

## TD STM32F411 - GPIOs et IRQ

1. Configuration des broches	1
2. Le coupleur d'interruption externe	1
3. Le contrôleur d'interruption	1
4. Synthèse	2
Annexe A. Brochage du connecteur Arduino, synoptique d'une GPIO, table des vecteurs	3
Annexe B. Schéma de la carte d'extension + extrait de datasheet	5

Le but est d'étudier comment une GPIO en entrée peut permettre de générer des demandes d'interruption externe au microcontrôleur. C'est également l'occasion de parler du contrôleur d'interruption NVIC (Nested Vectored Interrupt Controller).

Pour illustrer le propos, on souhaite écrire un programme qui permet d'allumer/éteindre la led bleue à partir du bouton central du joystick de la carte d'extension dont le schéma est fourni en annexe.

### 1. Configuration des broches

- Retrouver à l'aide du schéma et du brochage du connecteur Arduino, les broches à configurer pour commander la led bleue et récupérer l'état du bouton central.
- Rappeler le rôle des différents registres de l'interface de registres des GPIOs.
- Donner le code C permettant de configurer le bouton central.
- Donner le code C permettant de configurer et de contrôler la led bleue.

### 2. Le coupleur d'interruption externe

- Indiquer le rôle des registres IMR, EMR, RISR, FISR.
- Indiquer comment interviennent les registres `EXTICR[]` du bloc SYSCFG dans le choix des broches susceptibles de déclencher une demande d'interruption externe. Ecrire le code C pour permettre au signal issu du bouton central du joystick d'arriver à l'entrée du bloc EXTI.
- Ecrire le code C permettant de configurer le bloc EXTI pour qu'il génère une demande d'interruption sur l'appui du bouton central du joystick.
- Indiquer le rôle du registre PR.

### 3. Le contrôleur d'interruption

- Déterminer le nom et "IRQ number" correspondant à l'entrée du NVIC qui permet de capturer les demandes d'interruption en provenance du bloc d'interruptions externes. La priorité est choisie par le programmeur. La demande d'IRQ utilisera le niveau de priorité 6.
- Identifier les registres du NVIC permettant de fixer le niveau de priorité et d'autoriser les demandes d'interruption sur un canal d'entrée particulier. Ecrire le code permettant de configurer le NVIC pour prendre en compte les IRQ du bloc EXTI du microcontrôleur.
- Indiquer les fonctions équivalentes de la couche CMSIS. Donner le code C permettant de configurer le bloc EXTI.

#### 4. Synthèse

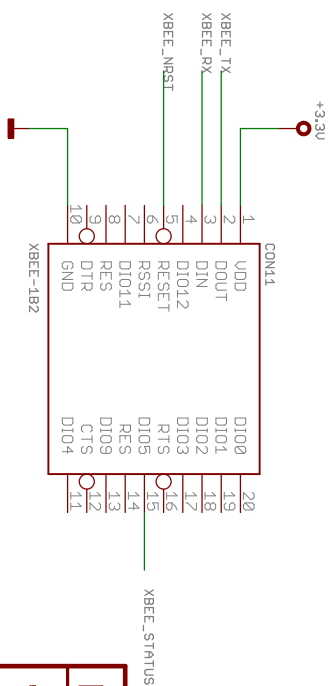
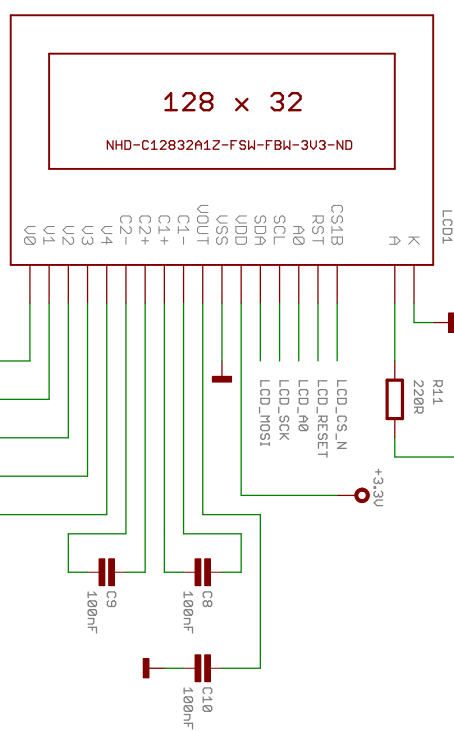
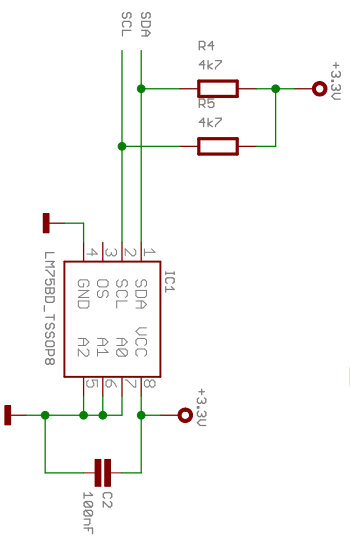
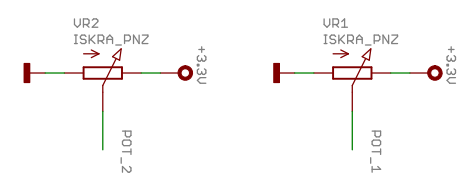
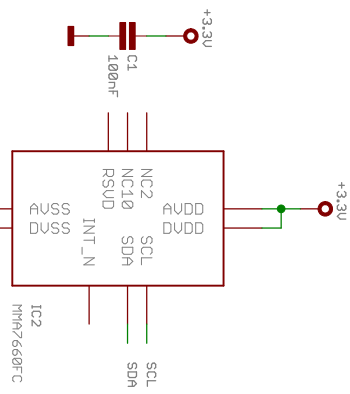
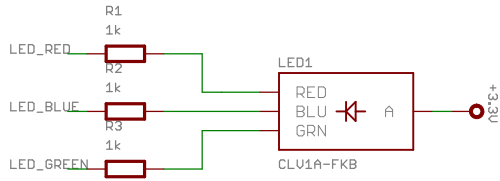
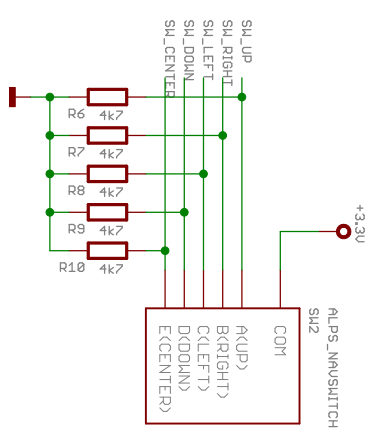
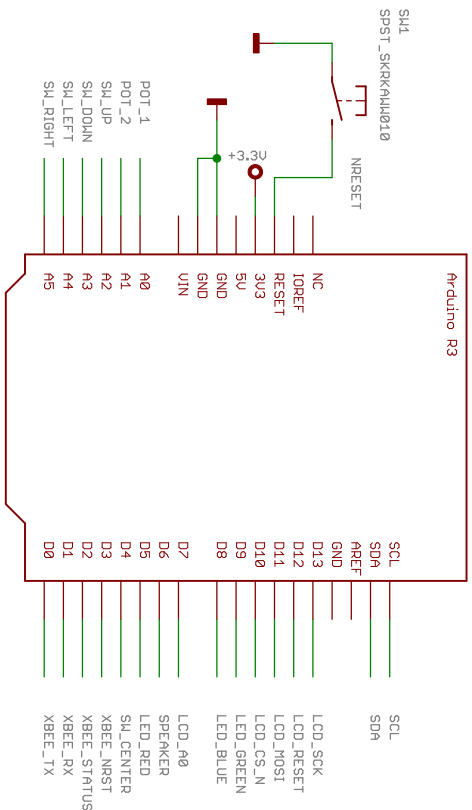
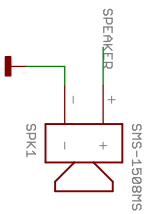
- a. Donner la structure de la fonction main et de l'ISR permettant le traitement de l'interruption générée par le bouton par l'intermédiaire du bloc EXTI.
- b. Indiquer la séquence d'actions qui résultent de l'appui sur le bouton.

