POLITECNICO
DI MILANO

www.polimi.it

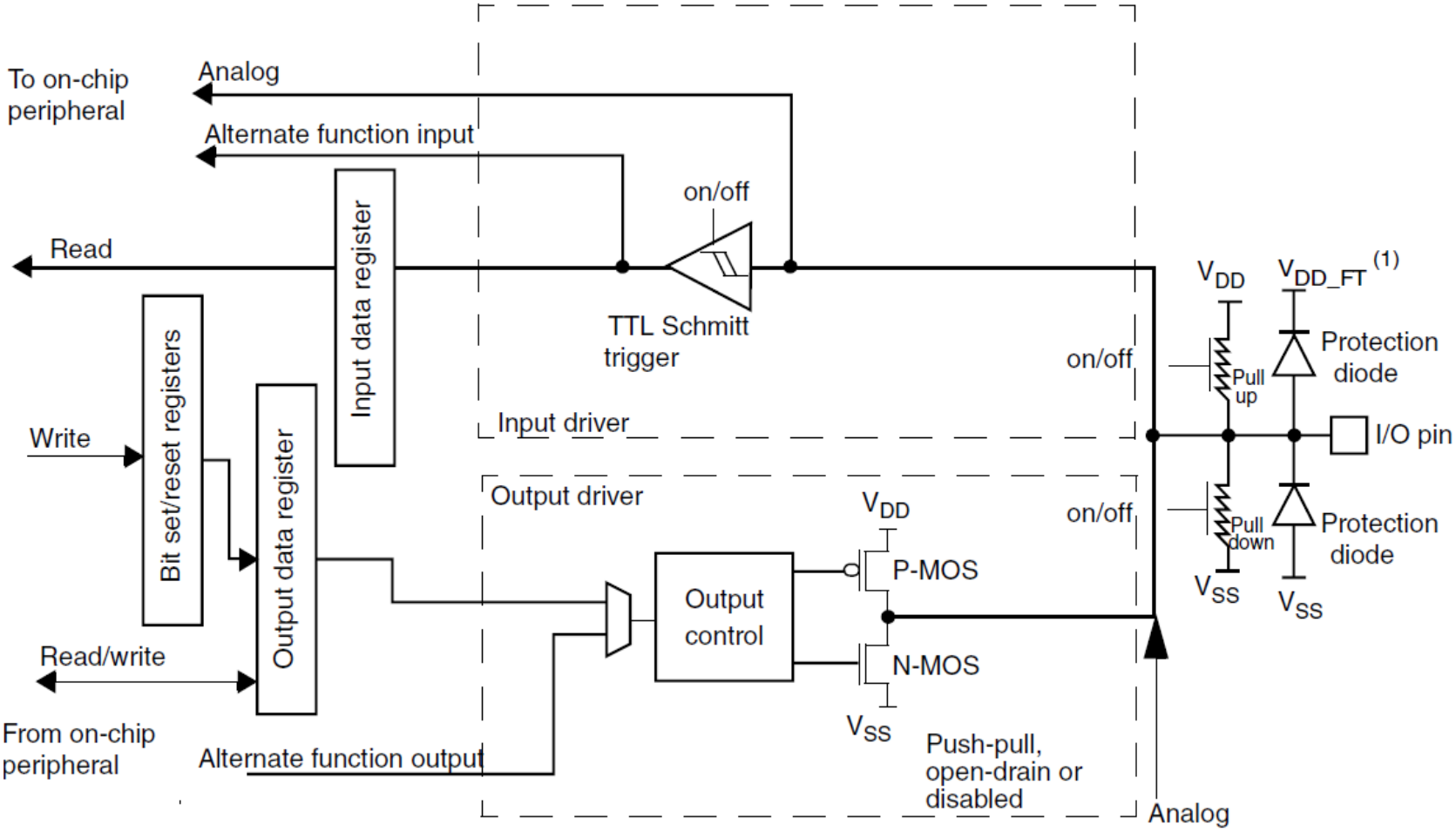




GPIO and Interrupt

Dr. Federica Villa

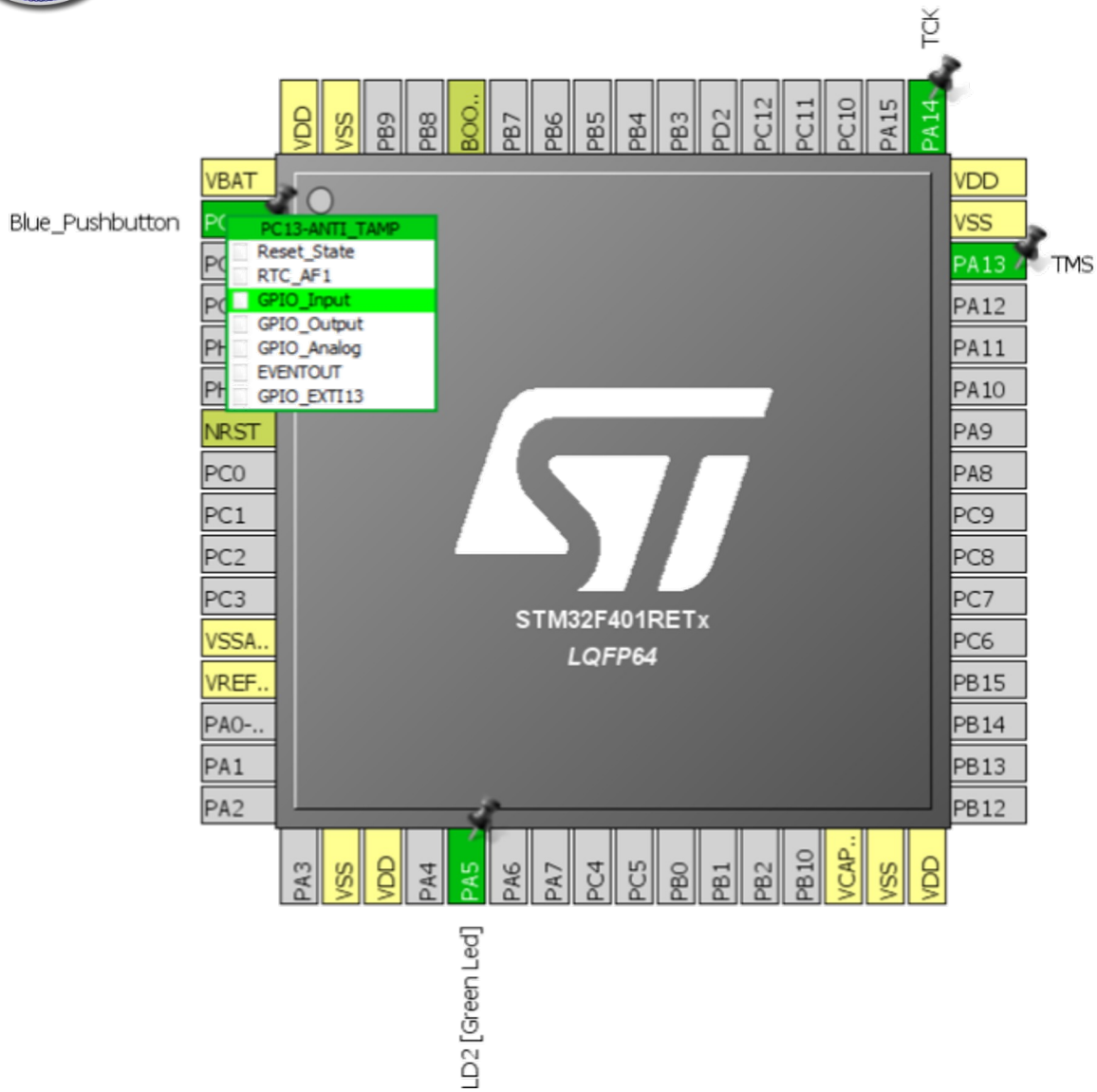
General Purpose Input/Outputs



GPIO:
6 ports (A…E, H)
each port 16 PIN

… but in STM32F401RE we have less GPIOs

CUBE project Pinout



- Open a new project (use default)

