STM hands-on session

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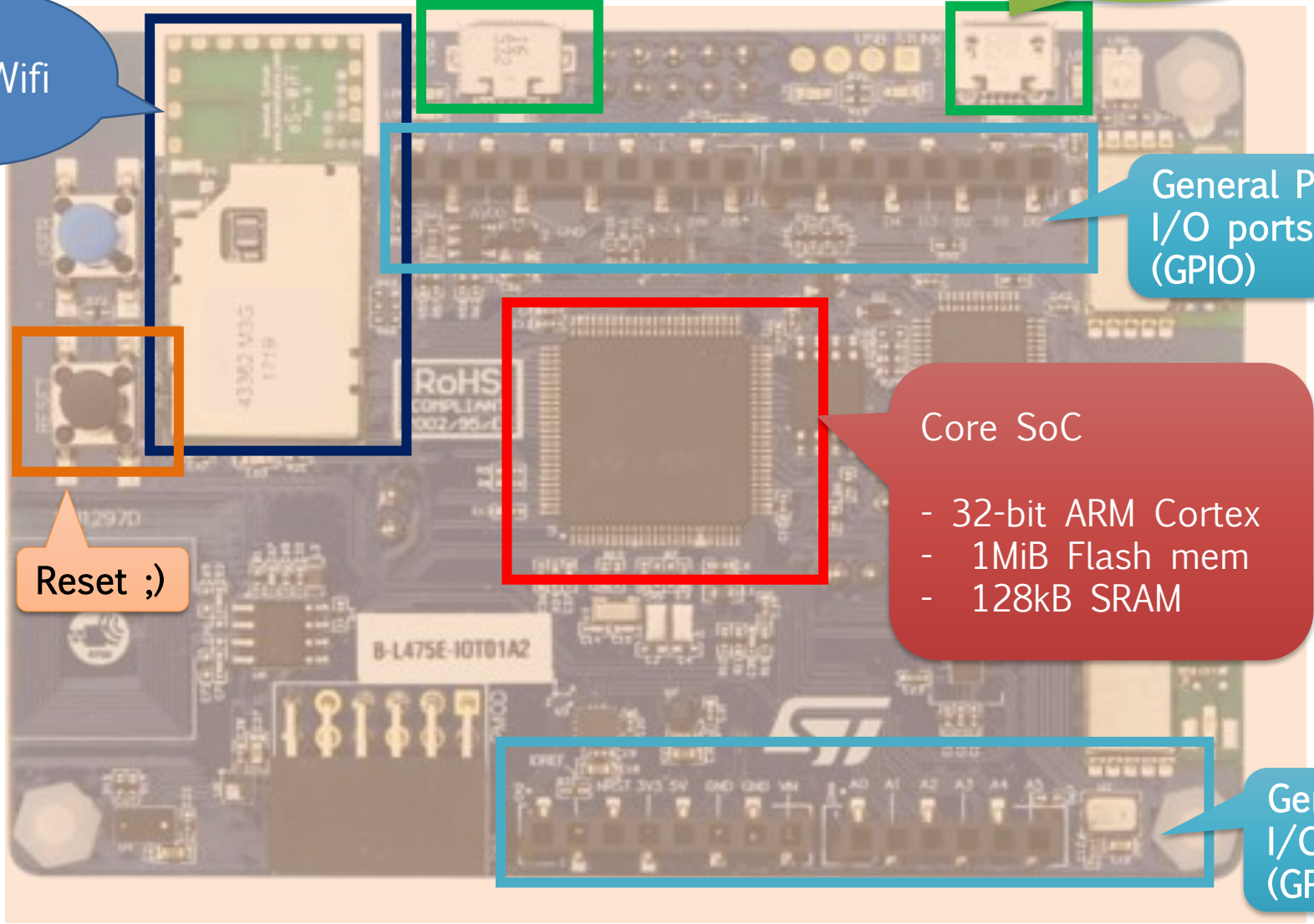
UNIMORE
UNIVERSITÀ DEGLI STUDI DI
MODENA E REGGIO EMILIA

High Performance
Real Time Lab

Programming is a skill best acquired by practice and example rather than from books.

ALAN TURING

Our guy (IoT node)



Software

Micro-kernel

› No OS, need to flash al memory regions

ST proprietary

› STM32 CubeIDE

› Debug via STLink (won't see this)