The diagram illustrates the internal architecture of an I/O pin. At the top, a 'From on-chip peripheral' signal path leads to 'Read/write' control, which manages the 'Bit set/reset registers'. These registers control the 'Output data register' and the 'Input data register'. The 'Output data register' is connected to an 'Output driver' (a buffer) and an 'Output control' block. The 'Input data register' is connected to a 'TTL Schmitt trigger' and an 'on/off' control signal. The 'Output control' block drives an N-MOS transistor, while the 'on/off' control drives a P-MOS transistor. Both transistors are connected to the I/O pin. The I/O pin is also protected by two diodes connected to  $V_{DD}$  and  $V_{DD\_FT}$  rails, with pull-up and pull-down resistors. The diagram is divided into sections for 'Alternate function output', 'Push-pull, open-drain or disabled', and 'Analog' modes.

## Table des vecteurs (partielle)

g_pfnVectors:	
.word _estack	/* MSP reset value */
.word Reset_Handler	/* Reset handler */
.word NMI_Handler	/* Non Maskable Interrupt */
.word HardFault_Handler	/* Hardware fault */
.word MemManage_Handler	
.word BusFault_Handler	
.word UsageFault_Handler	
.word 0	
.word 0	
.word 0	
.word 0	
.word SVC_Handler	
.word DebugMon_Handler	
.word 0	
.word PendSV_Handler	
.word SysTick_Handler	
/* External Interrupts */	
.word WWDG_IRQHandler	/* Window WatchDog */
.word PVD_IRQHandler	/* PVD through EXTI line detection */
.word TAMP_STAMP_IRQHandler	/* Tamper and TimeStamps through the EXTI line */
.word RTC_WKUP_IRQHandler	/* RTC Wakeup through the EXTI line */
.word FLASH_IRQHandler	/* FLASH */
.word RCC_IRQHandler	/* RCC */
.word EXTI0_IRQHandler	/* EXTI Line0 */
.word EXTI1_IRQHandler	/* EXTI Line1 */
.word EXTI2_IRQHandler	/* EXTI Line2 */
.word EXTI3_IRQHandler	/* EXTI Line3 */
.word EXTI4_IRQHandler	/* EXTI Line4 */
.word DMA1_Stream0_IRQHandler	/* DMA1 Stream 0 */
.word DMA1_Stream1_IRQHandler	/* DMA1 Stream 1 */
.word DMA1_Stream2_IRQHandler	/* DMA1 Stream 2 */
.word DMA1_Stream3_IRQHandler	/* DMA1 Stream 3 */
.word DMA1_Stream4_IRQHandler	/* DMA1 Stream 4 */
.word DMA1_Stream5_IRQHandler	/* DMA1 Stream 5 */
.word DMA1_Stream6_IRQHandler	/* DMA1 Stream 6 */
.word ADC_IRQHandler	/* ADC1, ADC2 and ADC3s */
.word 0	/* Reserved */
.word 0	/* Reserved */
.word 0	/* Reserved */
.word 0	/* Reserved */
.word EXTI9_5_IRQHandler	/* External Line[9:5]s */
.word TIM1_BRK_TIM9_IRQHandler	/* TIM1 Break and TIM9 */
.word TIM1_UP_TIM10_IRQHandler	/* TIM1 Update and TIM10 */
.word TIM1_TRG_COM_TIM11_IRQHandler	/* TIM1 Trigger and Commutation and TIM11 */
.word TIM1_CC_IRQHandler	/* TIM1 Capture Compare */
.word TIM2_IRQHandler	/* TIM2 */
.word TIM3_IRQHandler	/* TIM3 */
.word TIM4_IRQHandler	/* TIM4 */
.word I2C1_EV_IRQHandler	/* I2C1 Event */
.word I2C1_ER_IRQHandler	/* I2C1 Error */
.word I2C2_EV_IRQHandler	/* I2C2 Event */
.word I2C2_ER_IRQHandler	/* I2C2 Error */
.word SPI1_IRQHandler	/* SPI1 */
.word SPI2_IRQHandler	/* SPI2 */
.word USART1_IRQHandler	/* USART1 */
.word USART2_IRQHandler	/* USART2 */
.word 0	/* Reserved */
.word EXTI15_10_IRQHandler	/* External Line[15:10]s */
.word RTC_Alarm_IRQHandler	/* RTC Alarm (A and B) through EXTI line */
.word OTG_FS_WKUP_IRQHandler	/* USB OTG FS Wakeup through EXTI line */
.word 0	/* Reserved */
.word 0	/* Reserved */
.word 0	/* Reserved */
.word DMA1_Stream7_IRQHandler	/* DMA1 Stream7 */





**mbed-HDK**

### 6.3.9 RCC AHB1 peripheral clock enable register (RCC\_AHB1ENR)

Address offset: 0x30

Reset value: 0x0000 0000

Access: no wait state, word, half-word and byte access.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Reserved									DMA2EN	DMA1EN	Reserved				
									rw	rw					
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Reserved		CRCEN		Reserved				GPIOHEN	Reserved		GPIOEEN	GPIODEN	GPIOCEN	GPIOBEN	GPIOAEN
		rw						rw			rw	rw	rw	rw	rw

Bits 31:23 Reserved, must be kept at reset value.

Bit 22 **DMA2EN**: DMA2 clock enable  
Set and cleared by software.  
0: DMA2 clock disabled  
1: DMA2 clock enabled

Bit 21 **DMA1EN**: DMA1 clock enable  
Set and cleared by software.  
0: DMA1 clock disabled  
1: DMA1 clock enabled

Bits 20:13 Reserved, must be kept at reset value.

