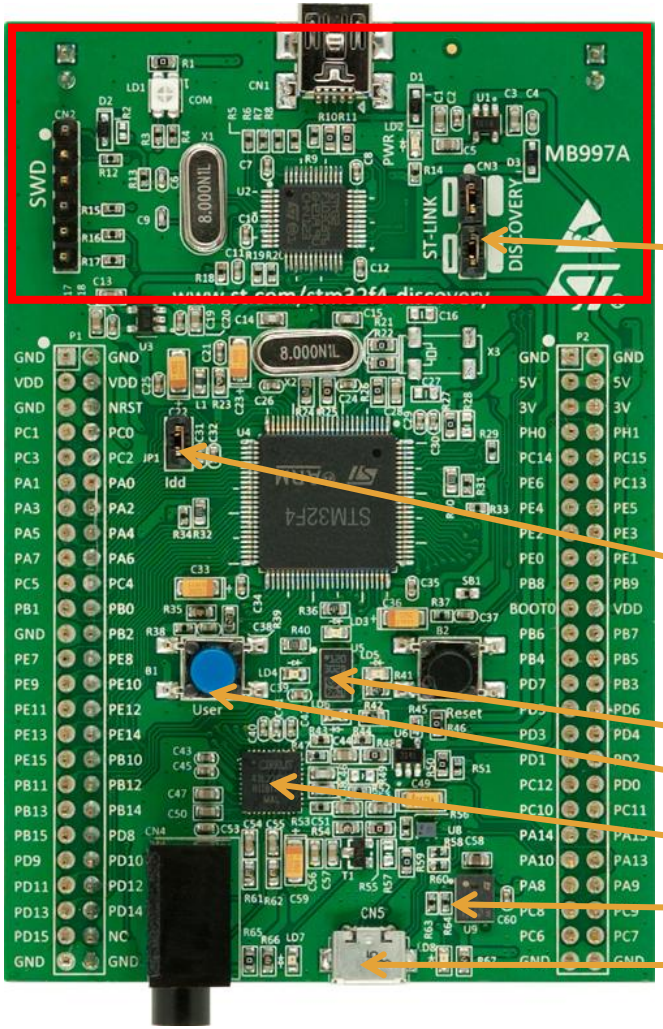
STM32F4 family – practical session

Atollic TrueSTUDIO STM32
+ STM32F4 discovery kit
modified by ***www.emcu.it***

Before the training

- Select/configure PC with MS Windows 2000/XP/Vista/7 in order to have administrative rights (required by ST-Link programmer/debugger)
- Install the current version of **Atollic TrueSTUDIO STM32**
- Prepare USB cable type A to mini-B
- Prepare STM32F4_Discovery board.
- Check whether there are no updates for ST-Link programmer/debugger available on www.st.com/stm32f4-discovery web page

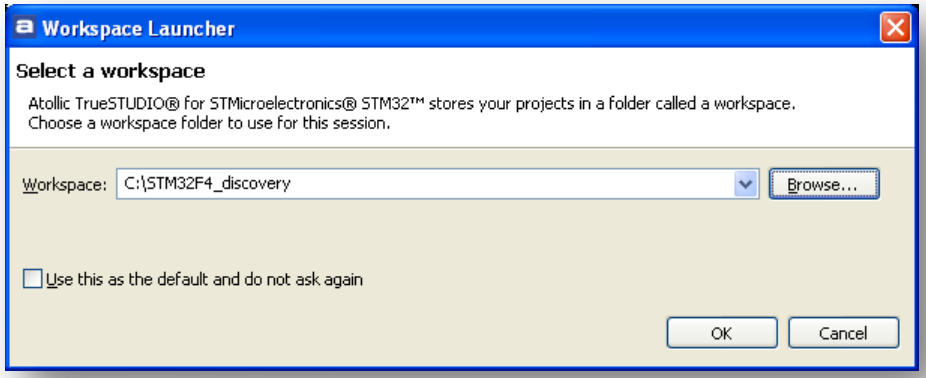
STM32F4_Discovery – in zoom



- STM32F4-Discovery board has two parts: ST-Link programmer/debugger and evaluation board with STM32F4xx MCU (CortexM4 based STM32)
- ST-Link can be used either as on board programmer (SEL jumpers must be ON) or as standalone programmer for external STM32 (SEL jumpers must be OFF). It is working only in SWD mode.
- Evaluation part is equipped with **STM32F407VGT6** MCU (1MB Flash, 192kB RAM, 100pin package) with built in clocking system (main oscillator for HSE generator 8MHz).
- it is possible to measure **current consumption** of the MCU using JP1 jumper.
- On board there are:
  - MEMS **accelerometer** (LIS302DL) connected via SPI1
  - Simple **user interface** (button + 4 LEDs)
  - **Audio codec** with audio output
  - MEMS **microphone** (MP45DT02)
  - **USB OTG** connector with 2 signaling LEDs

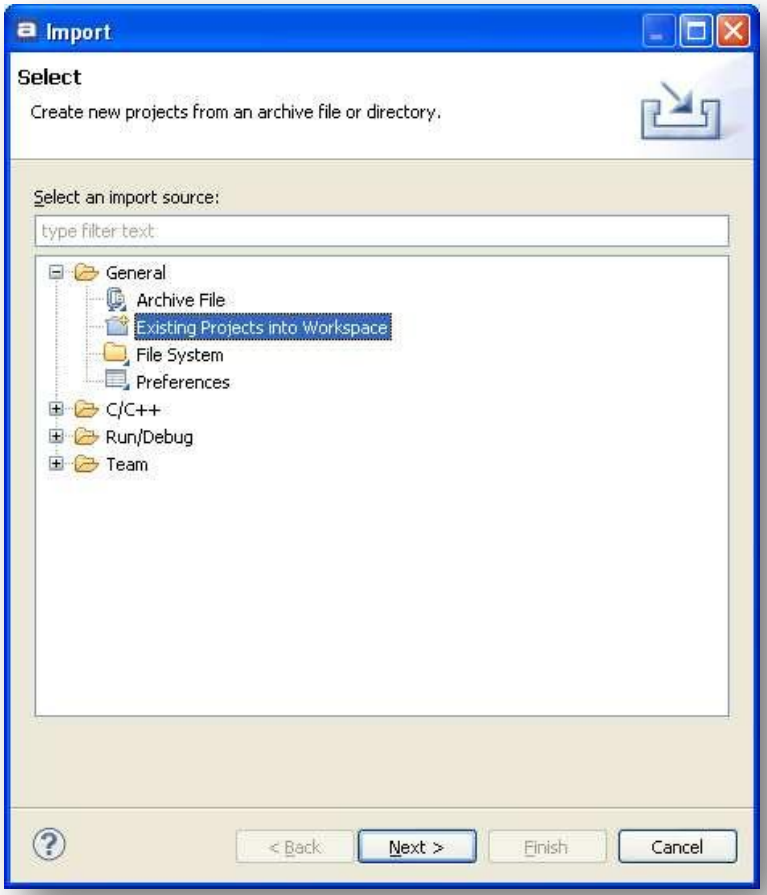
Atollic TrueSTUDIO/STM32 INTRODUCTION

- Run TrueSTUDIO STM32 PRO
- Enter path for your new workspace or path for existing one.
- It is better **NOT TO** mark “Use this as the default and do not ask again”.
- If it is a new project generation, welcome window will appear -> select Start using TrueSTUDIO



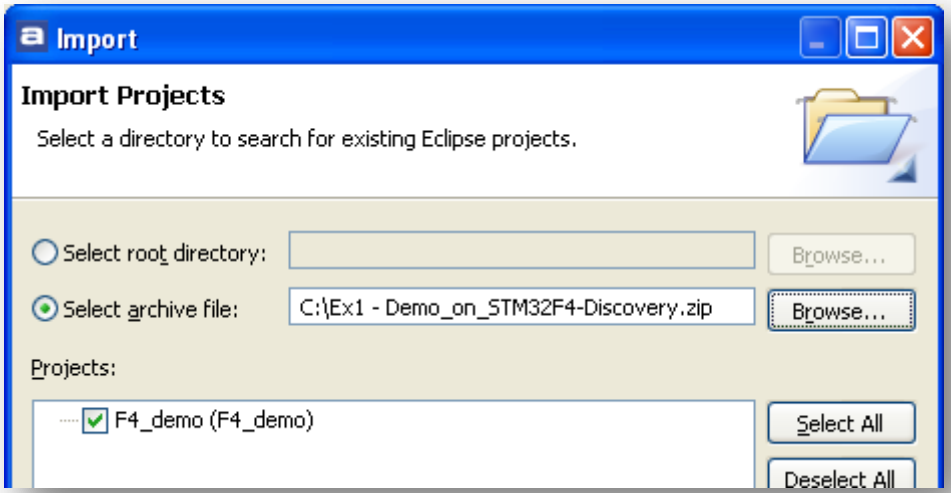
Atollic TrueSTUDIO/STM32
Import existing project (.ZIP) to workspace

- Select File->Import
- In Import window select General tab and then Existing Projects into Workspace
- Click Next



In Import project window:

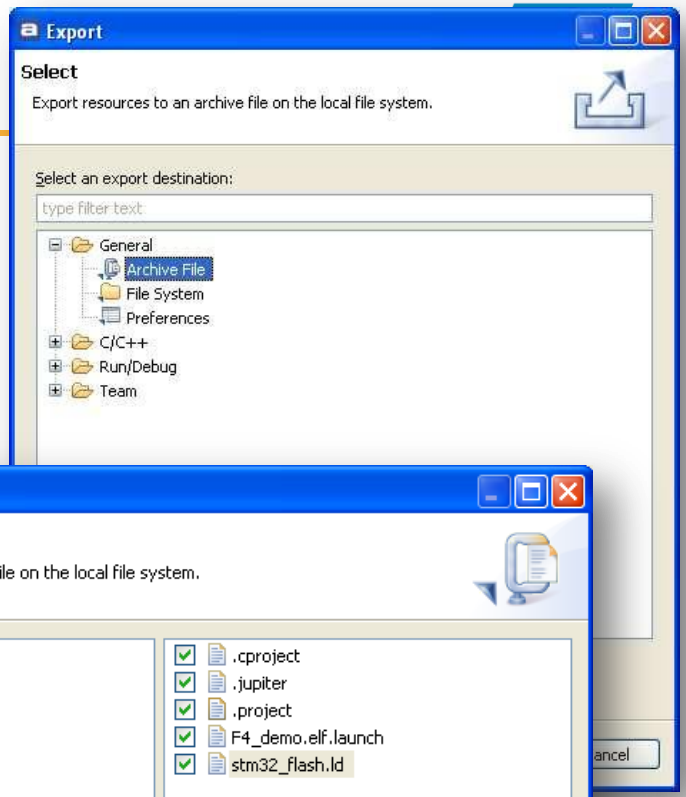
- Select archive file
- Select projects from the file
- Click Finish



As a result all imported project will be copied to workspace folder and would be build automatically