How to work

› No way is to compile our code directly on IoT Node

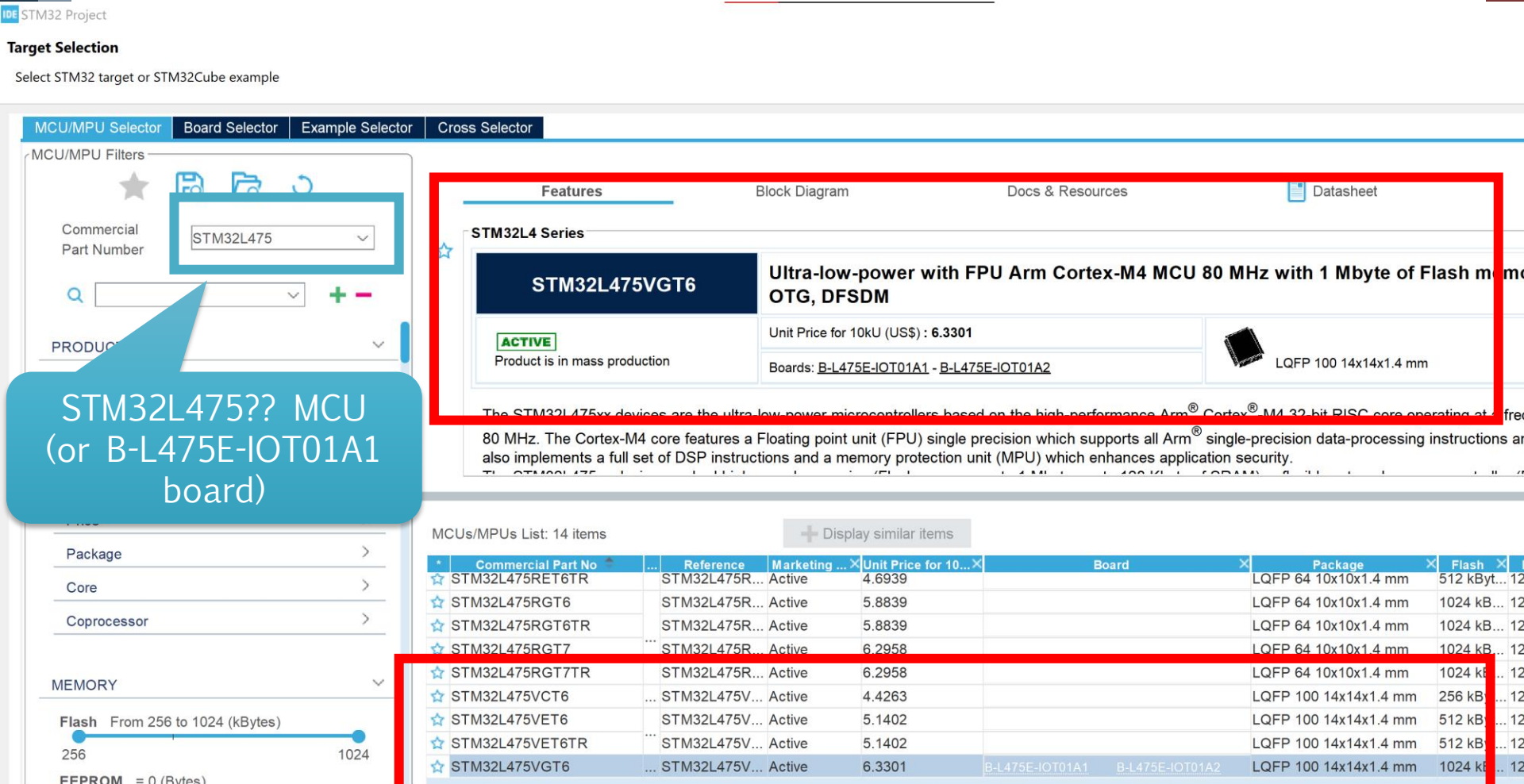
› Cross-compilation *via* the CubeIDE

› Flash the whole OS+program via USB

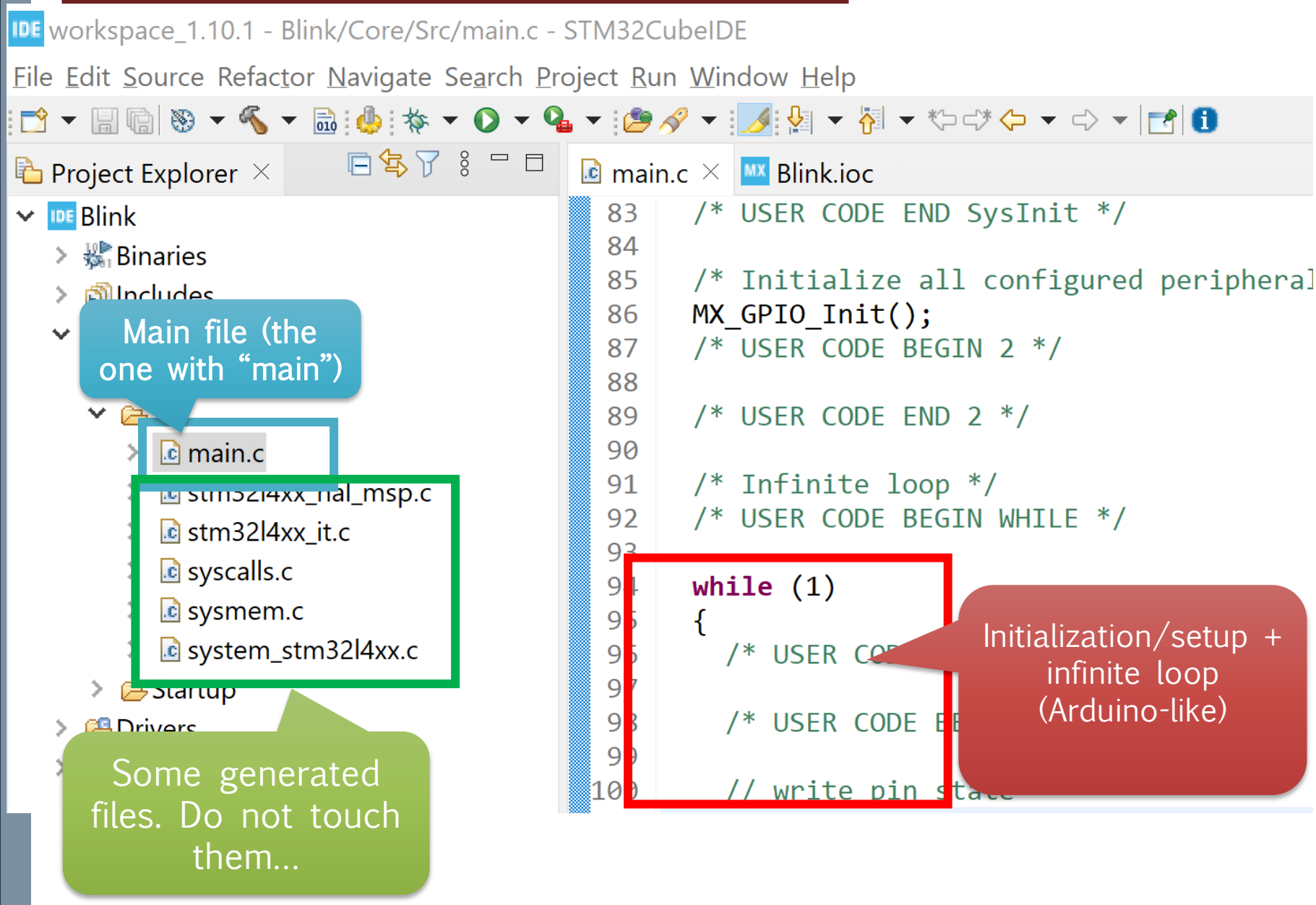
A simple application

Create a new “Blink” project

- File -> New Project
- Then. Select the MCU (or the board)
- **DO NOT initialize the peripherals in default mode!!! (**for this time..)



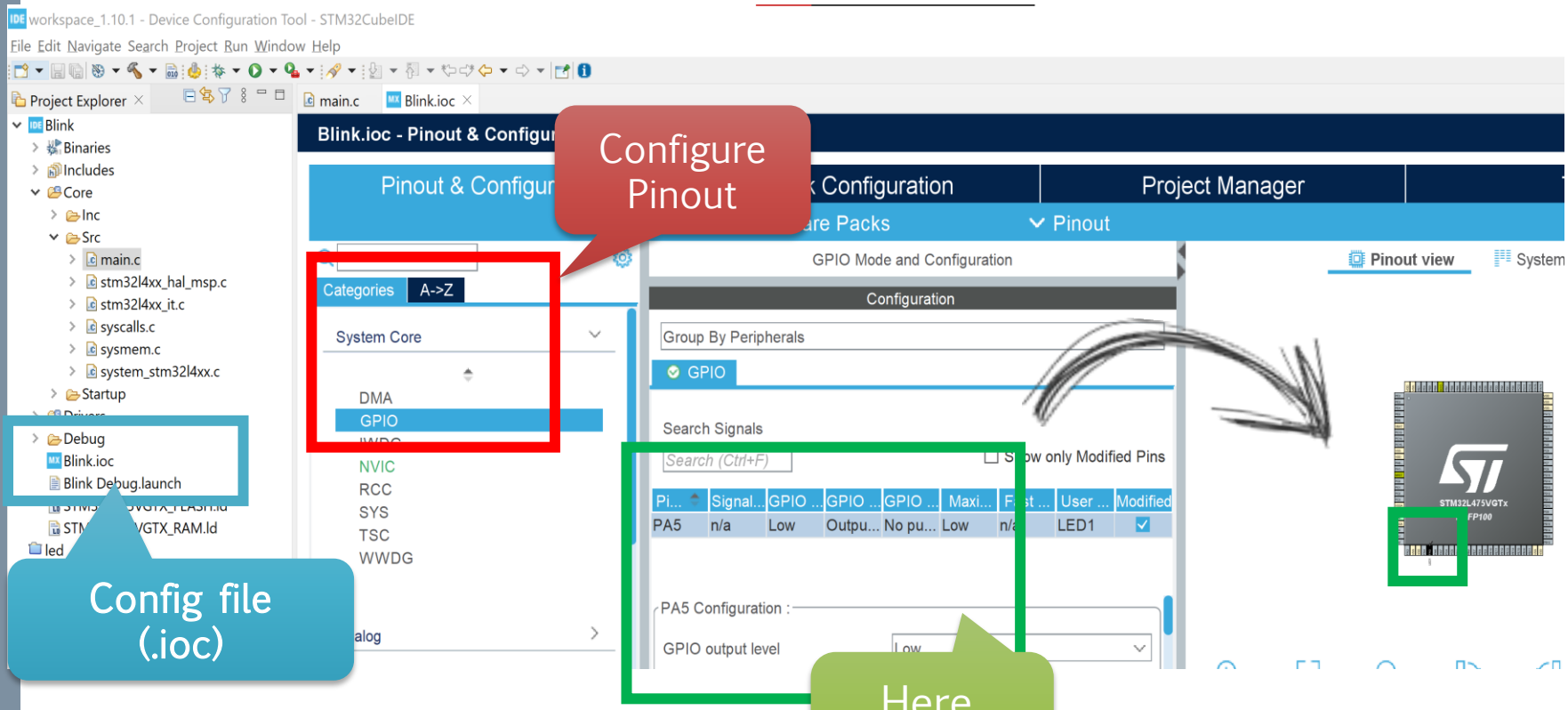
IDE


workspace_1.10.1 - Blink/Core/Src/main.c - STM32CubeIDE
File Edit Source Refactor Navigate Search Project Run Window Help
Project Explorer
Blink
Binaries
Includes
main.c
stm32l4xx_hal_msp.c
stm32l4xx_it.c
syscalls.c
sysmem.c
system_stm32l4xx.c
Startup
Drivers
main.c
Blink.ioc
/* USER CODE END SysInit */
/* Initialize all configured peripheral
MX_GPIO_Init();
/* USER CODE BEGIN 2 */
/* USER CODE END 2 */
/* Infinite loop */
/* USER CODE BEGIN WHILE */
while (1)
{
/* USER CO
/* USER CODE E
// write pin
Main file (the one with “main”)
Some generated files. Do not touch them...
Initialization/setup + infinite loop (Arduino-like)

