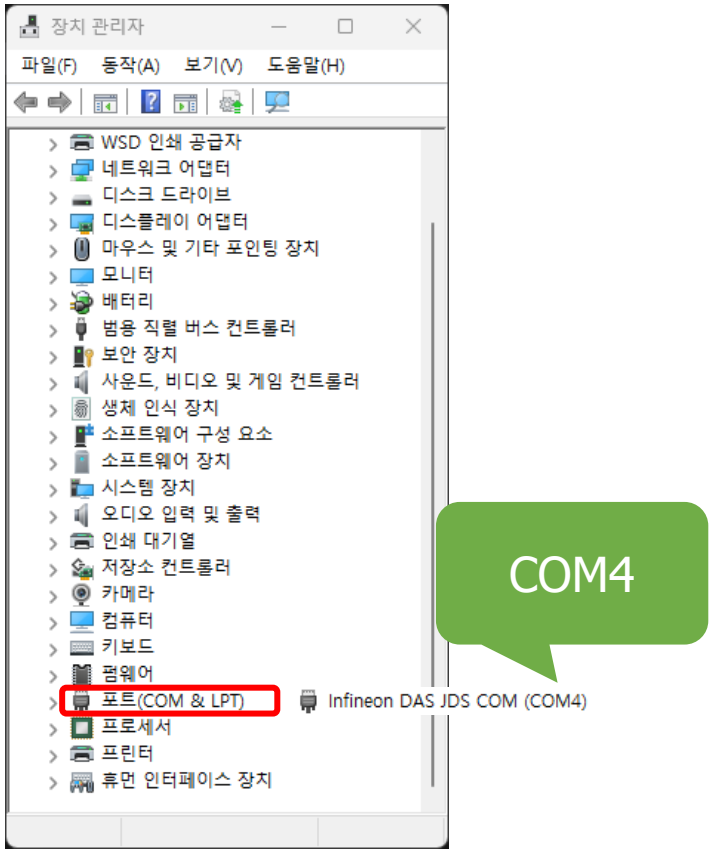
- erika/
  - OS source files

- out/
  - Generated files from the OIL file
  - Object files
  - Executable (ELF) file (`erika3app.elf`)



Serial Console

- 장치관리자에서 COM 포트 확인 (e.g., COM4)
- pyserial-miniterm 이용하여 시리얼 콘솔 시작 (Terminal #2)