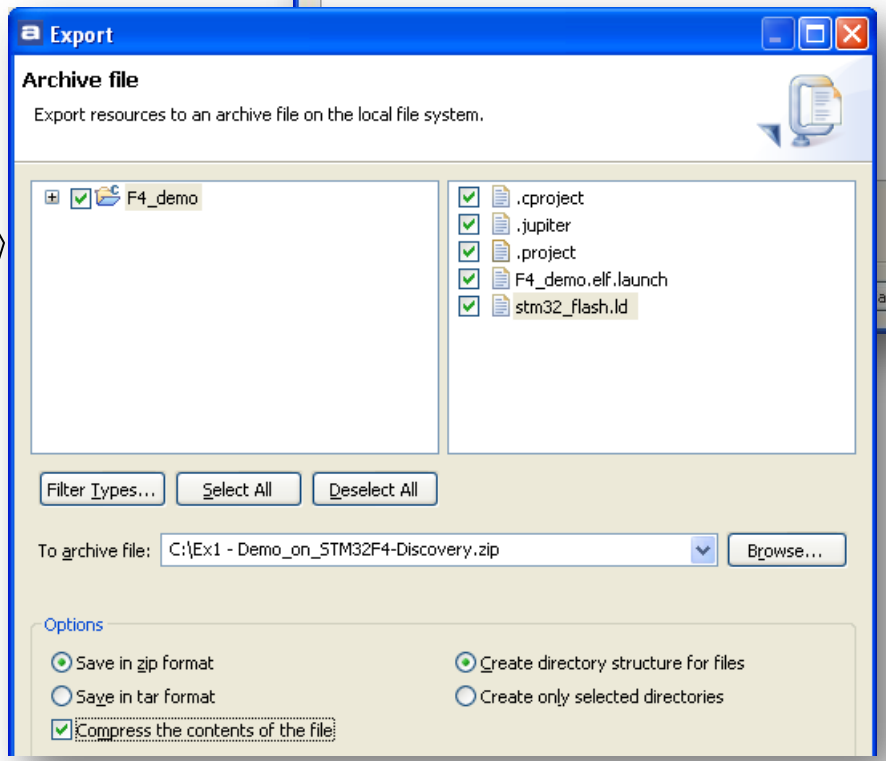
Atollic TrueSTUDIO/STM32
Export existing project to archive (.ZIP)

- Select File->Export
- In Export window select General tab and then Archive file
- Click Next



In Archive file window:

- Select requested projects from current workspace
- Select settings for the project (.cproject, .project and linker file *.ld)
- Select target file and its path
- Select output format (.zip, .tar)
- If necessary select compress of the content
- Select Create directory structure for files
- Click Finish



Atollic TrueSTUDIO/STM32 Project – file structure

- After create new project dedicated to one of the boards following file structure will be visible in project explorer:
  - Binaries
  - Includes
  - **Utilities** -> procedures to handle GUI on eval board
  - **src** -> main source directory (main.c – main.h – etc)
  - **Libraries** -> ST and CMSIS libraries
    - CMSIS
    - STM32F4xx_StdPeriph_Driver
  - Debug
- Physically on HDD project folder, there will be following subdirectories:
  - **.metadata** – main configuration of the workspace.
  - <Prj_name> -> main prj dir including sources, linker file (*.ld), object files and executables
    - .coverage -> used for code coverage analysis (not available in Lite version)
    - .settings -> used for hardware details concerning used MCU, eval board and programmer/debugger
    - Debug -> object files, executables of the project
    - Libraries
    - Utilities
    - src
- When using remote sources (link to external sources) only .settings and Debug folders are present.

Atollic TrueSTUDIO/STM32
Project – file structure operations

- Easiest way **to add new .c file** to the project is just copy it to one of source directories. Files will be detected automatically by the toolchain and will be included to compiler and linker files. Other methods are source files import or create remote link.

- Project Explorer important options are **valid for files and directories** (mouse right button):
  - **Exclude from build** can be used to not to build part of the code
  - **Delete** physically removes all selected sources and its headers from project directory on HDD
  - **Import** physically copies selected files to project directory

- Open/create new project in the same workspace using code generator will create the same folder structure including another copy of libraries. To avoid this we can use link to remote sources option.

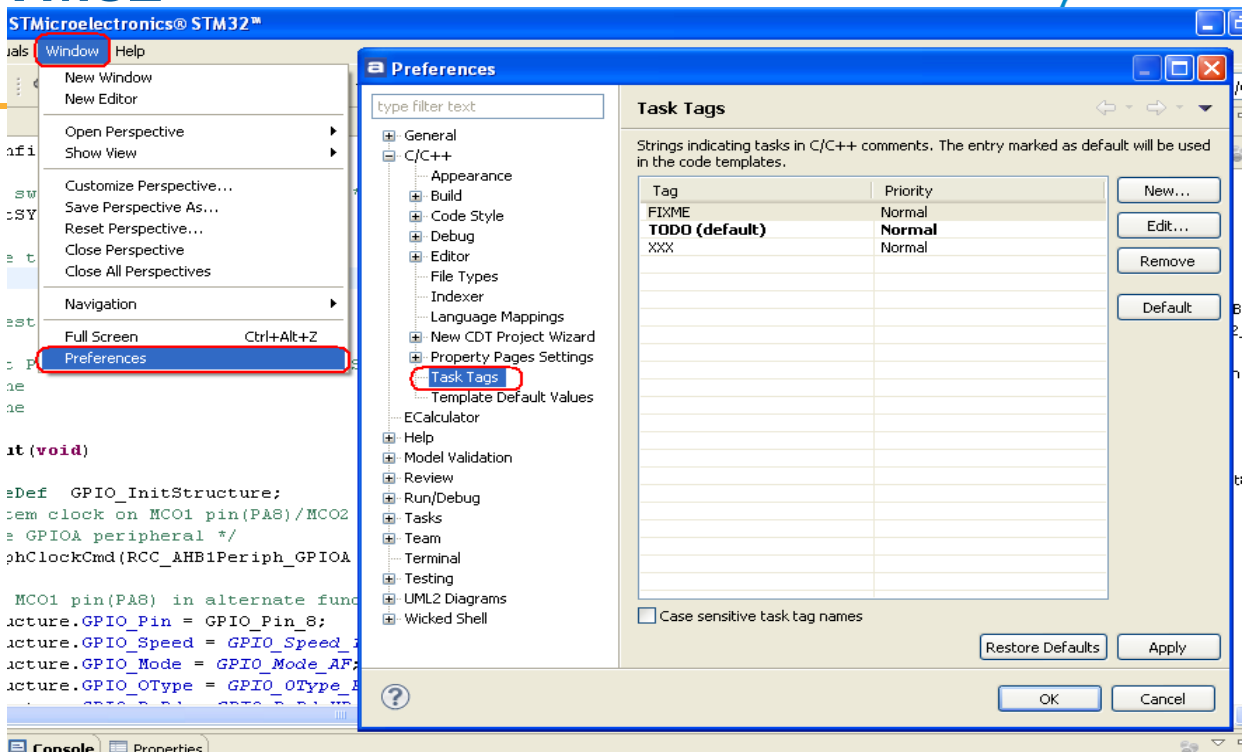
Atollic TrueSTUDIO/STM32 Tasks editor features

Come back later…. tasks

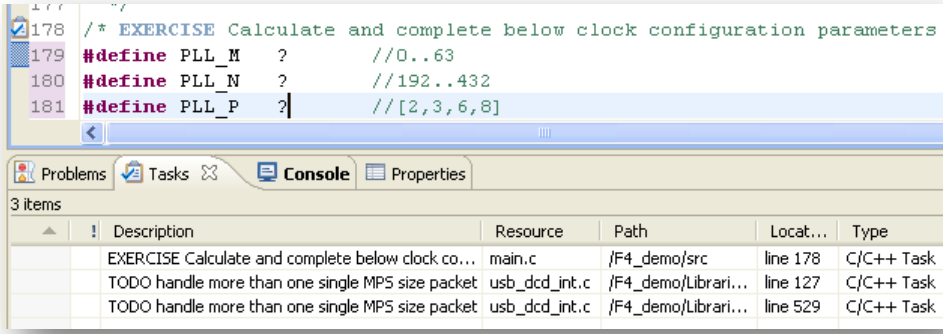
When there is a need to come back to some part of the code later on, it is useful to use Tasks.

To do so:

- Right click on line number where there is something to do later on.
- Insert C style comment (/* */) with the first word equal to one of the defined keywords (called task tags)
- Available Task Tags are visible under
  Window->Preferences->C/C++ section->Task Tags



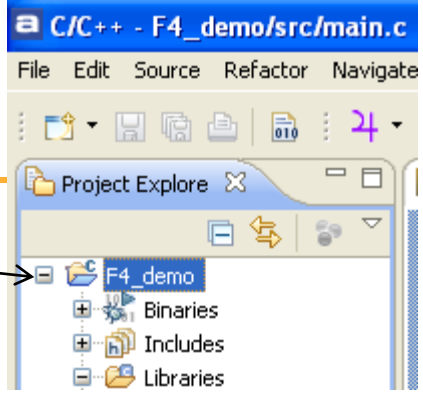
- It will be visible in **Tasks** list (bottom part of the screen) – double click on the task will open proper file at the line where the task was set
- To remove the task it is enough to right click on this name in Tasks list and select Delete or just delete the key word (task tag)

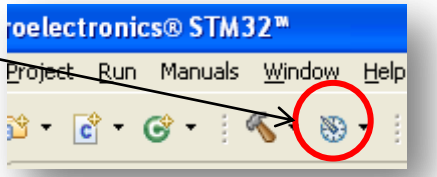


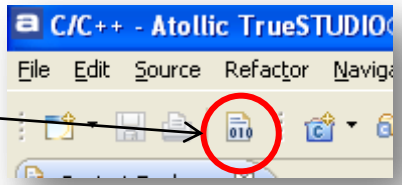
WARNING – user defined ***task tags*** are not exported with the projects so they will be not visible after import the project to new workspace. They should be added in Task Tags menu in new workspace.
After this operation all tasks will be visible.

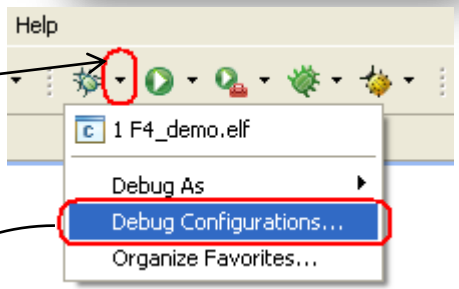
Atollic TrueSTUDIO/STM32
Build the project and configure debug session

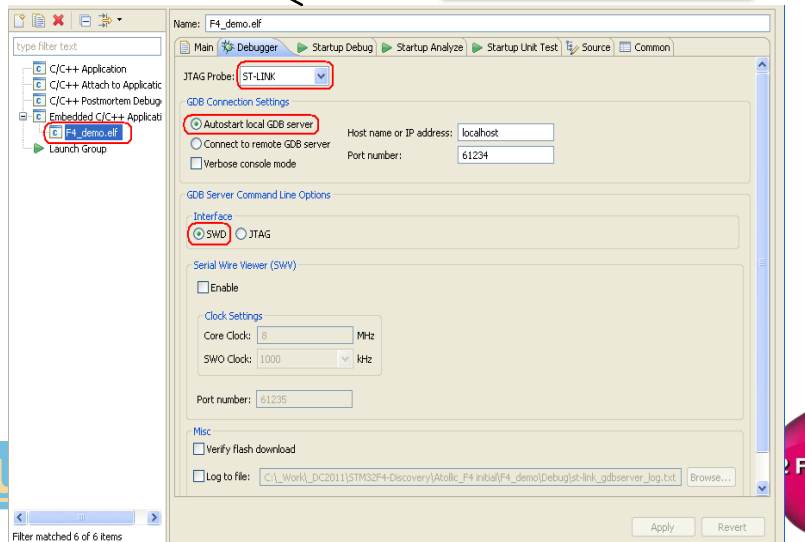
- Select project by click its name in project explorer
- Select proper configuration (debug or release)
  - Project -> Build Configuration -> Set Active or
- Build the project
  - Project->Build All or **Ctrl+B** or
- Configure debug session (run GDB server)
  - Run -> Debug Configurations, Debugger tab
    - Select “Autostart local GDB server”
    - Select SWD
- Run Debug session
  - Run -> Debug or **F11** or