GPIO HAL functions

GPIO_PinState **HAL_GPIO_ReadPin**(GPIO_TypeDef* GPIOx, uint16_t GPIO_Pin)

void **HAL_GPIO_WritePin**(GPIO_TypeDef* GPIOx, uint16_t GPIO_Pin, GPIO_PinState PinState)

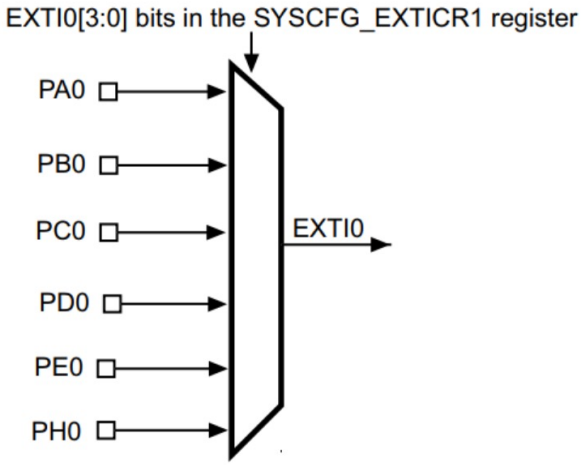
void **HAL_GPIO_TogglePin**(GPIO_TypeDef* GPIOx, uint16_t GPIO_Pin)

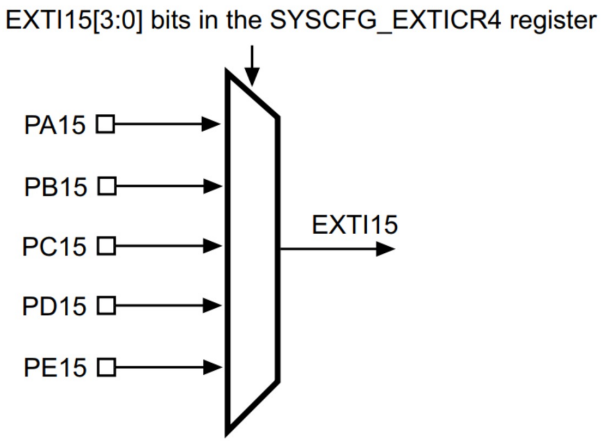
__weak void **HAL_GPIO_EXTI_Callback**(uint16_t GPIO_Pin)

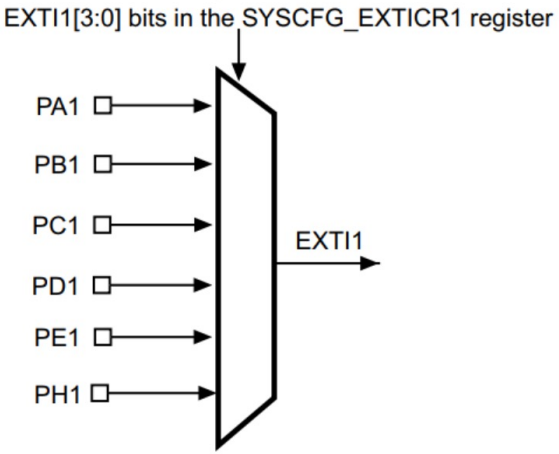
function called in the interrupt routine (after flag reset), it can be redefined by user in main.c

External interrupt/event line mapping

Up to 81 GPIOs (STM32F401xB/C and STM32F401xD/E) are connected to the 16 external interrupt/event lines in the following manner:







The five other EXTI lines are connected as follows:

– EXTI line 16 is connected to the PVD output

– EXTI line 17 is connected to the RTC Alarm event

– EXTI line 18 is connected to the USB OTG FS Wakeup event

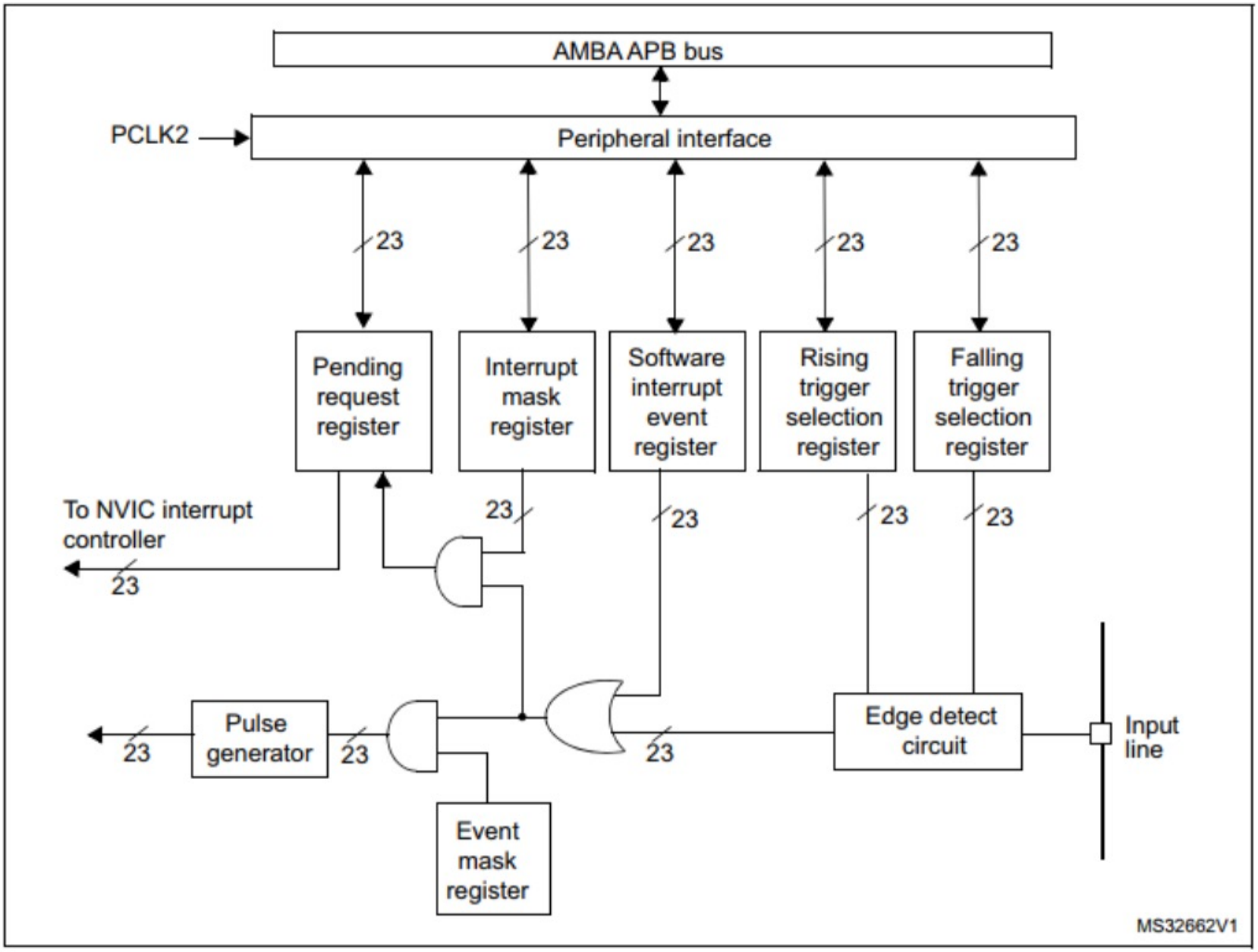
– EXTI line 21 is connected to the RTC Tamper and TimeStamp events