Bit 12 **CRCEN**: CRC clock enable  
Set and cleared by software.  
0: CRC clock disabled  
1: CRC clock enabled

Bits 11:8 Reserved, must be kept at reset value.

Bit 7 **GPIOHEN**: IO port H clock enable  
Set and reset by software.  
0: IO port H clock disabled  
1: IO port H clock enabled

Bits 6:5 Reserved, must be kept at reset value.

Bit 4 **GPIOEEN**: IO port E clock enable  
Set and cleared by software.  
0: IO port E clock disabled  
1: IO port E clock enabled

Bit 3 **GPIODEN**: IO port D clock enable  
Set and cleared by software.  
0: IO port D clock disabled  
1: IO port D clock enabled

Bit 2 **GPIOCEN**: IO port C clock enable  
Set and cleared by software.  
0: IO port C clock disabled  
1: IO port C clock enabled

### 6.3.12 RCC APB2 peripheral clock enable register (RCC\_APB2ENR)

Address offset: 0x44

Reset value: 0x0000 0000

Access: no wait state, word, half-word and byte access.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Reserved											SPI5EN	Reserved	TIM11EN	TIM10EN	TIM9EN
											rw		rw	rw	rw
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Reserved	SYSCFGEN	SPI4EN	SPI1EN	SDIOEN	Reserved			ADC1EN	Reserved		USART6EN	USART1EN	Reserved		TIM1EN
	rw	rw	rw	rw				rw			rw	rw			rw

Bits 31:21 Reserved, must be kept at reset value.

Bit 20 **SPI5EN**: SPI5 clock enable  
This bit is set and cleared by software  
0: SPI5 clock disabled  
1: SPI5 clock enabled

Bit 19 Reserved, must be kept at reset value.

Bit 18 **TIM11EN**: TIM11 clock enable  
Set and cleared by software.  
0: TIM11 clock disabled  
1: TIM11 clock enabled

Bit 17 **TIM10EN**: TIM10 clock enable  
Set and cleared by software.  
0: TIM10 clock disabled  
1: TIM10 clock enabled

Bit 16 **TIM9EN**: TIM9 clock enable  
Set and cleared by software.  
0: TIM9 clock disabled  
1: TIM9 clock enabled

Bit 15 Reserved, must be kept at reset value.

Bit 14 **SYSCFGEN**: System configuration controller clock enable  
Set and cleared by software.  
0: System configuration controller clock disabled  
1: System configuration controller clock enabled

Bit 13 **SPI4EN**: SPI4 clock enable  
Set and reset by software.  
0: SPI4 clock disabled  
1: SPI4 clock enabled

Bit 12 **SPI1EN**: SPI1 clock enable  
Set and cleared by software.  
0: SPI1 clock disabled  
1: SPI1 clock enabled

### 7.2.3 SYSCFG external interrupt configuration register 1 (SYSCFG\_EXTICR1)

Address offset: 0x08

Reset value: 0x0000 0000

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Reserved															
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
EXTI3[3:0]				EXTI2[3:0]				EXTI1[3:0]				EXTI0[3:0]			
r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w

Bits 31:16 Reserved, must be kept at reset value.

Bits 15:0 **EXTIx[3:0]**: EXTI x configuration (x = 0 to 3)

These bits are written by software to select the source input for the EXTIx external interrupt.

0000: PA[x] pin  
 0001: PB[x] pin  
 0010: PC[x] pin  
 0011: PD[x] pin  
 0100: PE[x] pin  
 0101: Reserved  
 0110: Reserved  
 0111: PH[x] pin

### 7.2.4 SYSCFG external interrupt configuration register 2 (SYSCFG\_EXTICR2)

Address offset: 0x0C

Reset value: 0x0000 0000

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Reserved															
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
EXTI7[3:0]				EXTI6[3:0]				EXTI5[3:0]				EXTI4[3:0]			
r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w

Bits 31:16 Reserved, must be kept at reset value.

Bits 15:0 **EXTIx[3:0]**: EXTI x configuration (x = 4 to 7)

These bits are written by software to select the source input for the EXTIx external interrupt.

0000: PA[x] pin  
 0001: PB[x] pin  
 0010: PC[x] pin  
 0011: PD[x] pin  
 0100: PE[x] pin  
 0101: Reserved  
 0110: Reserved  
 0111: PH[x] pin

### 7.2.5 SYSCFG external interrupt configuration register 3 (SYSCFG\_EXTICR3)

Address offset: 0x10

Reset value: 0x0000 0000

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Reserved															
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
EXTI11[3:0]				EXTI10[3:0]				EXTI9[3:0]				EXTI8[3:0]			
r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w

Bits 31:16 Reserved, must be kept at reset value.

Bits 15:0 **EXTIx[3:0]**: EXTI x configuration (x = 8 to 11)

These bits are written by software to select the source input for the EXTIx external interrupt.

0000: PA[x] pin  
 0001: PB[x] pin  
 0010: PC[x] pin  
 0011: PD[x] pin  
 0100: PE[x] pin  
 0101: Reserved  
 0110: Reserved  
 0111: PH[x] pin

### 7.2.6 SYSCFG external interrupt configuration register 4 (SYSCFG\_EXTICR4)

Address offset: 0x14

Reset value: 0x0000 0000

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Reserved															
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
EXTI15[3:0]				EXTI14[3:0]				EXTI13[3:0]				EXTI12[3:0]			
r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w

Bits 31:16 Reserved, must be kept at reset value.

Bits 15:0 **EXTIx[3:0]**: EXTI x configuration (x = 12 to 15)

These bits are written by software to select the source input for the EXTIx external interrupt.

0000: PA[x] pin  
 0001: PB[x] pin  
 0010: PC[x] pin  
 0011: PD[x] pin  
 0100: PE[x] pin  
 0101: Reserved  
 0110: Reserved  
 0111: PH[x] pin



## 8.4 GPIO registers

This section gives a detailed description of the GPIO registers.

For a summary of register bits, register address offsets and reset values, refer to [Table 26](#).

The GPIO registers can be accessed by byte (8 bits), half-words (16 bits) or words (32 bits).

### 8.4.1 GPIO port mode register (GPIOx\_MODER) (x = A..E and H)

Address offset: 0x00

Reset values:

- 0xA800 0000 for port A
- 0x0000 0280 for port B
- 0x0000 0000 for other ports

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
MODER15[1:0]		MODER14[1:0]		MODER13[1:0]		MODER12[1:0]		MODER11[1:0]		MODER10[1:0]		MODER9[1:0]		MODER8[1:0]	
r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
MODER7[1:0]		MODER6[1:0]		MODER5[1:0]		MODER4[1:0]		MODER3[1:0]		MODER2[1:0]		MODER1[1:0]		MODER0[1:0]	
r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w

Bits 2y:2y+1 **MODERy[1:0]**: Port x configuration bits (y = 0..15)

These bits are written by software to configure the I/O direction mode.

