南方科技大学
SOUTHERN UNIVERSITY OF SCIENCE AND TECHNOLOGY

Embedded System and Microcomputer Principle

LAB2 General-purpose Input/Output

2022 Fall
wangq9@mail.sustech.edu.cn

南方科技大学
SOUTHERN UNIVERSITY OF SCIENCE AND TECHNOLOGY

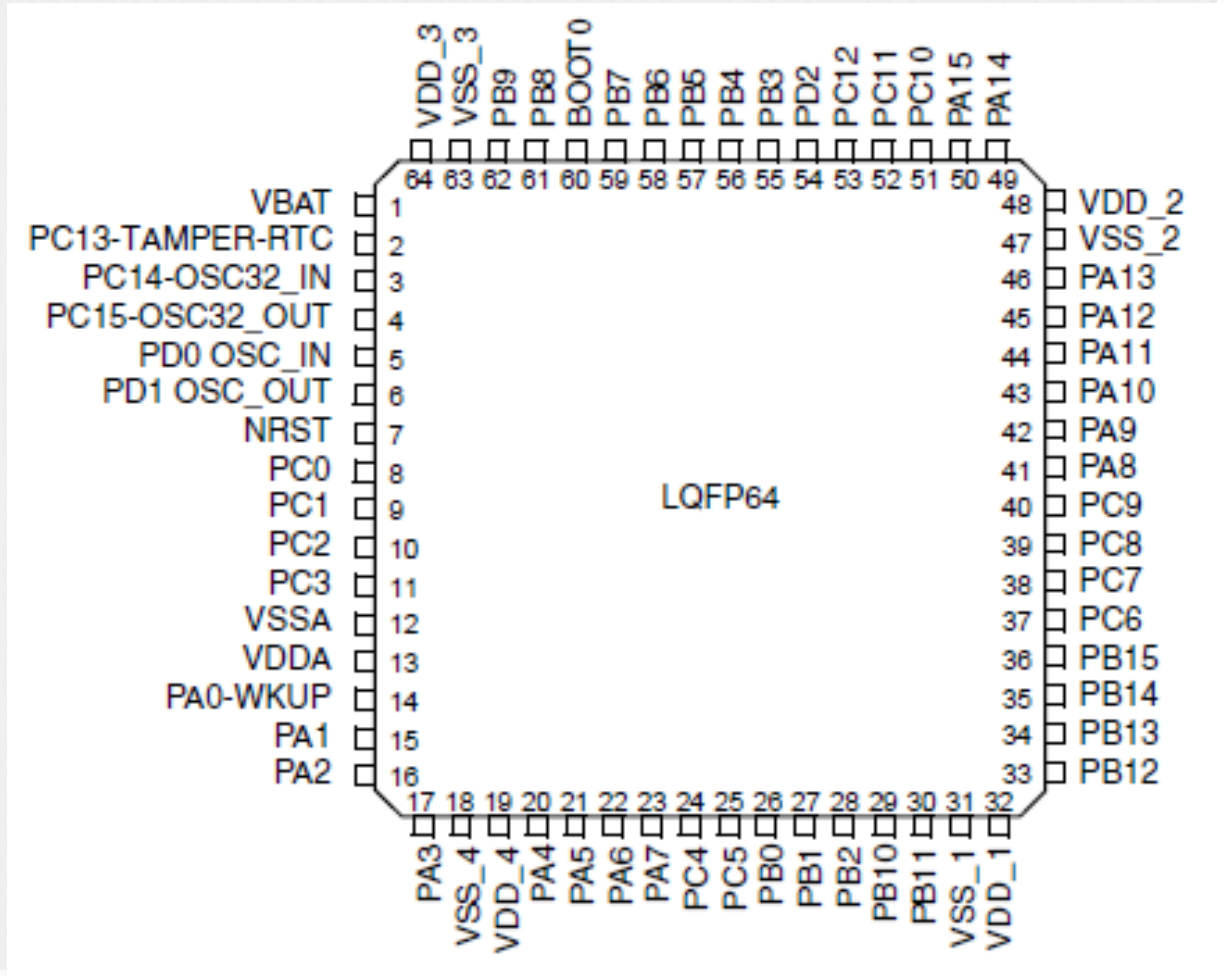
CONTENTS

01

GPIO Function Description

1. GPIO Function Description

- There are 4 groups of I/O in STM32F103RCT6
- 51 I/O ports
  - GPIOA0~A15
  - GPIOB0~B15
  - GPIOC0~C15
  - GPIOD0~D2
  - 16*3 + 3 = 51



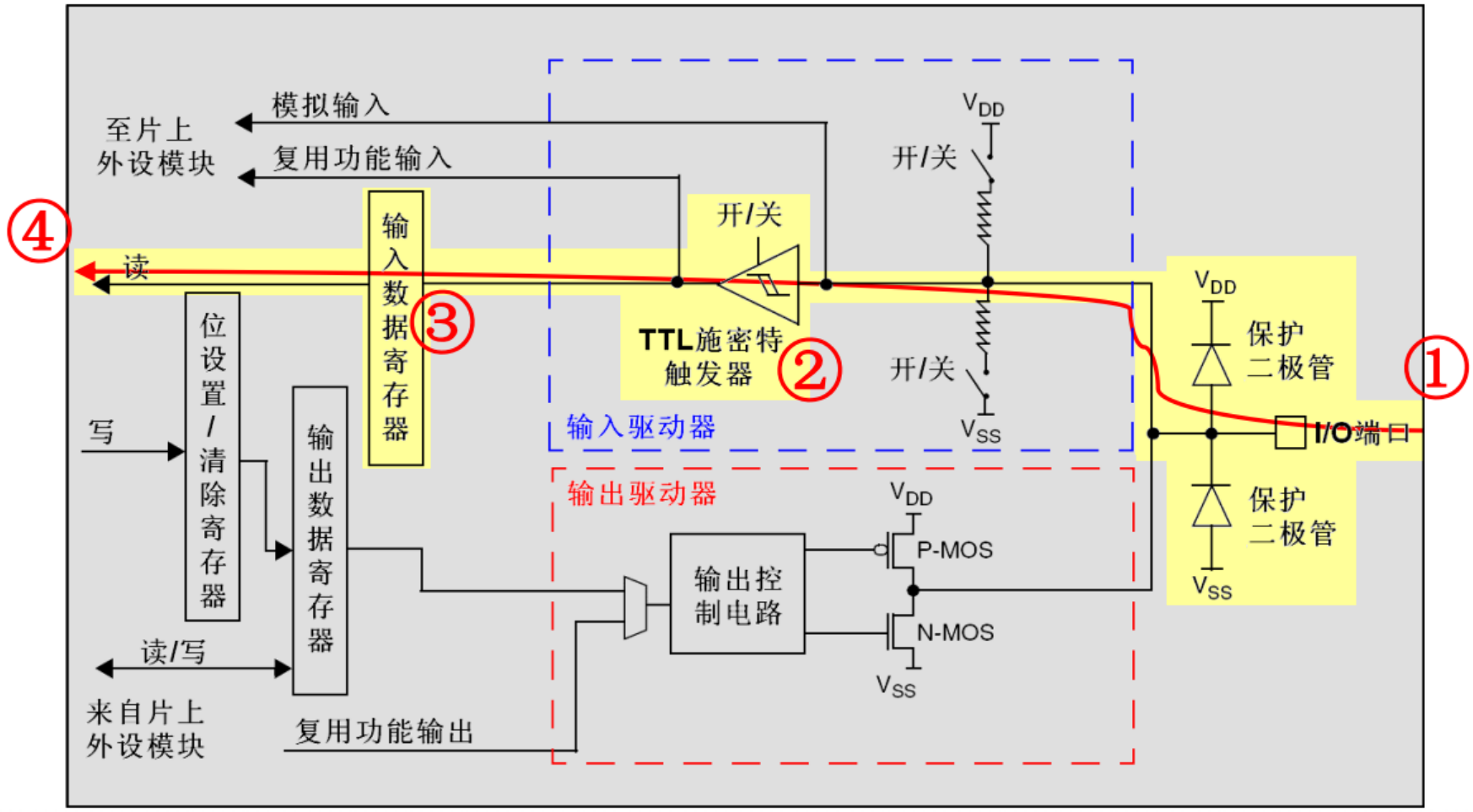
1. GPIO Function Description

南方科技大学 SOUTHERN UNIVERSITY OF SCIENCE AND TECHNOLOGY

- Each GPIO port in STM32 can be individually configured by software in 8 modes
  - 输入浮空 Input floating
  - 输入上拉 Input pull-up
  - 输入下拉 Input pull-down
  - 模拟输入 Analog
  - 开漏输出 Output open-drain with pull-up or pull-down capability
  - 开漏复用功能 Alternate function open-drain with pull-up or pull-down capability
  - 推挽式输出 Output push-pull with pull-up or pull-down capability
  - 推挽式复用功能 Alternate function push-pull with pull-up or pull-down capability
- More about GPIO and the corresponding feature
  - https://blog.stratifylabs.co/device/2013-10-21-Understanding-Microcontroller-Pin-Input-Output-Modes/
  - http://www.openedv.com/posts/list/21980.htm