– EXTI line 22 is connected to the RTC Wakeup event

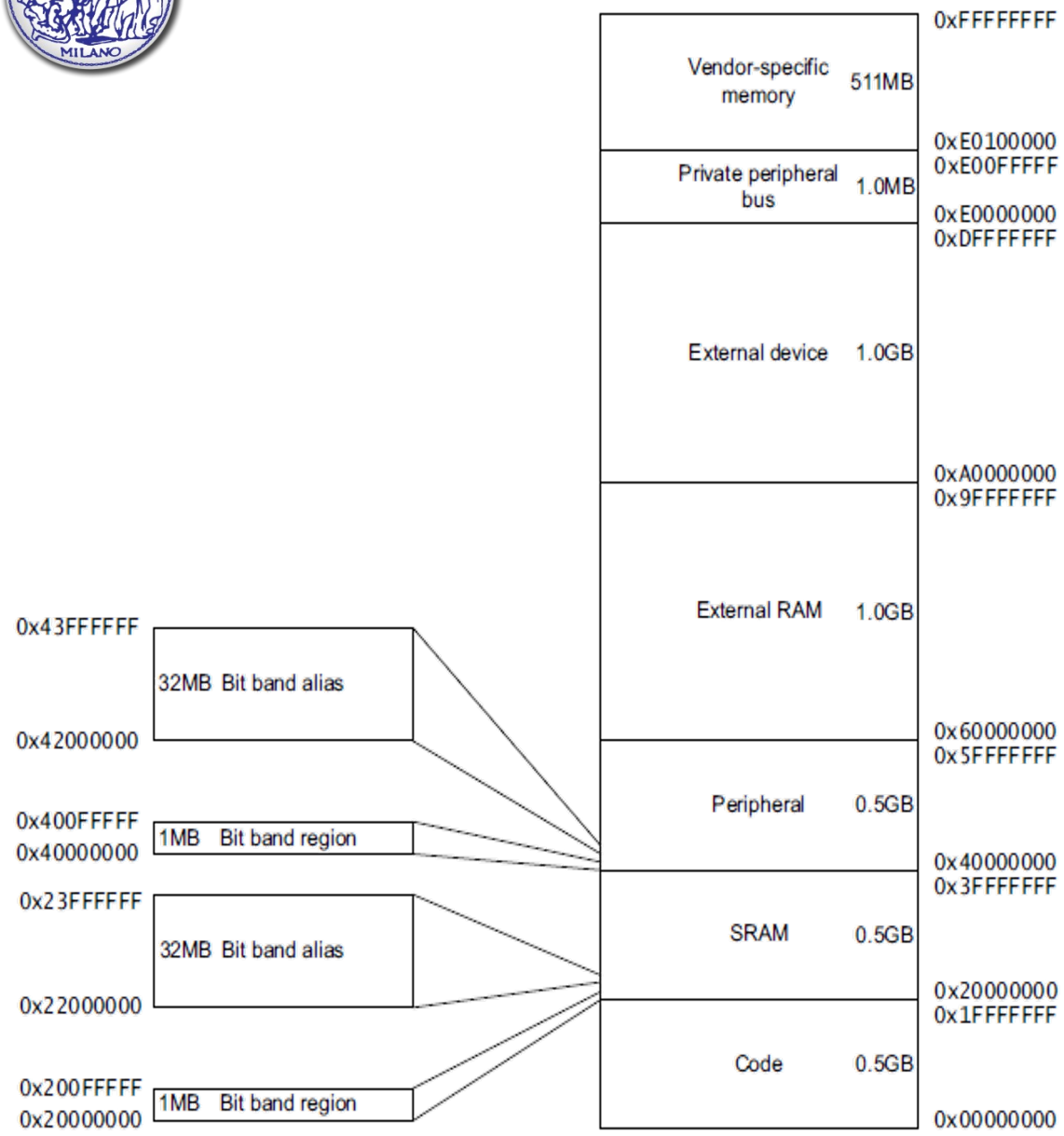
SYSCFG Register map

Offset	Register	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0x00	SYSCFG_ MEMRMP	Reserved																														MEM_MODE	
	Reset value																															x	x
0x04	SYSCFG_PMC	Reserved															ADC1DC2	Reserved															
	Reset value																0																
0x08	SYSCFG_ EXTICR1	Reserved																EXTI3[3:0]				EXTI2[3:0]				EXTI1[3:0]				EXTI0[3:0]			
	Reset value																	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0x0C	SYSCFG_ EXTICR2	Reserved																EXTI7[3:0]				EXTI6[3:0]				EXTI5[3:0]				EXTI4[3:0]			
	Reset value																	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0x10	SYSCFG_ EXTICR3	Reserved																EXTI11[3:0]				EXTI10[3:0]				EXTI9[3:0]				EXTI8[3:0]			
	Reset value																	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0x14	SYSCFG_ EXTICR4	Reserved																EXTI15[3:0]				EXTI14[3:0]				EXTI13[3:0]				EXTI12[3:0]			
	Reset value																	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0x20	SYSCFG_ CMPCR	Reserved																								READY	Reserved						CMP_PD
	Reset value																									0							0

EXTI block diagram



EXTI location in memory



Boundary address	Peripheral	Bus