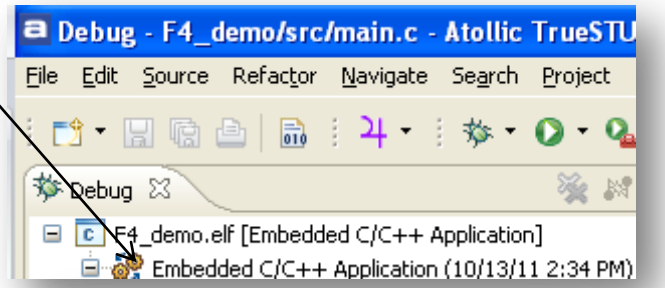




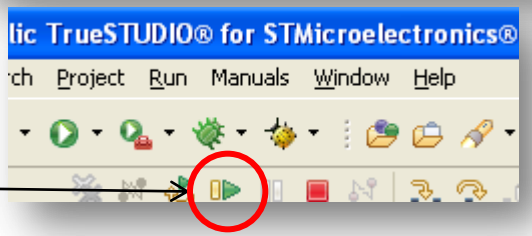


Atollic TrueSTUDIO/STM32
Run debug session

- Select GDB Hardware Debugger

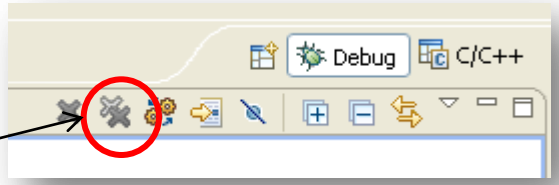


- Start the program
  - Run -> Resume or **F8** or



- Exit to debug
  - Run -> Terminate or **Ctrl+F2** or

- Add/remove breakpoint
  - Double click on the line number
- Remove all breakpoints
  - Run -> Remove All Breakpoints or

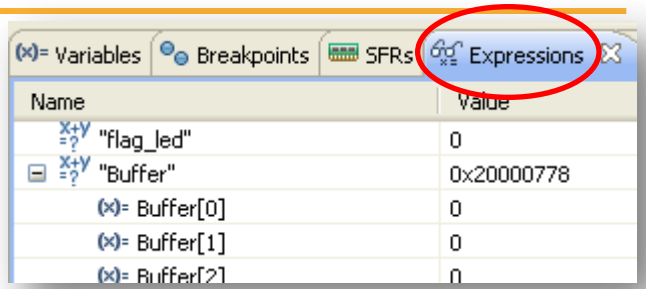


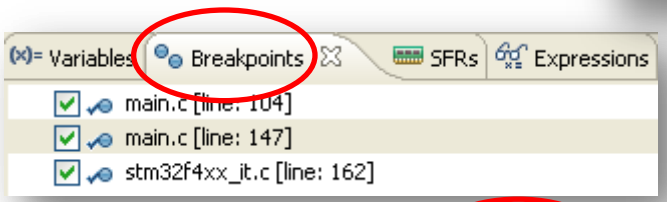
Atollic TrueSTUDIO/STM32 Debug session

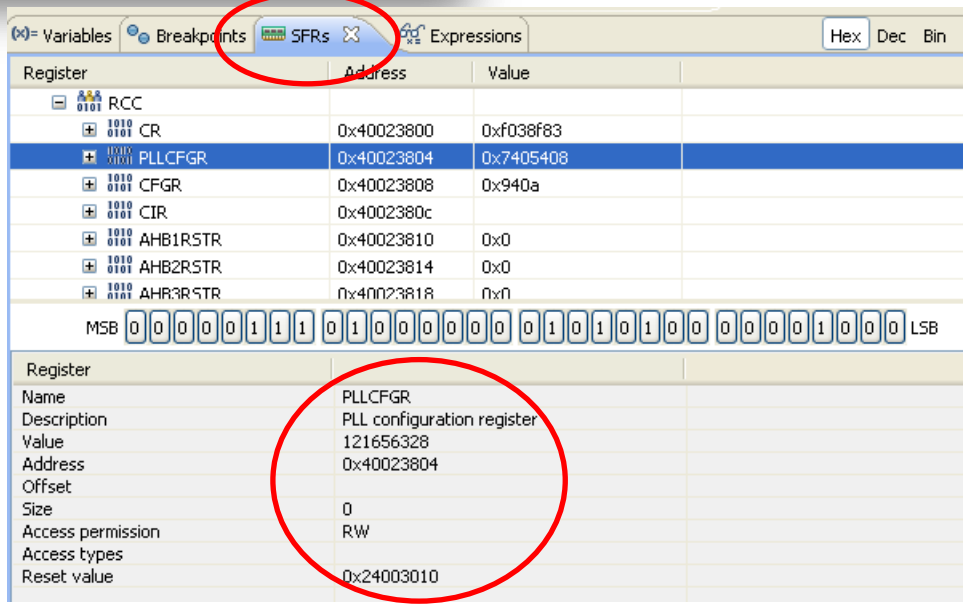
- To add variables to be watched -> drag&drop its name to Expressions tab or right click mouse and select “Add watch expression”

- To set breakpoint double click on the line. Breakpoints can be followed on/off in Breakpoints tab

- All necessary information concerning the registers of the peripherals is available (reset state, address, current value, bits value and the description).

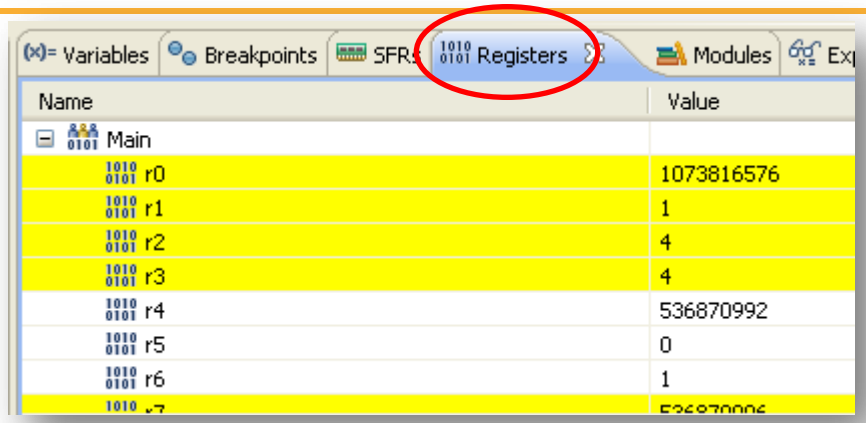






Atollic TrueSTUDIO/STM32 Debug session - operations

- It is possible to track changes in core registers -> Registers tab (any change is reported by yellow highlight)

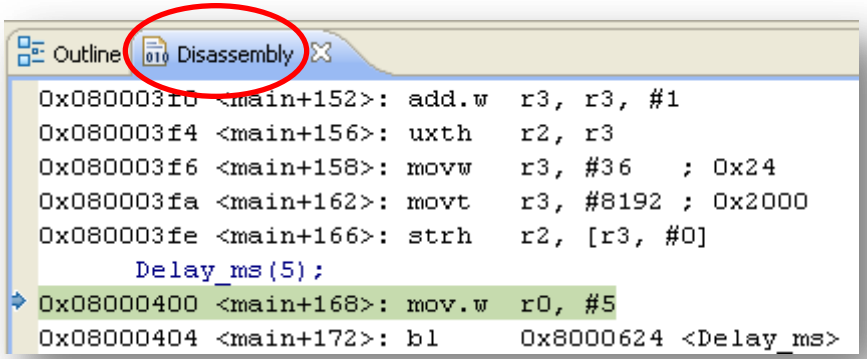


- Debug bar

Restart program
Run/resume program
Suspend program
Terminate program

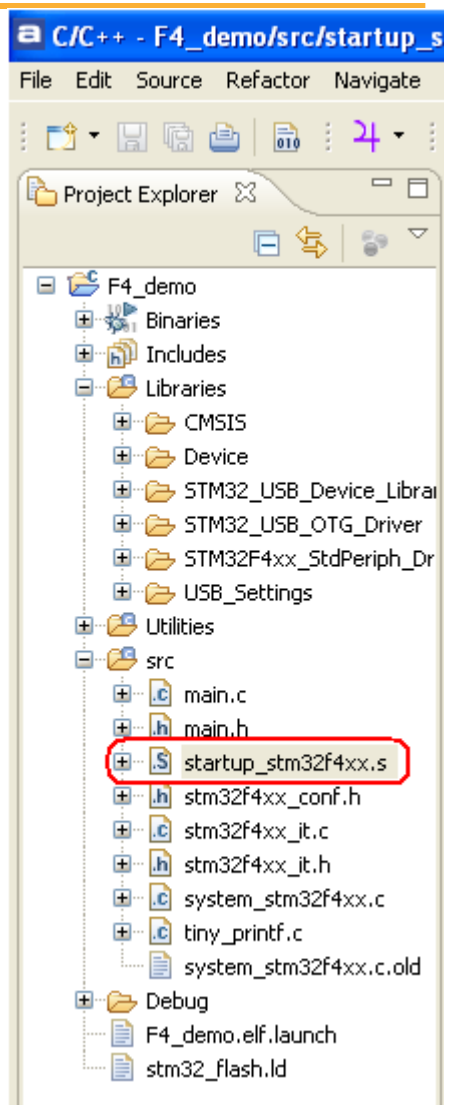
Step into (F5)
Step over (F6)