- 00: Input (reset state)
- 01: General purpose output mode
- 10: Alternate function mode
- 11: Analog mode

### 8.4.2 GPIO port output type register (GPIOx\_OTYPER) (x = A..E and H)

Address offset: 0x04

Reset value: 0x0000 0000

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Reserved															
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
OT15	OT14	OT13	OT12	OT11	OT10	OT9	OT8	OT7	OT6	OT5	OT4	OT3	OT2	OT1	OT0
r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w

Bits 31:16 Reserved, must be kept at reset value.

Bits 15:0 **OTy**: Port x configuration bits (y = 0..15)

These bits are written by software to configure the output type of the I/O port.

- 0: Output push-pull (reset state)
- 1: Output open-drain

### 8.4.3 GPIO port output speed register (GPIOx\_OSPEEDR) (x = A..E and H)

Address offset: 0x08

Reset values:

- 0x0C00 0000 for port A
- 0x0000 00C0 for port B
- 0x0000 0000 for other ports

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
OSPEEDR15[1:0]		OSPEEDR14[1:0]		OSPEEDR13[1:0]		OSPEEDR12[1:0]		OSPEEDR11[1:0]		OSPEEDR10[1:0]		OSPEEDR9[1:0]		OSPEEDR8[1:0]	
r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
OSPEEDR7[1:0]		OSPEEDR6[1:0]		OSPEEDR5[1:0]		OSPEEDR4[1:0]		OSPEEDR3[1:0]		OSPEEDR2[1:0]		OSPEEDR1[1:0]		OSPEEDR0[1:0]	
r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w

Bits 2y:2y+1 **OSPEEDRy[1:0]**: Port x configuration bits (y = 0..15)

These bits are written by software to configure the I/O output speed.

- 00: Low speed
- 01: Medium speed
- 10: Fast speed
- 11: High speed

*Note: Refer to the product datasheets for the values of OSPEEDRy bits versus V<sub>DD</sub> range and external load.*

### 8.4.4 GPIO port pull-up/pull-down register (GPIOx\_PUPDR) (x = A..E and H)

Address offset: 0x0C

Reset values:

- 0x6400 0000 for port A
- 0x0000 0100 for port B
- 0x0000 0000 for other ports

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
PUPDR15[1:0]		PUPDR14[1:0]		PUPDR13[1:0]		PUPDR12[1:0]		PUPDR11[1:0]		PUPDR10[1:0]		PUPDR9[1:0]		PUPDR8[1:0]	
r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
PUPDR7[1:0]		PUPDR6[1:0]		PUPDR5[1:0]		PUPDR4[1:0]		PUPDR3[1:0]		PUPDR2[1:0]		PUPDR1[1:0]		PUPDR0[1:0]	
r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w

Bits 2y:2y+1 **PUPDRy[1:0]**: Port x configuration bits (y = 0..15)

These bits are written by software to configure the I/O pull-up or pull-down

00: No pull-up, pull-down

01: Pull-up

10: Pull-down

11: Reserved

#### 8.4.5 GPIO port input data register (GPIOx\_IDR) (x = A..E and H)

Address offset: 0x10

Reset value: 0x0000 XXXX (where X means undefined)

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

Bits 31:16 **Reserved**, must be kept at reset value.

Bits 15:0 **IDRy**: Port input data (y = 0..15)

These bits are read-only and can be accessed in word mode only. They contain the input value of the corresponding I/O port.

#### 8.4.6 GPIO port output data register (GPIOx\_ODR) (x = A..E and H)

Address offset: 0x14

Reset value: 0x0000 0000

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

Bits 31:16 **Reserved**, must be kept at reset value.

Bits 15:0 **ODRy**: Port output data (y = 0..15)

These bits can be read and written by software.

*Note: For atomic bit set/reset, the ODR bits can be individually set and reset by writing to the GPIOx\_BSRR register (x = A..E and H).*

#### 8.4.7 GPIO port bit set/reset register (GPIOx\_BSRR) (x = A..E and H)

Address offset: 0x18

Reset value: 0x0000 0000

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

Bits 31:16 **BRy**: Port x reset bit y (y = 0..15)

These bits are write-only and can be accessed in word, half-word or byte mode. A read to these bits returns the value 0x0000.

0: No action on the corresponding ODRx bit

1: Resets the corresponding ODRx bit

*Note: If both BSx and BRx are set, BSx has priority.*

Bits 15:0 **BSy**: Port x set bit y (y = 0..15)

These bits are write-only and can be accessed in word, half-word or byte mode. A read to these bits returns the value 0x0000.

0: No action on the corresponding ODRx bit

1: Sets the corresponding ODRx bit

#### 8.4.8 GPIO port configuration lock register (GPIOx\_LCKR) (x = A..E and H)

This register is used to lock the configuration of the port bits when a correct write sequence is applied to bit 16 (LCKK). The value of bits [15:0] is used to lock the configuration of the GPIO. During the write sequence, the value of LCKR[15:0] must not change. When the LOCK sequence has been applied on a port bit, the value of this port bit can no longer be modified until the next MCU or peripheral reset.

*Note: A specific write sequence is used to write to the GPIOx\_LCKR register. Only word access (32-bit long) is allowed during this write sequence.*

Each lock bit freezes a specific configuration register (control and alternate function registers).

Address offset: 0x1C

Reset value: 0x0000 0000

Access: 32-bit word only, read/write register

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Reserved															LCKK
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
LCK15	LCK14	LCK13	LCK12	LCK11	LCK10	LCK9	LCK8	LCK7	LCK6	LCK5	LCK4	LCK3	LCK2	LCK1	LCK0
rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw

Bits 31:17 Reserved, must be kept at reset value.

Bit 16 **LCKK[16]**: Lock key

This bit can be read any time. It can only be modified using the lock key write sequence.

0: Port configuration lock key not active

1: Port configuration lock key active. The GPIOx\_LCKR register is locked until an MCU reset or a peripheral reset occurs.

LOCK key write sequence:

WR LCKR[16] = '1' + LCKR[15:0]

WR LCKR[16] = '0' + LCKR[15:0]

WR LCKR[16] = '1' + LCKR[15:0]

RD LCKR

RD LCKR[16] = '1' (this read operation is optional but it confirms that the lock is active)

*Note: During the LOCK key write sequence, the value of LCK[15:0] must not change.*

*Any error in the lock sequence aborts the lock.*

*After the first lock sequence on any bit of the port, any read access on the LCKK bit will return '1' until the next CPU reset.*

Bits 15:0 **LCKy**: Port x lock bit y (y = 0..15)

These bits are read/write but can only be written when the LCKK bit is '0'.

