

Embedded and ambient systems

2025.09.17.

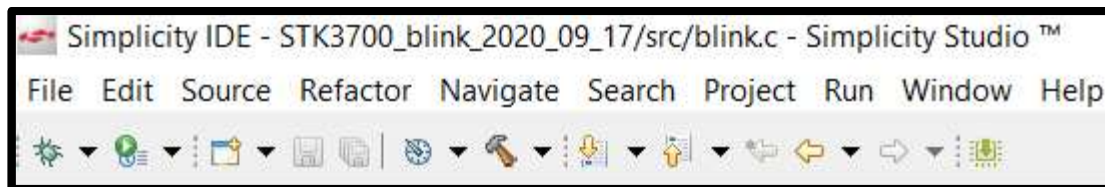
Practice 2



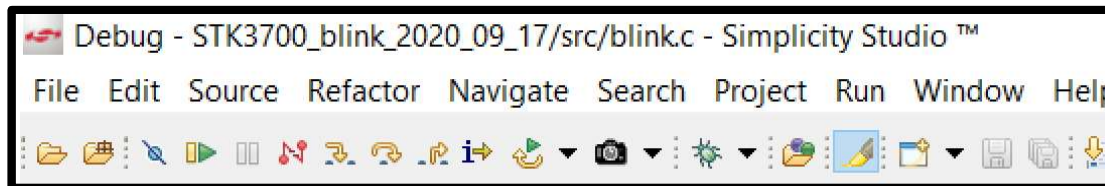
Department of
Artificial Intelligence and
Systems Engineering

Example: Blink project

- Review of Blink project at a source code level
- Note icon  : compiles and loads (Debug active)
- Note icon  : only compiles (IDE mode only)
 - Can my code be compiled?
 - Is there any syntactical error?
- Note icon  : starts the downloaded code
- Note icon  : disconnects and switches IDE mode



->IDE mode



->Debug mode

Example: Blink project

- Written in C programming language
- Entry point is the main function, this function is called and so the program starts here

```
int main(void)
{
    /* Chip errata */
    CHIP_Init(); → HW errors corrected in SW

    /* If first word of user data page is non-zero, enable Energy Profiler trace */
    BSP_TraceProfilerSetup(); → Real-time data acquisition

    /* Setup SysTick Timer for 1 msec interrupts */
    if (SysTick_Config(CMU_ClockFreqGet(CMU_Clock_CORE) / 1000)) {
        while (1); Initialize SysTick timer peripheral that calls  
SysTick_Handler interrupt function in every 1ms  
and increments msTicks variable in every 1ms
    }

    /* Initialize LED driver */
    BSP_LedsInit(); → Initialize the LEDs
    BSP_LedSet(0); → Set LED nr.0, i.e., turned on

    /* Infinite blink loop */
    while (1) { → In the while loop blinking LED algorithm is implemented
        BSP_LedToggle(0); → Change the state of LED nr.0
        BSP_LedToggle(1); → Change the state of LED nr.1
        Delay(1000); → Wait 1000ms
    }
}

void SysTick_Handler(void)
{
    msTicks++; /* increment msTicks variable */
}
```

Delay function

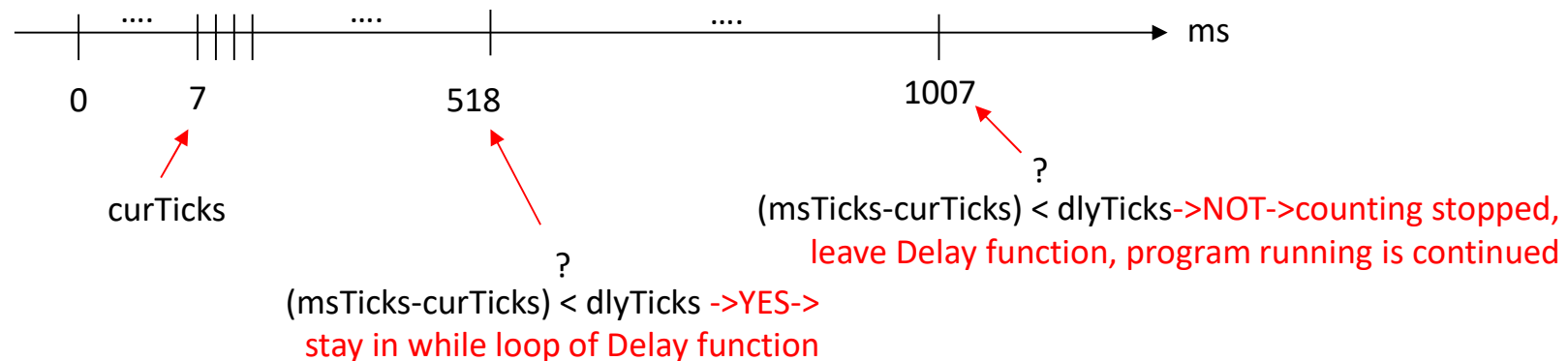
```
void Delay(uint32_t dlyTicks) → One input parameter: how many ticks to wait-> 1tick=1ms in this program
{
    uint32_t curTicks; → Create variable curTicks
    curTicks = msTicks; → Value of msTicks is passed to curTicks
    while ((msTicks - curTicks) < dlyTicks) ; → Wait until condition is met (program sticks in the while loop until condition is met)
}
```