COM4

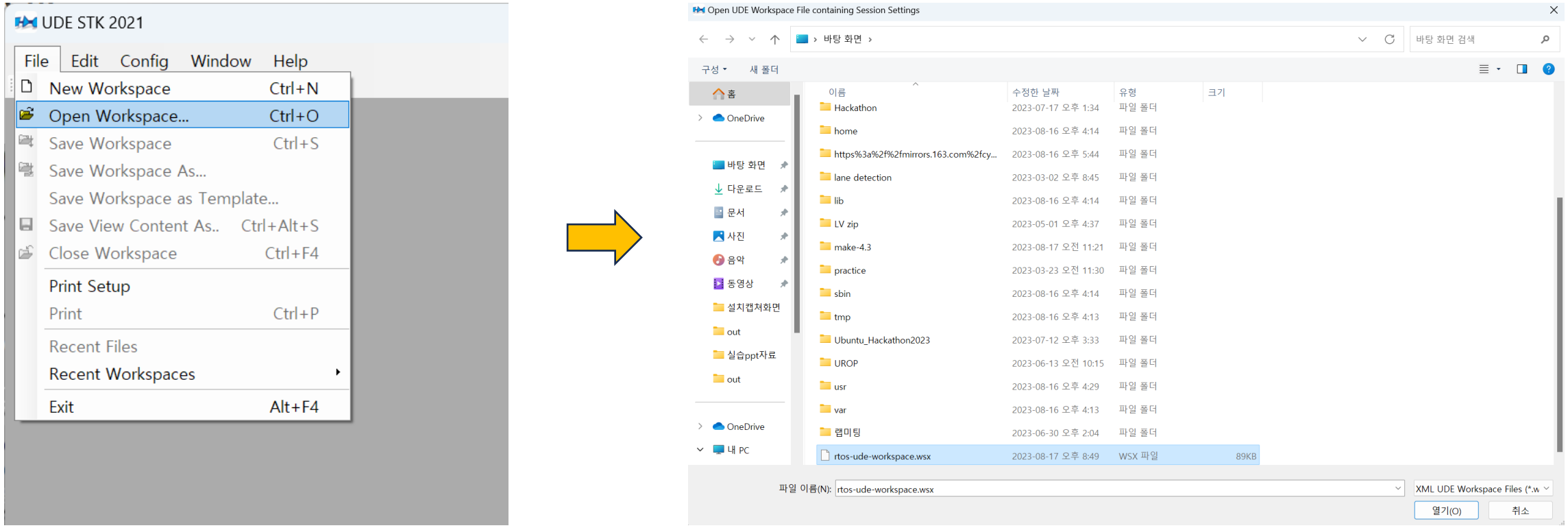
COM 포트

Baudrate

```
PS C:\Users\jongchank\work> pyserial-miniterm.exe COM4 115200
--- Miniterm on COM4  115200,8,N,1 ---
--- Quit: Ctrl+] | Menu: Ctrl+T | Help: Ctrl+T followed by Ctrl+H ---
```

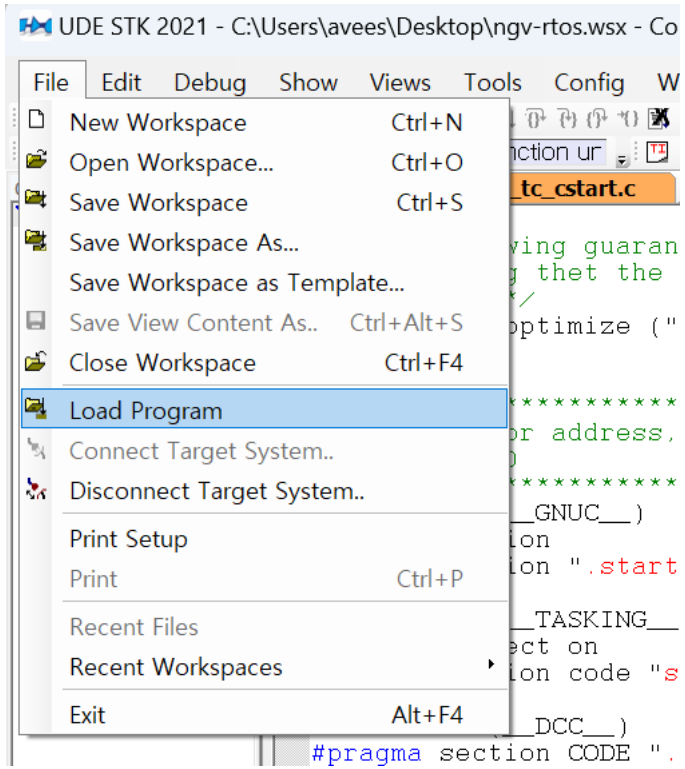
Program Flashing by UDE #1

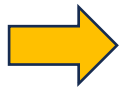
- File → Open Workspace
- 바탕화면의 rtos-ude-workspace.wsx 열기