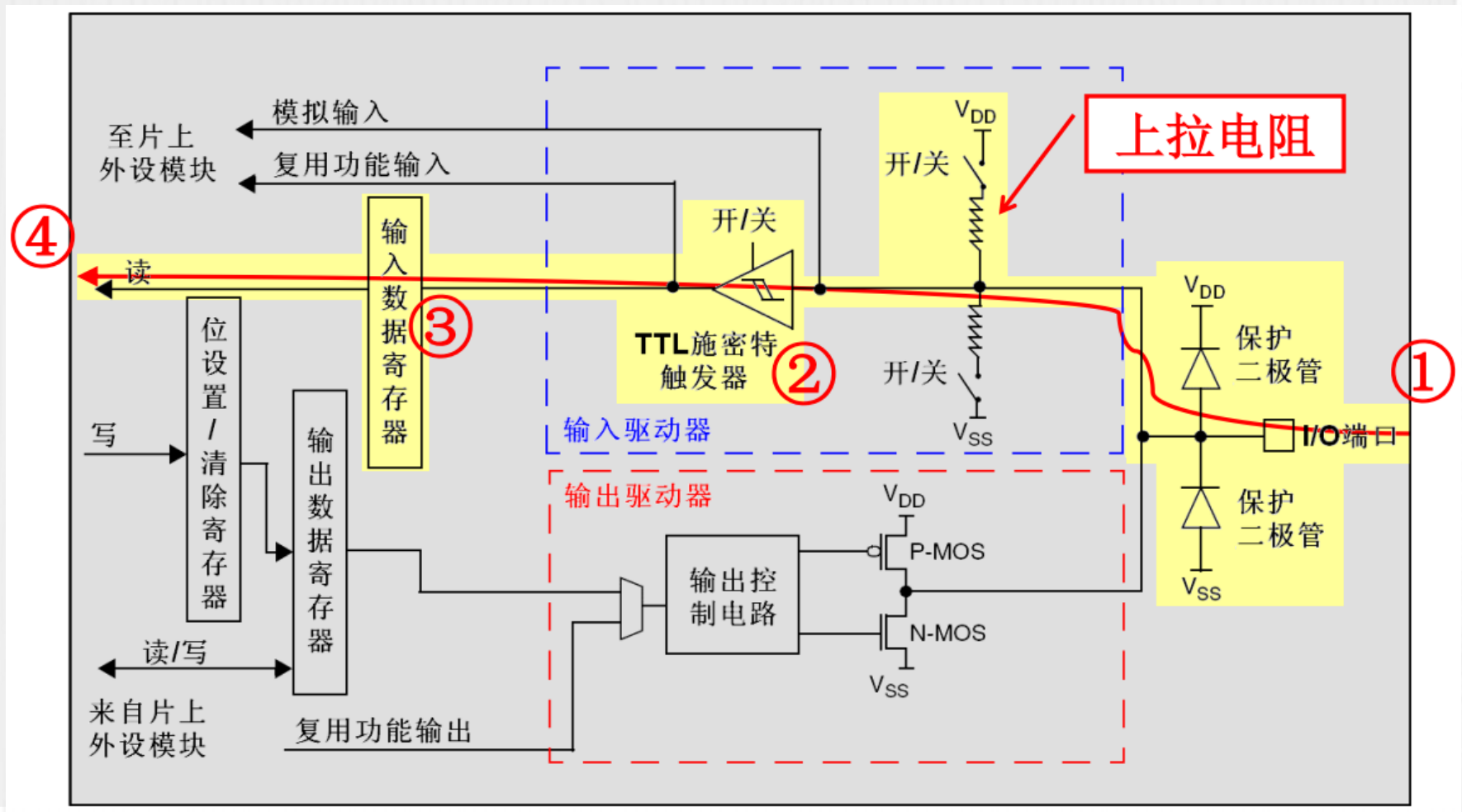
1. GPIO Function Description

- Input floating 输入浮空



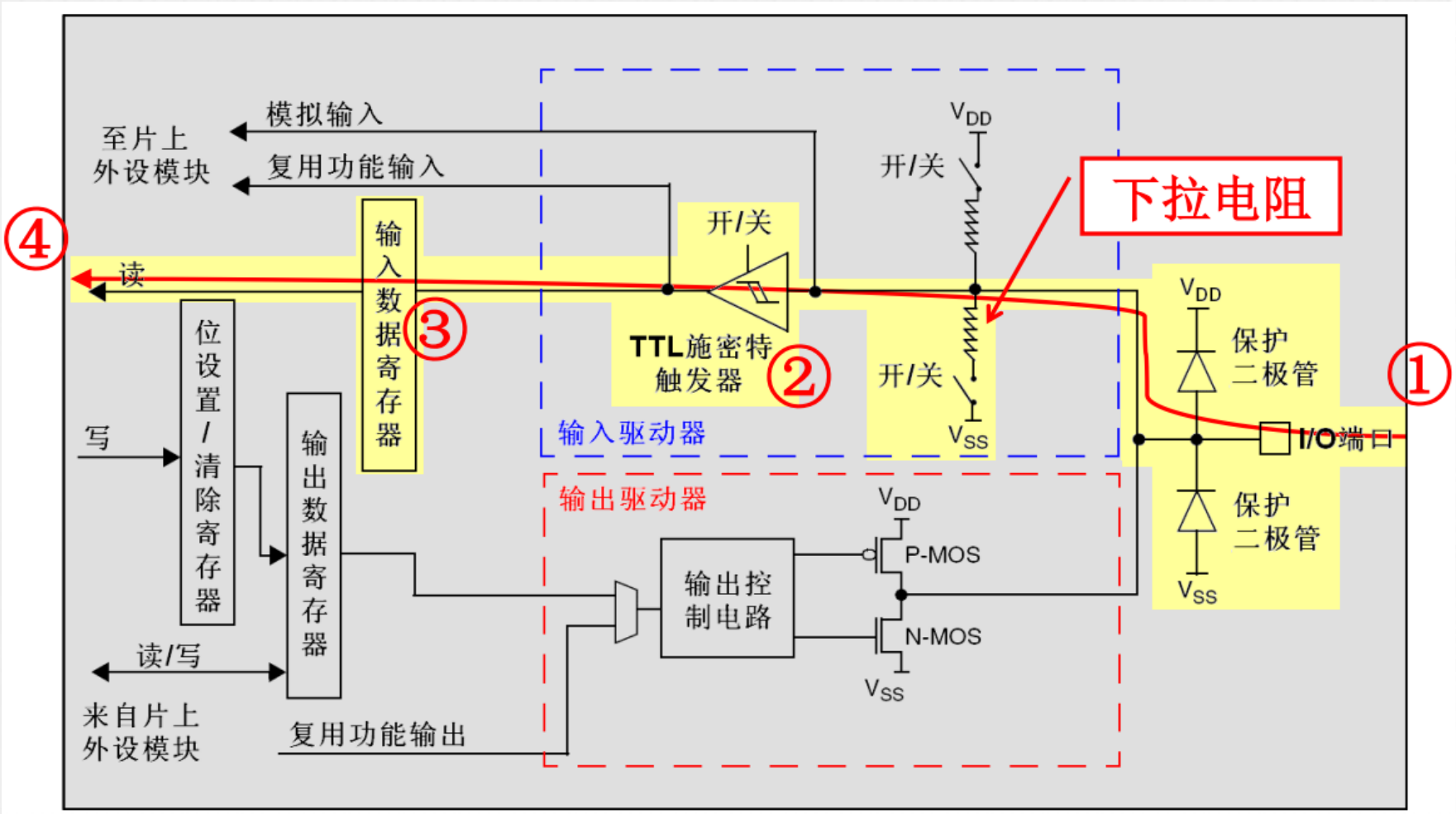
1. GPIO Function Description

- Input pull-up 输入上拉



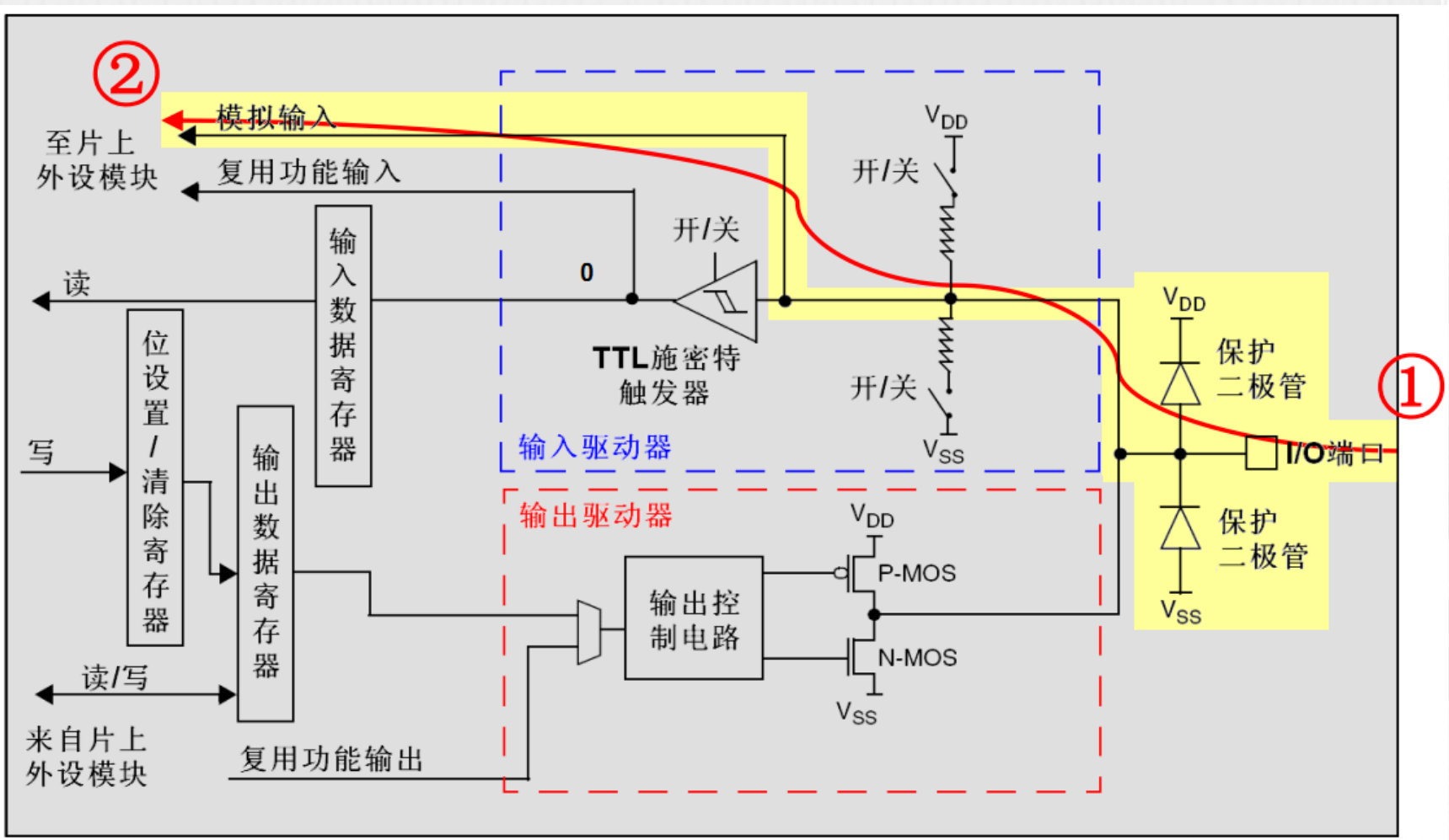
1. GPIO Function Description

- Input pull-down 输入下拉



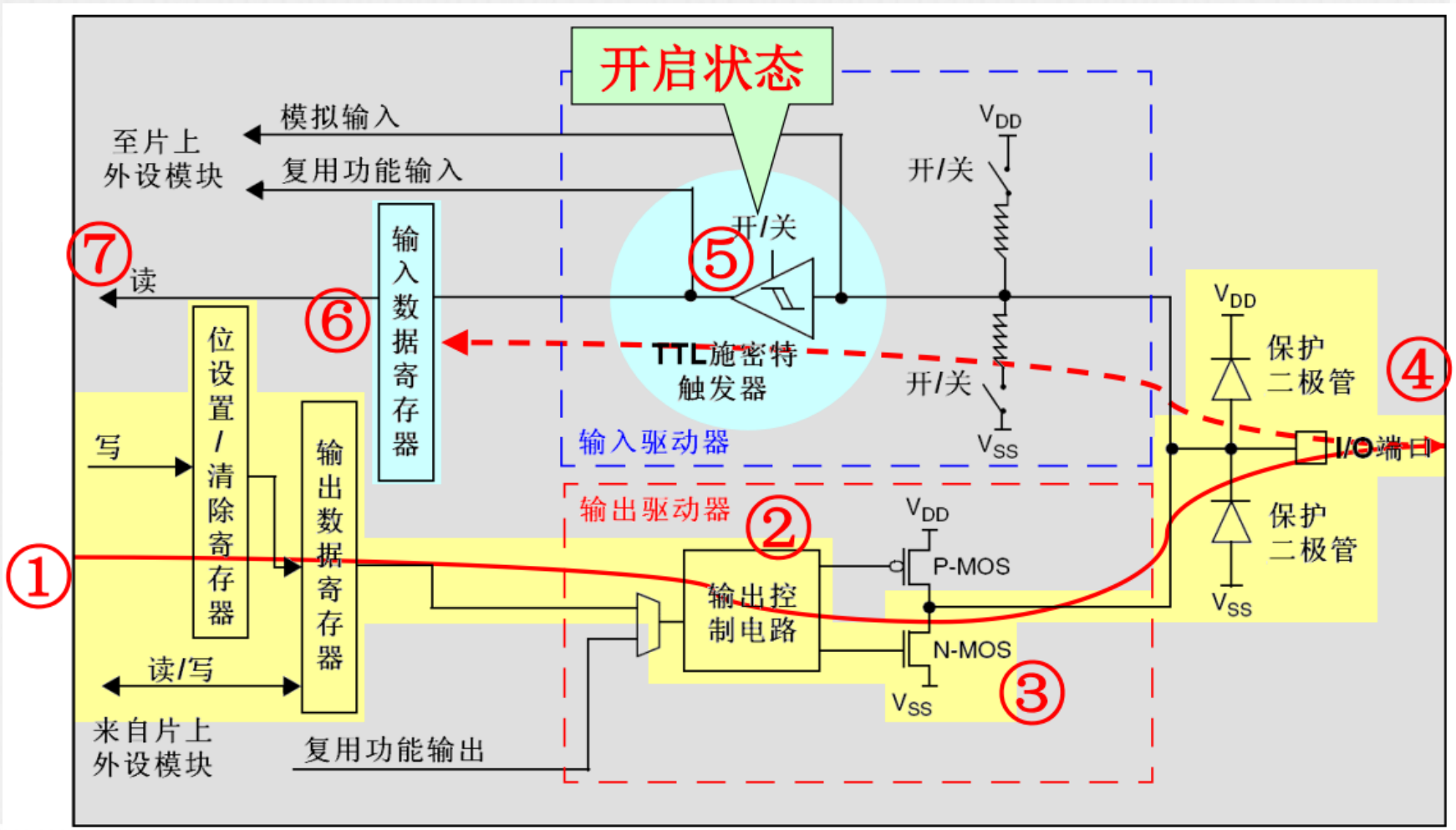
1. GPIO Function Description

- Analog 模拟输入



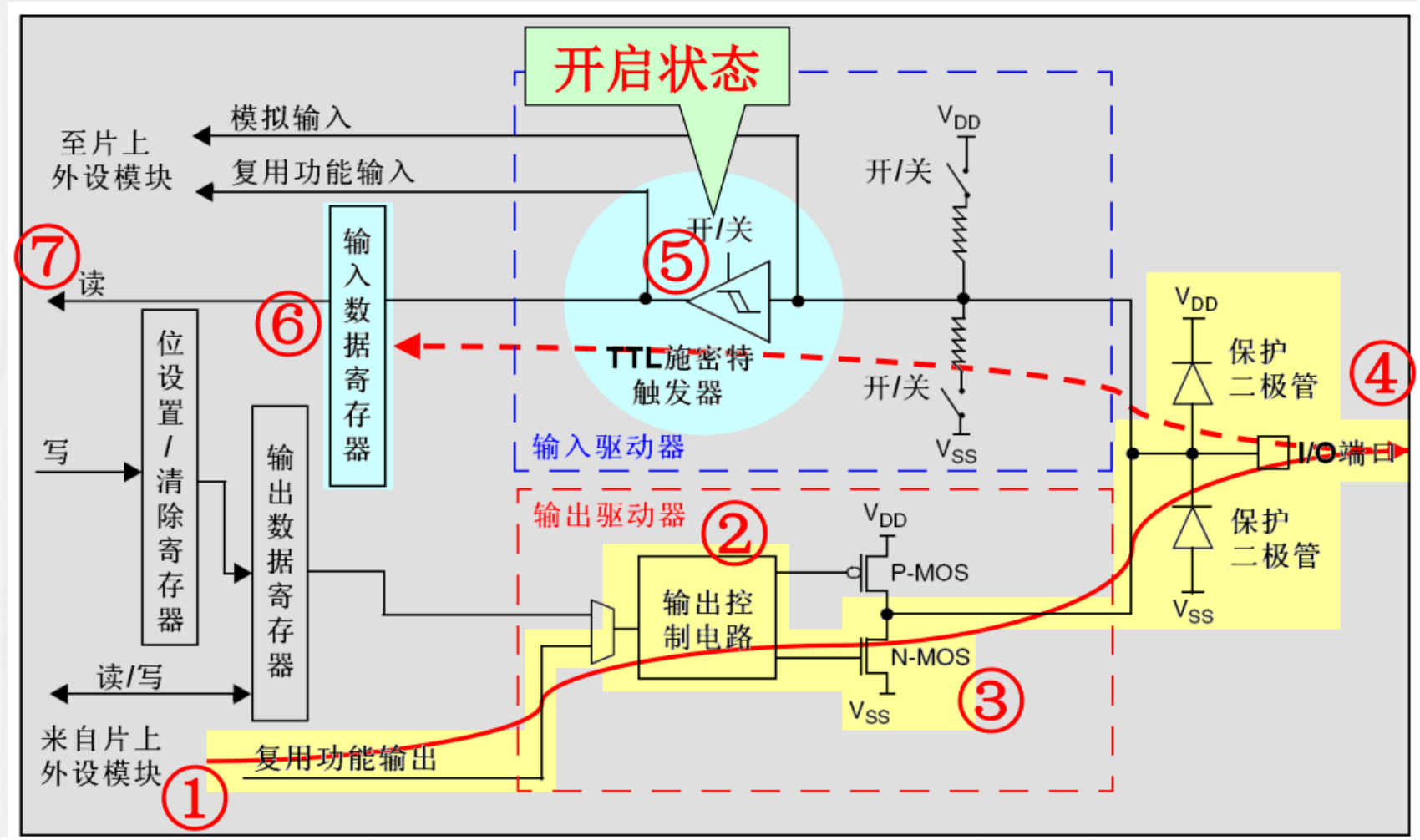
1. GPIO Function Description

- Output open-drain 开漏输出



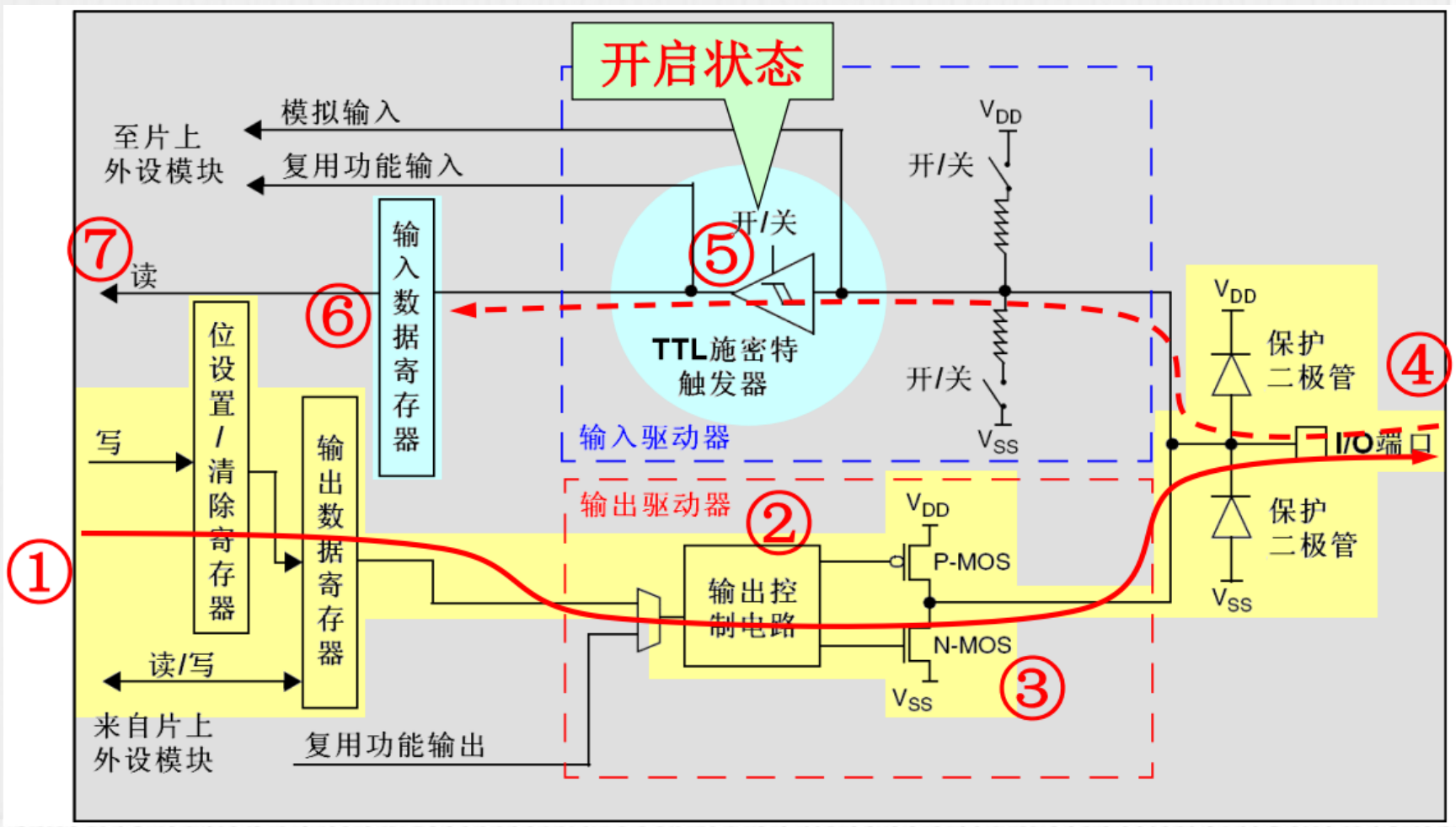
1. GPIO Function Description

- Alternate function open-drain 开漏复用功能



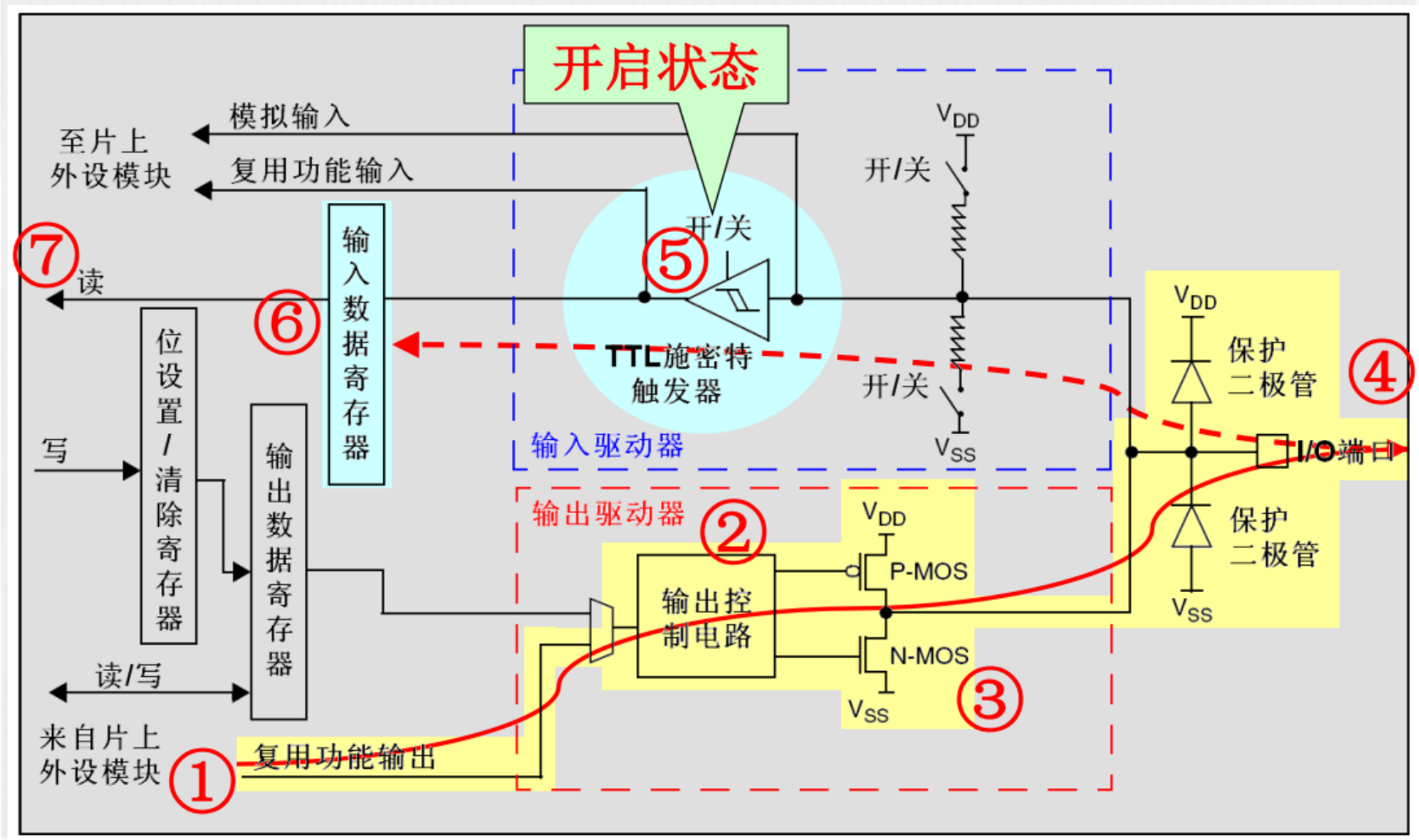
1. GPIO Function Description

- Output push-pull 推挽输出



1. GPIO Function Description

- Alternate function push-pull 推挽式复用功能



1. GPIO Function Description

- Each group GPIO ports has **7** registers
  - two 32-bit configuration registers (GPIOx_CRL, GPIOx_CRH)
    - GPIOx_CRL: Port configuration register low
    - GPIOx_CRH: Port configuration register high
  - two 32-bit data registers (GPIOx_IDR, GPIOx_ODR)
    - GPIOx_IDR: Port input data register
    - GPIOx_ODR: Port output data register
  - a 32-bit set/reset register (GPIOx_BSRR)
  - a 16-bit reset register (GPIOx_BRR)
  - a 32-bit locking register (GPIOx_LCKR)
- Each I/O port bit is freely programmable, however the I/O port registers have to be accessed as 32-bit words (half-word or byte accesses are not allowed)

1. GPIO Function Description
-- 端口配置低寄存器(GPIOx_CRL)

CNF7[1:0]	MODE7[1:0]	CNF6[1:0]	MODE6[1:0]	CNF5[1:0]	MODE5[1:0]	CNF4[1:0]	MODE4[1:0]
rw rw	rw rw	rw rw	rw rw	rw rw	rw rw	rw rw	rw rw
15 14	13 12	11 10	9 8	7 6	5 4	3 2	1 0
CNF3[1:0]	MODE3[1:0]	CNF2[1:0]	MODE2[1:0]	CNF1[1:0]	MODE1[1:0]	CNF0[1:0]	MODE0[1:0]
rw rw	rw rw	rw rw	rw rw	rw rw	rw rw	rw rw	rw rw

位31:30 27:26 23:22 19:18 15:14 11:10 7:6 3:2	**CNFy[1:0]**：端口x配置位(y = 0…7) (Port x configuration bits) 软件通过这些位配置相应的I/O端口，请参考表17端口位配置表。 在输入模式(MODE[1:0]=00)： 00：模拟输入模式 01：浮空输入模式(复位后的状态) 10：上拉/下拉输入模式 11：保留 在输出模式(MODE[1:0]>00)： 00：通用推挽输出模式 01：通用开漏输出模式 10：复用功能推挽输出模式 11：复用功能开漏输出模式
位29:28 25:24 21:20 17:16 13:12 9:8, 5:4 1:0	**MODEy[1:0]**：端口x的模式位(y = 0…7) (Port x mode bits) 软件通过这些位配置相应的I/O端口，请参考表17端口位配置表。 00：输入模式(复位后的状态) 01：输出模式，最大速度10MHz 10：输出模式，最大速度2MHz 11：输出模式，最大速度50MHz

1. GPIO Function Description
-- 端口配置低寄存器(GPIOx_CRL)

表17　端口位配置表

配置模式		CNF1	CNF0	MODE1	MODE0	PxODR寄存器
通用输出	推挽(Push-Pull)	0	0	01 10 11 见表18		0 或 1
	开漏(Open-Drain)		1			0 或 1
复用功能输出	推挽(Push-Pull)	1	0			不使用
	开漏(Open-Drain)		1			不使用
输入	模拟输入	0	0	00		不使用
	浮空输入		1			不使用
	下拉输入	1	0			0
	上拉输入					1

表18　输出模式位

MODE[1:0]	意义
00	保留
01	最大输出速度为10MHz
10	最大输出速度为2MHz
11	最大输出速度为50MHz

1. GPIO Function Description