0x5000 0000 - 0x5003 FFFF	USB OTG FS	AHB2
0x4002 6400 - 0x4002 67FF	DMA2	AHB1
0x4002 6000 - 0x4002 63FF	DMA1	
0x4002 3C00 - 0x4002 3FFF	Flash interface register	
0x4002 3800 - 0x4002 3BFF	RCC	
0x4002 3000 - 0x4002 33FF	CRC	
0x4002 1C00 - 0x4002 1FFF	GPIOH	
0x4002 1000 - 0x4002 13FF	GPIOE	
0x4002 0C00 - 0x4002 0FFF	GPIOD	
0x4002 0800 - 0x4002 0BFF	GPIOC	
0x4002 0400 - 0x4002 07FF	GPIOB	
0x4002 0000 - 0x4002 03FF	GPIOA	
0x4001 4800 - 0x4001 4BFF	TIM11	APB2
0x4001 4400 - 0x4001 47FF	TIM10	
0x4001 4000 - 0x4001 43FF	TIM9	
0x4001 3C00 - 0x4001 3FFF	EXTI	
0x4001 3800 - 0x4001 3BFF	SYSCFG	
0x4001 3400 - 0x4001 37FF	SPI4	
0x4001 3000 - 0x4001 33FF	SPI1	
0x4001 2C00 - 0x4001 2FFF	SDIO	
0x4001 2000 - 0x4001 23FF	ADC1	
0x4001 1400 - 0x4001 17FF	USART6	
0x4001 1000 - 0x4001 13FF	USART1	
0x4001 0000 - 0x4001 03FF	TIM1	
0x4000 7000 - 0x4000 73FF	PWR	APB1
0x4000 5C00 - 0x4000 5FFF	I2C3	
0x4000 5800 - 0x4000 5BFF	I2C2	
0x4000 5400 - 0x4000 57FF	I2C1	
0x4000 4400 - 0x4000 47FF	USART2	
0x4000 4000 - 0x4000 43FF	I2S3ext	
0x4000 3C00 - 0x4000 3FFF	SPI3 / I2S3	
0x4000 3800 - 0x4000 3BFF	SPI2 / I2S2	
0x4000 3400 - 0x4000 37FF	I2S2ext	
0x4000 3000 - 0x4000 33FF	IWDG	
0x4000 2C00 - 0x4000 2FFF	WWDG	
0x4000 2800 - 0x4000 2BFF	RTC & BKP Registers	
0x4000 0C00 - 0x4000 0FFF	TIM5	
0x4000 0800 - 0x4000 0BFF	TIM4	
0x4000 0400 - 0x4000 07FF	TIM3	
0x4000 0000 - 0x4000 03FF	TIM2	