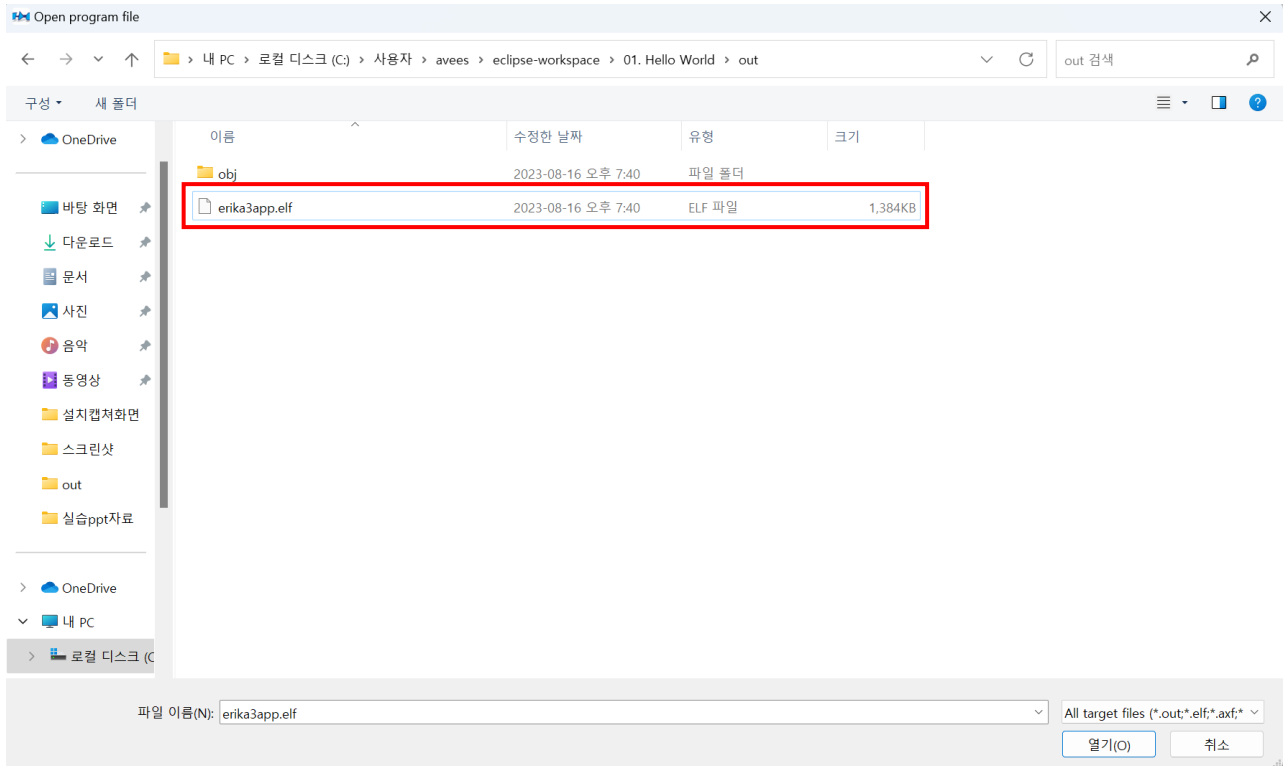


Program Flashing by UDE #2

- File → Load Program
- 프로젝트 폴더의 out/erika3app.elf 열기





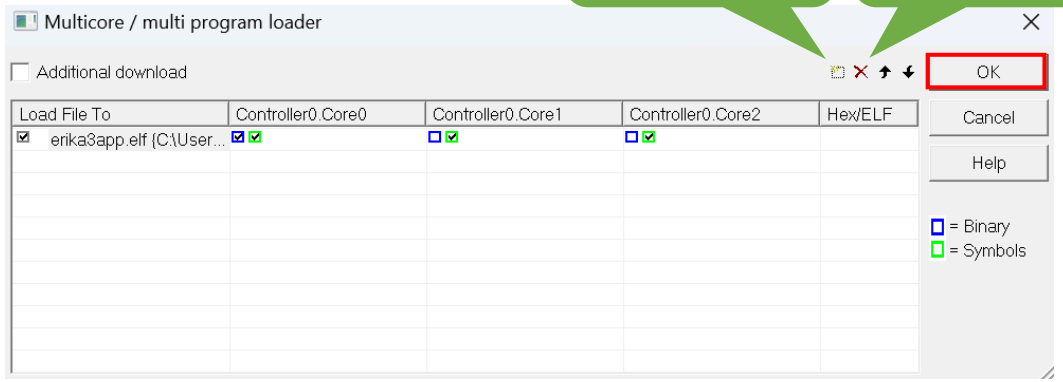