-- 端口配置高寄存器(GPIOx_CRH)

CNF15[1:0]	MODE15[1:0]	CNF14[1:0]	MODE14[1:0]	CNF13[1:0]	MODE13[1:0]	CNF12[1:0]	MODE12[1:0]
rw rw	rw rw	rw rw	rw rw	rw rw	rw rw	rw rw	rw rw
15 14	13 12	11 10	9 8	7 6	5 4	3 2	1 0
CNF11[1:0]	MODE11[1:0]	CNF10[1:0]	MODE10[1:0]	CNF9[1:0]	MODE9[1:0]	CNF8[1:0]	MODE8[1:0]
rw rw	rw rw	rw rw	rw rw	rw rw	rw rw	rw rw	rw rw

位31:30 27:26 23:22 19:18 15:14 11:10 7:6 3:2	**CNFy[1:0]**：端口x配置位(y = 8…15) (Port x configuration bits) 软件通过这些位配置相应的I/O端口，请参考表17端口位配置表。 在输入模式(MODE[1:0]=00)： 00：模拟输入模式 01：浮空输入模式(复位后的状态) 10：上拉/下拉输入模式 11：保留 在输出模式(MODE[1:0]>00)： 00：通用推挽输出模式 01：通用开漏输出模式 10：复用功能推挽输出模式 11：复用功能开漏输出模式
位9:28 25:24 21:20 17:16 13:12 9:8, 5:4 1:0	**MODEy[1:0]**：端口x的模式位(y = 8…15) (Port x mode bits) 软件通过这些位配置相应的I/O端口，请参考表17端口位配置表。 00：输入模式(复位后的状态) 01：输出模式，最大速度10MHz 10：输出模式，最大速度2MHz 11：输出模式，最大速度50MHz

1. GPIO Function Description
-- 端口输入数据寄存器(GPIOx_IDR)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
保留															

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
IDR15	IDR14	IDR13	IDR12	IDR11	IDR10	IDR9	IDR8	IDR7	IDR6	IDR5	IDR4	IDR3	IDR2	IDR1	IDR0
r	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r

位31:16	保留，始终读为0。
位15:0	**IDRy[15:0]**：端口输入数据(y = 0…15) (Port input data) 这些位为只读并只能以字(16位)的形式读出。读出的值为对应I/O口的状态。

1. GPIO Function Description
-- 端口输出数据寄存器(GPIOx_ODR)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
保留															

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
ODR15	ODR14	ODR13	ODR12	ODR11	ODR10	ODR9	ODR8	ODR7	ODR6	ODR5	ODR4	ODR3	ODR2	ODR1	ODR0
rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw

位31:16	保留，始终读为0。
位15:0	**ODRy[15:0]**：端口输出数据(y = 0…15) (Port output data) 这些位可读可写并只能以字(16位)的形式操作。 注：对GPIOx_BSRR(x = A...E)，可以分别地对各个ODR位进行独立的设置/清除。

1. GPIO Function Description
-- 端口位设置/清除寄存器(GPIOx_BSRR)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
BR15	BR14	BR13	BR12	BR11	BR10	BR9	BR8	BR7	BR6	BR5	BR4	BR3	BR2	BR1	BR0
w	w	w	w	w	w	w	w	w	w	w	w	w	w	w	w
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
BS15	BS14	BS13	BS12	BS11	BS10	BS9	BS8	BS7	BS6	BS5	BS4	BS3	BS2	BS1	BS0
w	w	w	w	w	w	w	w	w	w	w	w	w	w	w	w

位31:16	**BRy**: 清除端口x的位y (y = 0…15) (Port x Reset bit y) 这些位只能写入并只能以字(16位)的形式操作。 0：对对应的ODRy位不产生影响 1：清除对应的ODRy位为0 注：如果同时设置了BSy和BRy的对应位，BSy位起作用。
位15:0	**BSy**: 设置端口x的位y (y = 0…15) (Port x Set bit y) 这些位只能写入并只能以字(16位)的形式操作。 0：对对应的ODRy位不产生影响 1：设置对应的ODRy位为1

1. GPIO Function Description
-- 端口位清除寄存器(GPIOx_BRR)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
保留															
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
BR15	BR14	BR13	BR12	BR11	BR10	BR9	BR8	BR7	BR6	BR5	BR4	BR3	BR2	BR1	BR0
w	w	w	w	w	w	w	w	w	w	w	w	w	w	w	w