0: Port configuration not locked

1: Port configuration locked

#### 8.4.9 GPIO alternate function low register (GPIOx\_AFRL) (x = A..E and H)

Address offset: 0x20

Reset value: 0x0000 0000

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
AFRL7[3:0]				AFRL6[3:0]				AFRL5[3:0]				AFRL4[3:0]			
r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
AFRL3[3:0]				AFRL2[3:0]				AFRL1[3:0]				AFRL0[3:0]			
r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w

Bits 31:0 **AFRLy**: Alternate function selection for port x bit y (y = 0..7)

These bits are written by software to configure alternate function I/Os

AFRLy selection:

0000: AF0	1000: AF8
0001: AF1	1001: AF9
0010: AF2	1010: AF10
0011: AF3	1011: AF11
0100: AF4	1100: AF12
0101: AF5	1101: AF13
0110: AF6	1110: AF14
0111: AF7	1111: AF15

#### 8.4.10 GPIO alternate function high register (GPIOx\_AFRH) (x = A..E and H)

Address offset: 0x24

Reset value: 0x0000 0000

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
AFRH15[3:0]				AFRH14[3:0]				AFRH13[3:0]				AFRH12[3:0]			
r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
AFRH11[3:0]				AFRH10[3:0]				AFRH9[3:0]				AFRH8[3:0]			
r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w

Bits 31:0 **AFRHy**: Alternate function selection for port x bit y (y = 8..15)

These bits are written by software to configure alternate function I/Os

AFRHy selection:

0000: AF0	1000: AF8
0001: AF1	1001: AF9
0010: AF2	1010: AF10
0011: AF3	1011: AF11
0100: AF4	1100: AF12
0101: AF5	1101: AF13
0110: AF6	1110: AF14
0111: AF7	1111: AF15

#### 8.4.11 GPIO register map

The following table gives the GPIO register map and the reset values.

Table 26. GPIO register map and reset values

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	<b>GPIOA_MODER</b>	MODER15[1:0]																															
	Reset value	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0x00	<b>GPIOB_MODER</b>	MODER15[1:0]																															
	Reset value	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0
0x00	<b>GPIOx_MODER</b> (where x = C..E and H)	MODER15[1:0]																															
	Reset value	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 26. GPIO register map and reset values (continued)

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
0x04	<b>GPIOx_OTYPER</b> (where x = A..E and H)	Reserved																OT15	OT14	OT13	OT12	OT11	OT10	OT9	OT8	OT7	OT6	OT5	OT4	OT3	OT2	OT1	OT0
	Reset value																	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0x08	<b>GPIOx_OSPEEDR</b> (where x = C..E and H)	OSPEEDR15[1:0]	OSPEEDR14[1:0]	OSPEEDR13[1:0]	OSPEEDR12[1:0]	OSPEEDR11[1:0]	OSPEEDR10[1:0]	OSPEEDR9[1:0]	OSPEEDR8[1:0]	OSPEEDR7[1:0]	OSPEEDR6[1:0]	OSPEEDR5[1:0]	OSPEEDR4[1:0]	OSPEEDR3[1:0]	OSPEEDR2[1:0]	OSPEEDR1[1:0]	OSPEEDR0[1:0]																
	Reset value	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0x08	<b>GPIOA_OSPEEDER</b>	OSPEEDR15[1:0]	OSPEEDR14[1:0]	OSPEEDR13[1:0]	OSPEEDR12[1:0]	OSPEEDR11[1:0]	OSPEEDR10[1:0]	OSPEEDR9[1:0]	OSPEEDR8[1:0]	OSPEEDR7[1:0]	OSPEEDR6[1:0]	OSPEEDR5[1:0]	OSPEEDR4[1:0]	OSPEEDR3[1:0]	OSPEEDR2[1:0]	OSPEEDR1[1:0]	OSPEEDR0[1:0]																
	Reset value	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0x08	<b>GPIOB_OSPEEDR</b>	OSPEEDR15[1:0]	OSPEEDR14[1:0]	OSPEEDR13[1:0]	OSPEEDR12[1:0]	OSPEEDR11[1:0]	OSPEEDR10[1:0]	OSPEEDR9[1:0]	OSPEEDR8[1:0]	OSPEEDR7[1:0]	OSPEEDR6[1:0]	OSPEEDR5[1:0]	OSPEEDR4[1:0]	OSPEEDR3[1:0]	OSPEEDR2[1:0]	OSPEEDR1[1:0]	OSPEEDR0[1:0]																
	Reset value	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
0x0C	<b>GPIOA_PUPDR</b>	PUPDR15[1:0]	PUPDR14[1:0]	PUPDR13[1:0]	PUPDR12[1:0]	PUPDR11[1:0]	PUPDR10[1:0]	PUPDR9[1:0]	PUPDR8[1:0]	PUPDR7[1:0]	PUPDR6[1:0]	PUPDR5[1:0]	PUPDR4[1:0]	PUPDR3[1:0]	PUPDR2[1:0]	PUPDR1[1:0]	PUPDR0[1:0]																
	Reset value	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0x0C	<b>GPIOB_PUPDR</b>	PUPDR15[1:0]	PUPDR14[1:0]	PUPDR13[1:0]	PUPDR12[1:0]	PUPDR11[1:0]	PUPDR10[1:0]	PUPDR9[1:0]	PUPDR8[1:0]	PUPDR7[1:0]	PUPDR6[1:0]	PUPDR5[1:0]	PUPDR4[1:0]	PUPDR3[1:0]	PUPDR2[1:0]	PUPDR1[1:0]	PUPDR0[1:0]																
	Reset value	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
0x0C	<b>GPIOx_PUPDR</b> (where x = C..E and H)	PUPDR15[1:0]	PUPDR14[1:0]	PUPDR13[1:0]	PUPDR12[1:0]	PUPDR11[1:0]	PUPDR10[1:0]	PUPDR9[1:0]	PUPDR8[1:0]	PUPDR7[1:0]	PUPDR6[1:0]	PUPDR5[1:0]	PUPDR4[1:0]	PUPDR3[1:0]	PUPDR2[1:0]	PUPDR1[1:0]	PUPDR0[1:0]																
	Reset value	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0x10	<b>GPIOx_IDR</b> (where x = A..E and H)	Reserved																IDR15	IDR14	IDR13	IDR12	IDR11	IDR10	IDR9	IDR8	IDR7	IDR6	IDR5	IDR4	IDR3	IDR2	IDR1	IDR0
	Reset value																	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
0x14	<b>GPIOx_ODR</b> (where x = A..E and H)	Reserved																ODR15	ODR14	ODR13	ODR12	ODR11	ODR10	ODR9	ODR8	ODR7	ODR6	ODR5	ODR4	ODR3	ODR2	ODR1	ODR0
	Reset value																	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0x18	<b>GPIOx_BSRR</b> (where x = A..E and H)	BSR15	BSR14	BSR13	BSR12	BSR11	BSR10	BSR9	BSR8	BSR7	BSR6	BSR5	BSR4	BSR3	BSR2	BSR1	BSR0	BS15	BS14	BS13	BS12	BS11	BS10	BS9	BS8	BS7	BS6	BS5	BS4	BS3	BS2	BS1	BS0
	Reset value	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 26. GPIO register map and reset values (continued)

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	
0x1C	<b>GPIOx_LCKR</b> (where x = A..E and H)	Reserved																LCKK	LCK15	LCK14	LCK13	LCK12	LCK11	LCK10	LCK9	LCK8	LCK7	LCK6	LCK5	LCK4	LCK3	LCK2	LCK1	LCK0
	Reset value																	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0x20	<b>GPIOx_AFRLL</b> (where x = A..E and H)	AFRL7[3:0]		AFRL6[3:0]		AFRL5[3:0]		AFRL4[3:0]		AFRL3[3:0]		AFRL2[3:0]		AFRL1[3:0]		AFRL0[3:0]																		
	Reset value	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
0x24	<b>GPIOx_AFRH</b> (where x = A..E and H)	AFRH15[3:0]		AFRH14[3:0]		AFRH13[3:0]		AFRH12[3:0]		AFRH11[3:0]		AFRH10[3:0]		AFRH9[3:0]		AFRH8[3:0]																		
	Reset value	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		

Refer to [Section 2.3: Memory map](#) for the register boundary addresses.