EXTI register map

Offset	Register	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0x00	**EXTI_IMR**	Reserved									MR [22:21]		Reserved		MR[18:0]																		
	Reset value										0	0			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0x04	**EXTI_EMR**	Reserved									MR [22:21]		Reserved		MR[18:0]																		
	Reset value										0	0			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0x08	**EXTI_RTSR**	Reserved									TR [22:21]		Reserved		TR[18:0]																		
	Reset value										0	0			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0x0C	**EXTI_FTSR**	Reserved									TR [22:21]		Reserved		TR[18:0]																		
	Reset value										0	0			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0x10	**EXTI_SWIER**	Reserved									SWIER [22:21]		Reserved		SWIER[18:0]																		
	Reset value										0	0			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0x14	**EXTI_PR**	Reserved									PR [22:21]		Reserved		PR[18:0]																		
	Reset value										0	0			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

EXTI vector table

23	30	settable	EXTI9_5	EXTI Line[9:5] interrupts	0x0000 009C
24	31	settable	TIM1_BRK_TIM9	TIM1 Break interrupt and TIM9 global interrupt	0x0000 00A0
25	32	settable	TIM1_UP_TIM10	TIM1 Update interrupt and TIM10 global interrupt	0x0000 00A4
26	33	settable	TIM1_TRG_COM_TIM11	TIM1 Trigger and Commutation interrupts and TIM11 global interrupt	0x0000 00A8
27	34	settable	TIM1_CC	TIM1 Capture Compare interrupt	0x0000 00AC
28	35	settable	TIM2	TIM2 global interrupt	0x0000 00B0
29	36	settable	TIM3	TIM3 global interrupt	0x0000 00B4
30	37	settable	TIM4	TIM4 global interrupt	0x0000 00B8
31	38	settable	I2C1_EV	I^2C1 event interrupt	0x0000 00BC
32	39	settable	I2C1_ER	I^2C1 error interrupt	0x0000 00C0
33	40	settable	I2C2_EV	I^2C2 event interrupt	0x0000 00C4
34	41	settable	I2C2_ER	I^2C2 error interrupt	0x0000 00C8
35	42	settable	SPI1	SPI1 global interrupt	0x0000 00CC
36	43	settable	SPI2	SPI2 global interrupt	0x0000 00D0
37	44	settable	USART1	USART1 global interrupt	0x0000 00D4
38	45	settable	USART2	USART2 global interrupt	0x0000 00D8
40	47	settable	EXTI15_10	EXTI Line[15:10] interrupts	0x0000 00E0

Interrupts

- Interrupts must be enabled in CUBE
- All the interrupt routines are handled in stm32f4xx_it.c

Project 1a: Pushbutton - polling

Objective of this project is
to switch on the green LED on Nucleo board (LD2),
every time the blue pushbutton is pressed
and to switch it off
when the pushbutton is released.

A **polling** operation will be used to monitor the state of the pushbutton.

Project hints

1. Use the NUCLEO board Manual to find the GPIO connected to the blue push-button and LD2.

2. Configure the GPIO in CUBE and generate the code.

3. In NUCLEO board Manual find the state of the blue button (0 or 1) when it is pressed.

4. Use the GPIO function the check the state of the push-button and consequently update the state of LD2.

5. Debug and verify if the LED is ON when you press it and OFF when you release it.

Project 1b: Pushbutton - interrupt

Objective of this project is
to switch on an LED
every time the blue pushbutton is pressed,
and to switch it off
when the pushbutton is released.

The pushbutton input will be used in interrupt mode.

Project hints

1. Configure CUBE, remembering to enable the interrupt for the pushbutton. Note that you need to modify the status of the LED both when you press and when you release the pushbutton.

2. Check in the stm32f4xx_it.c file that the routine which handles the EXTI from the pushbutton has been automatically prepared by CUBE.

3. Use the HAL_GPIO_EXTI_Callback to manage the interrupt (switch ON/OFF the LED), using the GPIO functions.

4. Debug and verify if the LED is ON when you press it and OFF when you release it. You should see the same behavior you had in the first project (polling), **but now you are not using CPU resources just to wait for an event!**