位31:16	保留。
位15:0	**BRy**: 清除端口x的位y (y = 0…15) (Port x Reset bit y) 这些位只能写入并只能以字(16位)的形式操作。 0：对对应的ODRy位不产生影响 1：清除对应的ODRy位为0

1. GPIO Function Description

-- 端口复用功能

- STM32的大部分端口都具有复用功能
- 复用, 就是一些端口不仅仅可以做为通用IO口, 还可以复用为一些外设引脚, 比如PA9,PA10可以复用为STM32的串口1引脚
- 作用：最大限度的利用端口资源

Pins						Pin name	Type(1)	I / O Level(2)	Main function(3) (after reset)	Alternate functions	
BGA144	BGA100	WLCSP64	LQFP64	LQFP100	LQFP144					Default	Remap
D12	C9	D2	42	68	101	PA9	I/O	FT	PA9	USART1_TX(7)/ TIM1_CH2(7)	
D11	D10	D3	43	69	102	PA10	I/O	FT	PA10	USART1_RX(7)/ TIM1_CH3(7)	

1. GPIO Function Description

-- 端口重映射功能

- 就是可以把某些功能引脚映射到其他引脚
- 比如串口1默认引脚是PA9,PA10, 可以通过配置重映射映射到PB6,PB7
- 作用：方便布线
- 所有IO口都可以作为中断输入

Pins						Pin name	Type(1)	I / O Level(2)	Main function(3) (after reset)	Alternate functions	
BGA144	BGA100	WLCSP64	LQFP64	LQFP100	LQFP144					Default	Remap
C6	B5	B5	58	92	136	PB6	I/O	FT	PB6	I2C1_SCL(7)/ TIM4_CH1(7)	USART1_TX
D6	A5	C5	59	93	137	PB7	I/O	FT	PB7	I2C1_SDA(7) / FSMC_NADV / TIM4_CH2(7)	USART1_RX

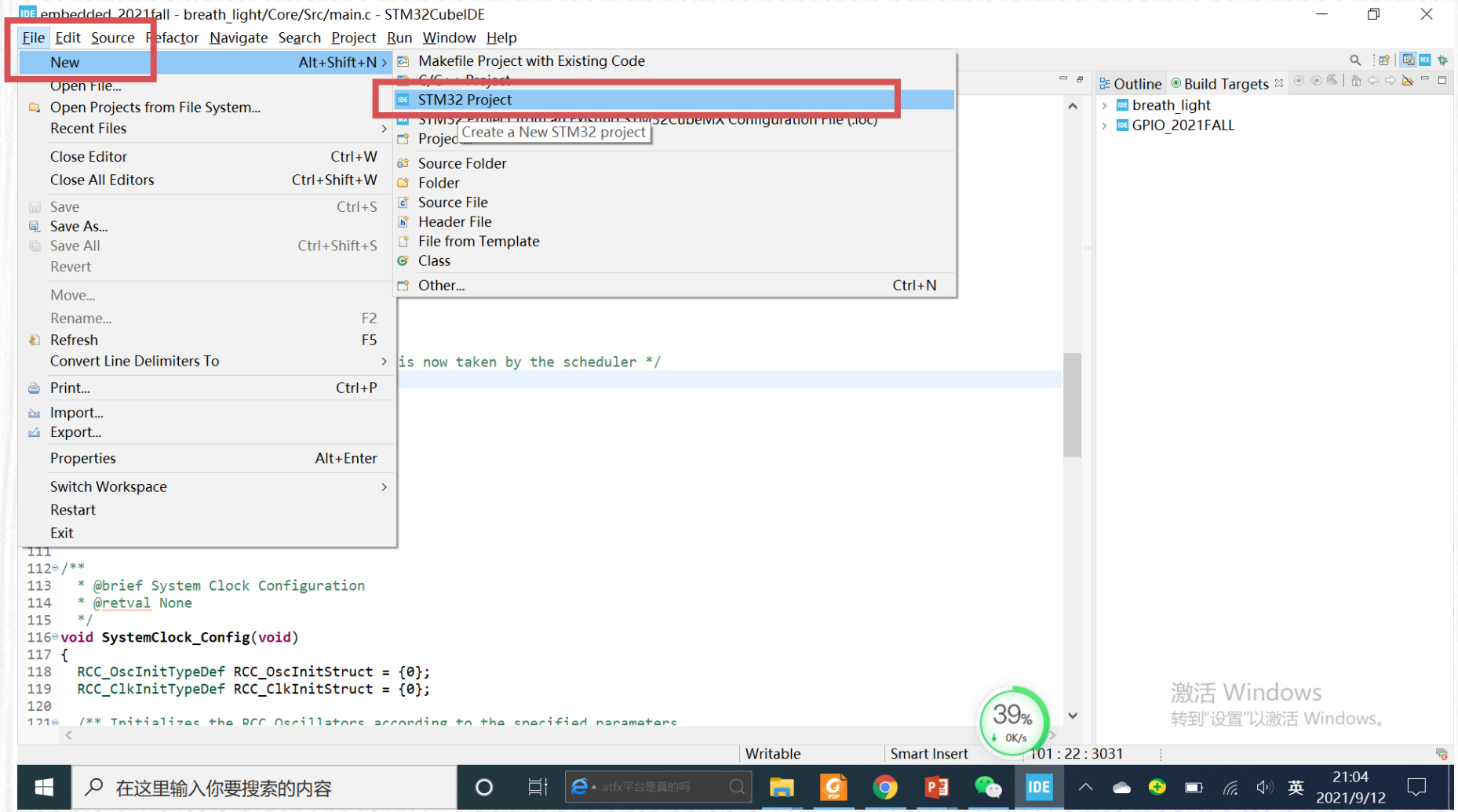
南方科技大学
SOUTHERN UNIVERSITY OF SCIENCE AND TECHNOLOGY