Program Flashing by UDE #3

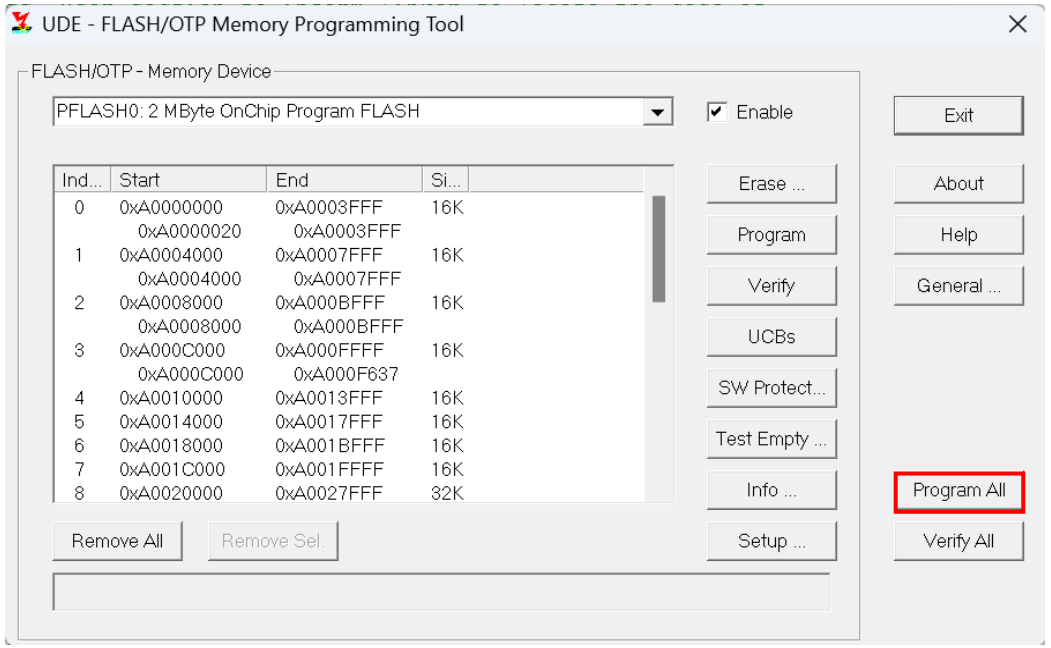
새 파일 열기

기존 파일 해제

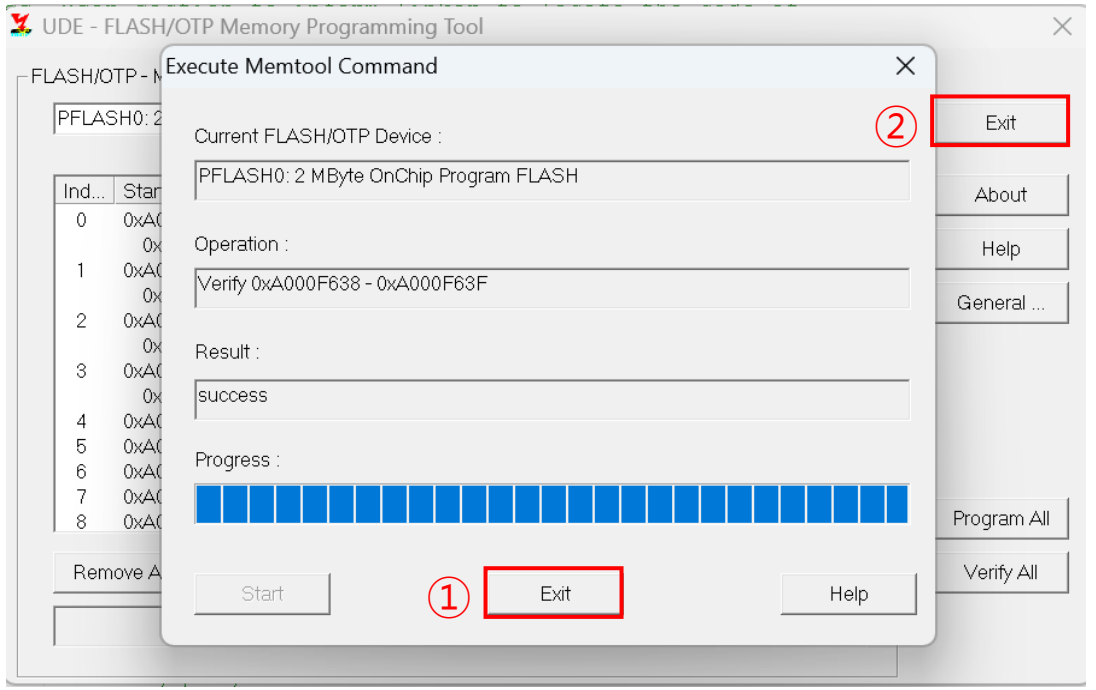
- Step1



- Step2

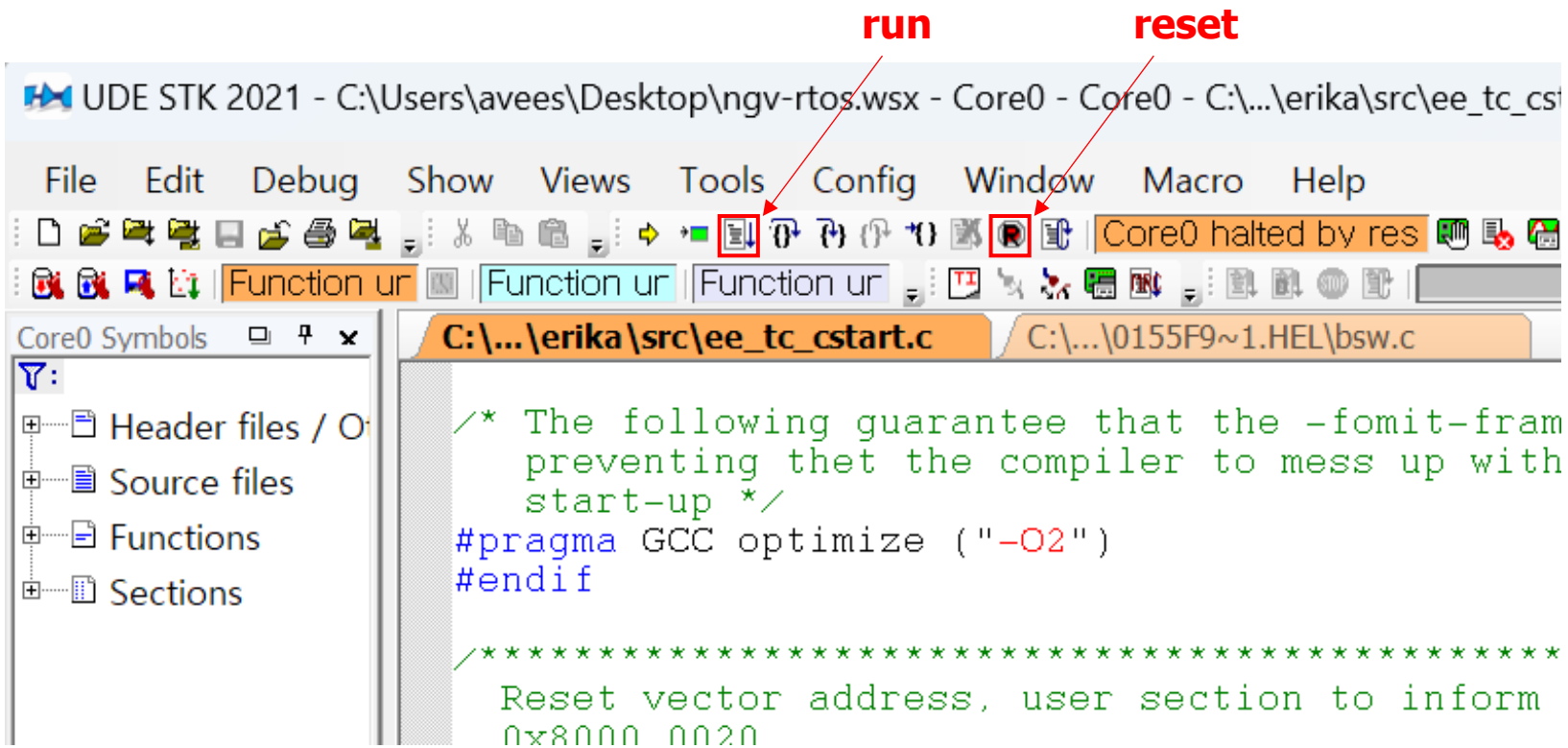


- Step3



Program Flashing by UDE #4

- 프로그램 실행 (run)
- 기존 프로그램 실행중일 경우 reset 후 실행



01. Hello World

- 00. Template 복사
- asw.c에 TASK 추가
- OIL 파일에 TASK 추가
- printfSerial() 함수 사용 (시리얼 콘솔 출력)

