

## 8 General-purpose I/Os (GPIO)

GPIO F/G/H/I/J/K (except GPIOH0 and GPIOH1) are not available in STM32F401xB/C and STM32F401xD/E.

### 8.1 GPIO introduction

Each general-purpose I/O port has four 32-bit configuration registers (GPIOx\_MODER, GPIOx\_OTYPER, GPIOx\_OSPEEDR and GPIOx\_PUPDR), two 32-bit data registers (GPIOx\_IDR and GPIOx\_ODR), a 32-bit set/reset register (GPIOx\_BSRR), a 32-bit locking register (GPIOx\_LCKR) and two 32-bit alternate function selection register (GPIOx\_AFRH and GPIOx\_AFRL).

### 8.2 GPIO main features

- Up to 16 I/Os under control
- Output states: push-pull or open drain + pull-up/down
- Output data from output data register (GPIOx\_ODR) or peripheral (alternate function output)
- Speed selection for each I/O
- Input states: floating, pull-up/down, analog
- Input data to input data register (GPIOx\_IDR) or peripheral (alternate function input)
- Bit set and reset register (GPIOx\_BSRR) for bitwise write access to GPIOx\_ODR
- Locking mechanism (GPIOx\_LCKR) provided to freeze the I/O configuration
- Analog function
- Alternate function input/output selection registers (at most 16 AFs per I/O)
- Fast toggle capable of changing every two clock cycles
- Highly flexible pin multiplexing allows the use of I/O pins as GPIOs or as one of several peripheral functions

### 8.3 GPIO functional description

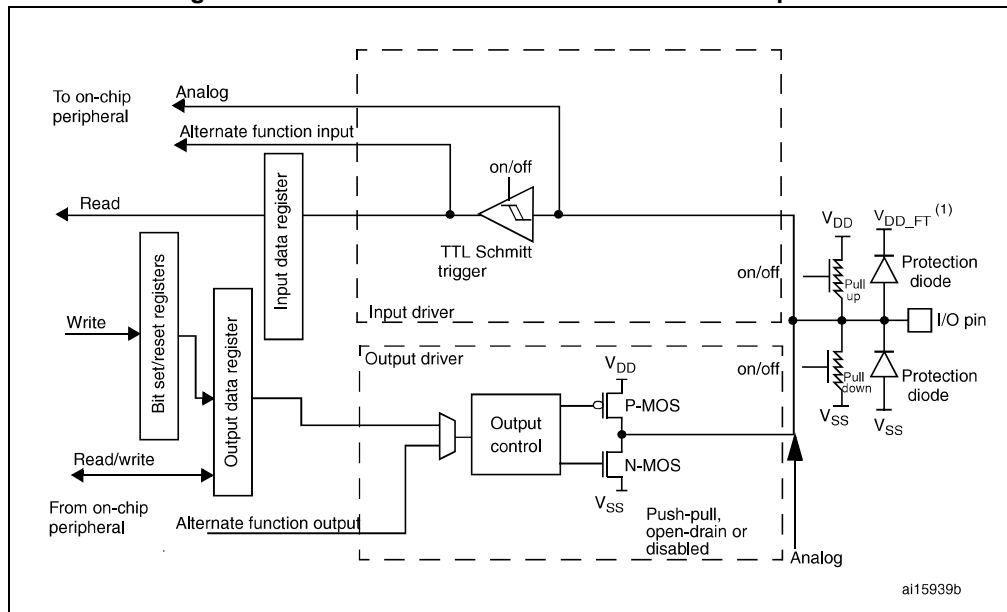
Subject to the specific hardware characteristics of each I/O port listed in the datasheet, each port bit of the general-purpose I/O (GPIO) ports can be individually configured by software in several modes:

- Input floating
- Input pull-up
- Input-pull-down
- Analog
- Output open-drain with pull-up or pull-down capability
- Output push-pull with pull-up or pull-down capability
- Alternate function push-pull with pull-up or pull-down capability
- Alternate function open-drain with pull-up or pull-down capability

Each I/O port bit is freely programmable, however the I/O port registers have to be accessed as 32-bit words, half-words or bytes. The purpose of the GPIOx\_BSRR register is to allow atomic read/modify accesses to any of the GPIO registers. In this way, there is no risk of an IRQ occurring between the read and the modify access.

show the basic structure of a 5 V tolerant I/O port bit. [Table 27](#) gives the possible port bit configurations.