Using step filters
Assembler instruction stepping mode

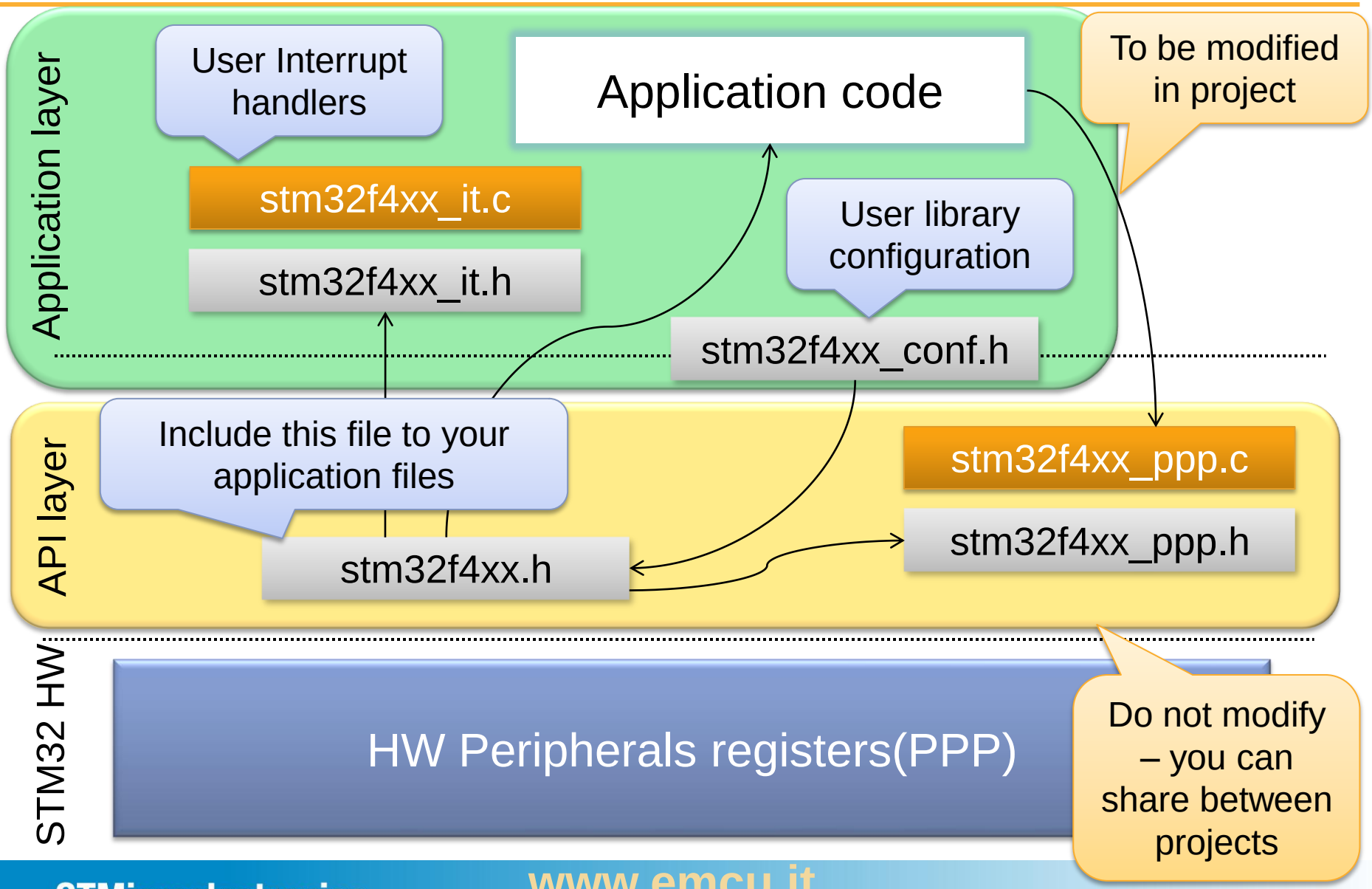


STM32 – startup procedure

- Minimum requirement for STM32 to start is to fill two first words in its vector table:
  - First word is always initial Main **Stack Pointer value**
  - Second word is always **address of reset procedure**
- It is recommended to implement as well main fault vectors (HardFault at least)
- In STM32 std library implementation with CMSIS standard, vector table is defined in startup file, which is prepared for each family member and each toolchain.
- In case of STM32F407VGT6 and Atollic it is **startup_stm32f4xx.s** file located in the folder **/src** inside the project
- In ST library there are some additional operations put before **main()** function will be executed. The most important is **SystemInit()** function coming from **system_stm32f4xx.c** file. This function is doing configuration of clock system and some GPIO pins in order to cooperate with external components of the MCU. This is not necessary for standard application running.
- To **switch off** this procedure, **line "bl SystemInit"** in **startup_stm32f4xx.s** file should be **commented** (line 104 in startup file)

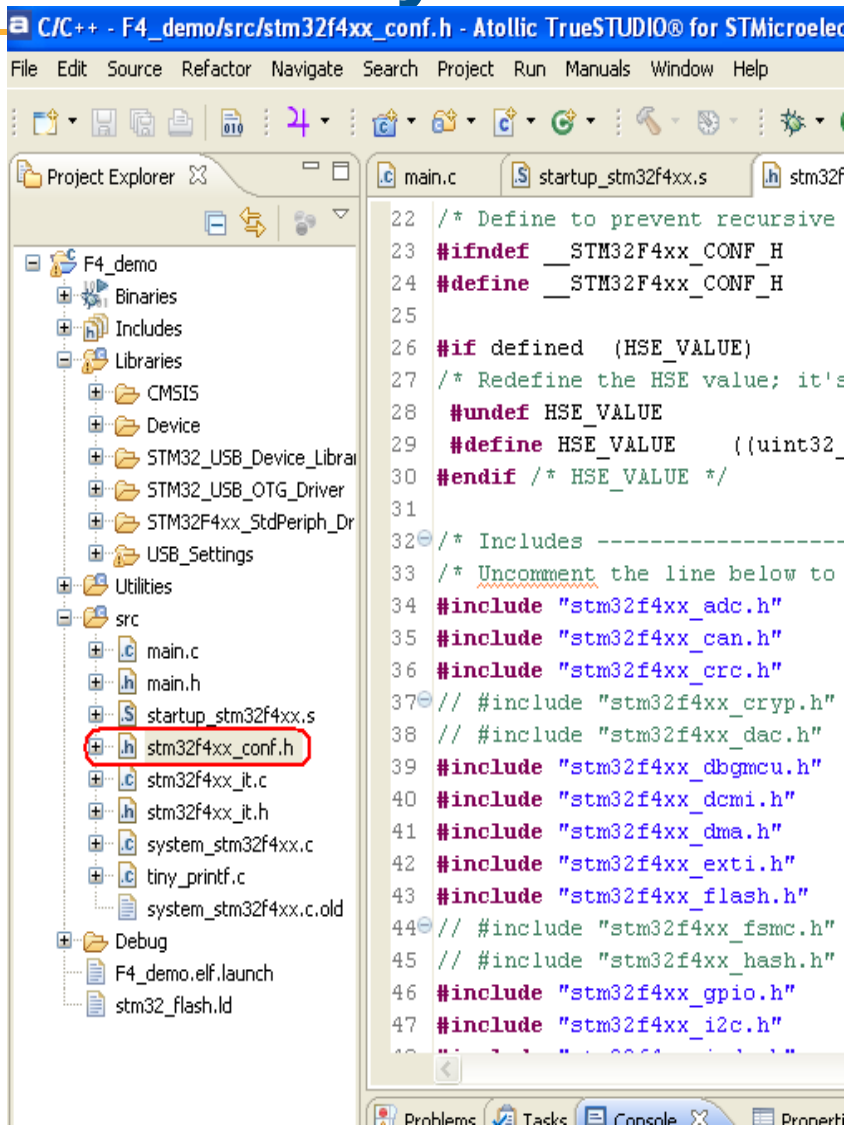


STM32 FW library – API structure



STM32 – standard peripherals library

- STM32 standard peripherals library is written in **ANSI C**
- For each peripheral there are separate source and header files, i.e.:
  - stm32f4xx_gpio.c
  - stm32f4xx_gpio.h
- To use it, it is required to:
  - **#include “stm32f4xx.h”**
  - add to the project source files for used peripherals, i.e. stm32f4xx_gpio.c for GPIO
- In ***stm32f4xx_conf.h*** uncomment lines with peripherals you are using in applications, i.e.:
  - #include "stm32f4xx_gpio.h"
- Empty interrupt procedures are present in ***stm32f4xx_it.c*** file. All interrupt functions should be put there.
- **Interrupt function** do not require any special coding and are **void function(void)** type
- Whole manual for the library is available in html format (delivered with library package). stm32f4xx_dsp_stdperiph_lib_um.chm
- Most of the peripherals has predefined one or two **data structures** which are used for the configuration. After fill up the structure it is used in **PPP_Init()** functions to configure registers in the peripherals



STM32 – library – how to use it ?

- Function and constant for each peripheral has prefix with its name, like: GPIO, TIM1:
  ie. **GPIO_Init**(), **ADC_Channel_0**, **USART_IT_TXE**
- Most of the settings is in **1fromN** convention and allow to use concatenation, like:
  GPIO_Pin_0 | GPIO_Pin_1, what means that **pins 0 and 1** from will be configured in the same time
- There are predefined types in ***stm32f4xx.h*** file, like:
  - **u8** – unsigned char
  - **u16** – unsigned short
  - **RESET** / **SET**
  - **FALSE** / **TRUE**
  - **DISABLE** / **ENABLE**
- Most of the peripherals (PPP) has set of instruction:
  - **PPP_DeInit**(...) – set all PPP register to its reset state
  - **PPP_Init**(...) – validation of the configuration for the peripheral
  - **PPP_Cmd**(ENABLE/DISABLE) – turn on/off PPP peripheral (not affects its clock)
  - **PPP_ITConfig**(...) – configuration (on/off) of sources of interrupts for PPP peripheral
  - **PPP_GetFlagStatus**(...) – read flags from the peripheral (polling)
  - **PPP_ClearFlag**(...) – clear flags from the peripheral
  - **PPP_ClearITPendingBit**(...) – clear IRQ flag

STM32 – library - FAQ

1. **Compiler is reporting a lot of errors like:**

   Missing prototype

   GPIO_Pin_0 undefined

Solution

Please check whether in ***stm32f4xx_conf.h*** all used library modules are **uncommented**

Please check, whether USE_STDPERIPH_DRIVER constant is defined in your environment

2. **Linker is reporting a lot of errors like:**

   Lab_library.lkf:1 symbol _GPIO_WriteHigh not defined (Debug/main.o)

Solution

Please check whether all **library source files are added**, ***stm32f4xx_gpio.c*** in this case.

EXERCISE n.1

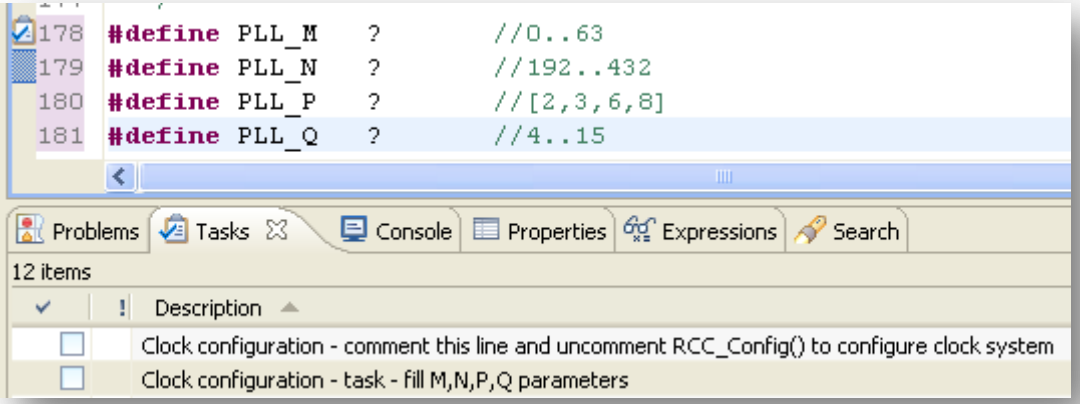
Basic configuration exercise 1/2

- Create a new workspace in Atollic IDE and IMPORT archive project:

  Ex1 – Demo_on_STM32F4-Discovery.zip

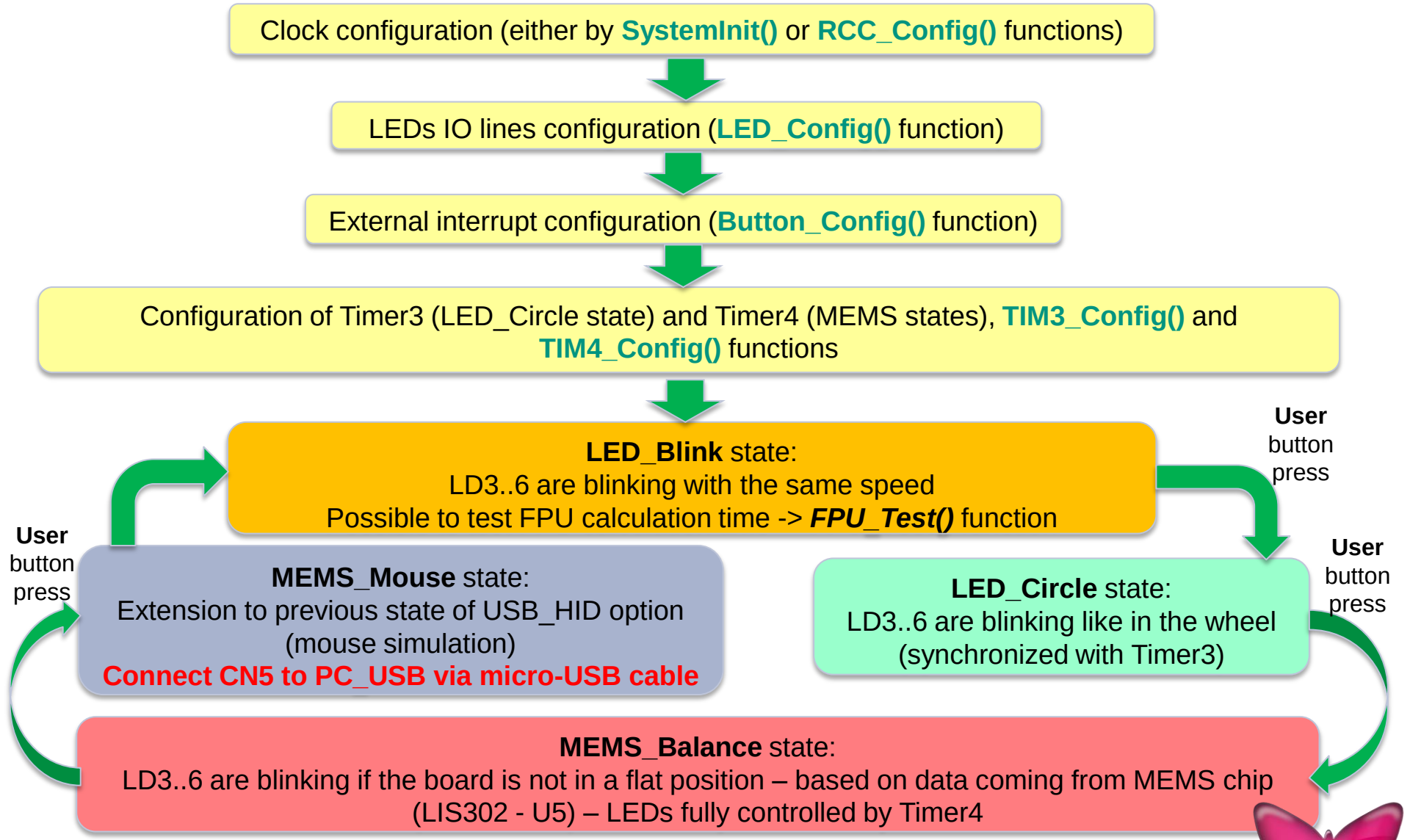
- The source code is damaged in few places (only few files from ***/src*** section).
- Modification should be done only in:
  - ***main.c*** -> main procedures
  - ***stm32f4xx_it.c*** -> interrupt procedures,
  - ***stm32f4xx_conf.h*** -> selection of correct modules from the library
- Places to be modified are marked "**?**" symbols and are combined into 5 mini-tasks fully described in coming sections.