Make config는 OIL 변경시에만

```
$ make config
$ make
```

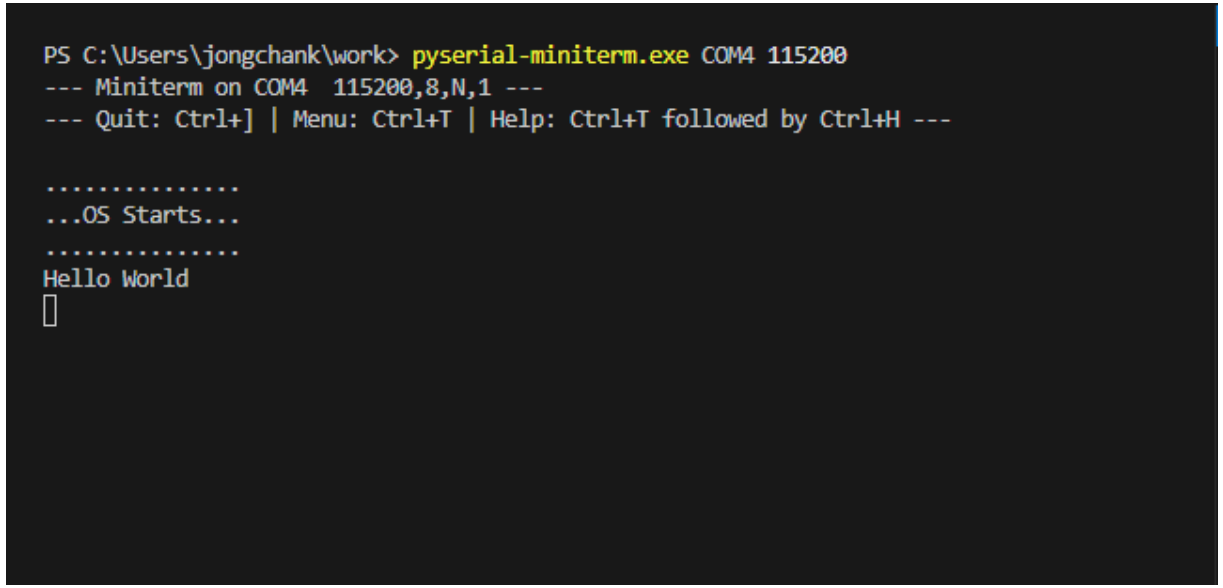
```c
#include "bsw.h"


TASK(Task1)
{
    printfSerial("Hello World\n");

    TerminateTask();
}
```

```
TASK Task1 {
    PRIORITY = 1;
    STACK = SHARED;
    SCHEDULE = FULL;
    AUTOSTART = TRUE;
    ACTIVATION = 1;
};
```

자동 시작

01. Hello World

- OS 시작 후
- Hello World 출력



02. Timer

- C 파일에 ISR2로 TimerISR 추가
- OIL 파일에 TimerISR 추가
  - Category 2

1초 뒤
interrupt 등록

```
ISR2(TimerISR)
{
    osEE_tc_stm_set_sr0_next_match(1000000U);
    printfSerial("Timer\n");
}
```

```
ISR TimerISR {
    CATEGORY = 2;
    SOURCE = "STM0SR0";
    PRIORITY = 2;
};
```