msTicks: the current tick (time, keeps increasing by 1ms)

curTicks: equals msTick value when Delay function was called, constant value during the Delay function runs

dlyTicks: time of delay, now it is 1000ms: the time to toggle LEDs

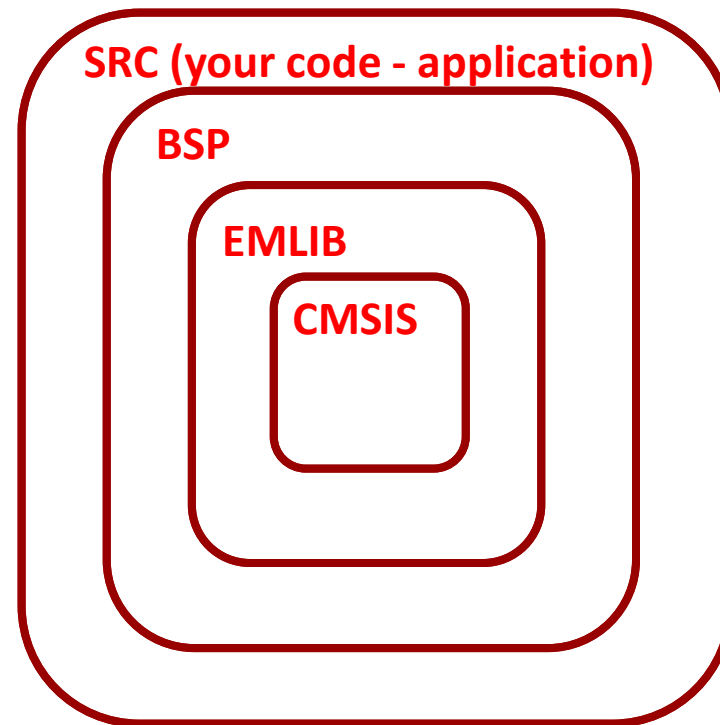
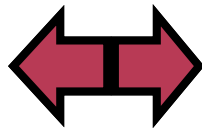
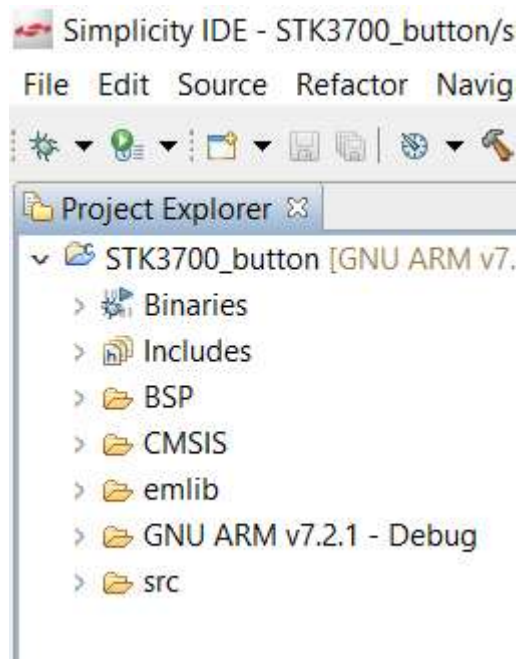
- Operation of Delay function:



- This Delay function is a blocking wait->program cannot run until 1000ms is elapsed

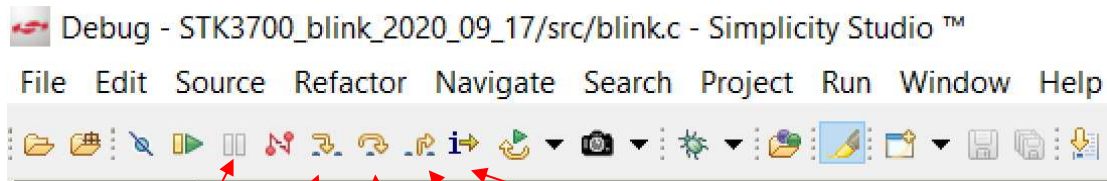
Hierarchy of functions

- Project Explorer window and the hierarchy of functions gathered in libraries



- All levels can be reached from SRC level directly

Examination of the Blink program



- When the program is suspended it runs most probably in the Delay function since LEDs changes quickly and uC runs the Delay function most of the time

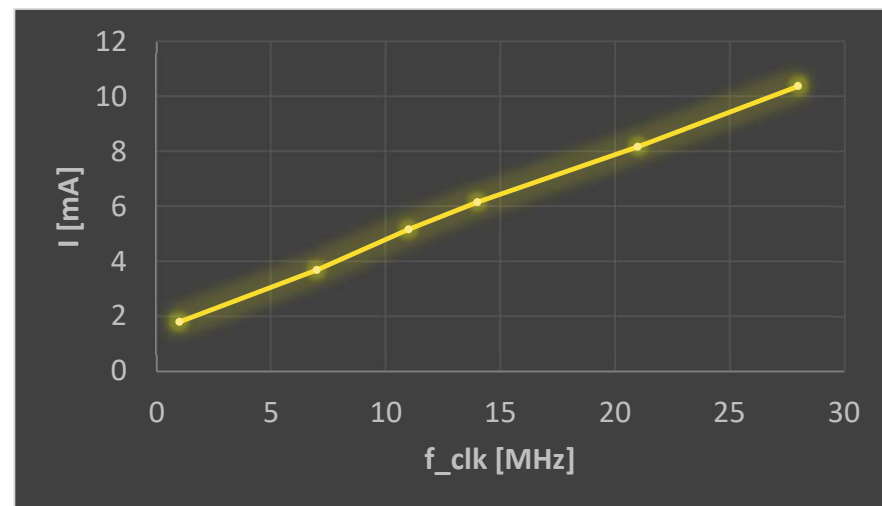
	Suspend	The [Suspend] button halts the MCU.
	Step Into	The [Step Into] button single steps into the first line of a function.
	Step Over	The [Step Over] button single steps over a function, executing the entire function.
	Step Return	The [Step Return] button steps out of a function, executing the rest of the function.
	Instruction Step- ping Mode	The [Instruction Stepping Mode] button toggles assembly single stepping. When enabled, single steps will execute a single assembly instruction at a time. See the [Disassembly] view for the assembly code corresponding to the source code at the current line of execution.

- Changes of variables and register content can be followed easily in Debug mode

Current consumption as a function of f_clk

- Modify the Blink program to measure current consumption as a function of uC clock frequency
- How the clock frequency can be accessed?
 - Insert the appropriate function:
 - `CMU_HFRCOBandSet(cmuHFRCOBand_1MHz);`
- Measure current consumption when clock frequency is set to 1, 7, 11, 14, 21 and 28MHz -> conclusion?

f_clk [MHz]	I [mA]
1	1.8
7	3.68
11	5.16
14	6.15
21	8.17
28	10.38



Hint for measurement of current consumption as a function of f_clk

```
int main(void)
{
    /* Chip errata */
    CHIP_Init();

    /* If first word of user data page is non-zero, enable Energy
    BSP_TraceProfilerSetup();

    CMU_HFRCOBandSet(cmuHFRCOBand_11MHz);

    /* Setup SysTick Timer for 1 msec interrupts */
    if (SysTick_Config(CMU_ClockFreqGet(cmuClock_CORE) / 1000)) {
        while (1);
    }

    /* Initialize LED driver */
    BSP_LedsInit();
    BSP_LedSet(0);
    BSP_LedSet(1);

    /* Infinite blink loop */
    while (1) {
        //BSP_LedToggle(0);
        //BSP_LedToggle(1);
        Delay(1000);
    }
}
```