- Tasks are visible as well in TrueStudio IDE in Tasks tab window with EXERCISE prefix.
- **To make them visible, please add EXERCISE tag in Tasks Tag window**



The task is to detect and eliminate all the issues in order to make program run on STM32F4-Discovery board in line with the algorithm from the next slide.

Basic configuration exercise 2/2



GPIO configuration - theory

- After the **reset** all pins are in **input floating** mode
- Pins are grouped into 16bit ports (GPIOA, GPIOB, ... GPIOI)
- Most of the pins tolerates 5V as input signal
- GPIO ports are configured by several registers [names follow reference manual] which are updated by **GPIO_Init()** function automatically with the values from the **GPIO_InitTypeDef** structure:

  - **GPIO_Pin** -> GPIO_Pin_0 .... 15, GPIO_Pin_All, GPIO_Pin_None
  - **GPIO_Mode**:
    - GPIO_Mode_AN //analog mode
    - GPIO_Mode_IN //input mode
    - GPIO_Mode_OUT //output mode
    - GPIO_Mode_AF //alternate function mode
  - **GPIO_OType**:
    - *GPIO_OType_PP*
    - *GPIO_OType_OD*
  - **GPIO_Speed**:
    - GPIO_Speed_2MHz //lowest EMI -> softer edges
    - GPIO_Speed_25MHz
    - GPIO_Speed_50MHz
    - GPIO_Speed_100MHz //highest EMI -> sharper edges
  - **GPIO_PuPd**:
    - *GPIO_PuPd_NOPULL*
    - *GPIO_PuPd_UP*
    - *GPIO_PuPd_DOWN*

GPIO configuration - task

Correct **LED_Config()** function (***main.c*** file) in order to configure lines 12..15 from port GPIOD:

- In GPIO state (used in LED_Blink and LED_Circle states):

  As general purpose output pins in push-pull configuration with 25MHz speed, without pull-up

- In other states (used in MEMS_Balance and MEMS_Mouse states):

  As IO lines connected to Timer4 (as its outputs) with 25MHz speed (alternate function configuration)

Do not forget about the connection of the clock of used peripherals BEFORE the configuration

GPIO configuration - solution

Correct **LED_Config()** function (***main.c*** file) in order to configure lines 12..15 from port GPIOD:

- In GPIO state (used in LED_Blink and LED_Circle states):

  As general purpose output pins in push-pull configuration with 25MHz speed, without pull-up

```
GPIO_InitStructure.GPIO_Pin = GPIO_Pin_12 | GPIO_Pin_13| GPIO_Pin_14| GPIO_Pin_15;
GPIO_InitStructure.GPIO_OType = GPIO_OType_PP;
GPIO_InitStructure.GPIO_Speed = GPIO_Speed_25MHz;
GPIO_InitStructure.GPIO_PuPd = GPIO_PuPd_NOPULL;
GPIO_InitStructure.GPIO_Mode = GPIO_Mode_OUT;
```

- In other states (used in MEMS_Balance and MEMS_Mouse states):

  As IO lines connected to Timer4 (as its outputs) with 25MHz speed (alternate function configuration)

```
GPIO_InitStructure.GPIO_Mode = GPIO_Mode_AF;

GPIO_PinAFConfig(GPIOD, GPIO_PinSource12, GPIO_AF_TIM4);
GPIO_PinAFConfig(GPIOD, GPIO_PinSource13, GPIO_AF_TIM4);
GPIO_PinAFConfig(GPIOD, GPIO_PinSource14, GPIO_AF_TIM4);
GPIO_PinAFConfig(GPIOD, GPIO_PinSource15, GPIO_AF_TIM4);
```

Do not forget about the connection of the clock of used peripherals BEFORE the configuration

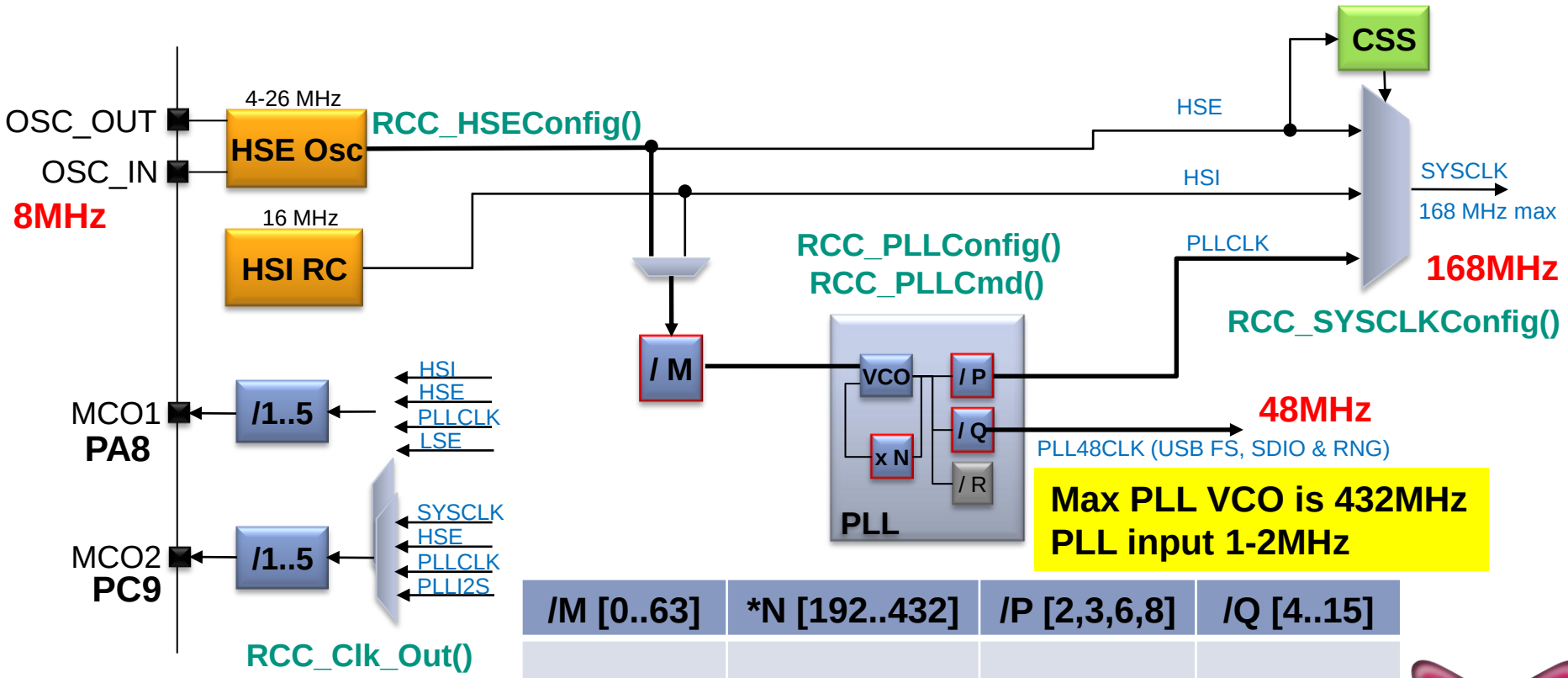
```
RCC_AHB1PeriphClockCmd(RCC_AHB1Periph_GPIOD, ENABLE);
```

Clock configuration - theory

- **After the reset system clock is set to HSI = 16MHz**
- After the **reset all peripherals (GPIOs as well) have clock disconnected**
- There is **Clock Security System for HSE monitoring**. In case of problems with HSE - an automatic switch to HSI (reset state) occurs
- It is possible to send main clock to output pins (MCO1 or MCO2) -> up to 100MHz
- It is not possible to clock core and main peripherals by low speed oscillators (LSI and LSE).
- **When using STM32 standard firmware library there is an automatic clock configuration performed before main code, which switch clock to its maximum frequency (168MHz) based on HSE source.** It is done by **SystemInit()** function called from startup file before the **main()**.

Clock configuration - task

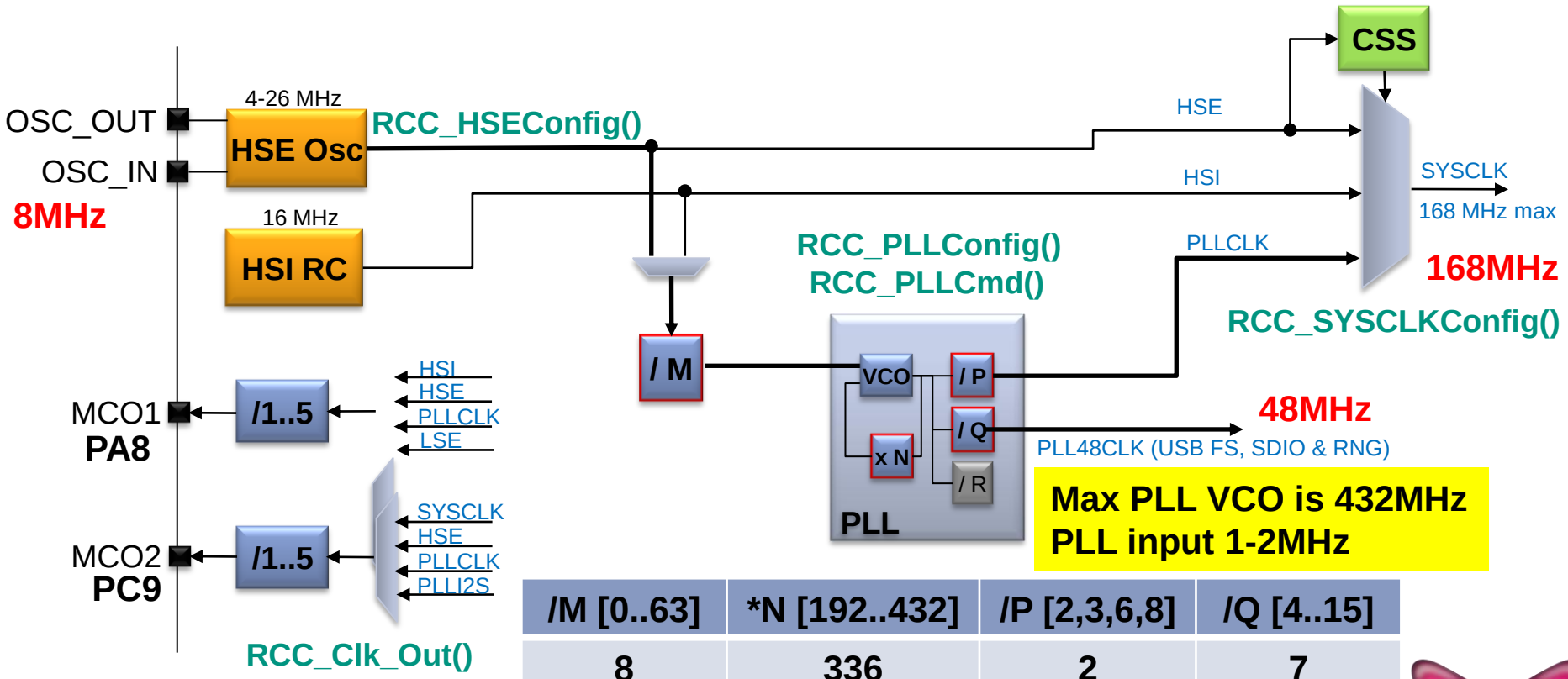
- Calculate correct values of parameters **M**,**N**,**P**,**Q** and insert them in **RCC_Config()** function (***main.c*** file). Target frequencies are put in RED on below diagram.
- Comment line 104 (C /**/ or C++ style //) in ***startup_stm32f4xx.s*** file (**src** section) – turn off initial clock configuration done by **SystemInit()** function
- Uncomment line 110 in ***main.c*** file (run the clock configuration function **RCC_Config()**