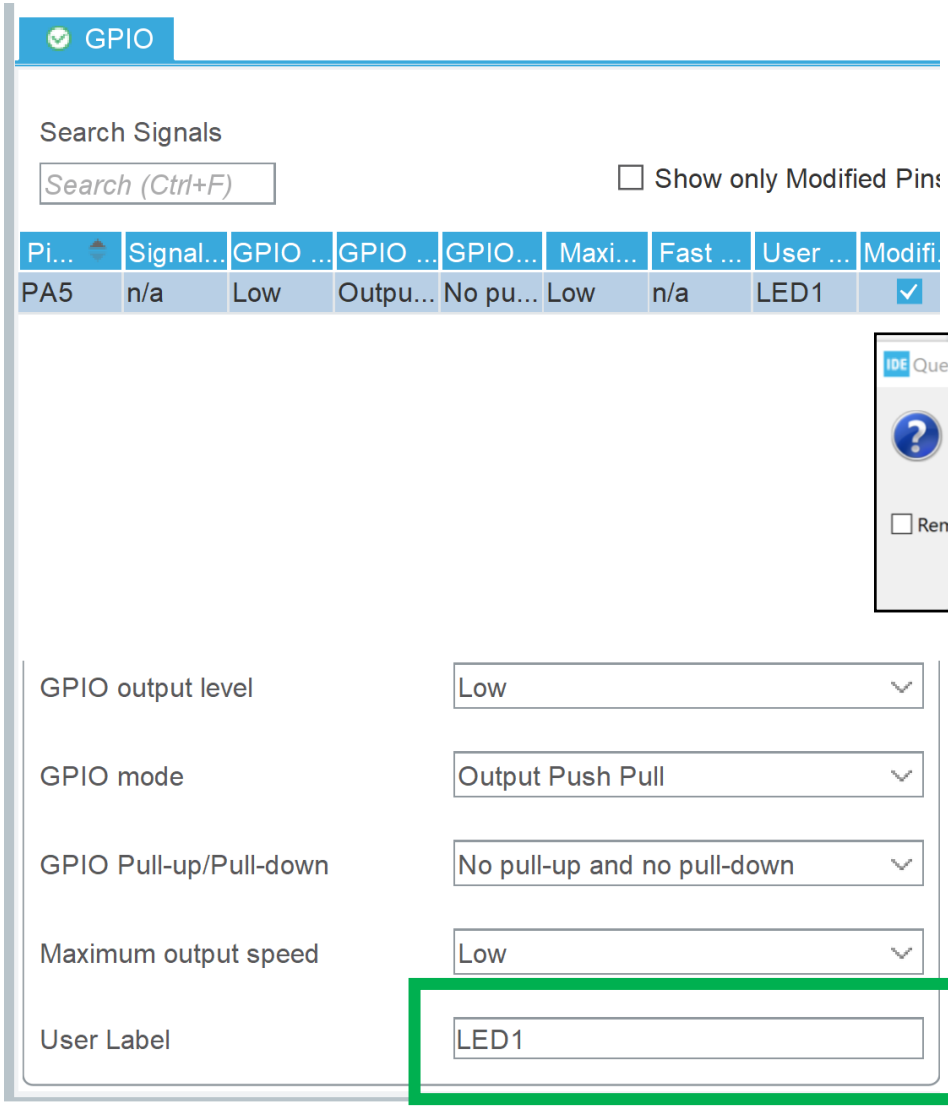
Configure LEDs

We want to create **an alias** for GPIOs

› So we don't need to change code when we change LEDs

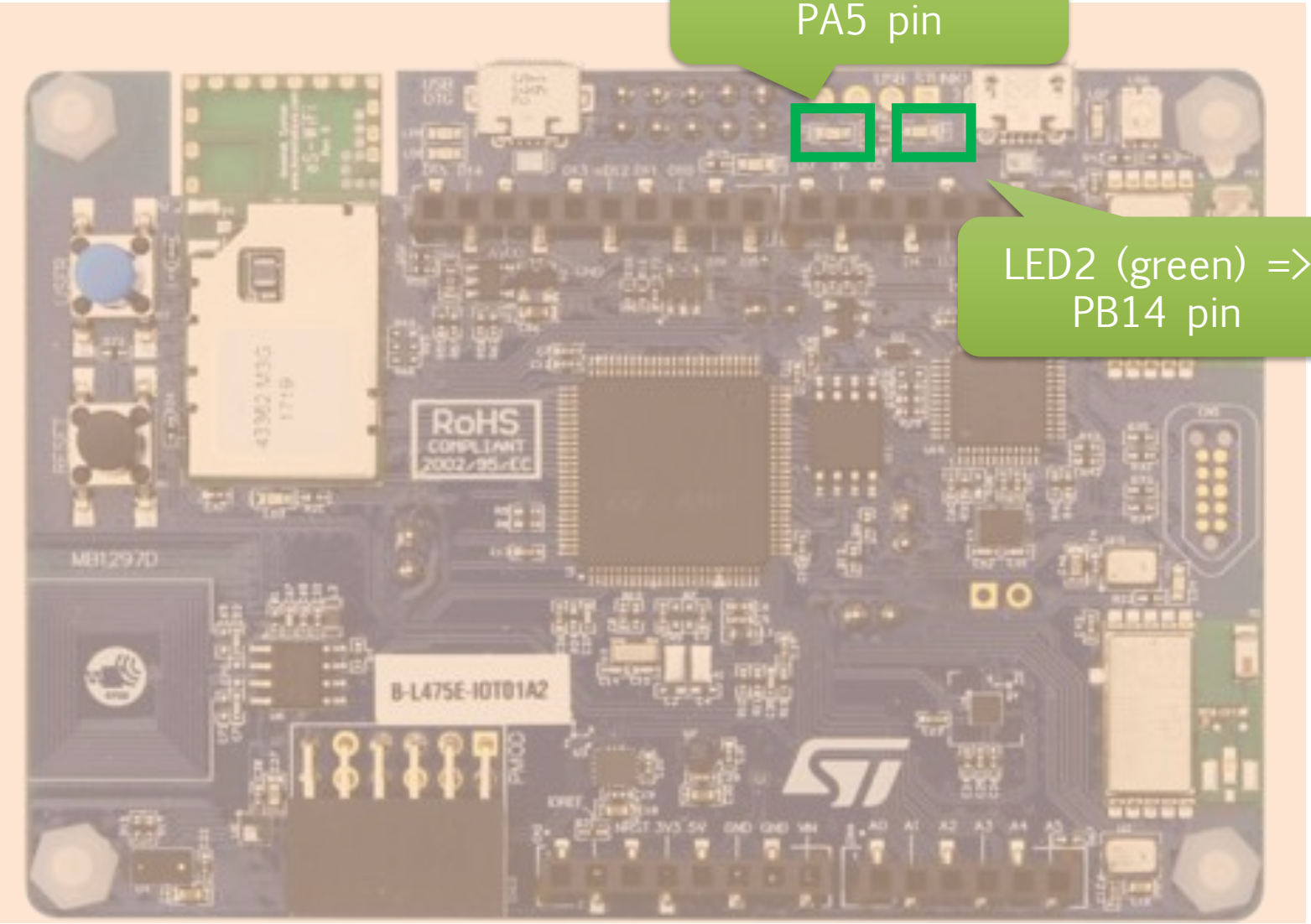


Let’s configure PA5



That’s our Alias!!