## 10 Interrupts and events

### 10.1 Nested vectored interrupt controller (NVIC)

#### 10.1.1 NVIC features

The nested vector interrupt controller NVIC includes the following features:

- 52 maskable interrupt channels (not including the 16 interrupt lines of Cortex®-M4 with FPU)
- 16 programmable priority levels (4 bits of interrupt priority are used)
- low-latency exception and interrupt handling
- power management control
- implementation of system control registers

The NVIC and the processor core interface are closely coupled, which enables low latency interrupt processing and efficient processing of late arriving interrupts.

All interrupts including the core exceptions are managed by the NVIC. For more information on exceptions and NVIC programming, refer to programming manual PM0214.

#### 10.1.2 SysTick calibration value register

The SysTick calibration value is fixed to 10500, which gives a reference time base of 1 ms with the SysTick clock set to 10.5 MHz (HCLK/8, with HCLK set to 84 MHz).

#### 10.1.3 Interrupt and exception vectors

See [Table 37](#), for the vector table for the STM32F411xC/E devices.

### 10.2 External interrupt/event controller (EXTI)

The external interrupt/event controller consists of up to 23 edge detectors for generating event/interrupt requests. Each input line can be independently configured to select the type (interrupt or event) and the corresponding trigger event (rising or falling or both). Each line can also be masked independently. A pending register maintains the status line of the interrupt requests.

Table 37. Vector table for STM32F411xC/E

Position	Priority	Type of priority	Acronym	Description	Address
	-	-	-	Reserved	0x0000 0000
	-3	fixed	Reset	Reset	0x0000 0004

Table 37. Vector table for STM32F411xC/E (continued)

Position	Priority	Type of priority	Acronym	Description	Address
	-2	fixed	NMI	Non maskable interrupt, Clock Security System	0x0000 0008
	-1	fixed	HardFault	All class of fault	0x0000 000C
	0	settable	MemManage	Memory management	0x0000 0010
	1	settable	BusFault	Pre-fetch fault, memory access fault	0x0000 0014
	2	settable	UsageFault	Undefined instruction or illegal state	0x0000 0018
	-	-	-	Reserved	0x0000 001C - 0x0000 002B
	3	settable	SVCall	System Service call via SWI instruction	0x0000 002C
	4	settable	Debug Monitor	Debug Monitor	0x0000 0030
	-	-	-	Reserved	0x0000 0034
	5	settable	PendSV	Pendable request for system service	0x0000 0038
	6	settable	Systick	System tick timer	0x0000 003C
0	7	settable	WWDG	Window Watchdog interrupt	0x0000 0040
1	8	settable	EXTI16 / PVD	EXTI Line 16 interrupt / PVD through EXTI line detection interrupt	0x0000 0044
2	9	settable	EXTI21 / TAMP_STAMP	EXTI Line 21 interrupt / Tamper and TimeStamp interrupts through the EXTI line	0x0000 0048
3	10	settable	EXTI22 / RTC_WKUP	EXTI Line 22 interrupt / RTC Wakeup interrupt through the EXTI line	0x0000 004C
4	11	settable	FLASH	Flash global interrupt	0x0000 0050
5	12	settable	RCC	RCC global interrupt	0x0000 0054
6	13	settable	EXTI0	EXTI Line0 interrupt	0x0000 0058
7	14	settable	EXTI1	EXTI Line1 interrupt	0x0000 005C
8	15	settable	EXTI2	EXTI Line2 interrupt	0x0000 0060
9	16	settable	EXTI3	EXTI Line3 interrupt	0x0000 0064
10	17	settable	EXTI4	EXTI Line4 interrupt	0x0000 0068
11	18	settable	DMA1_Stream0	DMA1 Stream0 global interrupt	0x0000 006C
12	19	settable	DMA1_Stream1	DMA1 Stream1 global interrupt	0x0000 0070
13	20	settable	DMA1_Stream2	DMA1 Stream2 global interrupt	0x0000 0074
14	21	settable	DMA1_Stream3	DMA1 Stream3 global interrupt	0x0000 0078

Table 37. Vector table for STM32F411xC/E (continued)

Position	Priority	Type of priority	Acronym	Description	Address
15	22	settable	DMA1_Stream4	DMA1 Stream4 global interrupt	0x0000 007C
16	23	settable	DMA1_Stream5	DMA1 Stream5 global interrupt	0x0000 0080
17	24	settable	DMA1_Stream6	DMA1 Stream6 global interrupt	0x0000 0084
18	25	settable	ADC	ADC1 global interrupts	0x0000 0088
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 <sup>2</sup> C1 event interrupt	0x0000 00BC
32	39	settable	I2C1_ER	I <sup>2</sup> C1 error interrupt	0x0000 00C0
33	40	settable	I2C2_EV	I <sup>2</sup> C2 event interrupt	0x0000 00C4
34	41	settable	I2C2_ER	I <sup>2</sup> C2 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
41	48	settable	EXTI17 / RTC_Alarm	EXTI Line 17 interrupt / RTC Alarms (A and B) through EXTI line interrupt	0x0000 00E4
42	49	settable	EXTI18 / OTG_FS_WKUP	EXTI Line 18 interrupt / USB On-The-Go FS Wakeup through EXTI line interrupt	0x0000 00E8
47	54	settable	DMA1_Stream7	DMA1 Stream7 global interrupt	0x0000 00FC
49	56	settable	SDIO	SDIO global interrupt	0x0000 0104
50	57	settable	TIM5	TIM5 global interrupt	0x0000 0108
51	58	settable	SPI3	SPI3 global interrupt	0x0000 010C

Table 37. Vector table for STM32F411xC/E (continued)