Buttons

- Certain version of SDK does not contain functions for the buttons in the BSP library, but they are available from the manufacturer (can be downloaded from the course web)
 - `bsp_stk_buttons.c` and `bsp_stk_buttons.h`
 - Copy `bsp_stk_buttons.h` and `.c` into the Includes lib. (see project explorer window->follow the path to be able to copy)
 - Copy `bsp_stk_buttons.c` into the BSP lib. (see project explorer window->drag and drop works)
- Check `bsp_stk_buttons.h` to find and use in the code these:
 - `BSP_ButtonsInit(void)` -> initialize buttons, e.g. `BSP_ButtonsInit();`
 - `BSP_ButtonGet(int btnNo)` -> read button, e.g. `BSP_ButtonGet(0);`
 - Do not forget to put in the code: `#include "bsp_stk_buttons.h"`
- Modify the program to light up LEDx if BTNx is pushed

Modified code for push buttons

```
/* Initialize LED driver */
BSP_LedsInit();
BSP_LedClear(0);
BSP_LedClear(1);

/* Initialize Buttons */
BSP_ButtonsInit();

/* Infinite button loop */
while (1) {
    if (BSP_ButtonGet(0)) {
        BSP_LedClear(0);
    } else {
        BSP_LedSet(0);
    }
}
```

The building process (see console)

15:28:17 **** Build of configuration GNU ARM v7.2.1 - Debug for project STK3700_button ****

make -j4 all

Building file: ../src/button.c

Invoking: GNU ARM C Compiler

```
arm-none-eabi-gcc -g3 -gdwarf-2 -mcpu=cortex-m3 -mthumb -std=c99 -DDEBUG_EFM=1 -DEFM32GG990F1024=1 -
-I"/Simplicity_studio/developer/sdks/gecko_sdk_suite/v2.6//hardware/kit/EFM32GG_STK3700/config" -
-I"/Simplicity_studio/developer/sdks/gecko_sdk_suite/v2.6//platform/CMSIS/Include" -
-I"/Simplicity_studio/developer/sdks/gecko_sdk_suite/v2.6//platform/emlib/inc" -
-I"/Simplicity_studio/developer/sdks/gecko_sdk_suite/v2.6//hardware/kit/common/bsp" -
-I"/Simplicity_studio/developer/sdks/gecko_sdk_suite/v2.6//platform/Device/SiliconLabs/EFM32GG/Include" -O0 -
Wall -c -fmessage-length=0 -mno-sched-prolog -fno-builtin -ffunction-sections -fdata-sections -MMD -MP -
MF"src/button.d" -MT"src/button.o" -o "src/button.o" "../src/button.c"
```

Finished building: ../src/button.c

Building target: STK3700_button.axf

Invoking: GNU ARM C Linker

```
arm-none-eabi-gcc -g3 -gdwarf-2 -mcpu=cortex-m3 -mthumb -T "STK3700_button.ld" -Xlinker --gc-sections -Xlinker -
Map="STK3700_button.map" --specs=nano.specs -o STK3700_button.axf "/BSP/bsp_bcc.o" "/BSP/bsp_stk.o"
"/BSP/bsp_stk_buttons.o" "/BSP/bsp_stk_leds.o" "/BSP/bsp_trace.o" "/CMSIS/EFM32GG/startup_gcc_efm32gg.o"
"/CMSIS/EFM32GG/system_efm32gg.o" "/emlib/em_assert.o" "/emlib/em_cmu.o" "/emlib/em_core.o"
"/emlib/em_ebi.o" "/emlib/em_emu.o" "/emlib/em_gpio.o" "/emlib/em_system.o" "/emlib/em_usart.o"
"/src/button.o" -Wl,--start-group -lgcc -lc -lnosys -Wl,--end-group
```

Finished building target: STK3700_button.axf



The building process (see console)

Building hex file: STK3700_button.hex

```
arm-none-eabi-objcopy -O ihex "STK3700_button.axf" "STK3700_button.hex"
```

Building bin file: STK3700_button.bin

```
arm-none-eabi-objcopy -O binary "STK3700_button.axf" "STK3700_button.bin"
```