Leds and GPIOs



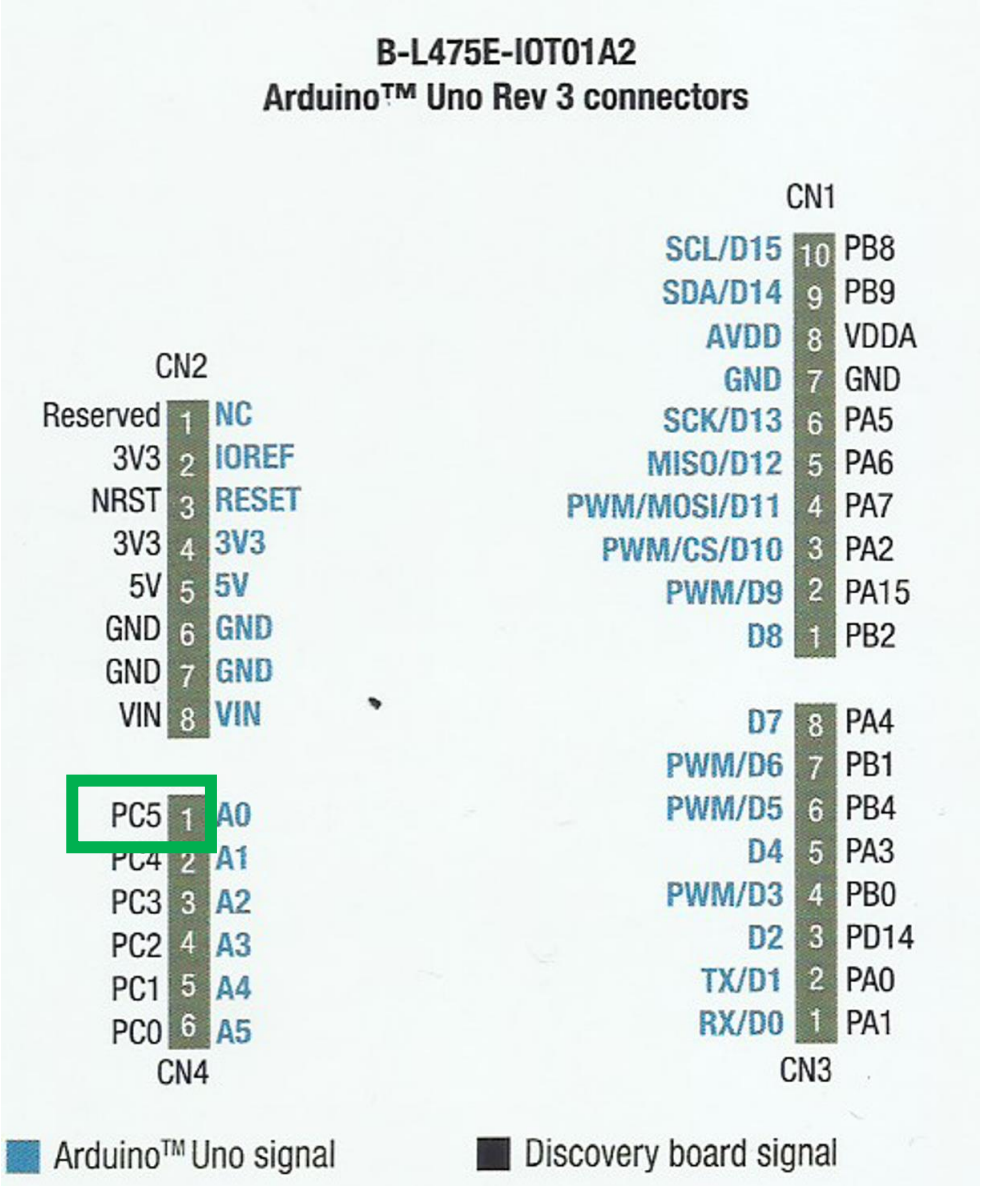
General Purpose I/O Ports

Our interface towards the external world

- Also supports Arduino Uno R3
- Let's skip this…

GPIOs are divided into two **board blocks**, and five **SoC ports**

- CN1,2
- Port A, B, C, D, E
- (not all ports are available on the board!!!)



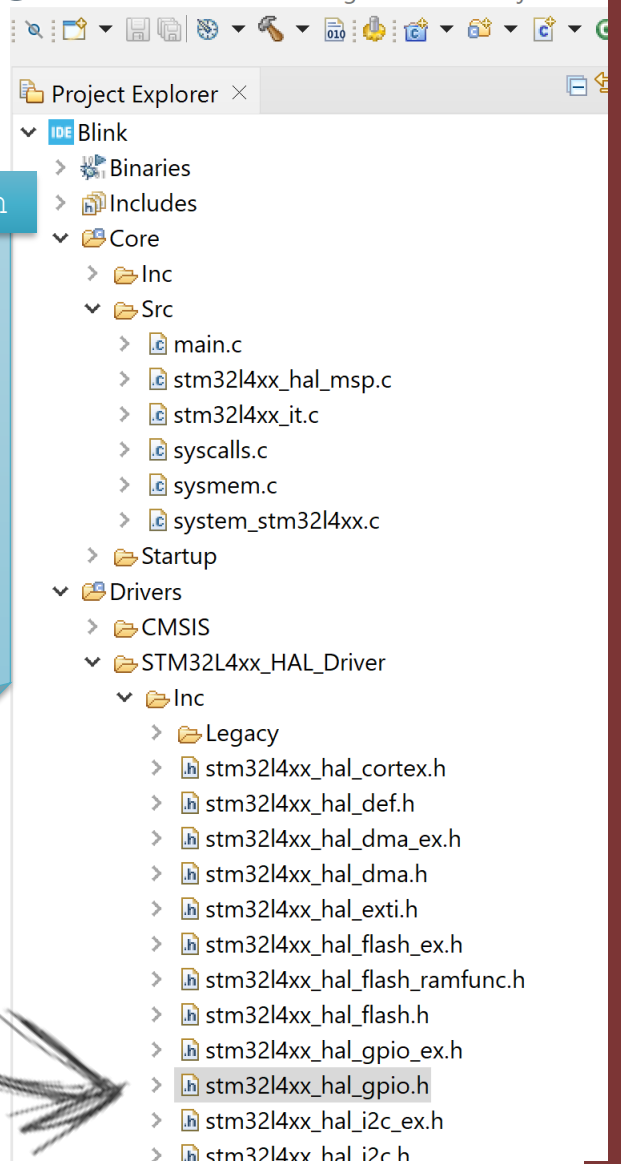
Write on GPIO PINs

stm32l4xx_hal_gpio.h

```
void HAL_GPIO_TogglePin (GPIO_TypeDef *GPIOx,
                         int16_t GPIO_Pin );

GPIO_PinSTate HAL_GPIO_ReadPin (GPIO_TypeDef *GPIOx,
                                int16_t GPIO_Pin );

void HAL_GPIO_WritePin (GPIO_TypeDef *GPIOx,
                        int16_t GPIO_Pin,
                        GPIO_PinSTate PinState);
```