Position	Priority	Type of priority	Acronym	Description	Address
56	63	settable	DMA2_Stream0	DMA2 Stream0 global interrupt	0x0000 0120
57	64	settable	DMA2_Stream1	DMA2 Stream1 global interrupt	0x0000 0124
58	65	settable	DMA2_Stream2	DMA2 Stream2 global interrupt	0x0000 0128
59	66	settable	DMA2_Stream3	DMA2 Stream3 global interrupt	0x0000 012C
60	67	settable	DMA2_Stream4	DMA2 Stream4 global interrupt	0x0000 0130
67	74	settable	OTG_FS	USB On The Go FS global interrupt	0x0000 014C
68	75	settable	DMA2_Stream5	DMA2 Stream5 global interrupt	0x0000 0150
69	76	settable	DMA2_Stream6	DMA2 Stream6 global interrupt	0x0000 0154
70	77	settable	DMA2_Stream7	DMA2 Stream7 global interrupt	0x0000 0158
71	78	settable	USART6	USART6 global interrupt	0x0000 015C
72	79	settable	I2C3_EV	I <sup>2</sup> C3 event interrupt	0x0000 0160
73	80	settable	I2C3_ER	I <sup>2</sup> C3 error interrupt	0x0000 0164
81	88	Settable	FPU	FPU global interrupt	0x0000 0184
84	91	settable	SPI4	SPI 4 global interrupt	0x0000 0190
85	92	settable	SPI5	SPI 5 global interrupt	0x0000 0194

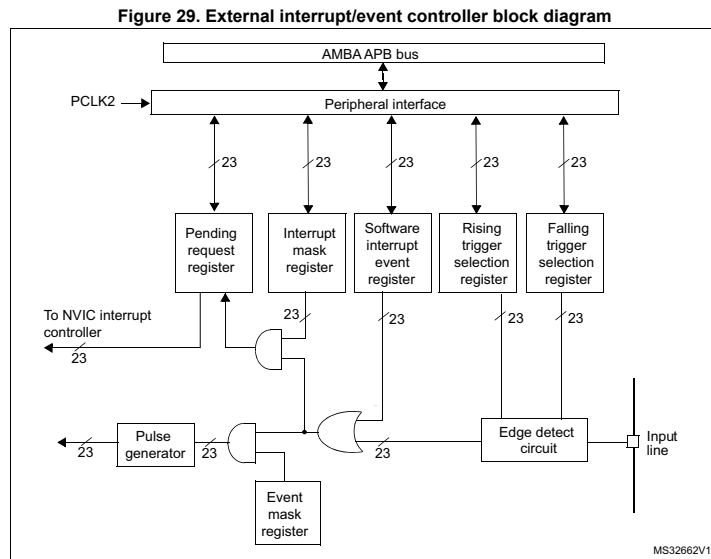
## 10.2.1 EXTI main features

The main features of the EXTI controller are the following:

- independent trigger and mask on each interrupt/event line
- dedicated status bit for each interrupt line
- generation of up to 23 software event/interrupt requests
- detection of external signals with a pulse width lower than the APB2 clock period. Refer to the electrical characteristics section of the STM32F4xx datasheets for details on this parameter.

### 10.2.2 EXTI block diagram

Figure 29 shows the block diagram.



### 10.2.3 Wakeup event management

The STM32F4xx are able to handle external or internal events in order to wake up the core (WFE). The wakeup event can be generated either by:

- enabling an interrupt in the peripheral control register but not in the NVIC, and enabling the SEVONPEND bit in the Cortex<sup>®</sup>-M4 with FPU System Control register. When the MCU resumes from WFE, the peripheral interrupt pending bit and the peripheral NVIC IRQ channel pending bit (in the NVIC interrupt clear pending register) have to be cleared.
- or configuring an external or internal EXTI line in event mode. When the CPU resumes from WFE, it is not necessary to clear the peripheral interrupt pending bit or the NVIC IRQ channel pending bit as the pending bit corresponding to the event line is not set.

To use an external line as a wakeup event, refer to [Section 10.2.4: Functional description](#).

### 10.2.4 Functional description

To generate the interrupt, the interrupt line should be configured and enabled. This is done by programming the two trigger registers with the desired edge detection and by enabling the interrupt request by writing a '1' to the corresponding bit in the interrupt mask register. When the selected edge occurs on the external interrupt line, an interrupt request is

generated. The pending bit corresponding to the interrupt line is also set. This request is reset by writing a '1' in the pending register.

To generate the event, the event line should be configured and enabled. This is done by programming the two trigger registers with the desired edge detection and by enabling the event request by writing a '1' to the corresponding bit in the event mask register. When the selected edge occurs on the event line, an event pulse is generated. The pending bit corresponding to the event line is not set.

An interrupt/event request can also be generated by software by writing a '1' in the software interrupt/event register.

#### Hardware interrupt selection

To configure the 23 lines as interrupt sources, use the following procedure:

- Configure the mask bits of the 23 interrupt lines (EXTI\_IMR)
- Configure the Trigger selection bits of the interrupt lines (EXTI\_RTISR and EXTI\_FTISR)
- Configure the enable and mask bits that control the NVIC IRQ channel mapped to the external interrupt controller (EXTI) so that an interrupt coming from one of the 23 lines can be correctly acknowledged.

#### Hardware event selection

To configure the 23 lines as event sources, use the following procedure:

- Configure the mask bits of the 23 event lines (EXTI\_EMR)
- Configure the Trigger selection bits of the event lines (EXTI\_RTISR and EXTI\_FTISR)

#### Software interrupt/event selection

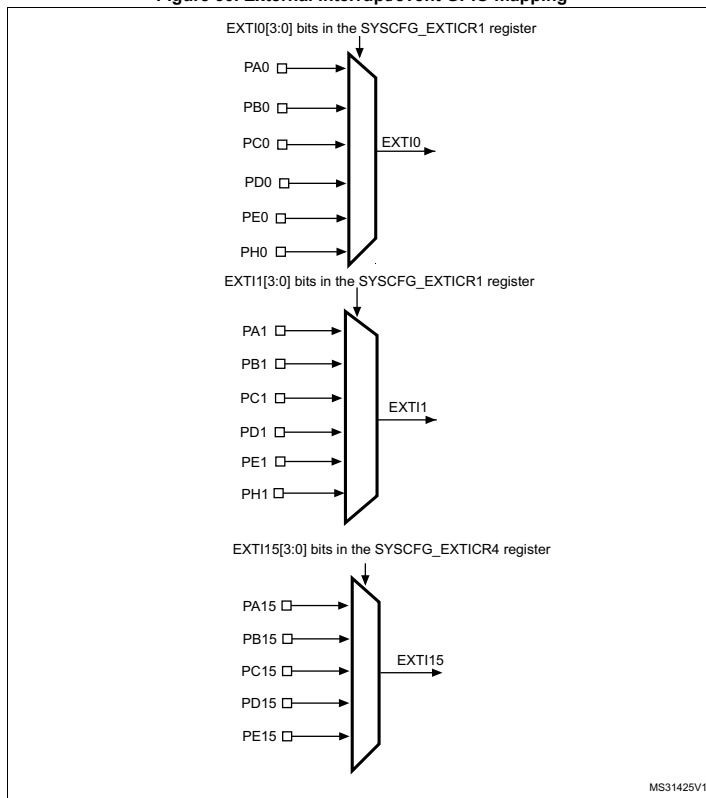
The 23 lines can be configured as software interrupt/event lines. The following is the procedure to generate a software interrupt.