**Figure 16. Basic structure of a five-volt tolerant I/O port bit**



1.  $V_{DD\_FT}$  is a potential specific to five-volt tolerant I/Os and different from  $V_{DD}$ .

**Table 24. Port bit configuration table<sup>(1)</sup>**

MODER(i) [1:0]	OTYPER(i)	OSPEEDR(i) [B:A]	PUPDR(i) [1:0]		I/O configuration	
01	0	SPEED [B:A]	0	0	GP output	PP
	0		0	1	GP output	PP + PU
	0		1	0	GP output	PP + PD
	0		1	1	Reserved	
	1		0	0	GP output	OD
	1		0	1	GP output	OD + PU
	1		1	0	GP output	OD + PD
	1		1	1	Reserved (GP output OD)	

Table 24. Port bit configuration table<sup>(1)</sup> (continued)

MODER(i) [1:0]	OTYPER(i)	OSPEEDR(i) [B:A]		PUPDR(i) [1:0]		I/O configuration	
10	0	SPEED [B:A]		0	0	AF	PP
	0			0	1	AF	PP + PU
	0			1	0	AF	PP + PD
	0			1	1	Reserved	
	1			0	0	AF	OD
	1			0	1	AF	OD + PU
	1			1	0	AF	OD + PD
	1			1	1	Reserved	
00	x	x	x	0	0	Input	Floating
	x	x	x	0	1	Input	PU
	x	x	x	1	0	Input	PD
	x	x	x	1	1	Reserved (input floating)	
11	x	x	x	0	0	Input/output	Analog
	x	x	x	0	1	Reserved	
	x	x	x	1	0		
	x	x	x	1	1		

1. GP = general-purpose, PP = push-pull, PU = pull-up, PD = pull-down, OD = open-drain, AF = alternate function.

### 8.3.1 General-purpose I/O (GPIO)

During and just after reset, the alternate functions are not active and the I/O ports are configured in input floating mode.

The debug pins are in AF pull-up/pull-down after reset:

- PA15: JTDI in pull-up
- PA14: JTCK/SWCLK in pull-down
- PA13: JTMS/SWDAT in pull-up
- PB4: NJTRST in pull-up
- PB3: JTDO in floating state

When the pin is configured as output, the value written to the output data register (GPIOx\_ODR) is output on the I/O pin. It is possible to use the output driver in push-pull mode or open-drain mode (only the N-MOS is activated when 0 is output).

The input data register (GPIOx\_IDR) captures the data present on the I/O pin at every AHB clock cycle.

All GPIO pins have weak internal pull-up and pull-down resistors, which can be activated or not depending on the value in the GPIOx\_PUPDR register.

### 8.3.2 I/O pin multiplexer and mapping

The microcontroller I/O pins are connected to onboard peripherals/modules through a multiplexer that allows only one peripheral's alternate function (AF) connected to an I/O pin at a time. In this way, there can be no conflict between peripherals sharing the same I/O pin.

Each I/O pin has a multiplexer with sixteen alternate function inputs (AF0 to AF15) that can be configured through the GPIOx\_AFRL (for pin 0 to 7) and GPIOx\_AFRH (for pin 8 to 15) registers:

- After reset all I/Os are connected to the system's alternate function 0 (AF0)
- The peripherals' alternate functions are mapped from AF1 to AF13
- Cortex®-M4 with FPU EVENTOUT is mapped on AF15

This structure is shown in [Figure 17](#) below.

In addition to this flexible I/O multiplexing architecture, each peripheral has alternate functions mapped onto different I/O pins to optimize the number of peripherals available in smaller packages.