/M [0..63]	*N [192..432]	/P [2,3,6,8]	/Q [4..15]

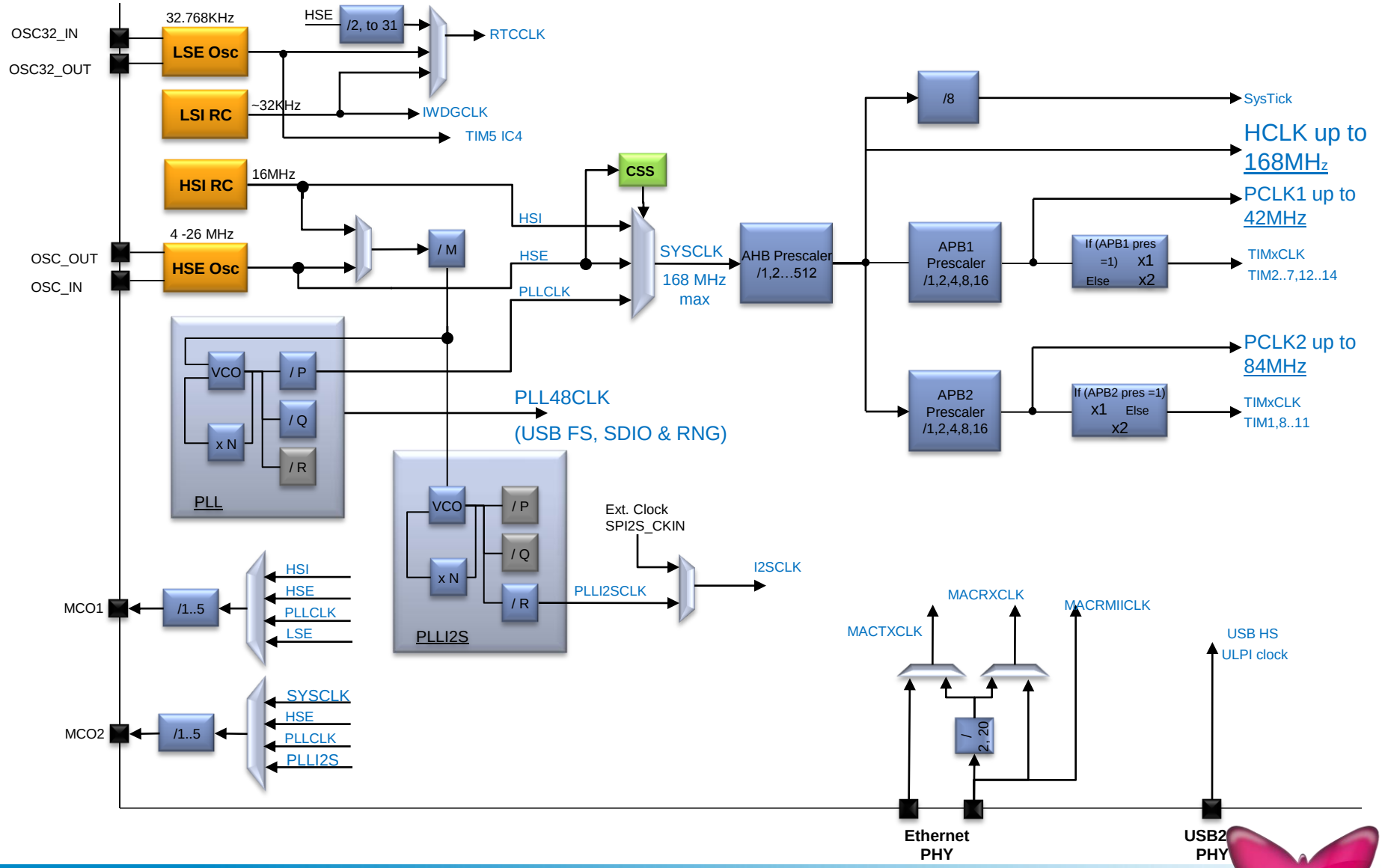
Clock configuration - solution

- Calculate correct values of parameters **M**,**N**,**P**,**Q** and insert them in **RCC_Config()** function (***main.c*** file). Target frequencies are put in RED on below diagram.
- Comment line 104 (C /**/ or C++ style //) in ***startup_stm32f4xx.s*** file (**src** section) – turn off initial clock configuration done by **SystemInit()** function
- Uncomment line 110 in ***main.c*** file (run the clock configuration function **RCC_Config()**



/M [0..63]	*N [192..432]	/P [2,3,6,8]	/Q [4..15]
8	336	2	7

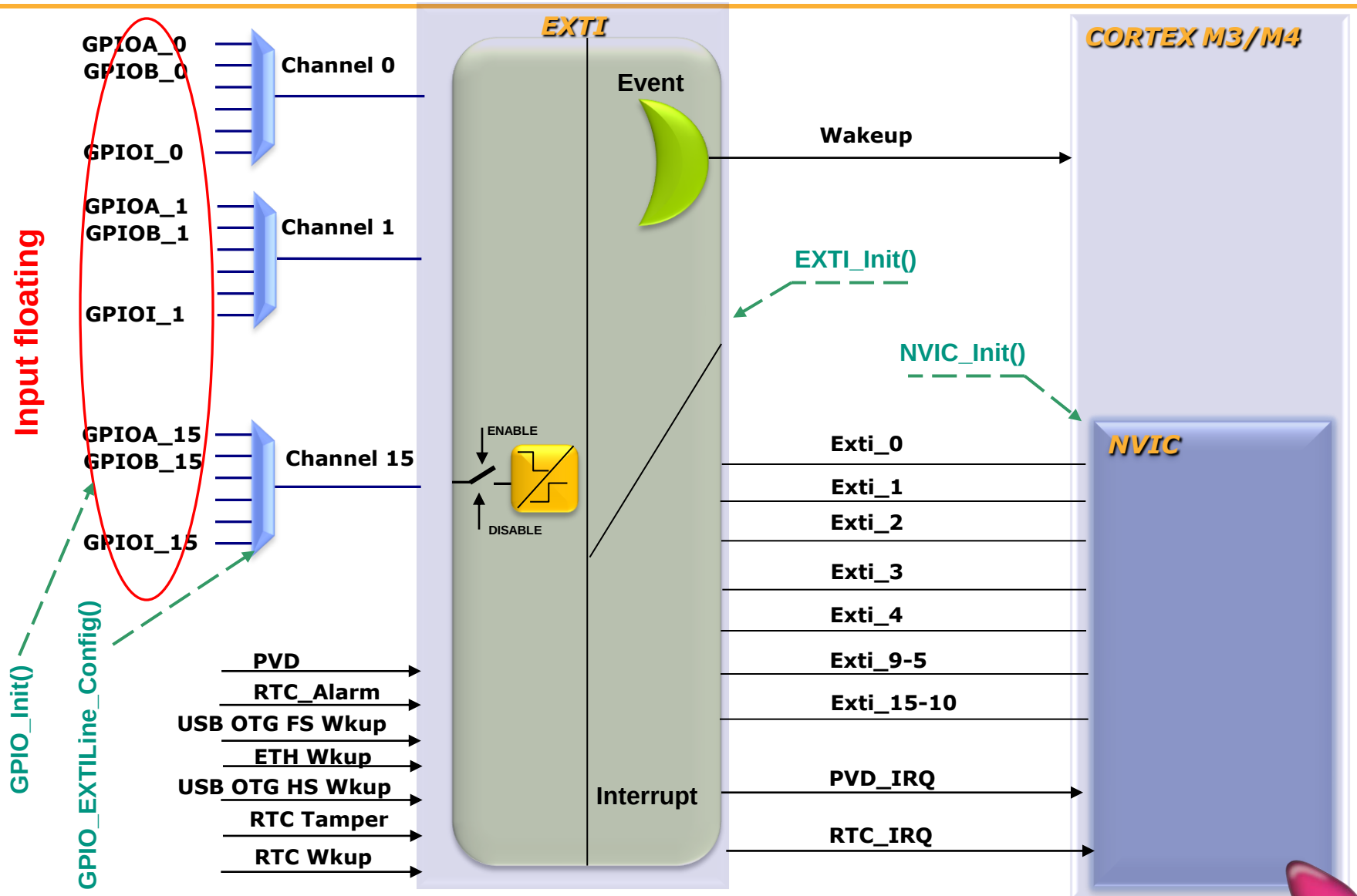
Clock Scheme – complete view



Interrupts - theory

- After the **reset** all peripheral **interrupts** are **disabled**, vector table is located at the beginning of the Flash memory
- Interrupt should be:
  - enabled at peripheral -> exact source of the interrupt
  - configured in NVIC (interrupt controller) -> priorities, location in memory
  - programmed in ***stm32f4xx_it.c*** -> body of its procedure
- In addition external interrupt requires:
  - Configuration of dedicated IO pin as **input** (GPIO module)
  - Specify if it will be **event or interrupt** mode (EXTI module)
  - Select **proper port to source interrupt** at the selected channel (i.e Channel 1 can be sourced by Pin 1 from any port (SYSCFG module)
  - Enable external interrupt channel (EXTI module)
  - Select **sensitivity** of the channel (raising or falling edge) (EXTI module)

EXTI module: from pin to NVIC



EXTI & NVIC configuration

- GPIO_InitTypeDef -> select input pin and configure it in input mode
- GPIO_EXTILineConfig -> configure input multiplexers
- EXTI_InitTypeDef:
  - **EXTI_Line** -> EXTI_Line0 15
  - **EXTI_Mode**:
    - EXTI_Mode_Event (for wakeup the core without interrupt generation)
    - EXTI_Mode_Interrupt
  - **EXTI_Trigger**:
    - EXTI_Trigger_Rising
    - EXTI_Trigger_Falling
  - **EXTI_LineCmd**:
    - ENABLE (turn on the channel)
    - DISABLE
- NVIC_InitTypeDef:
  - **NVIC_IRQChannel**: PPP_IRQn ***)**
  - **NVIC_IRQChannelPreemptionPriority**: 0..15 (lower number, higher priority)
  - **NVIC_IRQChannelSubPriority**: 0..15
  - **NVIC_IRQChannelCmd** -> ENABLE/DISABLE