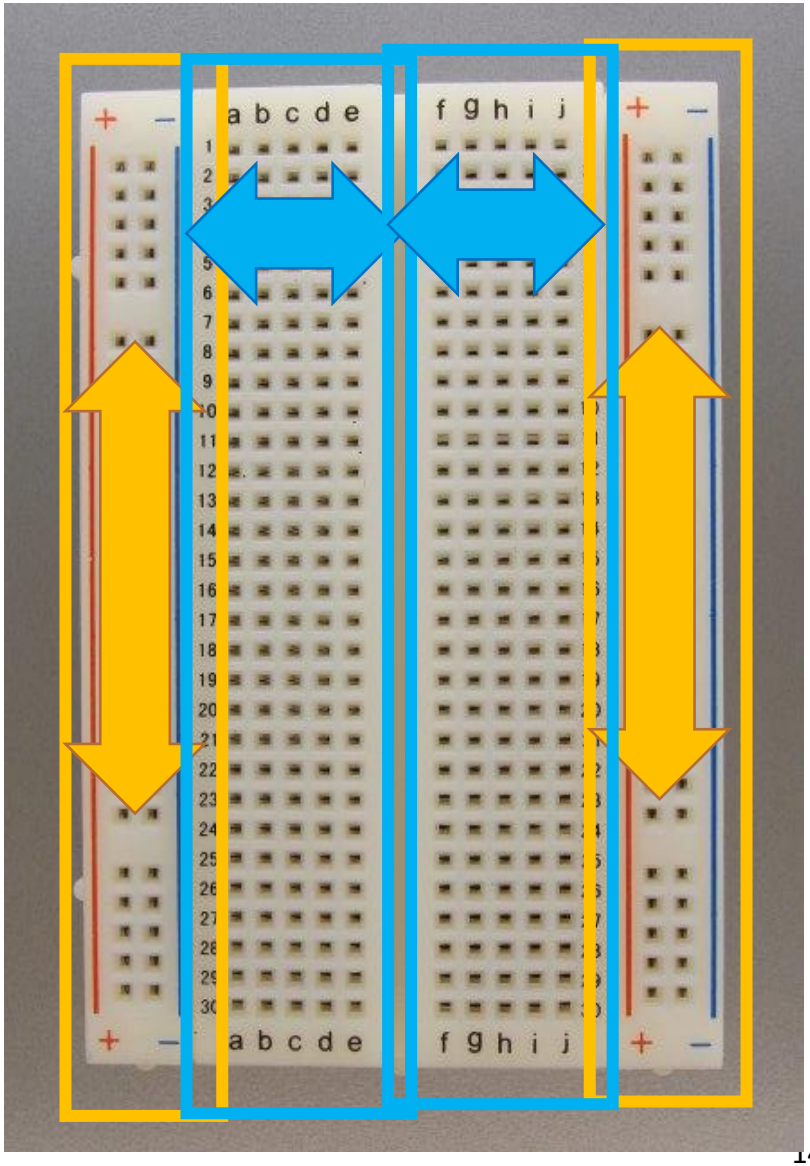
It's a generated file!!

Let’s play!

Breadboard

Provides electrical connectivity

- Vertical vs. horizontal rails
- (Typically, power vs other)
- Can use jumper wires



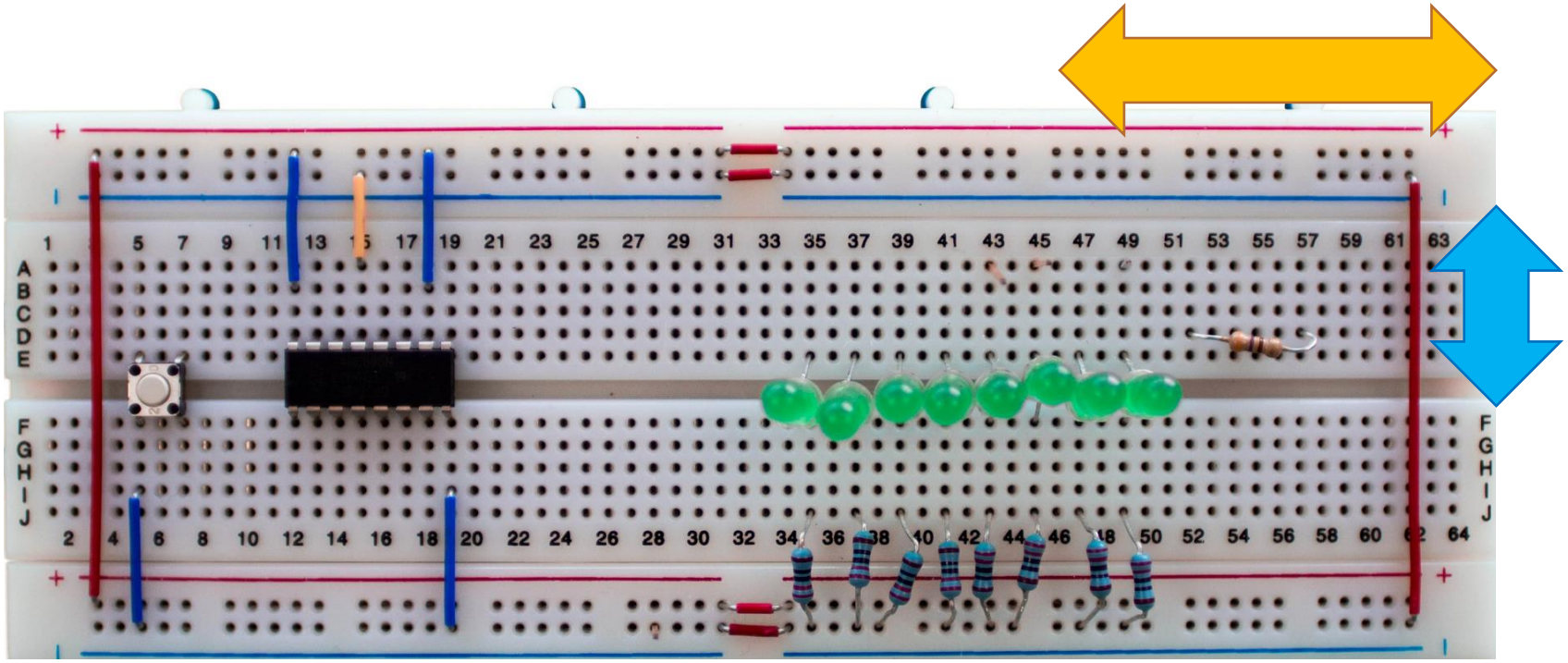
Breadboard

The two sides of the + and - rails are wired together

› Typically, used for power/GND

Brought to the internal rails with jumper wires

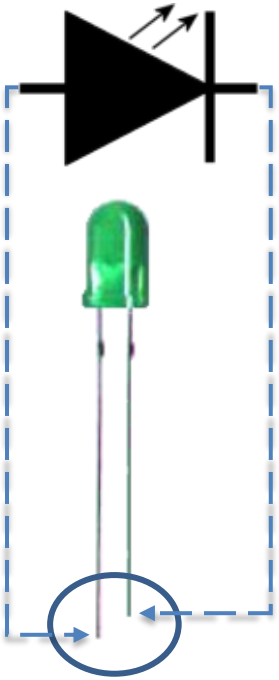
› Where core/chip and other stuff reside