To use an I/O in a given configuration, proceed as follows:

- **System function**

Connect the I/O to AF0 and configure it depending on the function used:

- JTAG/SWD, after each device reset these pins are assigned as dedicated pins immediately usable by the debugger host (not controlled by the GPIO controller)
- RTC\_REFIN: this pin should be configured in Input floating mode
- MCO1 and MCO2: these pins have to be configured in alternate function mode.

*Note:* The user can disable some or all of the JTAG/SWD pins and so release the associated pins for GPIO usage (released pins highlighted in gray in the table).

For more details please refer to [Section 6.2.10: Clock-out capability](#).

Table 25. Flexible SWJ-DP pin assignment

Available debug ports	SWJ I/O pin assigned				
	PA13 / JTMS/ SWDIO	PA14 / JTCK/ SWCLK	PA15 / JTDI	PB3 / JTDO	PB4/ NJTRST
Full SWJ (JTAG-DP + SW-DP) - Reset state	X	X	X	X	X
Full SWJ (JTAG-DP + SW-DP) but without NJTRST	X	X	X	X	
JTAG-DP Disabled and SW-DP Enabled	X	X			
JTAG-DP Disabled and SW-DP Disabled	Released				

- **GPIO**

Configure the desired I/O as output or input in the GPIOx\_MODER register.

- **Peripheral alternate function**

For the ADC, configure the desired I/O as analog in the GPIOx\_MODER register.

For other peripherals:

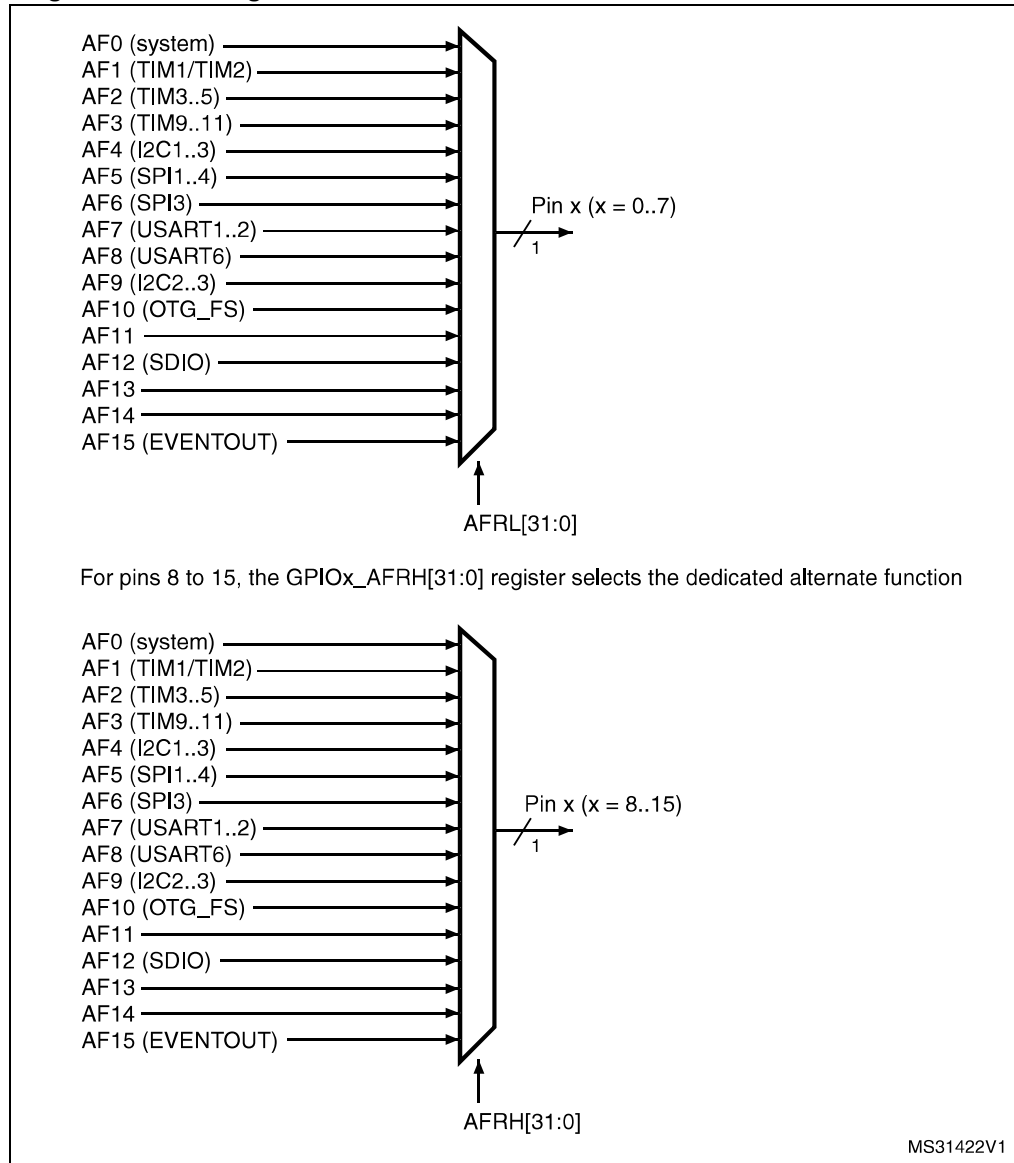
- Configure the desired I/O as an alternate function in the GPIOx\_MODER register
- Select the type, pull-up/pull-down and output speed via the GPIOx\_OTYPER, GPIOx\_PUPDR and GPIOx\_OSPEEDR registers, respectively
- Connect the I/O to the desired AFx in the GPIOx\_AFR1 or GPIOx\_AFR2 register