02. Timer

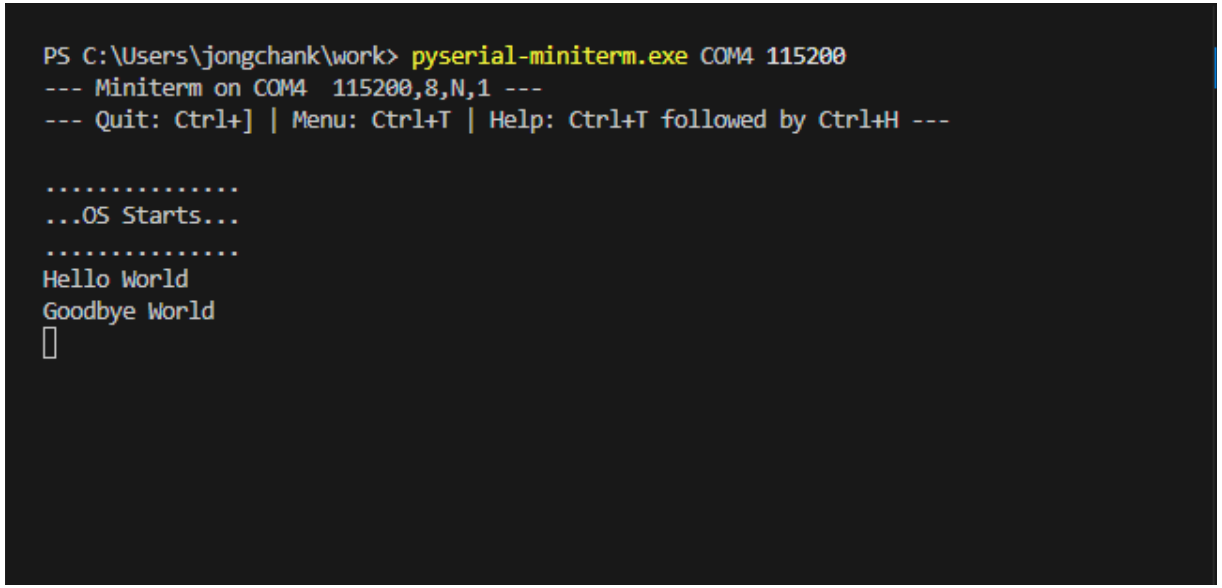
- Hello World 출력후 Timer 반복

```
PS C:\Users\jongchank\work> pyserial-miniterm.exe COM4 115200
--- Miniterm on COM4  115200,8,N,1 ---
--- Quit: Ctrl+] | Menu: Ctrl+T | Help: Ctrl+T followed by Ctrl+H ---

..............
...OS Starts...
..............
Hello World
Timer
Timer
Timer
Timer
Timer
```

03. mdelay

- mdelay 함수 이용 3초 실행시간

```
TASK(Task1)
{
    printfSerial("Hello World\n");

    mdelay(3000);

    printfSerial("Goodbye World\n");
    TerminateTask();
}
```



04. Timeline

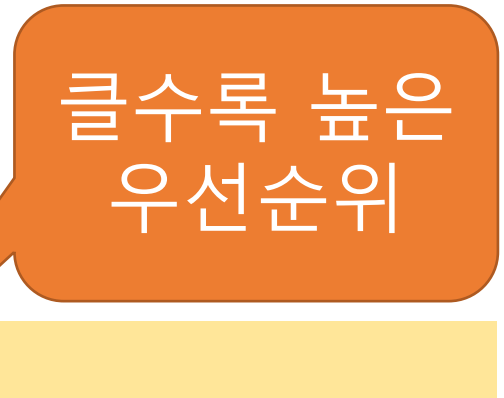
- TimerISR 이용 초단위 Timeline 출력

```
ISR2(TimerISR)
{
    static long c = 0;
    osEE_tc_stm_set_sr0_next_match(1000000U);
    printfSerial("\n%4ld: ", c++);
}
```

05. Tasks

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

    TerminateTask();
}

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

    TerminateTask();
}
```

- 우선순위 2의 Task2 추가




```
TASK Task2 {
    PRIORITY = 2;
    STACK = SHARED;
    SCHEDULE = FULL;
    AUTOSTART = TRUE;
    ACTIVATION = 1;
};
```

05. Tasks

- Task2가 먼저 시작
- Task2 종료 후 Task1 시작

- 우선순위를 바꾼다면?