02

How to create a new project

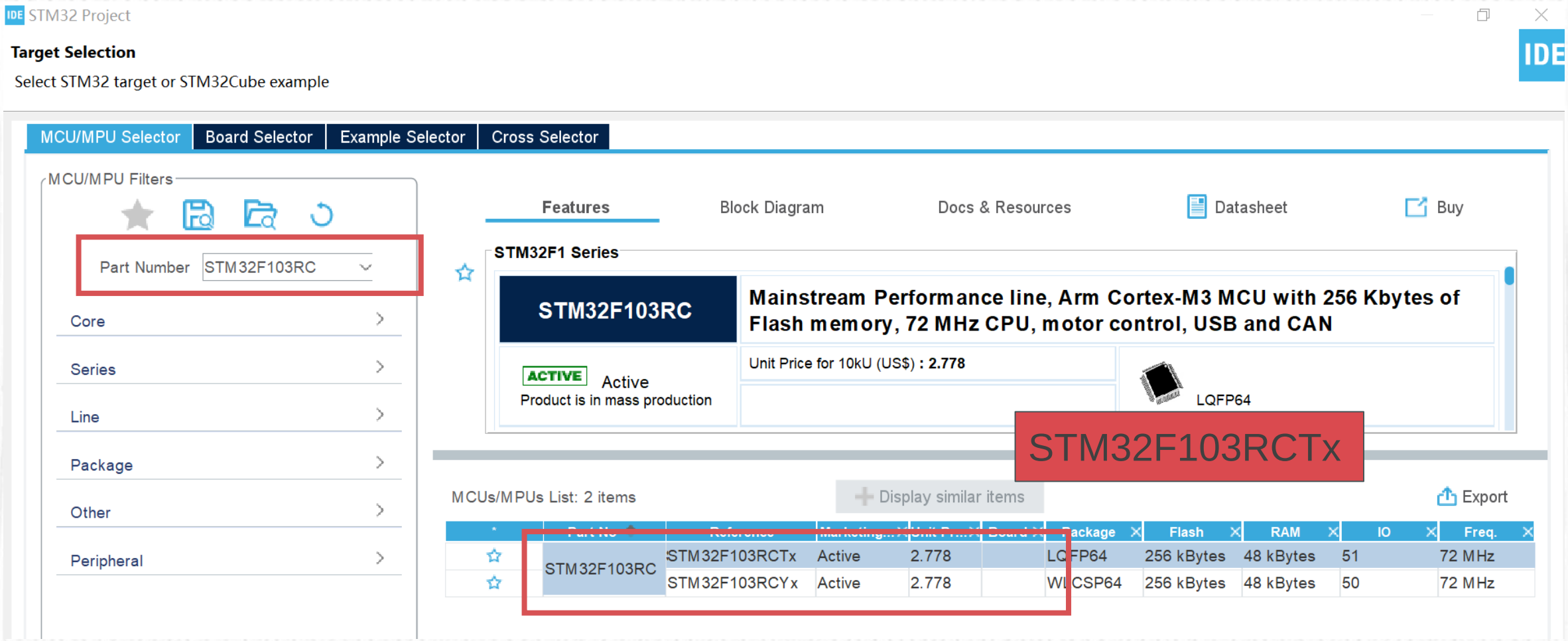
2. How to create a new project

- Create a new STM32 project



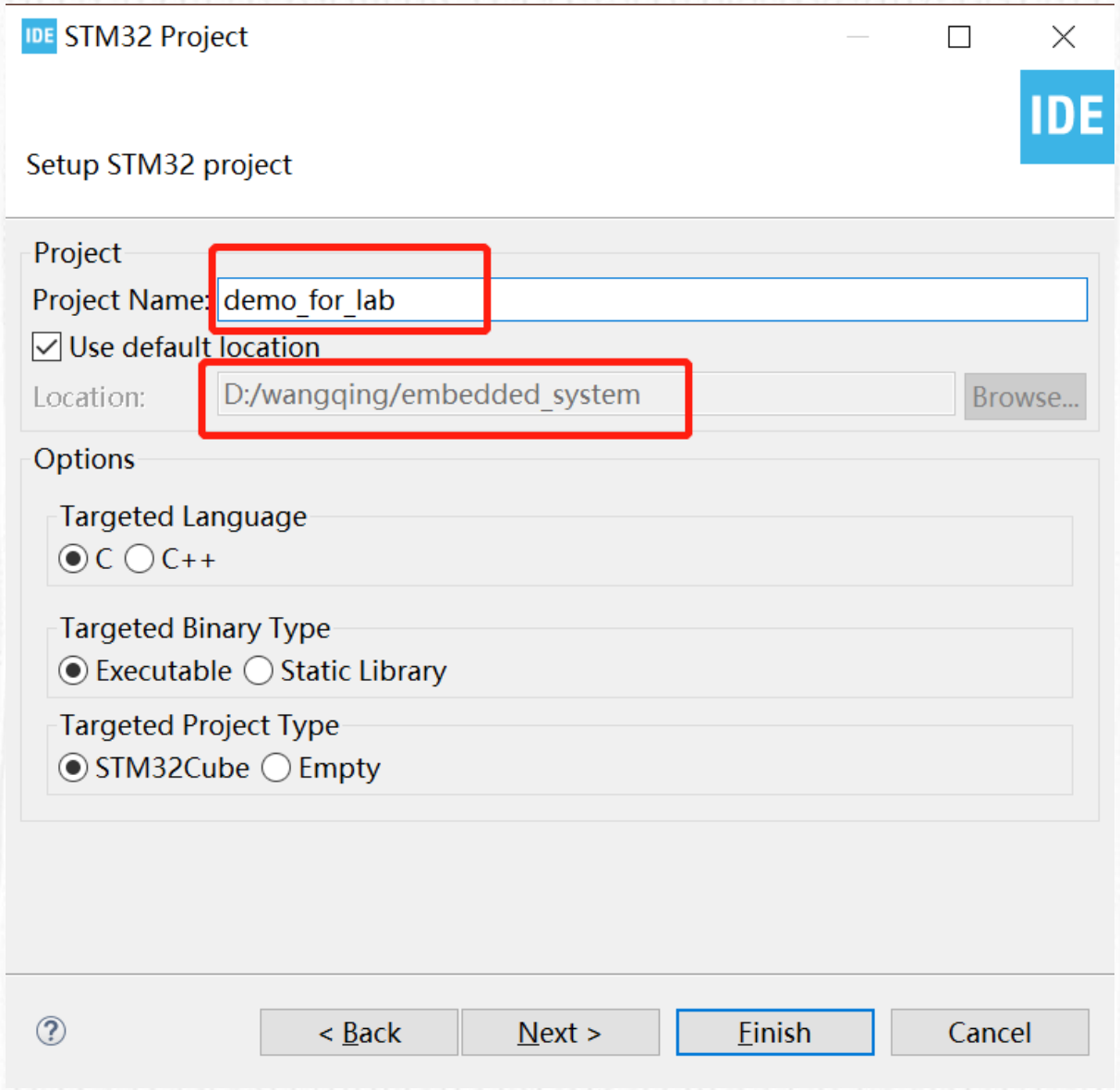
2. How to create a new project

- Target selection -- STM32F103RCTx



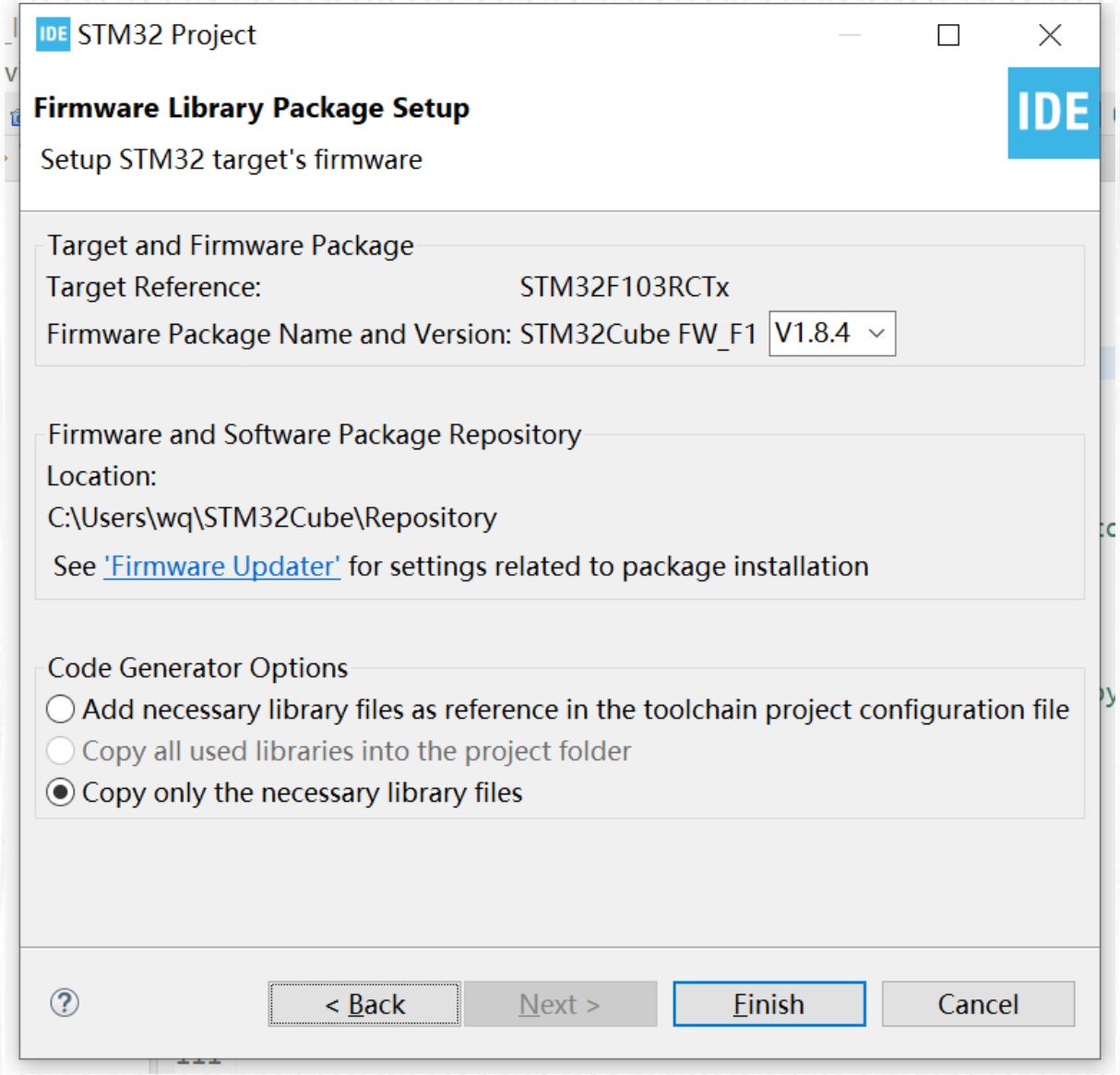
2. How to create a new project

- Enter the project name – only ASCII characters
- Keep other options as default



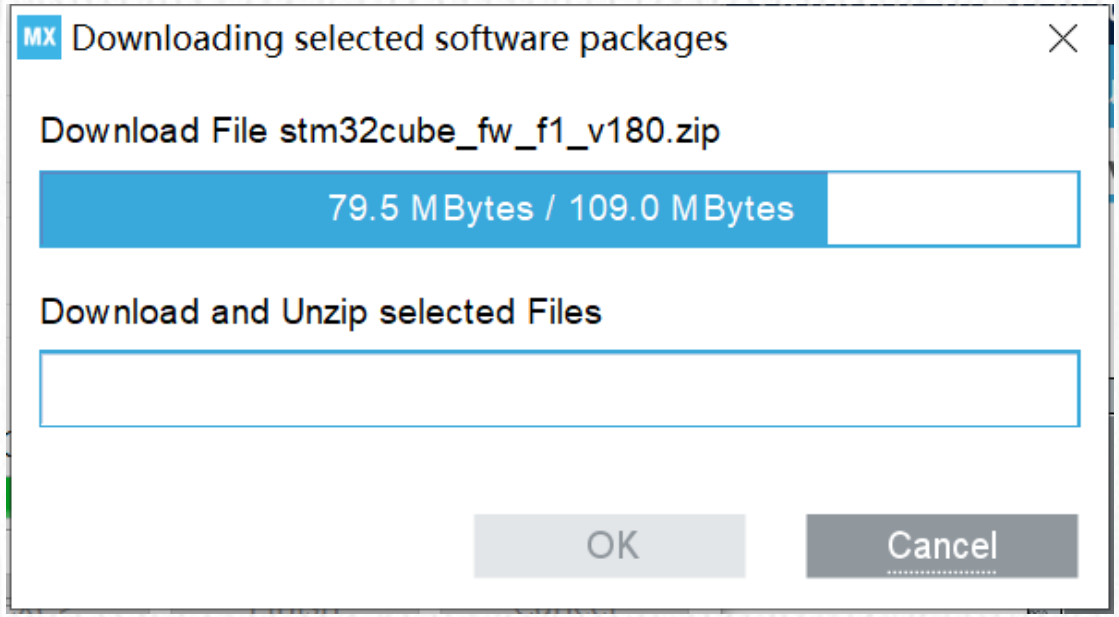
2. How to create a new project

- Check the project information
- Click ***Finish***



2. How to create a new project

- Download software packages

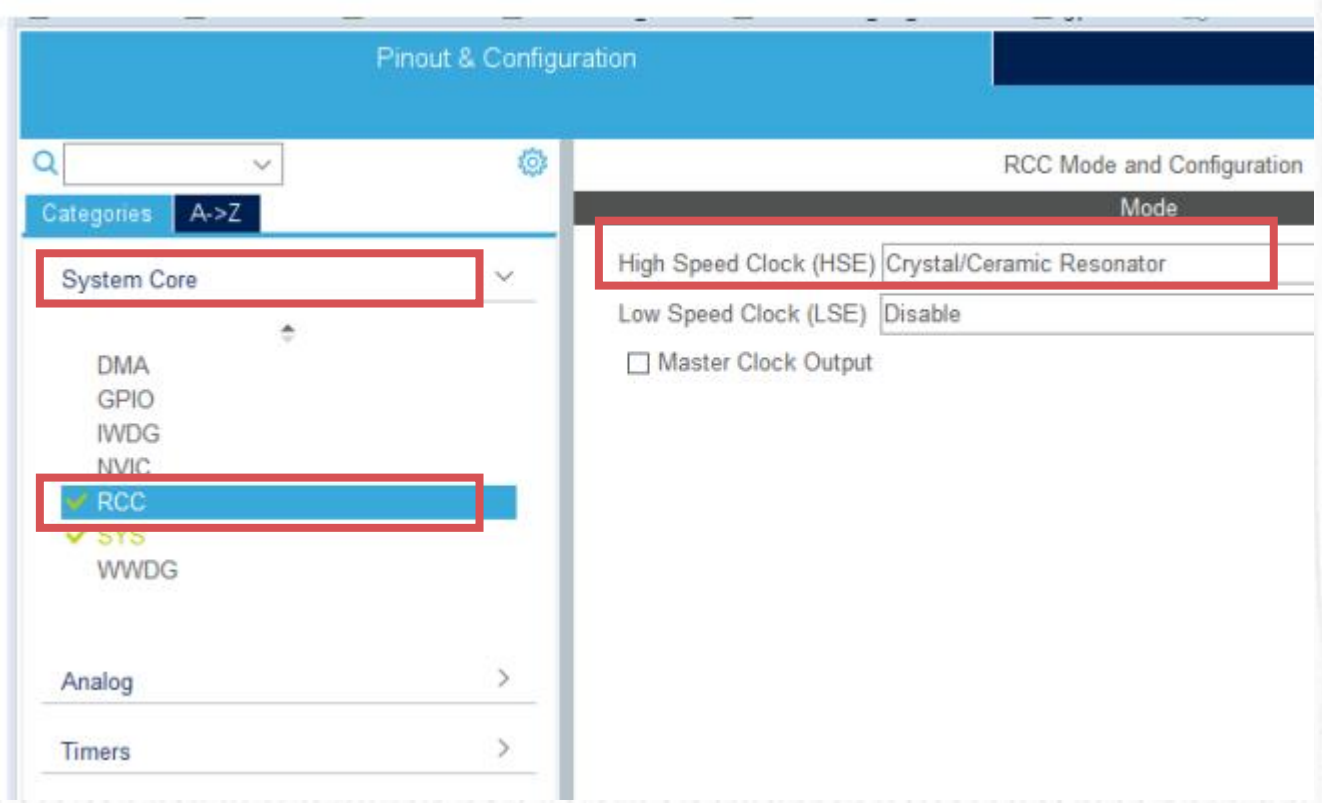


2. How to create a new project

南方科技大学 SOUTHERN UNIVERSITY OF SCIENCE AND TECHNOLOGY

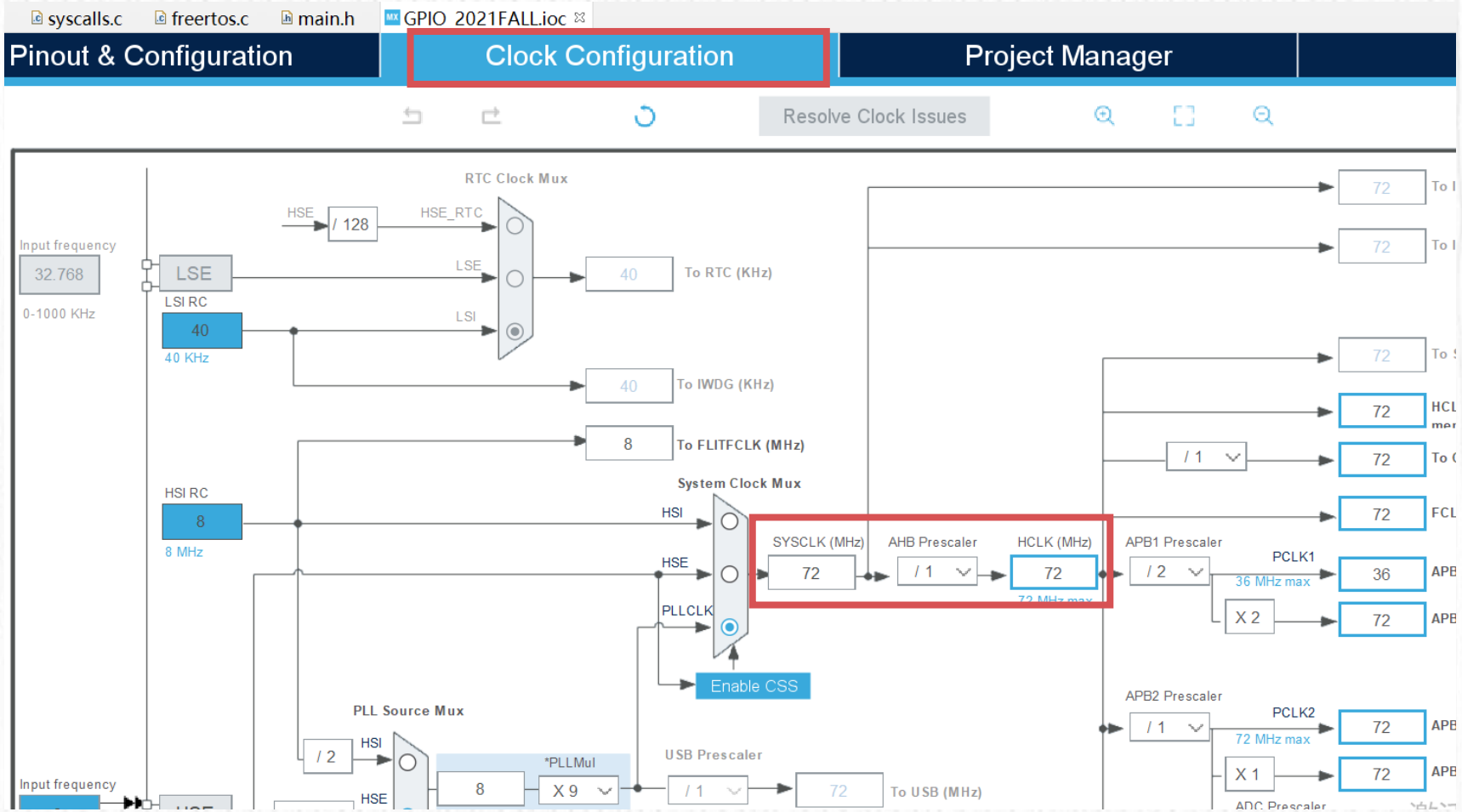
- RCC and Clock Configuration

- There are four kinds of clock sources in STM32: HSE clock, HSI clock, LSE clock and LSI clock (HS for high speed, LS for low speed, E for external and I for internal)
- Only HSE and HIS clock can used to driven the SYSCLK
- Most of the case we use an external crystal oscillator or ceramic resonator (HSE) to drive the SYSCLK because it is more accurate



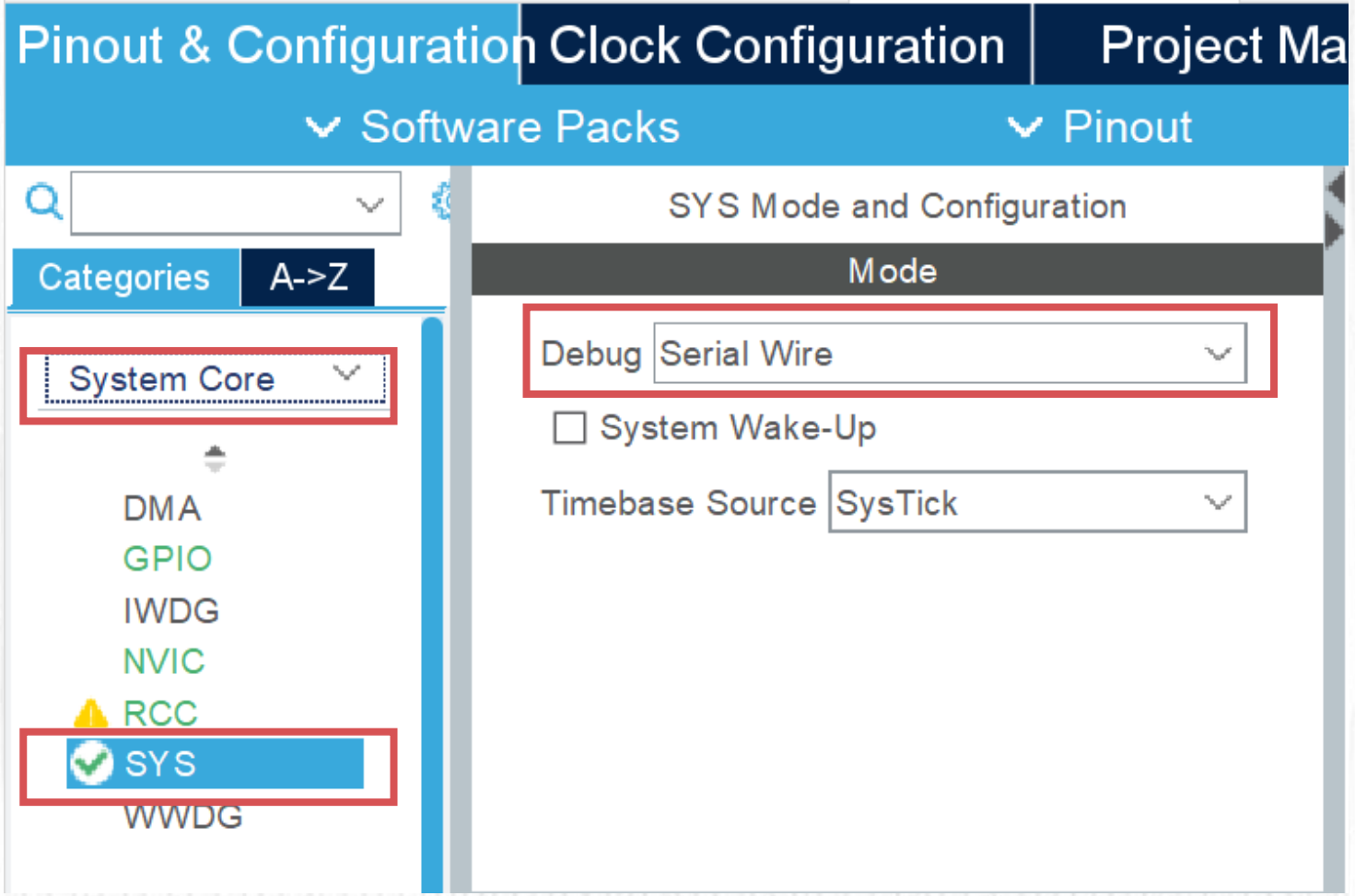
2. How to create a new project

- Clock Configuration
  - Change to **clock configuration**
  - Set SYSCLK as 72M (maximum)