- **EVENTOUT**

Configure the I/O pin used to output the Cortex®-M4 with FPU EVENTOUT signal by connecting it to AF15

*Note:* **EVENTOUT** is not mapped onto the following I/O pins: PC13, PC14, PC15, PH0 and PH1.

Please refer to the “Alternate function mapping” table in the datasheets for the detailed mapping of the system and peripherals’ alternate function I/O pins.

**Figure 17. Selecting an alternate function on STM32F401xB/C and STM32F401xD/E**

1. Configured in FS.

### 8.3.3 I/O port control registers

Each of the GPIOs has four 32-bit memory-mapped control registers (GPIOx\_MODER, GPIOx\_OTYPER, GPIOx\_OSPEEDR, GPIOx\_PUPDR) to configure up to 16 I/Os.

The GPIOx\_MODER register is used to select the I/O direction (input, output, AF, analog). The GPIOx\_OTYPER and GPIOx\_OSPEEDR registers are used to select the output type (push-pull or open-drain) and speed (the I/O speed pins are directly connected to the corresponding GPIOx\_OSPEEDR register bits whatever the I/O direction). The GPIOx\_PUPDR register is used to select the pull-up/pull-down whatever the I/O direction.

### 8.3.4 I/O port data registers

Each GPIO has two 16-bit memory-mapped data registers: input and output data registers (GPIOx\_IDR and GPIOx\_ODR). GPIOx\_ODR stores the data to be output, it is read/write accessible. The data input through the I/O are stored into the input data register (GPIOx\_IDR), a read-only register.

See [Section 8.4.5: GPIO port input data register \(GPIOx\\_IDR\) \(x = A..E and H\)](#) and [Section 8.4.6: GPIO port output data register \(GPIOx\\_ODR\) \(x = A..E and H\)](#) for the register descriptions.

### 8.3.5 I/O data bitwise handling

The bit set reset register (GPIOx\_BSRR) is a 32-bit register which allows the application to set and reset each individual bit in the output data register (GPIOx\_ODR). The bit set reset register has twice the size of GPIOx\_ODR.

To each bit in GPIOx\_ODR, correspond two control bits in GPIOx\_BSRR: BSRR(i) and BSRR(i+SIZE). When written to 1, bit BSRR(i) sets the corresponding ODR(i) bit. When written to 1, bit BSRR(i+SIZE) resets the ODR(i) corresponding bit.