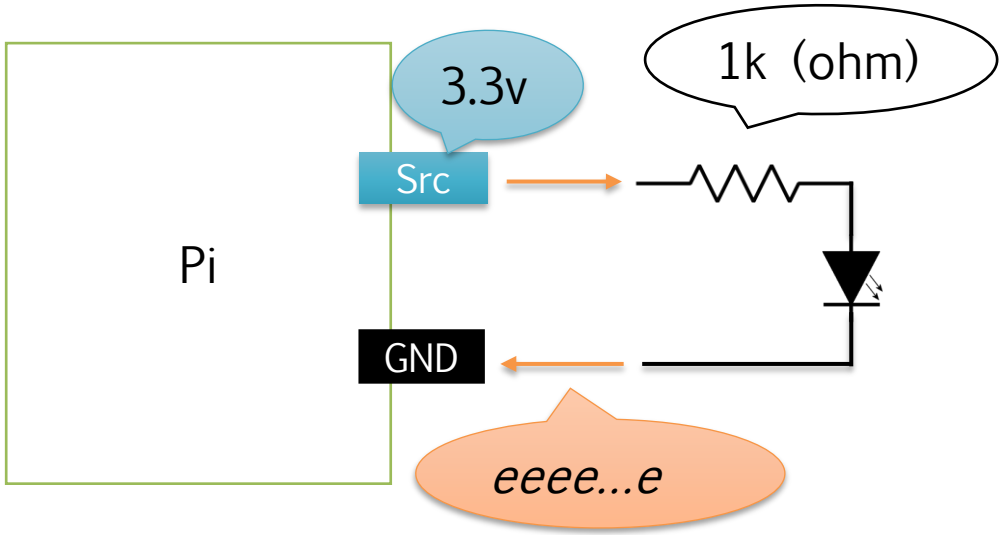
Finally…LEDs

Light Emitting Diodes

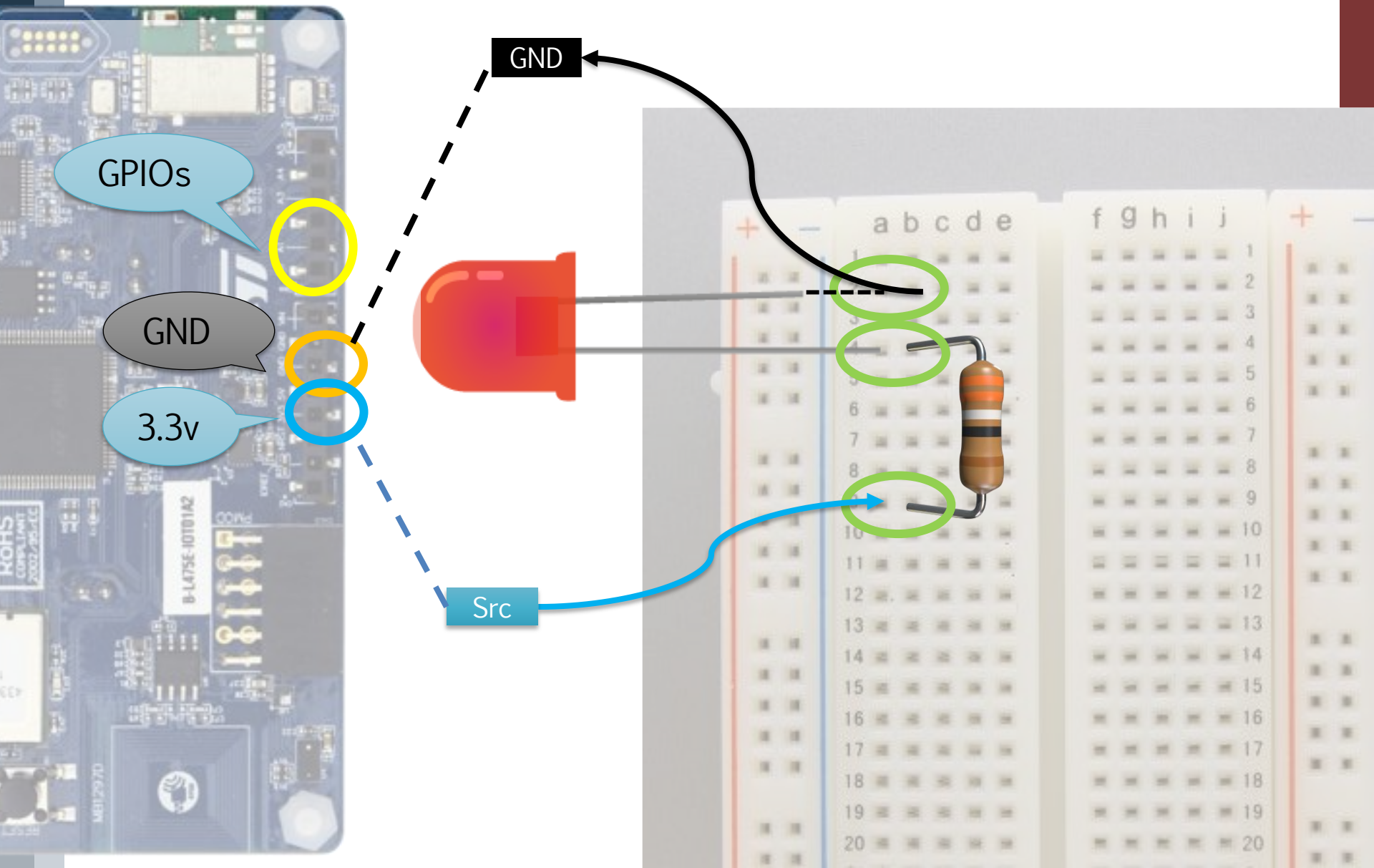
- You feed with electrons; they light up
- They have a side!!!!
- They need a resistance to lower the charge



Wrong wiring => you burn them…



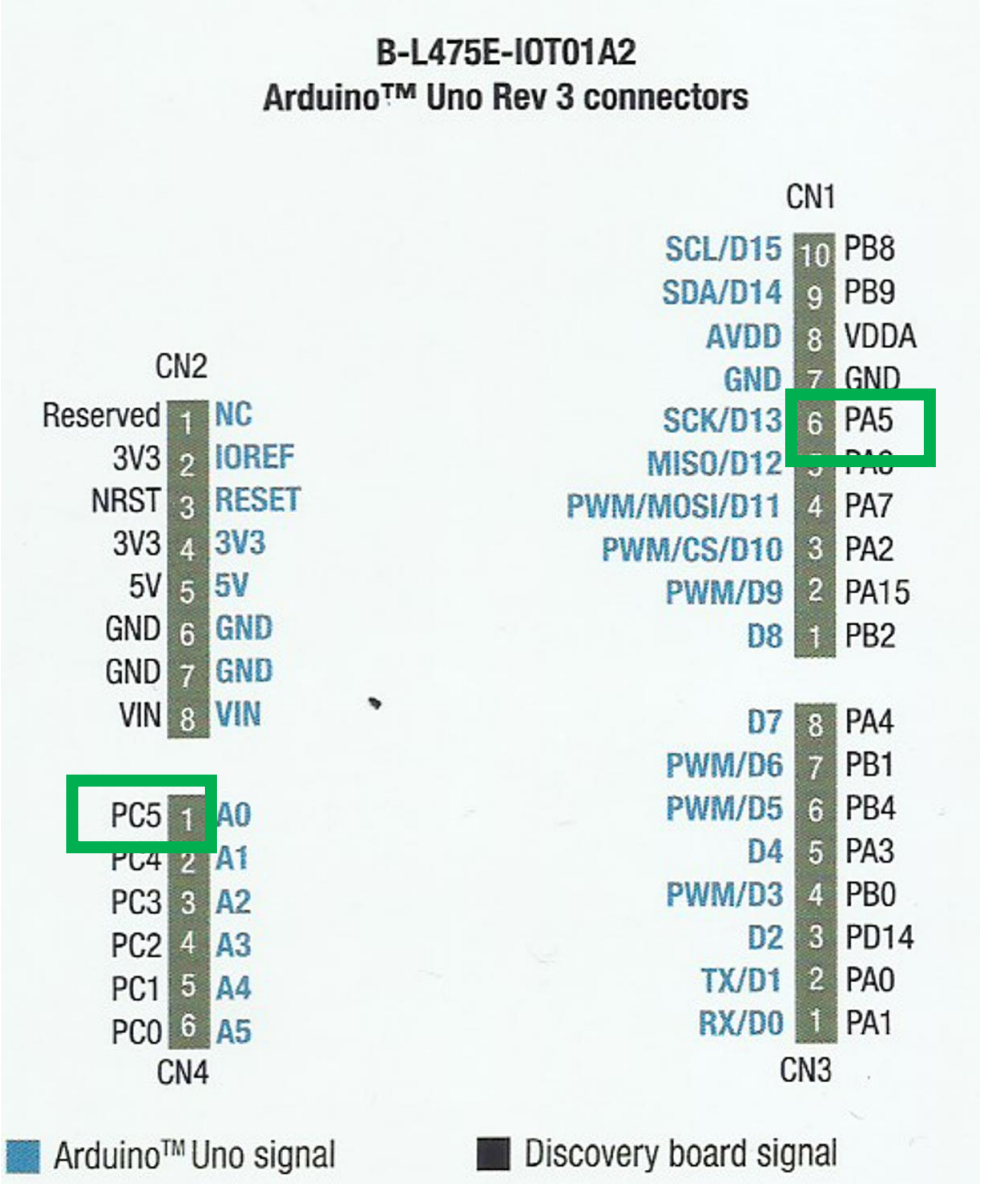
E/E system



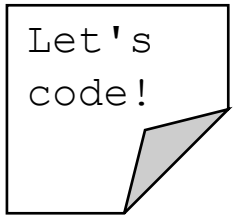
Let’s play with Pins

PA5 is also in board pinout

- Connect our led to them
- PB14 is not…



Exercise



- Implement the following two applications:

1. A firmware to control the LED1 of the STM32 board, using the PA5 pin;

2. A firmware to control an external led mounted on a breadboard. To drive the signal to the external led you have to configure and use a GPIO on the STM32.