*) PPP – name of interrupt vector defined in ***stm32f4xx.h*** (or described in library manual)

Interrupts - task

Correct **Button_Config()** function (***main.c*** file) in order to make User button working:

- Configure GPIOA, pin0 as input (GPIO module)
- Configure pin as working with the port (no other peripheral) (SYSCFG module)
- Configure its mode (interrupt) and sensitivity (rising edge) (EXTI module)
- Configure interrupt vector and its priorities (NVIC module)

Correct interrupt vector function - **EXTI0_IRQHandler()** in ***stm32f4xx_it.c*** file

- Clear the interrupt flag:

Interrupts - solution

Correct **Button_Config()** function (***main.c*** file) in order to make User button working:

- Configure GPIOA, pin0 as input (GPIO module)

  can be left untouched after the reset due to default configuration (input floating)

- Configure pin as working with the port (no other peripheral) (SYSCFG module)

  SYSCFG_EXTILineConfig(EXTI_PortSourceGPIOA,EXTI_PinSource0);

- Configure its mode (interrupt) and sensitivity (rising edge) (EXTI module)

```
EXTI_InitStructure.EXTI_Line = EXTI_Line0 ;
EXTI_InitStructure.EXTI_Mode = EXTI_Mode_Interrupt;
EXTI_InitStructure.EXTI_Trigger = EXTI_Trigger_Rising;
EXTI_InitStructure.EXTI_LineCmd = ENABLE;
EXTI_Init(&EXTI_InitStructure);
```

- Configure interrupt vector and its priorities (NVIC module)

```
NVIC_InitStructure.NVIC_IRQChannel = EXTI0_IRQn ;
NVIC_InitStructure.NVIC_IRQChannelPreemptionPriority = 0;
NVIC_InitStructure.NVIC_IRQChannelSubPriority = 0;
NVIC_InitStructure.NVIC_IRQChannelCmd = ENABLE;
```

Correct interrupt vector function - **EXTI0_IRQHandler()** in ***stm32f4xx_it.c*** file

- Clear the interrupt flag:

```
EXTI_ClearITPendingBit(EXTI_Line0);
```

Timer configuration - procedure

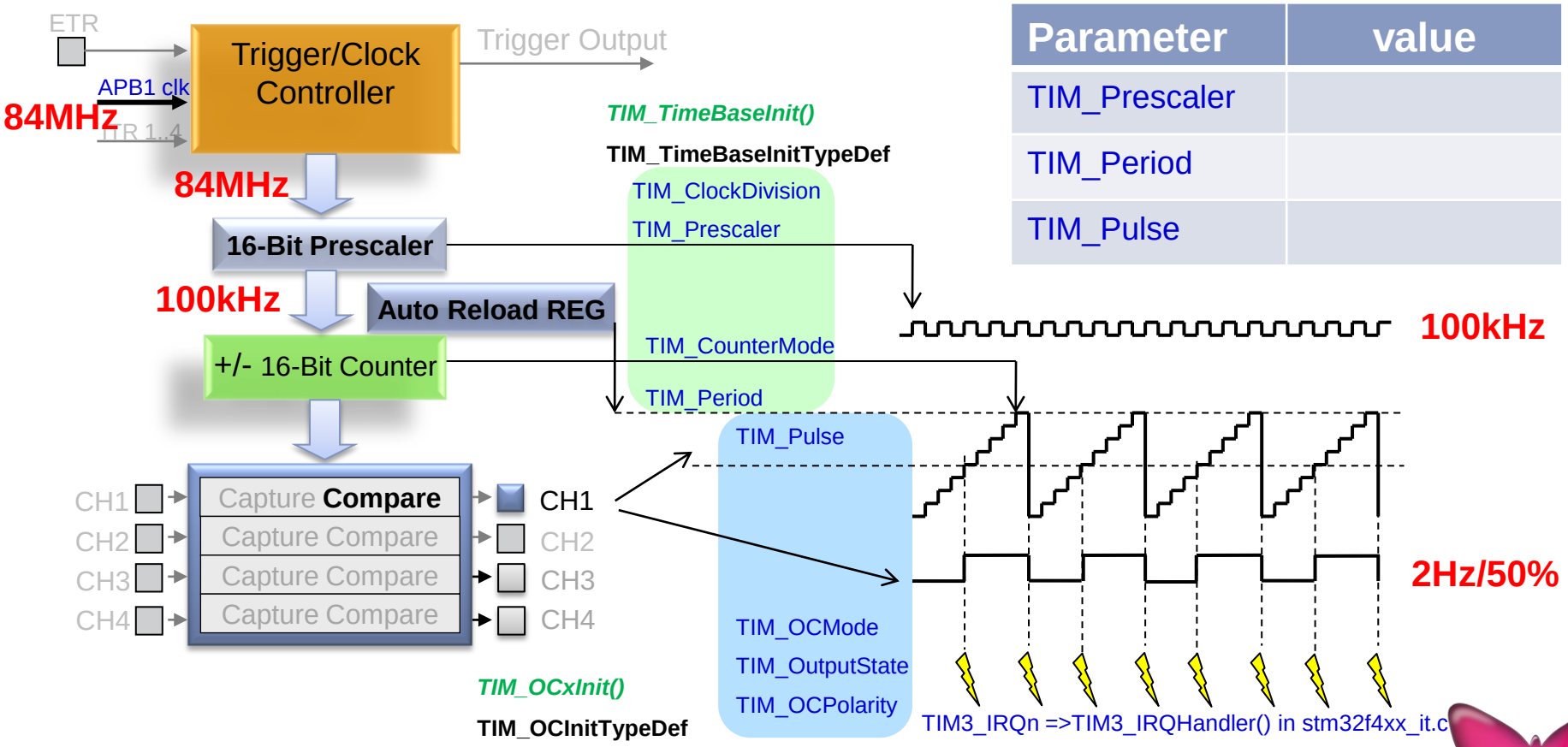
- Turn on Timer clock at RCC module (APBx bus) using function **RCC_APBxPeriphClockCmd()**
- Configure timer base module using **TIM_TimeBaseInitTypeDef** structure for selected timer and then function **TIM_TimeBaseInit()**
- Configure **TIM_OCInitTypeDef** structure and then function **TIM_OCxInit()** for selected channels of the timer.
- Initiate preload autoreload register using **TIM_OCxPreloadConfig()** function and preload of capture compare registers using **TIM_ARRPreloadConfig()** function for each used channel
- Enable the timer using **TIM_Cmd()** function

Timer configuration - structures

- There are two structures to be filled in in order to configure selected channel to PWM generation:
  - Time Base -> **TIM_TimeBaseInitTypeDef**
    - **TIM_Period** – autoreload value
      - **f_{pwm} = TIM_counter_clk/(Period+1)**
    - **TIM_Prescaler** - [0 -> 2^{16}-1] – TIM3 input clock prescaler value
      - **TIM_counter_clk=APB1_clk/(prescaler+1)**
    - **TIM_ClockDivision** – used for input digital filters, can be left 0
      - 0
    - **TIM_CounterMode** – TIM_CounterMode_ [Up/Down/CenterAligned1..3]
      - TIM_CounterMode_Up
  - Capture Compare section for channel x -> **TIM_OCInitTypeDef**
    - **TIM_OCMode** – different configurations for Output Compare mode
      - TIM_OCMode_PWM1
    - **TIM_OutputState** – input mode: capture enable, output mode: output enable
      - TIM_OutputState_Enable
    - **TIM_Pulse** – [0 -> 2^{16}-1] – capture compare for channel x register value
      - **Duty_cycle = (TIM_Pulse/TIM_Period)*100%**
    - **TIM_OCPolarity** – output signal active high or low
      - TIM_OCPolarity_High

Timer3 – Output Compare mode - task

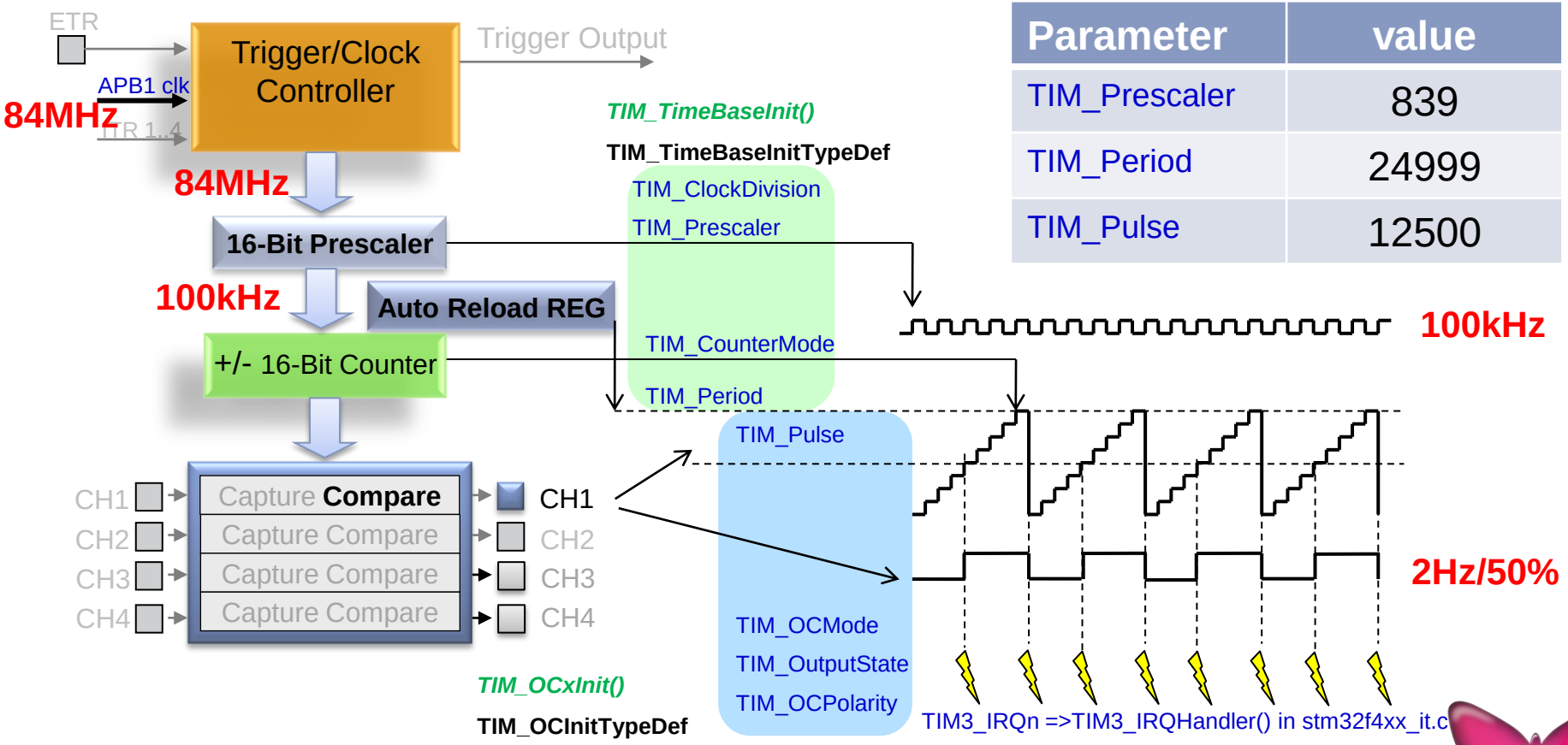
- Correct **TIM3_Config()** function in ***main.c*** file in order to configure Timer3 in output compare mode to generate update/overflow interrupts with 2Hz frequency and in the meantime capture/compare interrupt on channel 1. In Timer3 interrupt routine there is a control of LD3..6.
- Result: in LED_Circle state of main loop LD3..6 should blink with 1Hz frequency and with phase shift to the next one (circle flashing)