Writing any bit to 0 in GPIOx\_BSRR does not have any effect on the corresponding bit in GPIOx\_ODR. If there is an attempt to both set and reset a bit in GPIOx\_BSRR, the set action takes priority.

Using the GPIOx\_BSRR register to change the values of individual bits in GPIOx\_ODR is a “one-shot” effect that does not lock the GPIOx\_ODR bits. The GPIOx\_ODR bits can always be accessed directly. The GPIOx\_BSRR register provides a way of performing atomic bitwise handling.

There is no need for the software to disable interrupts when programming the GPIOx\_ODR at bit level: it is possible to modify one or more bits in a single atomic AHB1 write access.

### 8.3.6 GPIO locking mechanism

It is possible to freeze the GPIO control registers by applying a specific write sequence to the GPIOx\_LCKR register. The frozen registers are GPIOx\_MODER, GPIOx\_OTYPER, GPIOx\_OSPEEDR, GPIOx\_PUPDR, GPIOx\_AFRL and GPIOx\_AFRH.

To write the GPIOx\_LCKR register, a specific write / read sequence has to be applied. When the right LOCK sequence is applied to bit 16 in this register, the value of LCKR[15:0] is used to lock the configuration of the I/Os (during the write sequence the LCKR[15:0] value must be the same). When the LOCK sequence has been applied to a port bit, the value of the port bit can no longer be modified until the next MCU or peripheral reset. Each GPIOx\_LCKR bit

freezes the corresponding bit in the control registers (GPIOx\_MODER, GPIOx\_OTYPER, GPIOx\_OSPEEDR, GPIOx\_PUPDR, GPIOx\_AFRL and GPIOx\_AFRH).

The LOCK sequence (refer to [Section 8.4.8: GPIO port configuration lock register \(GPIOx\\_LCKR\) \(x = A..E and H\)](#)) can only be performed using a word (32-bit long) access to the GPIOx\_LCKR register due to the fact that GPIOx\_LCKR bit 16 has to be set at the same time as the [15:0] bits.

For more details please refer to LCKR register description in [Section 8.4.8: GPIO port configuration lock register \(GPIOx\\_LCKR\) \(x = A..E and H\)](#).

### 8.3.7 I/O alternate function input/output

Two registers are provided to select one out of the sixteen alternate function inputs/outputs available for each I/O. With these registers, you can connect an alternate function to some other pin as required by your application.

This means that a number of possible peripheral functions are multiplexed on each GPIO using the GPIOx\_AFRL and GPIOx\_AFRH alternate function registers. The application can thus select any one of the possible functions for each I/O. The AF selection signal being common to the alternate function input and alternate function output, a single channel is selected for the alternate function input/output of one I/O.

To know which functions are multiplexed on each GPIO pin, refer to the datasheets.

*Note:* The application is allowed to select one of the possible peripheral functions for each I/O at a time.

### 8.3.8 External interrupt/wakeup lines

All ports have external interrupt capability. To use external interrupt lines, the port must be configured in input mode, refer to [Section 10.2: External interrupt/event controller \(EXTI\)](#) and [Section 10.2.3: Wakeup event management](#).