Building s37 file: STK3700_button.s37

```
arm-none-eabi-objcopy -O srec "STK3700_button.axf" "STK3700_button.s37"
```

Running size tool

```
arm-none-eabi-size "STK3700_button.axf" -A
```

STK3700_button.axf :

section	size	addr
.text	6612	0
.data	116	536870912
.bss	32	536871028
.heap	3072	536871064
.stack_dummy	1024	536871064
.comment	126	0
.debug_macro	7809	0

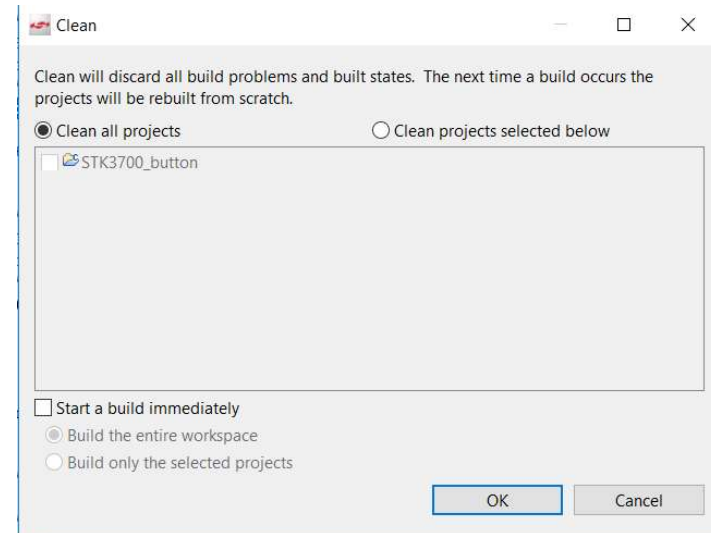
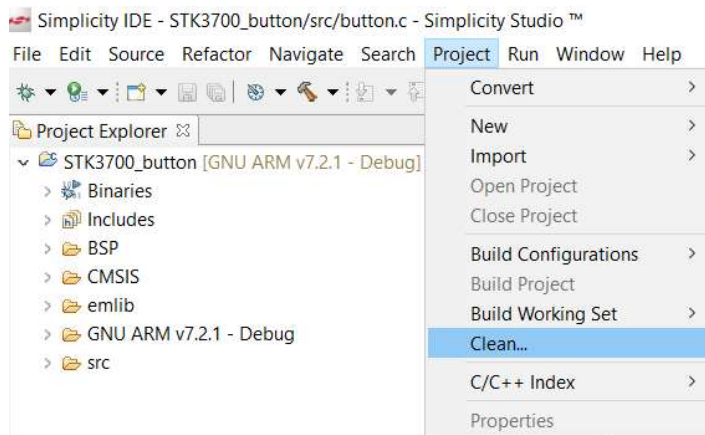
..... Some more lines.....

.debug_frame	3764	0
Total	960914	

15:28:26 Build Finished (took 8s.456ms)



The clean process (see console)



15:48:05 **** Clean-only build of configuration GNU ARM v7.2.1 - Debug for project STK3700_button ****

make -j4 clean

```
rm -rf ./src/button.o ./emlib/em_assert.o ./emlib/em_cmu.o ./emlib/em_core.o ./emlib/em_ebi.o ./emlib/em_emu.o
./emlib/em_gpio.o ./emlib/em_system.o ./emlib/em_usart.o ./CMSIS/EFM32GG/startup_gcc_efm32gg.o
./CMSIS/EFM32GG/system_efm32gg.o ./BSP/bsp_bcc.o ./BSP/bsp_stk.o ./BSP/bsp_stk_buttons.o ./BSP/bsp_stk_leds.o
./BSP/bsp_trace.o ./src/button.d ./emlib/em_assert.d ./emlib/em_cmu.d ./emlib/em_core.d ./emlib/em_ebi.d
./emlib/em_emu.d ./emlib/em_gpio.d ./emlib/em_system.d ./emlib/em_usart.d
./CMSIS/EFM32GG/system_efm32gg.d ./BSP/bsp_bcc.d ./BSP/bsp_stk.d ./BSP/bsp_stk_buttons.d ./BSP/bsp_stk_leds.d
./BSP/bsp_trace.d STK3700_button.axf
```

15:48:05 Build Finished (took 658ms)