```
PS C:\Users\jongchank\work> pyserial-miniterm.exe COM4 115200
--- Miniterm on COM4  115200,8,N,1 ---
--- Quit: Ctrl+] | Menu: Ctrl+T | Help: Ctrl+T followed by Ctrl+H ---

..............
...OS Starts...
..............
Task2 Begins...
   0:
   1:
   2: Task2 Finishes...Task1 Begins...
   3:
   4:
   5: Task1 Finishes...
   6:
   7:
```

06. Task Activation

```
ISR2(TimerISR)
{
    static long c = -4;
    osEE_tc_stm_set_sr0_next_match(1000000U);
    if (c == 0)
        ActivateTask(Task1);
    printfSerial("\n%4ld: ", c++);
}

TASK(Task1)
{
    printfSerial("Task1 Begins...");
    mdelay(3000);
    ActivateTask(Task2);
    mdelay(3000);
    printfSerial("Task1 Finishes...");
    TerminateTask();
}
```

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

```
TASK Task1 {
    …
    AUTOSTART = FALSE;
    …
};

TASK Task2 {
    …
    AUTOSTART = FALSE;
    …
};
```

06. Task Activation

- Timeline -4부터 카운트다운
- Task2의 Task1 선점 확인
- ActivateTask 위치 바꾸면?
- 우선순위가 바뀌면?
- ChainTask 활용
- Task3까지 만들어서 연쇄 실행

```
-4:
-3:
-2:
-1:
 0: Task1 Begins...
 1:
 2:
 3: Task2 Begins...
 4:
 5:
 6: Task2 Finishes...
 7:
 8:
 9: Task1 Finishes...
10:
11:
```

07. GetTaskID

```
TASK(Task1)
{
    TaskType id;
    printfSerial("Task1 Begins...");
    mdelay(3000);
    ActivateTask(Task2);
    mdelay(3000);
    GetTaskID(&id);
    printfSerial("Task ID = %d...", id);
    printfSerial("Task1 Finishes...");
    TerminateTask();
}
```

```
TASK(Task2)
{
    TaskType id;
    printfSerial("Task2 Begins...");
    mdelay(3000);
    GetTaskID(&id);
    printfSerial("Task ID = %d...", id);
    printfSerial("Task2 Finishes...");
    TerminateTask();
}
```

07. GetTaskID

- 자연수 Task ID 확인
- Unique ID일 뿐 정의된 의미 없음

08. GetTaskState

```
TASK(TaskM)
{
    printState(Task1);
    printState(Task2);

    TerminateTask();
}
```

```
TASK TaskM {
    PRIORITY = 3;
    STACK = SHARED;
    SCHEDULE = FULL;
    AUTOSTART = FALSE;
    ACTIVATION = 1;
};
```

```
void printState(TaskType id) {
    TaskStateType state;

    if (GetTaskState(id, &state) == E_OK) {
        switch (state) {
            case SUSPENDED:
                printfSerial("%d: suspended...", id);
                break;
            case READY:
                printfSerial("%d: ready...", id);
                break;
            case WAITING:
                printfSerial("%d: waiting...", id);
                break;
            case RUNNING:
                printfSerial("%d: running...", id);
                break;
            }
    }
}
```

08. GetTaskState

```
TASK(Task1)
{
    TaskType id;
    printfSerial("Task1 Begins...");
    printState(Task1);
    printState(Task2);
    mdelay(3000);
    ActivateTask(Task2);
    printState(Task1);
    printState(Task2);
    mdelay(3000);
    GetTaskID(&id);
    printfSerial("Task ID = %d...", id);
    printfSerial("Task1 Finishes...");
    ChainTask(TaskM);
}
```

```
TASK(Task2)
{
    TaskType id;
    printfSerial("Task2 Begins...");
    printState(Task1);
    printState(Task2);
    mdelay(3000);
    GetTaskID(&id);
    printfSerial("Task ID = %d...", id);
    printfSerial("Task2 Finishes...");
    ChainTask(TaskM);
}
```

08. GetTaskState

- Task 상태 변화 관찰

- 우선순위, Activation 패턴 변화의 영향은?

```
 -1:
  0: Task1 Begins...2: running...4: suspended...
  1:
  2:
  3: Task2 Begins...2: ready...4: running...
  4:
  5:
  6: Task ID = 4...Task2 Finishes...2: ready...4: suspended...2: running...4: suspend
ed...
  7:
  8:
  9: Task ID = 2...Task1 Finishes...2: suspended...4: suspended...
 10:
 11:
 12:
 13:
 14:
```

Questions