- Configure the mask bits of the 23 interrupt/event lines (EXTI\_IMR, EXTI\_EMR)
- Set the required bit in the software interrupt register (EXTI\_SWIER)

### 10.2.5 External interrupt/event line mapping

Up to 81 GPIOs (STM32F411xC/E) are connected to the 16 external interrupt/event lines in the following manner:

Figure 30. External interrupt/event GPIO mapping



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

## 10.3 EXTI registers

Refer to [Section 1.1: List of abbreviations for registers](#) for a list of abbreviations used in register descriptions.

### 10.3.1 Interrupt mask register (EXTI\_IMR)

Address offset: 0x00

Reset value: 0x0000 0000

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Reserved									MR22	MR21	Reserved		MR18	MR17	MR16
									r/w	r/w			r/w		
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
MR15	MR14	MR13	MR12	MR11	MR10	MR9	MR8	MR7	MR6	MR5	MR4	MR3	MR2	MR1	MR0
r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w

Bits 31:23 Reserved, must be kept at reset value.

Bits 22:0 **MRx**: Interrupt mask on line x

0: Interrupt request from line x is masked

1: Interrupt request from line x is not masked

### 10.3.2 Event mask register (EXTI\_EMR)

Address offset: 0x04

Reset value: 0x0000 0000

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	
Reserved									MR22	MR21	Reserved			MR18	MR17	MR16
									r/w	r/w				r/w	r/w	
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
MR15	MR14	MR13	MR12	MR11	MR10	MR9	MR8	MR7	MR6	MR5	MR4	MR3	MR2	MR1	MR0	
r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	

Bits 31:23 Reserved, must be kept at reset value.

Bits 22:0 **MRx**: Event mask on line x

0: Event request from line x is masked

1: Event request from line x is not masked



### 10.3.3 Rising trigger selection register (EXTI\_RTSR)

Address offset: 0x08  
Reset value: 0x0000 0000

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Reserved									TR22	TR21	Reserved		TR18	TR17	TR16
									rw	rw			rw	rw	rw
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
TR15	TR14	TR13	TR12	TR11	TR10	TR9	TR8	TR7	TR6	TR5	TR4	TR3	TR2	TR1	TR0
rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw

Bits 31:23 Reserved, must be kept at reset value.

Bits 22:0 **TRx**: Rising trigger event configuration bit of line x  
0: Rising trigger disabled (for Event and Interrupt) for input line  
1: Rising trigger enabled (for Event and Interrupt) for input line

*Note:* The external wakeup lines are edge triggered, no glitch must be generated on these lines. If a rising edge occurs on the external interrupt line while writing to the EXTI\_RTSR register, the pending bit is be set.  
Rising and falling edge triggers can be set for the same interrupt line. In this configuration, both generate a trigger condition.

### 10.3.4 Falling trigger selection register (EXTI\_FTSR)

Address offset: 0x0C  
Reset value: 0x0000 0000

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Reserved									TR22	TR21	Reserved		TR18	TR17	TR16
									rw	rw			rw	rw	rw
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
TR15	TR14	TR13	TR12	TR11	TR10	TR9	TR8	TR7	TR6	TR5	TR4	TR3	TR2	TR1	TR0
rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw

Bits 31:23 Reserved, must be kept at reset value.

Bits 22:0 **TRx**: Falling trigger event configuration bit of line x  
0: Falling trigger disabled (for Event and Interrupt) for input line  
1: Falling trigger enabled (for Event and Interrupt) for input line.

*Note:* The external wakeup lines are edge triggered, no glitch must be generated on these lines. If a falling edge occurs on the external interrupt line while writing to the EXTI\_FTSR register, the pending bit is not set.  
Rising and falling edge triggers can be set for the same interrupt line. In this configuration, both generate a trigger condition.

### 10.3.5 Software interrupt event register (EXTI\_SWIER)

Address offset: 0x10  
Reset value: 0x0000 0000

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Reserved									SWIER 22	SWIER 21	Reserved		SWIER 18	SWIER 17	SWIER 16
									rw	rw			rw	rw	rw
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
SWIER 15	SWIER 14	SWIER 13	SWIER 12	SWIER 11	SWIER 10	SWIER 9	SWIER 8	SWIER 7	SWIER 6	SWIER 5	SWIER 4	SWIER 3	SWIER 2	SWIER 1	SWIER 0
rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw

Bits 31:23 Reserved, must be kept at reset value.

Bits 22:0 **SWIERx**: Software Interrupt on line x

If interrupt are enabled on line x in the EXTI\_IMR register, writing '1' to SWIERx bit when it is set at '0' sets the corresponding pending bit in the EXTI\_PR register, thus resulting in an interrupt request generation.

This bit is cleared by clearing the corresponding bit in EXTI\_PR (by writing a 1 to the bit).

### 10.3.6 Pending register (EXTI\_PR)

Address offset: 0x14  
Reset value: undefined

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Reserved									PR22	PR21	Reserved		PR18	PR17	PR16
									rc_w1	rc_w1			rc_w1	rc_w1	rc_w1
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
PR15	PR14	PR13	PR12	PR11	PR10	PR9	PR8	PR7	PR6	PR5	PR4	PR3	PR2	PR1	PR0
rc_w1	rc_w1	rc_w1	rc_w1	rc_w1	rc_w1	rc_w1	rc_w1	rc_w1	rc_w1	rc_w1	rc_w1	rc_w1	rc_w1	rc_w1	rc_w1

Bits 31:23 Reserved, must be kept at reset value.

Bits 22:0 **PRx**: Pending bit

0: No trigger request occurred

1: selected trigger request occurred

This bit is set when the selected edge event arrives on the external interrupt line.

This bit is cleared by programming it to '1'.

### 10.3.7 EXTI register map

[Table 38](#) gives the EXTI register map and the reset values.

**Table 38. External interrupt/event controller register map and reset values**

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]	Reser ved	MR[18:0]																			
	Reset value											0																				0	
0x04	EXTI_EMR	Reserved										MR [22:21]	Reser ved	MR[18:0]																			
	Reset value											0																				0	
0x08	EXTI_RTSR	Reserved										TR [22:21]	Reser ved	TR[18:0]																			
	Reset value											0																				0	
0x0C	EXTI_FTSR	Reserved										TR [22:21]	Reser ved	TR[18:0]																			
	Reset value											0																				0	
0x10	EXTI_SWIER	Reserved										SWIER [22:21]	Reser ved	SWIER[18:0]																			
	Reset value											0																				0	
0x14	EXTI_PR	Reserved										PR [22:21]	Reser ved	PR[18:0]																			
	Reset value											0																				0	

Refer to [Section 2.3: Memory map](#) for the register boundary addresses.