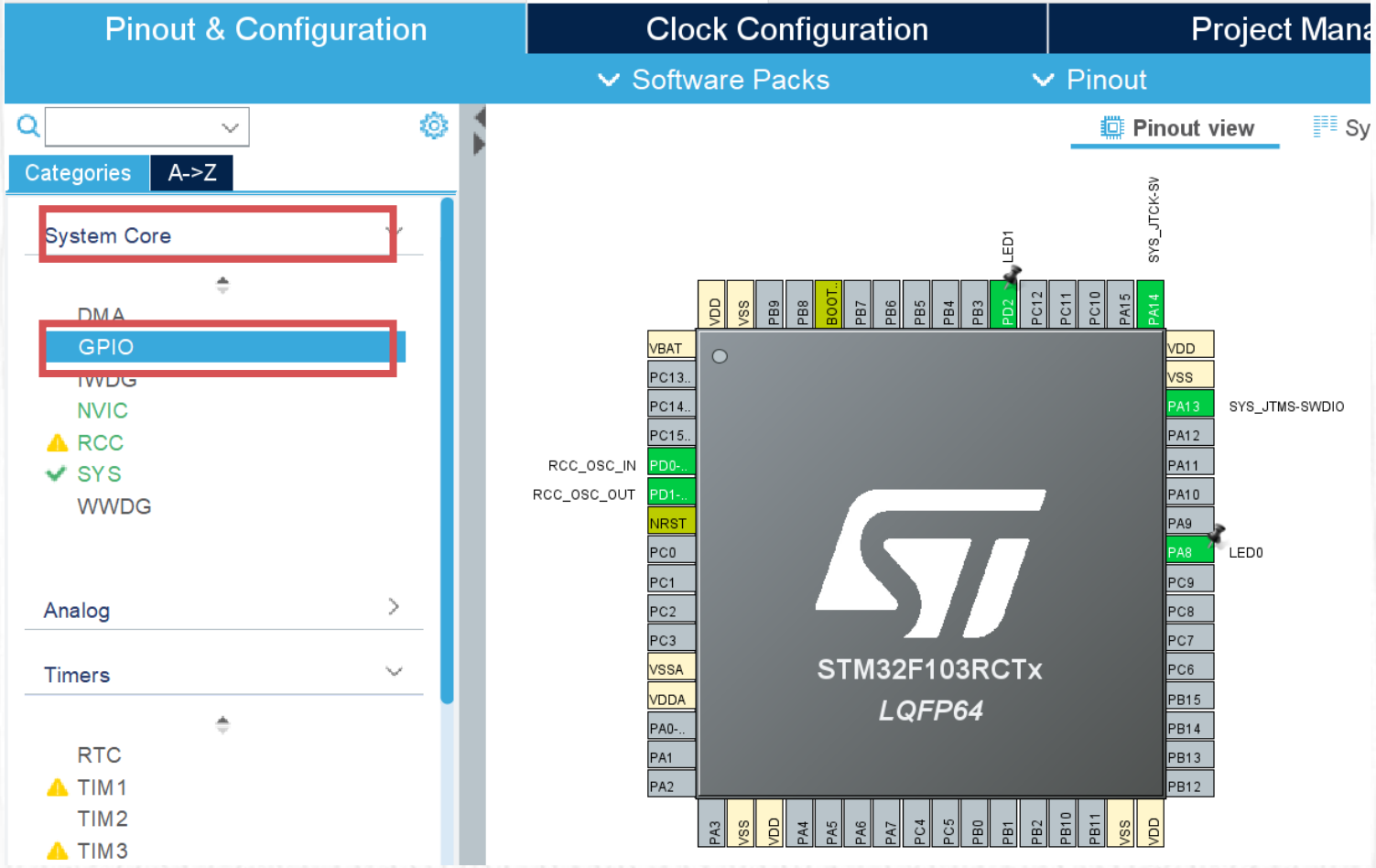
2. How to create a new project

- SYS Mode and Configuration
  - Back to **Pinout & Configuration -> Categories -> System Core -> SYS**
  - Use Serial Wire(SW) as debug wire



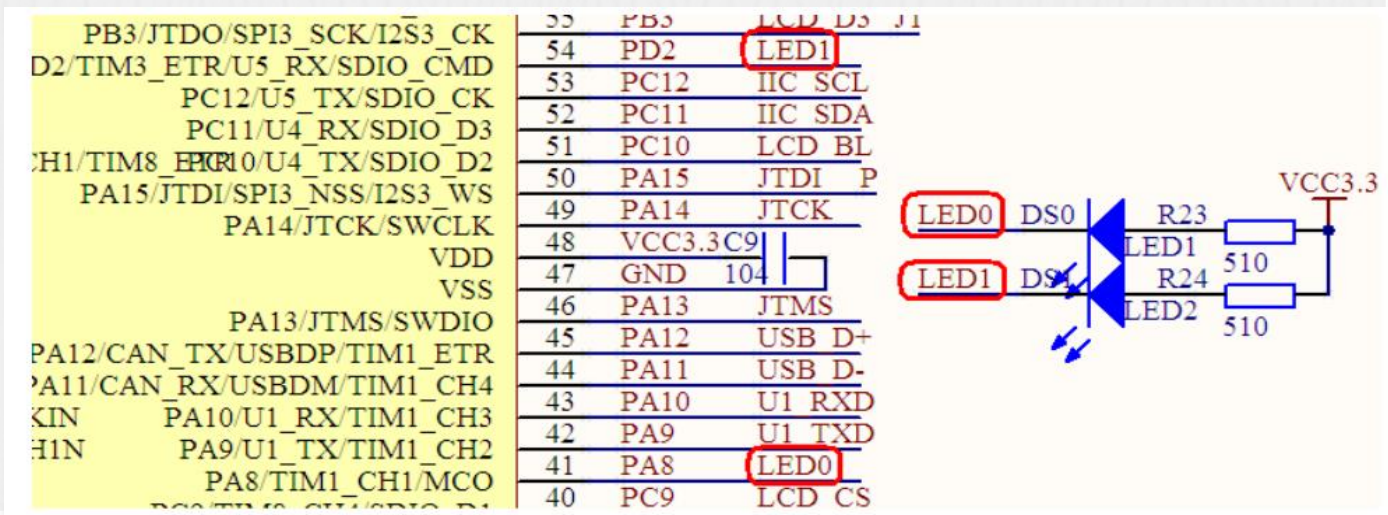
2. How to create a new project

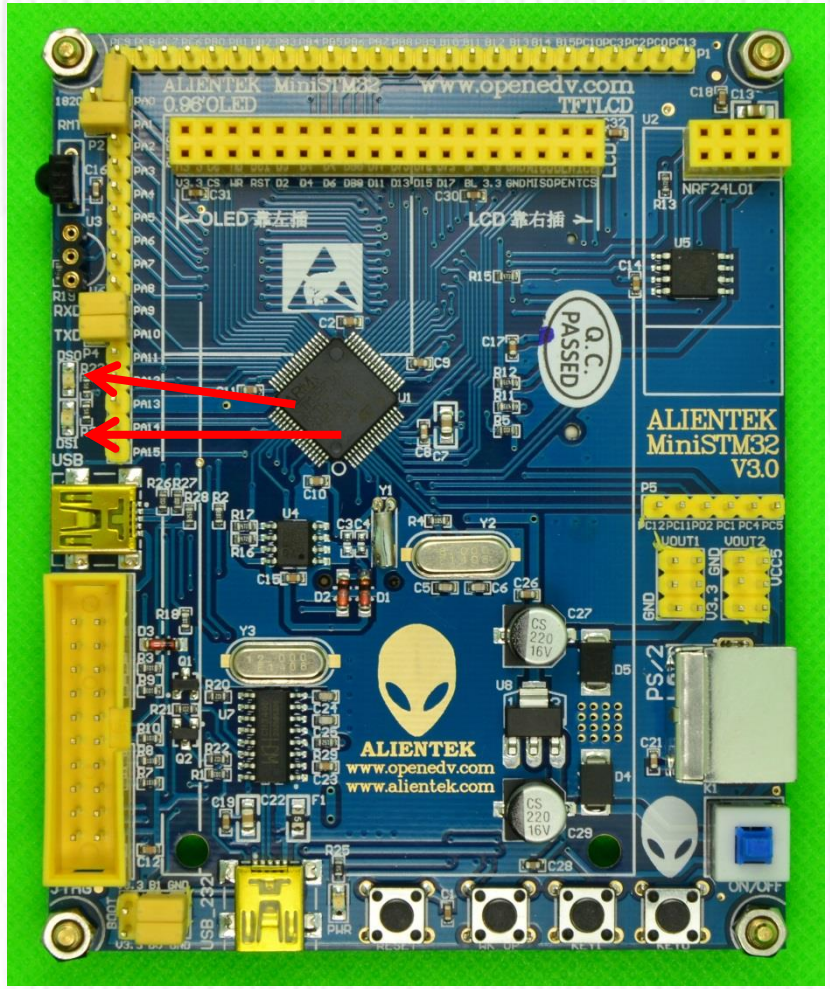
- GPIO Configuration
  - Still in **Pinout & Configuration -> Categories -> System Core -> GPIO**
  - Set PA8 as GPIO_Output, and rename as LED0
  - Set PD2 as GPIO_Output, and rename as LED1