Parameter	value
TIM_Prescaler	
TIM_Period	
TIM_Pulse	

Timer3 – Output Compare mode - solution

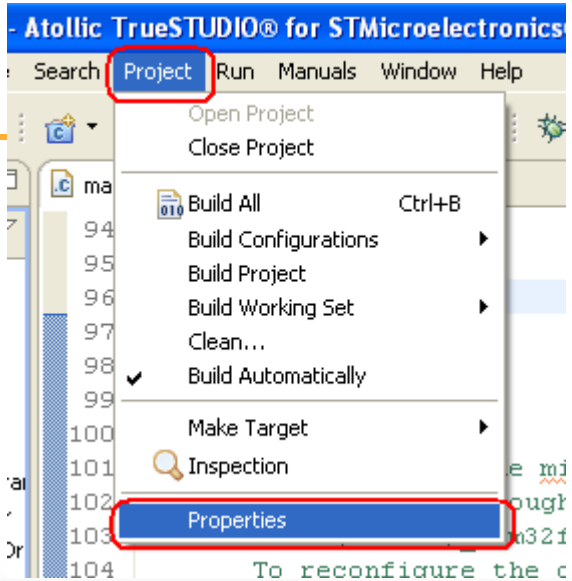
- Correct **TIM3_Config()** function in ***main.c*** file in order to configure Timer3 in output compare mode to generate update/overflow interrupts with 2Hz frequency and in the meantime capture/compare interrupt on channel 1. In Timer3 interrupt routine there is a control of LD3..6.
- Result: in LED_Circle state of main loop LD3..6 should blink with 1Hz frequency and with phase shift to the next one (circle flashing)



Parameter	value
TIM_Prescaler	839
TIM_Period	24999
TIM_Pulse	12500

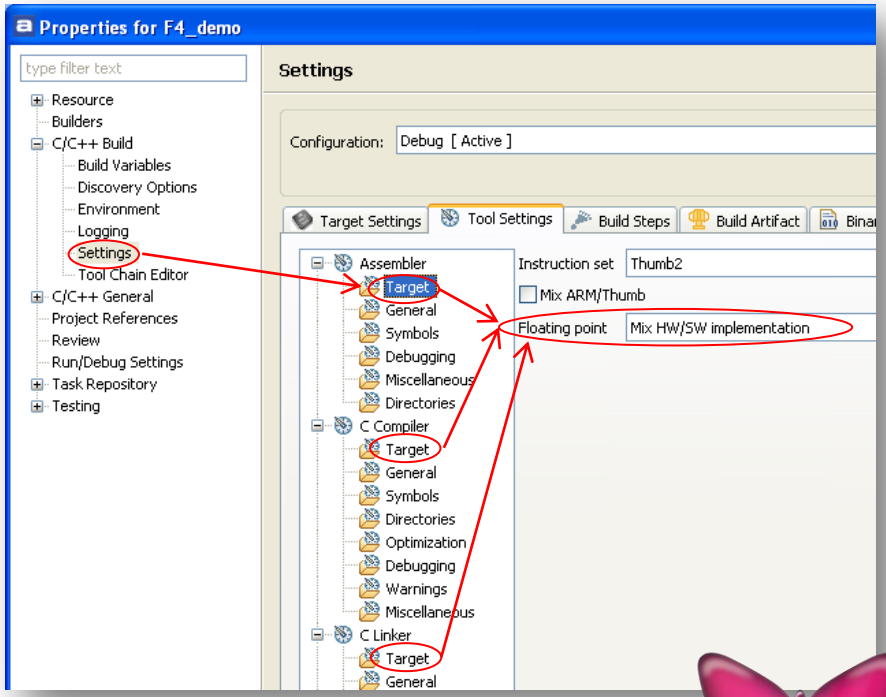
FPU configuration in STM32 TrueStudio

- In order to use hardware support of floating point calculations please select the option for floating point:
  “Mix HW/SW implementation”
  in project settings:
  Project->Properties->C/C++ Build->Settings->Tool Settings tab
  Target windows in Assembler, C Compiler and C Linker sections



- When exit from debug session program stops working.
  Reset of the MCU will cause the restart of the program.

- On the STM32F4_Discovery board there is embedded STLink debugger working in SWD mode only.

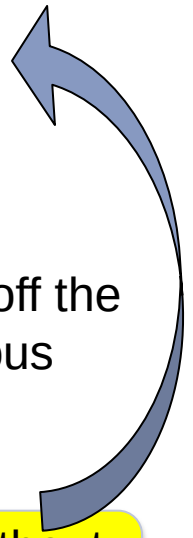


FPU - task

- inside the code there is a function **FPU_Test()** within LED_Blink part of the main loop of the code
- within the function there are two random floating point number generated and basic operations are performed.
- by usage of System Timer (SysTick) it is possible to check how many system clock cycles each operation on two floating point argument is using:
  - **time_add** – addition
  - **time_sub**– subtraction
  - **time_mul**– multiplication
  - **time_div** – division

No FPU	FPU

- using Atollic STM32 TrueStudio configuration it is possible to turn on and off the hardware support for floating point operations -> please refer to the previous slide



TASK: please check how many clock cycles uses each operation with and without hardware floating point support from the core (usage of FPU module)

FPU - solution

- inside the code there is a function **FPU_Test()** within LED_Blink part of the main loop of the code
- within the function there are two random floating point number generated and basic operations are performed.
- by usage of System Timer (SysTick) it is possible to check how many system clock cycles each operation on two floating point argument is using:
  - **time_add** – addition
  - **time_sub**– subtraction
  - **time_mul**– multiplication
  - **time_div** – division

No FPU	FPU
160	19
165	19
120	19
247	30

- using Atollic STM32 TrueStudio configuration it is possible to turn on and off the hardware support for floating point operations -> please refer to the previous slide

Fine tuning of the application - task

- The MEMS_Mouse state is working in so called “reverse orientation” like in the plane, like on figure A.
- The task would be to change way of operation to work like on the figure B. The answer to this question is located in the file ***stm32f4xx_it.c***, see lines 330…360.

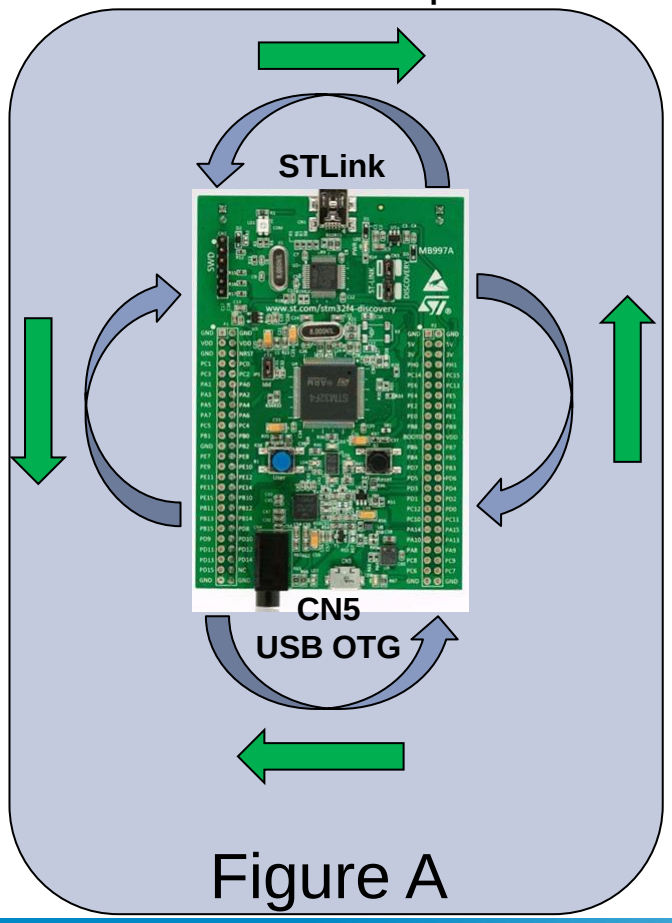


Figure A

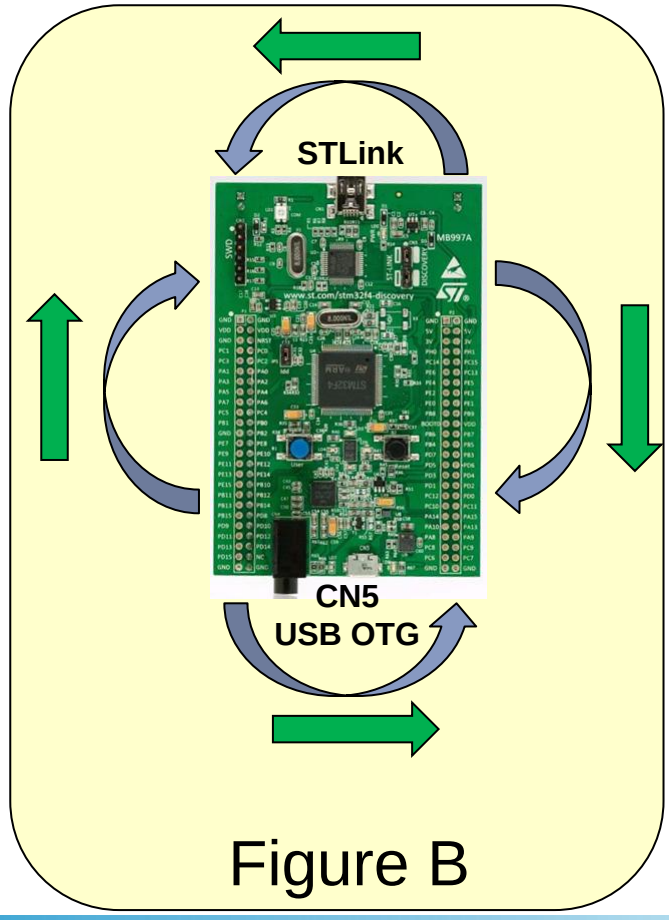


Figure B

PC cursor movement direction

Board movement direction

More info

STM32F4xx are here
STM32 motor control is here
STM32W is here
SPEAr is here
ST-Link-v2 is here
M24LRxx memory + RFID is here
Power Line Module is here
MEMS is here
ATOLLIC tips and tricks are here

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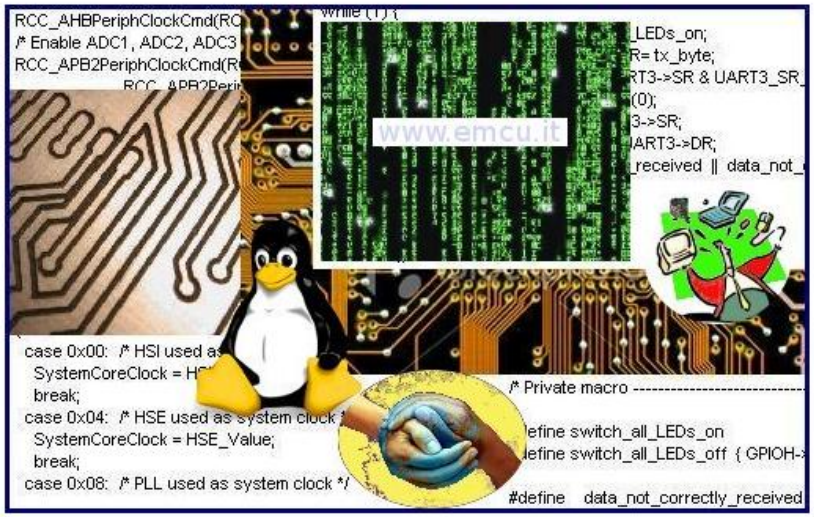

In general information concerning STM32xx, STM8xx, MEMS, RFID, SMART Meter, ZigBee, Blue Tooth, etc are here