Serial communication

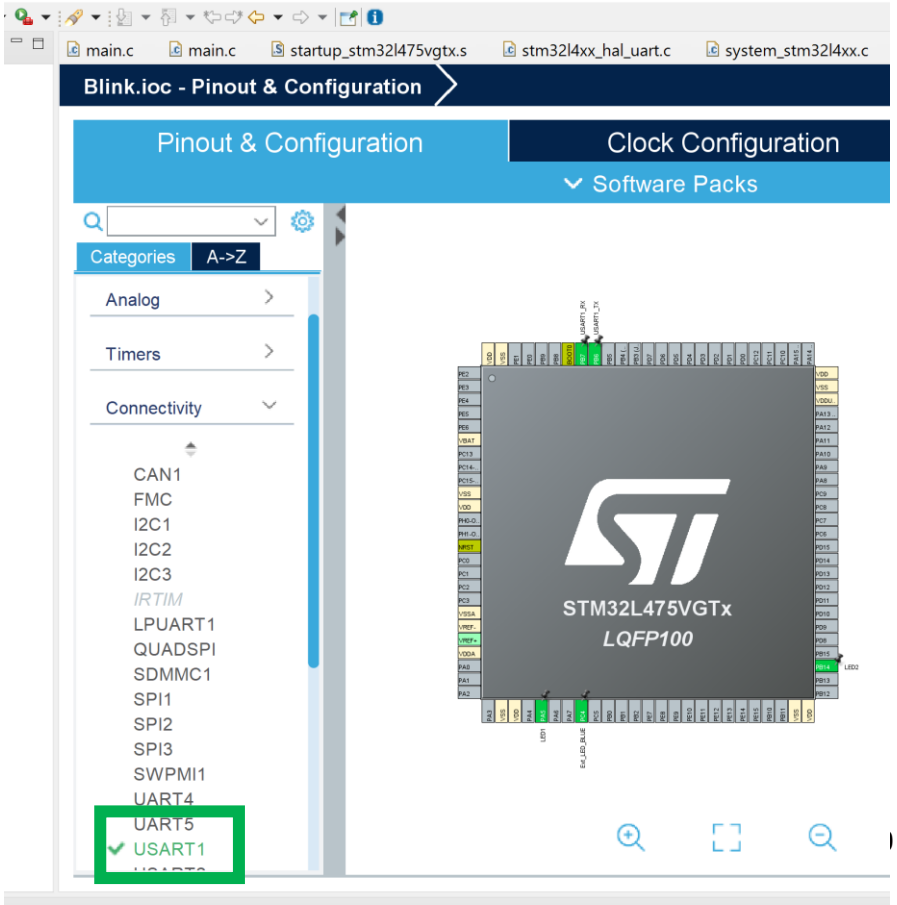
Universal asynchronous receiver-transmitter – UART

› “Asynchronous” -> One channel for TX, one channel for RX

USART Universal Synchronous/Asynchronous Receiver/Transmitter

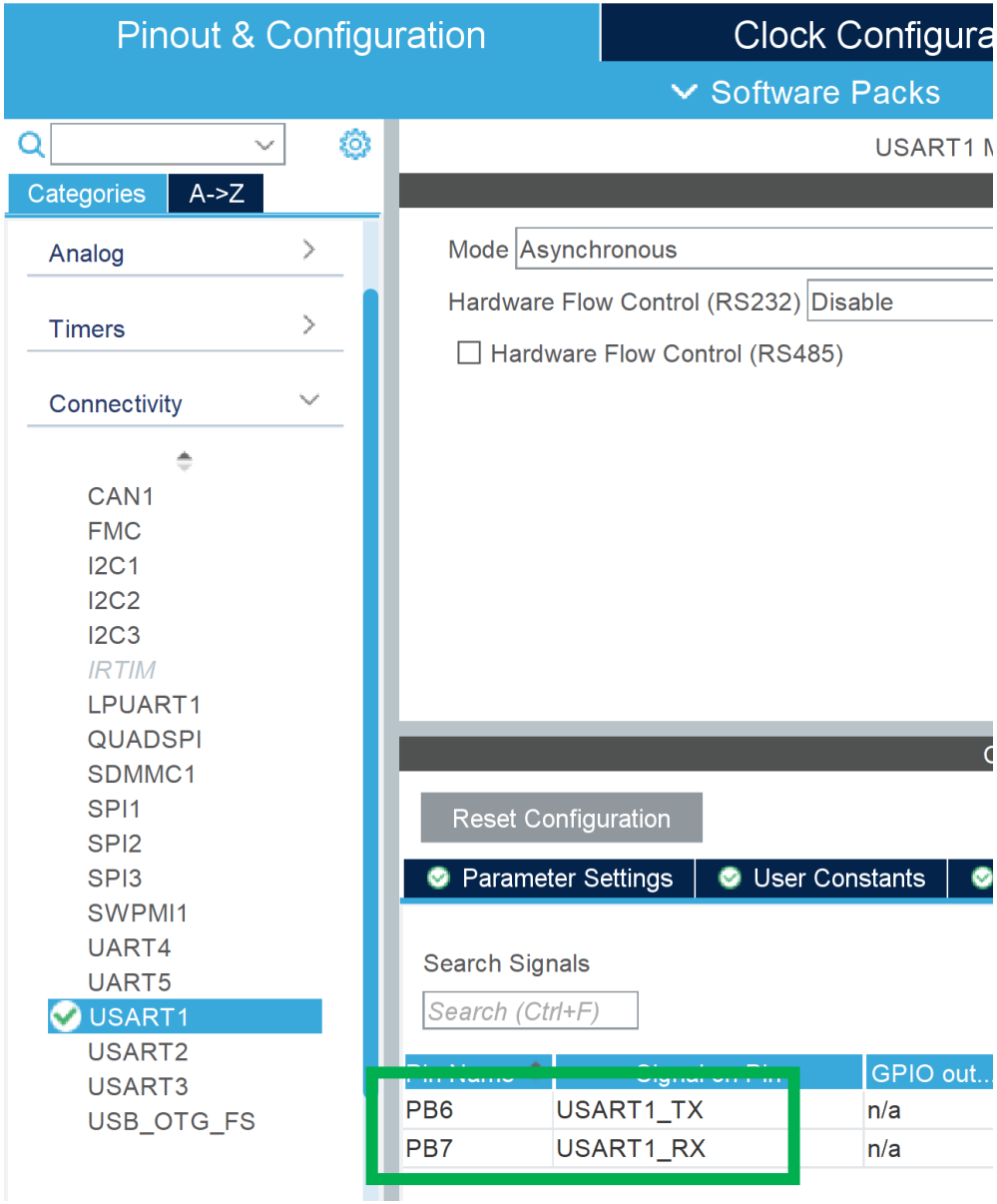
› w/bitstream

› USART1 in our board



Configure USART1

- PB6 for Tx
- PB7 for Rx



Write code

```
/* USER CODE BEGIN 3 */


uint8_t Test[] = "Hello World !!!\r\n"; //Data to send

HAL_StatusTypeDef retval =
        HAL_UART_Transmit(&huart1,Test,sizeof(Test),10);

//Let's add some delay
HAL_Delay(1000);


/* USER CODE END 3 */
```