2. How to create a new project

- GPIO Configuration

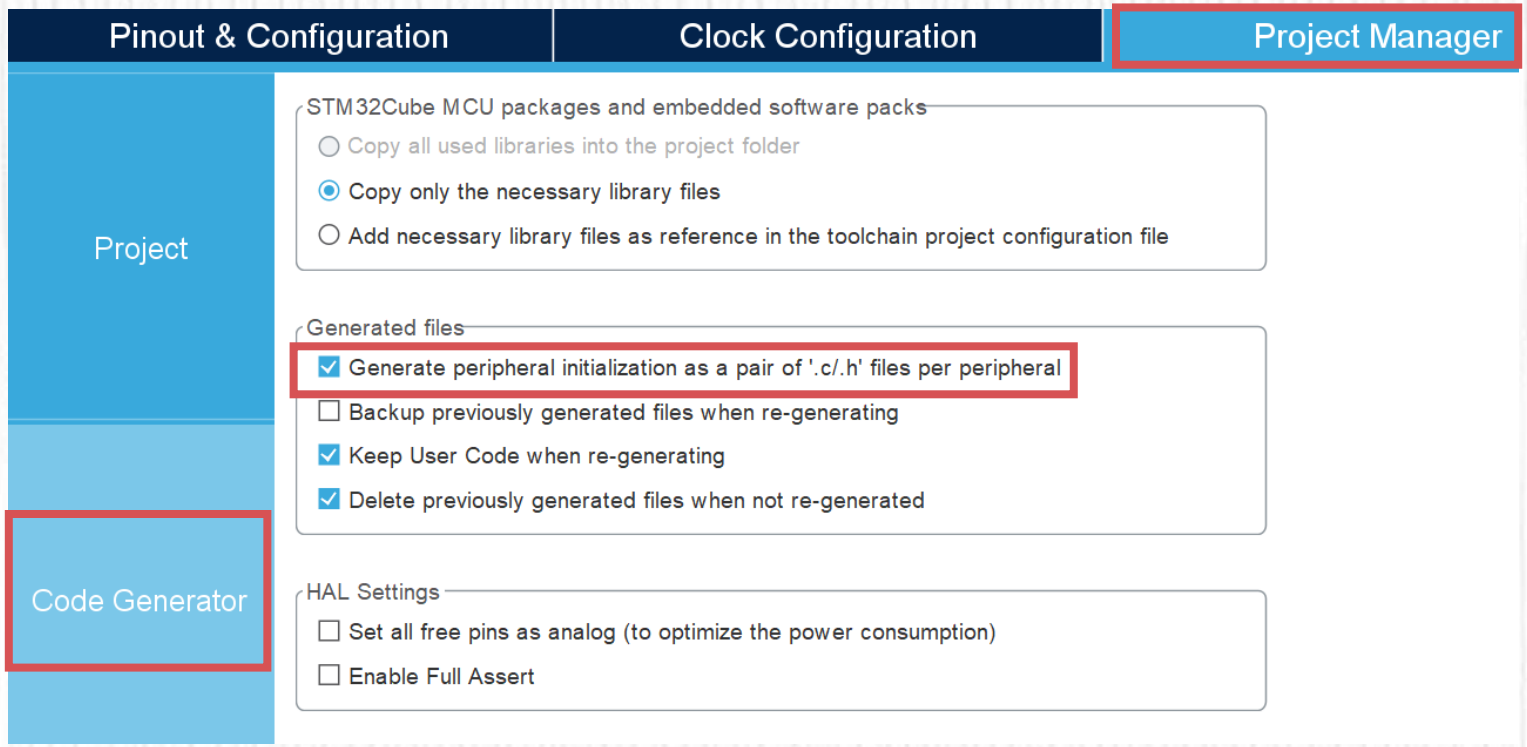




2. How to create a new project

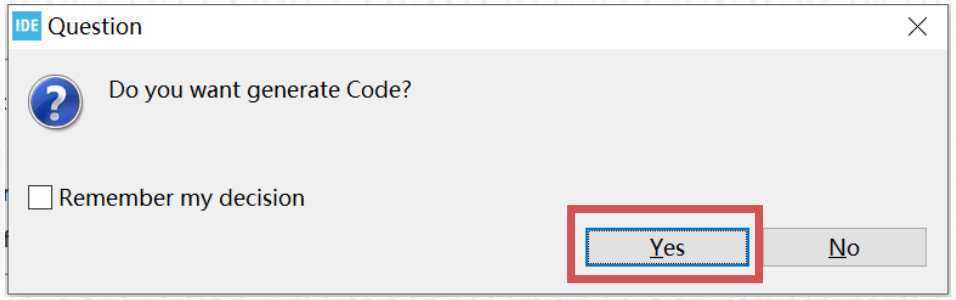
- Project Management

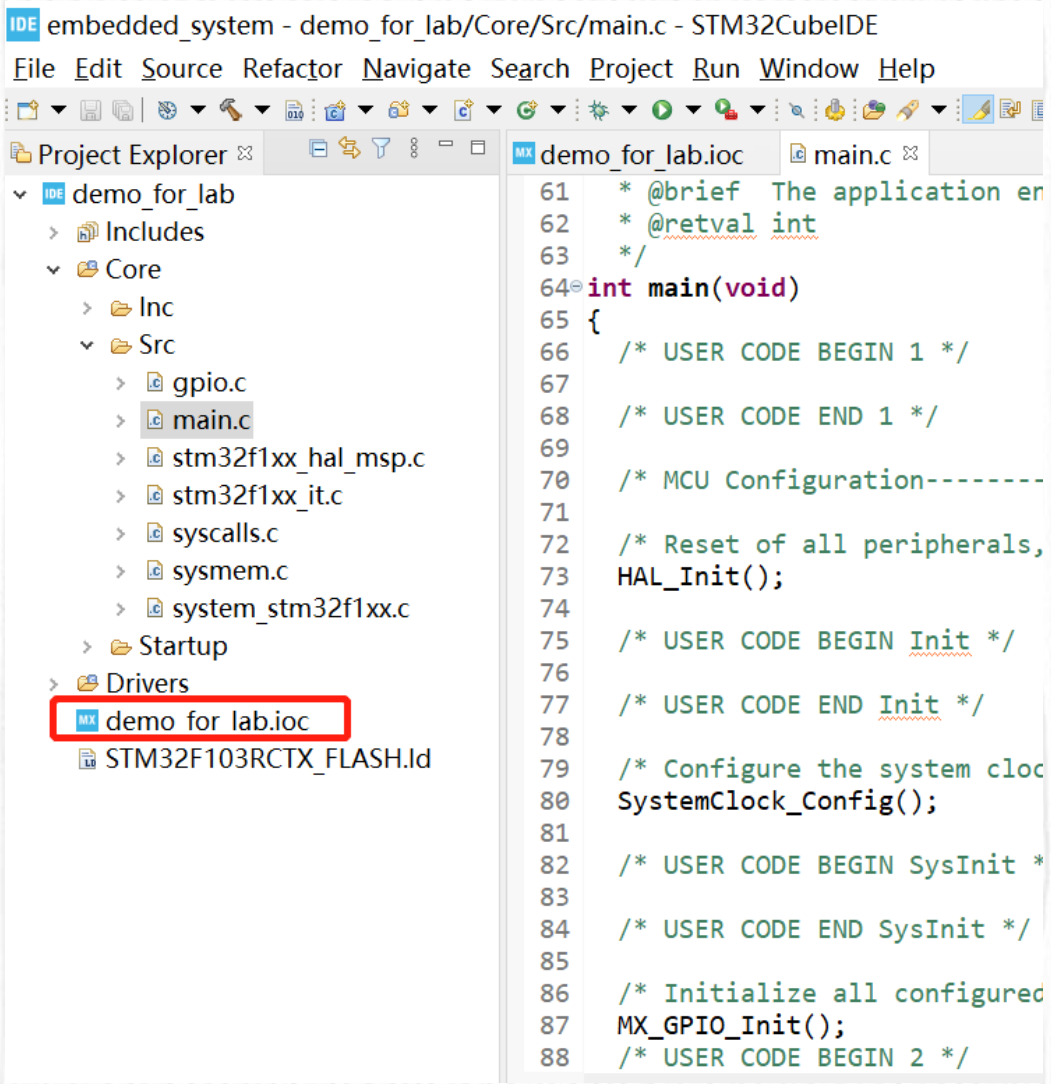
- Change to **Project Manager -> Code Generator**
- Check up ***Generate peripheral initialization as a pair of '.c/.h' files per peripheral***, which will make the codes more modular



2. How to create a new project

- Project Management
- Save the configuration information and start a new project





南方科技大学
SOUTHERN UNIVERSITY OF SCIENCE AND TECHNOLOGY

03

How to programming

3. How to programming

- HAL(Hardware Abstract Layer) library
- Keep updating, bugs will be changed at the next version
- Rapid development, work with cube tool and generate code with one click
- It's convenient to replace the chip and transplant it. You don't have to think about what special registers this chip has. The manufacturer has made it for you
- Learn more about HAL
  - https://bbs.21ic.com/icview-2512392-1-1.html?_dsign=133c8287
  - https://www.jianshu.com/p/c6809c2bcb4f?from=timeline

3. How to programming

- STM32CubeIDE has generated codes for us according our configuration. The last thing we need to do is flash the LED
- Remember to put our own codes **into the USER CODE comment block**, otherwise, STM32CubeIDE will overwrite them.

```
int main(void)
{
  /* USER CODE BEGIN 1 */

  /* USER CODE END 1 */

  /* MCU Configuration--------------------------------------------------------*/

  /* Reset of all peripherals, Initializes the Flash interface and the Systick. */
  HAL_Init();

  /* USER CODE BEGIN Init */

  /* USER CODE END Init */

  /* Configure the system clock */
  SystemClock_Config();

  /* USER CODE BEGIN SysInit */

  /* USER CODE END SysInit */

  /* Initialize all configured peripherals */
  MX_GPIO_Init();
  /* USER CODE BEGIN 2 */

  /* USER CODE END 2 */

  /* Infinite loop */
  /* USER CODE BEGIN WHILE */
  while (1)
  {
    /* USER CODE END WHILE */

    /* USER CODE BEGIN 3 */
    HAL_Delay(1000);
    HAL_GPIO_TogglePin(GPIOA, GPIO_PIN_8);
    HAL_GPIO_TogglePin(GPIOD, GPIO_PIN_2);
  }
  /* USER CODE END 3 */
}
```

3. How to programming

- Functions used frequently

HAL_GPIO_Init

Function name	**void HAL_GPIO_Init (GPIO_TypeDef * GPIOx, GPIO_InitTypeDef * GPIO_Init)**
Function description	Initializes the GPIOx peripheral according to the specified parameters in the GPIO_Init.
Parameters	• **GPIOx:** where x can be (A..G depending on device used) to select the GPIO peripheral • **GPIO_Init:** pointer to a GPIO_InitTypeDef structure that contains the configuration information for the specified GPIO peripheral.
Return values	• **None:**

HAL_GPIO_DeInit

Function name	**void HAL_GPIO_DeInit (GPIO_TypeDef * GPIOx, uint32_t GPIO_Pin)**
Function description	De-initializes the GPIOx peripheral registers to their default reset values.
Parameters	• **GPIOx:** where x can be (A..G depending on device used) to select the GPIO peripheral • **GPIO_Pin:** specifies the port bit to be written. This parameter can be one of GPIO_PIN_x where x can be (0..15).
Return values	• **None:**

HAL_GPIO_ReadPin

Function name	**GPIO_PinState HAL_GPIO_ReadPin (GPIO_TypeDef * GPIOx, uint16_t GPIO_Pin)**
Function description	Reads the specified input port pin.
Parameters	• **GPIOx:** where x can be (A..G depending on device used) to select the GPIO peripheral • **GPIO_Pin:** specifies the port bit to read. This parameter can be GPIO_PIN_x where x can be (0..15).
Return values	• **The:** input port pin value.

HAL_GPIO_WritePin

Function name	**void HAL_GPIO_WritePin (GPIO_TypeDef * GPIOx, uint16_t GPIO_Pin, GPIO_PinState PinState)**
Function description	Sets or clears the selected data port bit.
Parameters	• **GPIOx:** where x can be (A..G depending on device used) to select the GPIO peripheral • **GPIO_Pin:** specifies the port bit to be written. This parameter can be one of GPIO_PIN_x where x can be (0..15). • **PinState:** specifies the value to be written to the selected bit. This parameter can be one of the GPIO_PinState enum values: – GPIO_BIT_RESET: to clear the port pin – GPIO_BIT_SET: to set the port pin
Return values	• **None:**
Notes	• This function uses GPIOx_BSRR register to allow atomic read/modify accesses. In this way, there is no risk of an IRQ occurring between the read and the modify access.

3. How to programming

- Functions used frequently

HAL_GPIO_TogglePin

Function name	**void HAL_GPIO_TogglePin (GPIO_TypeDef * GPIOx, uint16_t GPIO_Pin)**
Function description	Toggles the specified GPIO pin.
Parameters	• **GPIOx:** where x can be (A..G depending on device used) to select the GPIO peripheral • **GPIO_Pin:** Specifies the pins to be toggled.
Return values	• **None:**

HAL_GPIO_LockPin

Function name	**HAL_StatusTypeDef HAL_GPIO_LockPin (GPIO_TypeDef * GPIOx, uint16_t GPIO_Pin)**
Function description	Locks GPIO Pins configuration registers.
Parameters	• **GPIOx:** where x can be (A..G depending on device used) to select the GPIO peripheral • **GPIO_Pin:** specifies the port bit to be locked. This parameter can be any combination of GPIO_Pin_x where x can be (0..15).
Return values	• **None:**
Notes	• The locking mechanism allows the IO configuration to be frozen. When the LOCK sequence has been applied on a port bit, it is no longer possible to modify the value of the port bit until the next reset.

HAL_GPIO_EXTI_IRQHandler

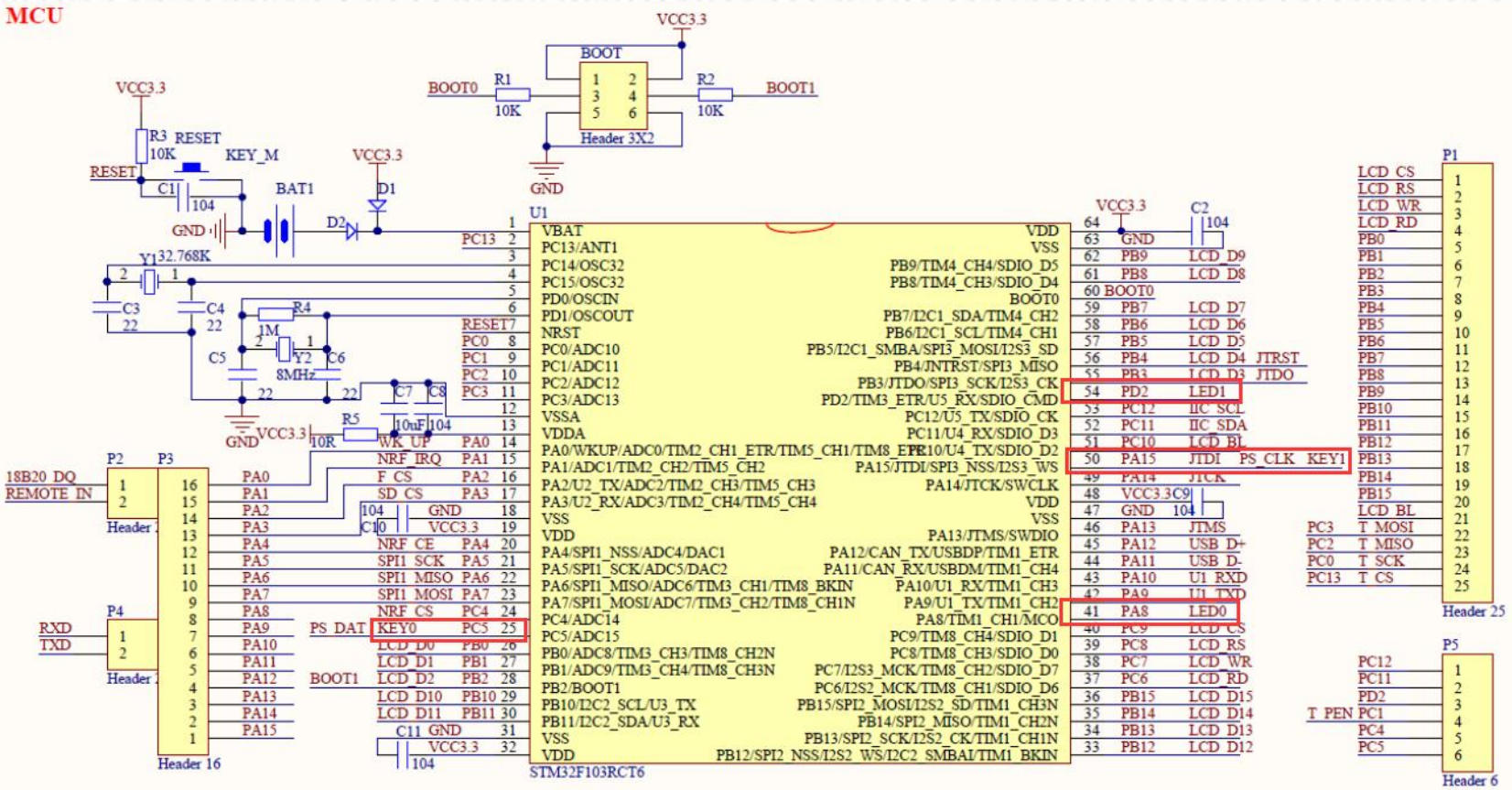
Function name	**void HAL_GPIO_EXTI_IRQHandler (uint16_t GPIO_Pin)**
Function description	This function handles EXTI interrupt request.
Parameters	• **GPIO_Pin:** Specifies the pins connected EXTI line
Return values	• **None:**

HAL_GPIO_EXTI_Callback

Function name	**void HAL_GPIO_EXTI_Callback (uint16_t GPIO_Pin)**
Function description	EXTI line detection callbacks.

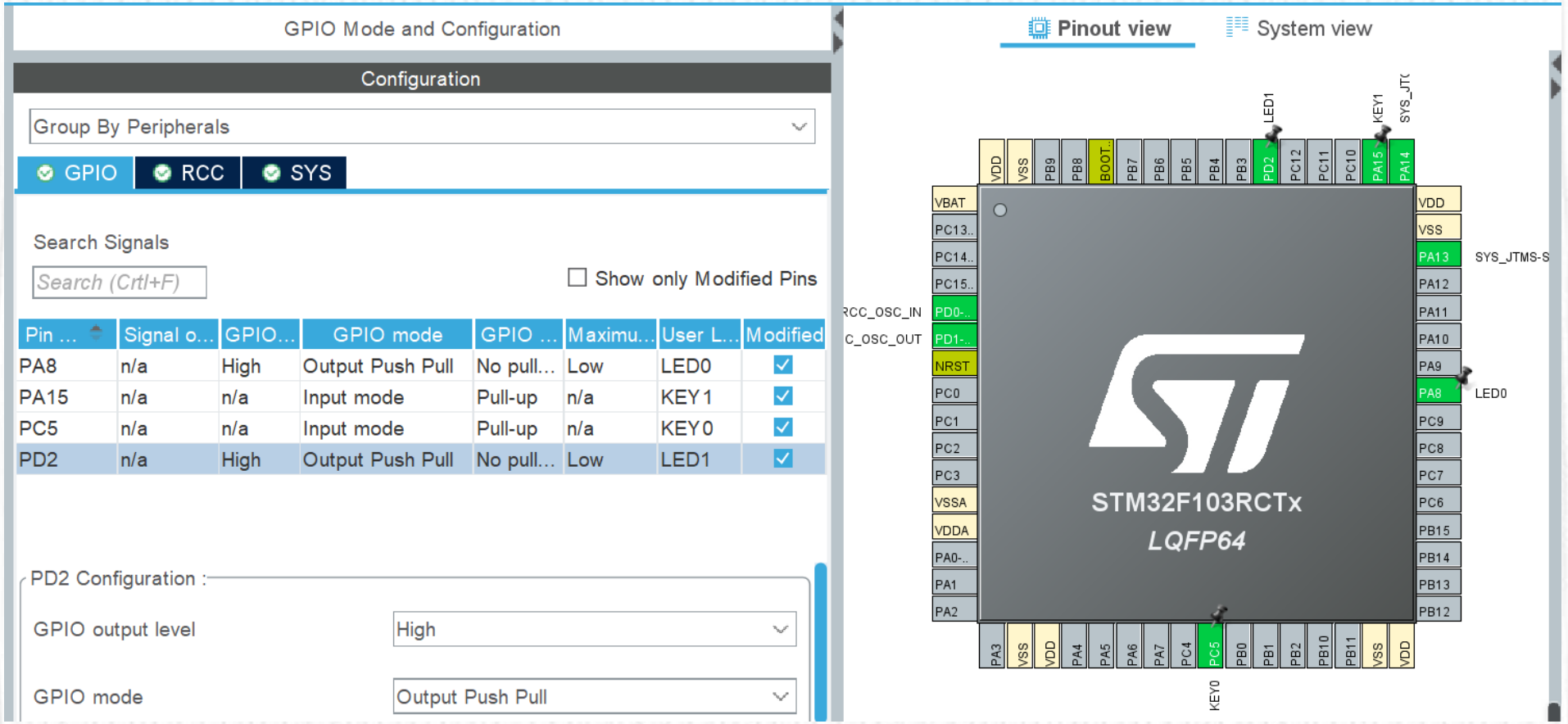
3. How to programming

- Our goal in this lab
  - On the ALIENTEK MiniSTM32 board, use KEY0 and KEY1 to control two LED LED0 and LED1 individually



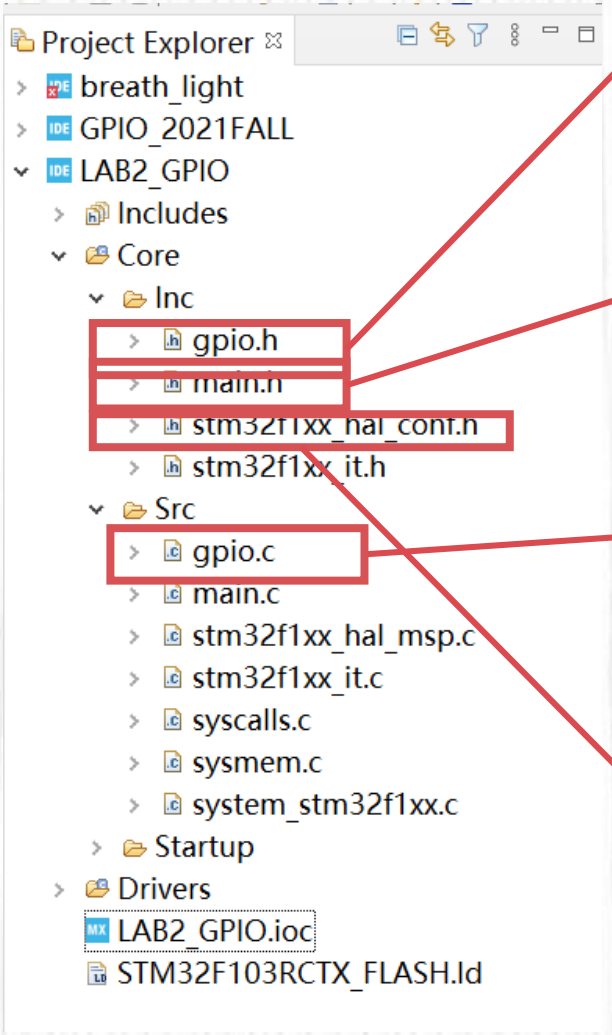
3. How to programming

- GPIO Configuration
  - Find the pins connected to KEY0, KEY1, LED0 and LED1, which are PC5, PA15, PA8 and PD2



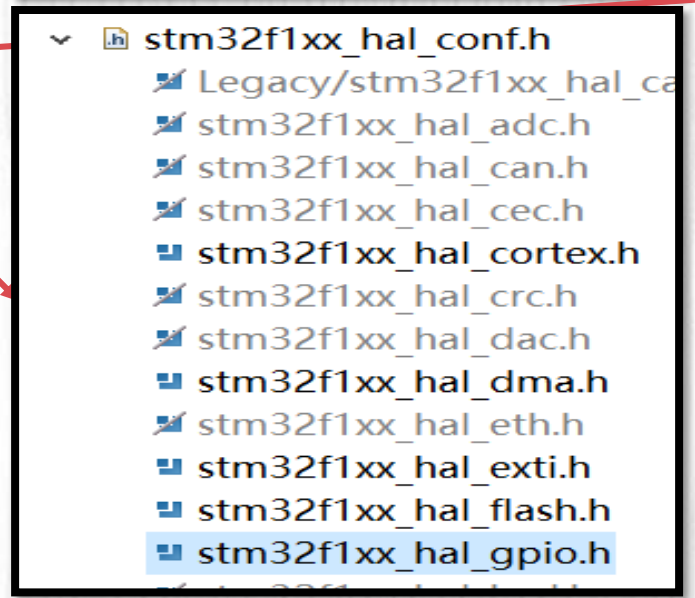
3. How to programming

- The generated files and codes




```
void MX_GPIO_Init(void);
```

```
#define KEY0_Pin GPIO_PIN_5
#define KEY0_GPIO_Port GPIOC
#define LED0_Pin GPIO_PIN_8
#define LED0_GPIO_Port GPIOA
#define KEY1_Pin GPIO_PIN_15
#define KEY1_GPIO_Port GPIOA
#define LED1_Pin GPIO_PIN_2
#define LED1_GPIO_Port GPIOD
```



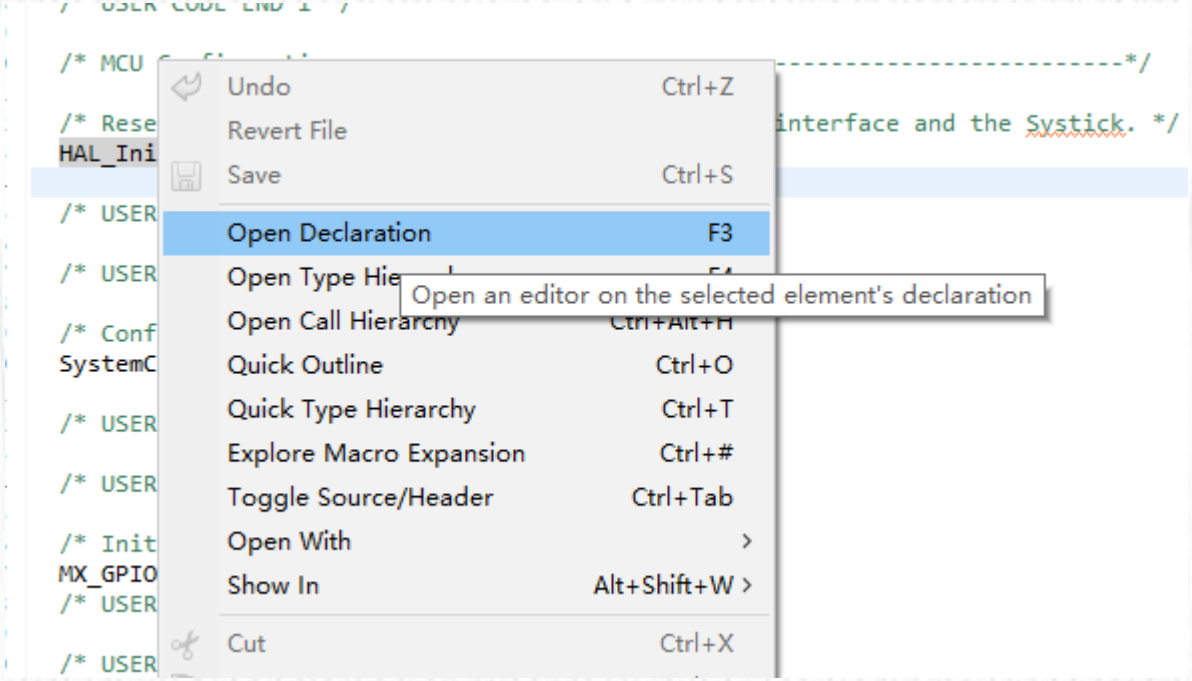

```
void MX_GPIO_Init(void){
  GPIO_InitTypeDef GPIO_InitStruct = {0};
  /* GPIO Ports Clock Enable */
  __HAL_RCC_GPIOD_CLK_ENABLE();
  __HAL_RCC_GPIOC_CLK_ENABLE();
  __HAL_RCC_GPIOA_CLK_ENABLE();

  /*Configure GPIO pin Output Level */
  HAL_GPIO_WritePin(LED0_GPIO_Port, LED0_Pin, GPIO_PIN_SET);
  /*Configure GPIO pin Output Level */
  HAL_GPIO_WritePin(LED1_GPIO_Port, LED1_Pin, GPIO_PIN_SET);

  /*Configure GPIO pin : PtPin */
  GPIO_InitStruct.Pin = KEY0_Pin;
  GPIO_InitStruct.Mode = GPIO_MODE_INPUT;
  GPIO_InitStruct.Pull = GPIO_PULLUP;
  HAL_GPIO_Init(KEY0_GPIO_Port, &GPIO_InitStruct);
  /*Configure GPIO pin : PtPin */
  GPIO_InitStruct.Pin = LED0_Pin;
  GPIO_InitStruct.Mode = GPIO_MODE_OUTPUT_PP;
  GPIO_InitStruct.Pull = GPIO_NOPULL;
  GPIO_InitStruct.Speed = GPIO_SPEED_FREQ_LOW;
  HAL_GPIO_Init(LED0_GPIO_Port, &GPIO_InitStruct);
  /*Configure GPIO pin : PtPin */
  GPIO_InitStruct.Pin = KEY1_Pin;
  GPIO_InitStruct.Mode = GPIO_MODE_INPUT;
  GPIO_InitStruct.Pull = GPIO_PULLUP;
  HAL_GPIO_Init(KEY1_GPIO_Port, &GPIO_InitStruct);
  /*Configure GPIO pin : PtPin */
  GPIO_InitStruct.Pin = LED1_Pin;
  GPIO_InitStruct.Mode = GPIO_MODE_OUTPUT_PP;
  GPIO_InitStruct.Pull = GPIO_NOPULL;
  GPIO_InitStruct.Speed = GPIO_SPEED_FREQ_LOW;
  HAL_GPIO_Init(LED1_GPIO_Port, &GPIO_InitStruct);
}
```

3. How to programming

- Use right click menu ***"Open Declaration"*** to check the definition of functions or structures



3. How to programming

- The structure used frequently

stm32f1xx_hal_gpio.h

```
typedef struct
{
  uint32_t Pin;       /*!< Specifies the GPIO pins to be configured.
                           This parameter can be any value of @ref GPIO_pins_define */

  uint32_t Mode;      /*!< Specifies the operating mode for the selected pins.
                           This parameter can be a value of @ref GPIO_mode_define */

  uint32_t Pull;      /*!< Specifies the Pull-up or Pull-Down activation for the selected pins.
                           This parameter can be a value of @ref GPIO_pull_define */

  uint32_t Speed;     /*!< Specifies the speed for the selected pins.
                           This parameter can be a value of @ref GPIO_speed_define */
} GPIO_InitTypeDef;
```

3. How to programming

- Add our codes in main.c

```
while (1)
{
  /* USER CODE END WHILE */

  /* USER CODE BEGIN 3 */
  if (HAL_GPIO_ReadPin(KEY0_GPIO_Port, KEY0_Pin) == GPIO_PIN_RESET) {
      HAL_Delay(100);
      HAL_GPIO_TogglePin(LED0_GPIO_Port, LED0_Pin);
  }
  else
      HAL_GPIO_WritePin(LED0_GPIO_Port, LED0_Pin, HAL_GPIO_ReadPin(LED0_GPIO_Port, LED0_Pin));

  if (HAL_GPIO_ReadPin(KEY1_GPIO_Port, KEY1_Pin) == GPIO_PIN_RESET) {
      HAL_Delay(100);
      HAL_GPIO_TogglePin(LED1_GPIO_Port, LED1_Pin);
  }
  //else
       //HAL_GPIO_WritePin(LED1_GPIO_Port, LED1_Pin, HAL_GPIO_ReadPin(LED1_GPIO_Port, LED1_Pin));
}
/* USER CODE END 3 */
```

南方科技大学
SOUTHERN UNIVERSITY OF SCIENCE AND TECHNOLOGY

04

Practice

4. Practice

- Run the demo on MiniSTM32 board