- Copy-paste this in your main loop

System header

```
/**
 * @brief Send an amount of data in blocking mode.
 * [...]
 * @param huart UART handle.
 * @param pData Pointer to data buffer (u8 or u16 data elements).
 * @param Size Amount of data elements (u8 or u16) to be sent.
 * @param Timeout Timeout duration.
 * @retval HAL status
 */
HAL_StatusTypeDef HAL_UART_Transmit(UART_HandleTypeDef *huart,
const uint8_t *pData, uint16_t Size, uint32_t Timeout);
```

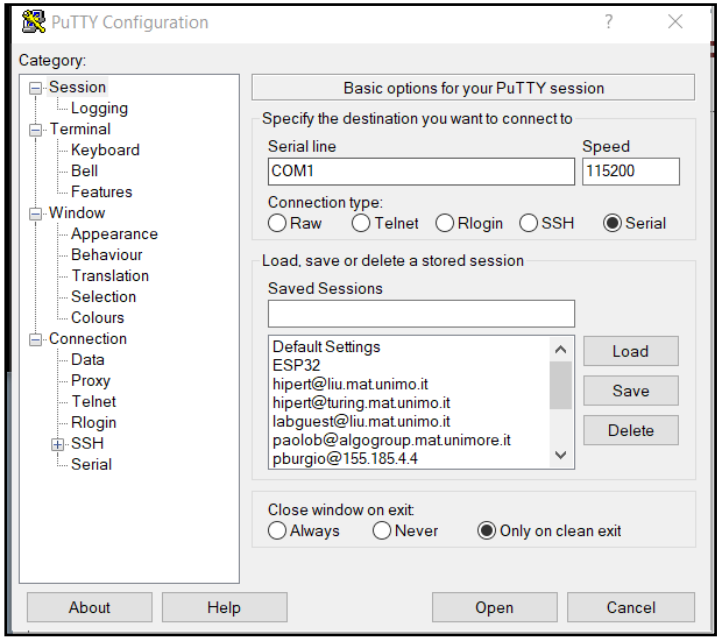
- Returns “check”

On your machine... (1)

First, test with a “standard” serial Monitor

- Linux
  - `sudo apt install minicom`
  - Serial/USB ports are typically `/dev/ttySOMETHING`
- Windows
  - Putty
  - Serial/USB ports are COMx

115200 Baud, no parity, 8 bit



On your machine... (2)

Programmatically read from serial/USB

- C++
  - https://github.com/imabot2/serialib
- Python
  - pySerial

I/O using printf and scanf (1)

The standard **printf** and **scanf** are based on the **putchar** and **getchar** functions, that can be used to write and read a single character;

› On the STM32, the putchar/getchar functions can be re-defined using the HAL_UART_* functions that we used in the previous examples:

```
int __io_putchar(int ch)
{
   /* Place your implementation of fputc here */
   /* e.g. write a character to the USART1 and Loop until
the end of transmission */
   HAL_UART_Transmit(&huart1, (uint8_t *)&ch, 1, 0xFFFF);

   return ch;
}
```

I/O using printf and scanf (2)

The standard **printf** and **scanf** are based on the **putchar** and **getchar** functions, that can be used to write and read a single character;

› On the STM32, the putchar/getchar functions can be re-defined using the HAL_UART_* functions that we used in the previous examples:

```
int __io_getchar(void)
{
   int ch;
   /* Place your implementation of fgutc here */
   /* e.g. read a character from the USART1 and Loop until
the end of transmission */
   HAL_UART_Receive(&huart1, (uint8_t *)&ch, 1, 0xFFFF);

   return ch;
}
```

I/O using printf and scanf (3)

The stdin/stdout should be configured to avoid buffering, otherwise printf and scanf may not work properly.

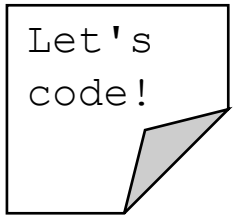
```
int main(void)
{
     …

     setvbuf(stdin,  NULL, _IONBF, 0);
     setvbuf(stdout, NULL, _IONBF, 0);

     …

     while (1) {
          …
     }
}
```

Exercise



- Implement the following four applications:

1. A firmware that writes the «Hello World» string to the serial monitor;
2. Configure the **printf** using the **__io_putchar()** function and implement an application that writes the first ten numbers to the serial monitor;
3. A mirroring application, where the STM32 receives a byte from the serial monitor and re-transmit the byte to the monitor;
4. A LED controller using the UART. Implement the following logic:
   - If the input character is '1' turn on the LED1;
   - If the input character is '2' turn on the LED2;
   - If the input character is '0' turn off both LEDs.

Exercise (1)

Let's code!

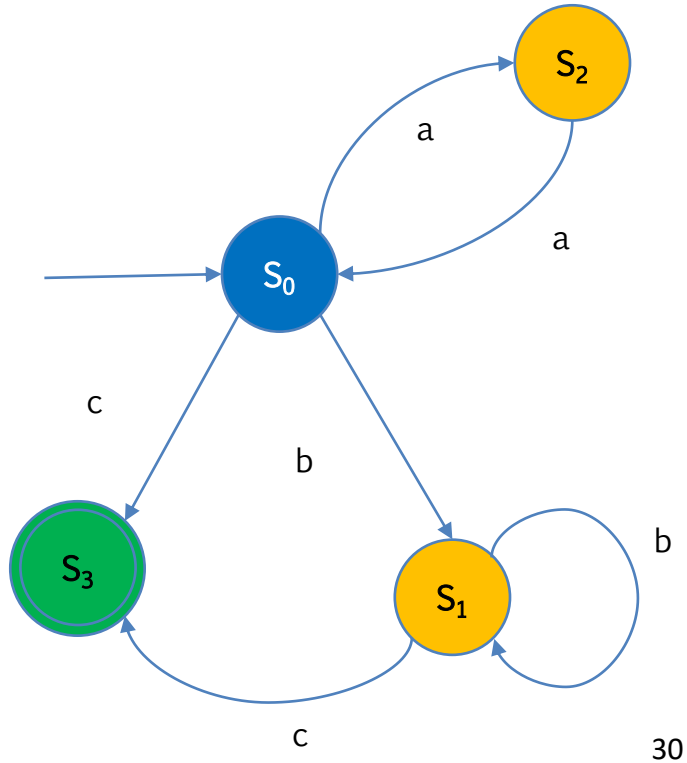
› Implement the Moore machine of the FSM that understands whether a words is from L

"Identify even sequences of a (even empty),

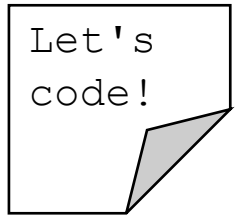
followed by one, or more, or no, b, ended by c"

› ..and turns on the corresponding led color

- **Blue** => GPIO 0
- **Red (error state)** => GPIO 1
- **Yellow** => GPIO 2
- **Green** => GPIO 3



Exercise (2)



- Implement a Moore FSM to control a traffic light. The traffic light has **four different phases** (OFF, Green, Yellow and Red). The OFF state is the initial one. The *next_state(…)* function is regulated by a timer.
  - Use a configurable timer of the SMT32 (refer to the UM2153 manual for the details);
  - Otherwise you can start from the *HAL_Delay(…)* function.
- The timer should read a STOP and START signal using the UART.
  - If the input is '1' the traffic light controller starts its execution;
  - If the input is '0' the traffic light is off.

References

Course website

- http://hipert.unimore.it/people/paolob/pub/Industrial_Informatics/index.html

My contacts

- paolo.burgio@unimore.it
- http://hipert.mat.unimore.it/people/paolob/

Resources

- A "small blog -> http://www.google.com
- Serial comms
  - https://wiki.st.com/stm32mcu/wiki/STM32StepByStep:Step3_Introduction_to_the_UART
  - https://github.com/imabot2/serialib