### 8.3.9 Input configuration

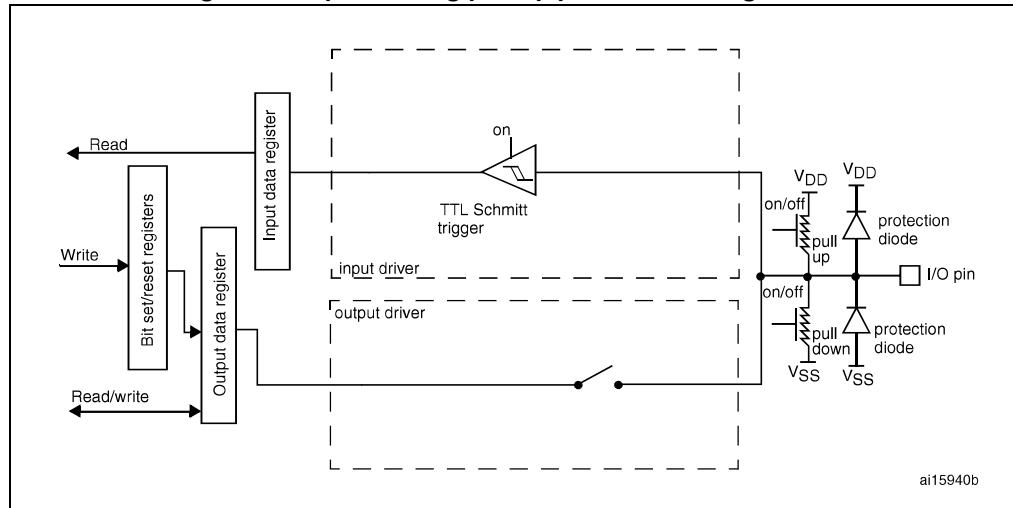
When the I/O port is programmed as Input:

- the output buffer is disabled
- the Schmitt trigger input is activated
- the pull-up and pull-down resistors are activated depending on the value in the GPIOx\_PUPDR register
- The data present on the I/O pin are sampled into the input data register every AHB clock cycle
- A read access to the input data register provides the I/O State

[Figure 18](#) shows the input configuration of the I/O port bit.



Figure 18. Input floating/pull up/pull down configurations



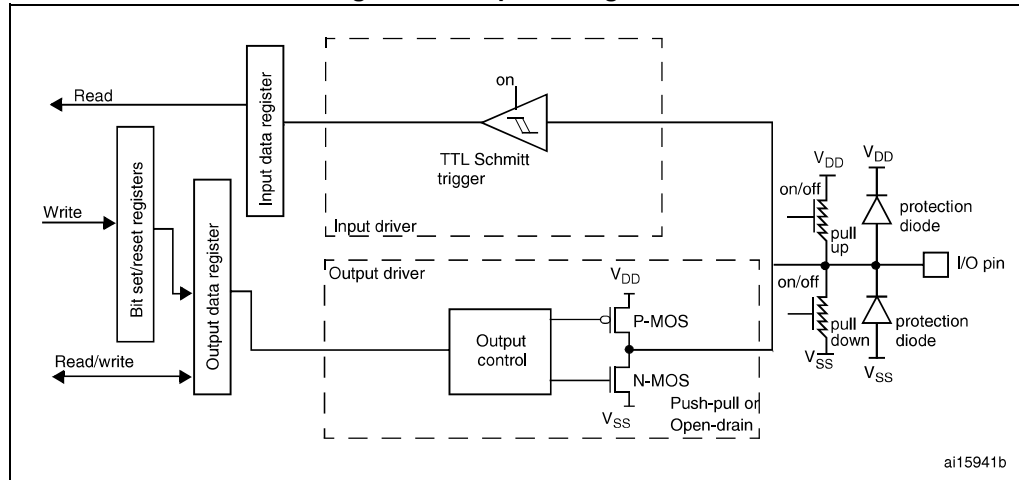
### 8.3.10 Output configuration

When the I/O port is programmed as output:

- The output buffer is enabled:
  - Open drain mode: A “0” in the Output register activates the N-MOS whereas a “1” in the Output register leaves the port in Hi-Z (the P-MOS is never activated)
  - Push-pull mode: A “0” in the Output register activates the N-MOS whereas a “1” in the Output register activates the P-MOS
- The Schmitt trigger input is activated
- The weak pull-up and pull-down resistors are activated or not depending on the value in the GPIOx\_PUPDR register
- The data present on the I/O pin are sampled into the input data register every AHB clock cycle
- A read access to the input data register gets the I/O state
- A read access to the output data register gets the last written value

Figure 19 shows the output configuration of the I/O port bit.

Figure 19. Output configuration



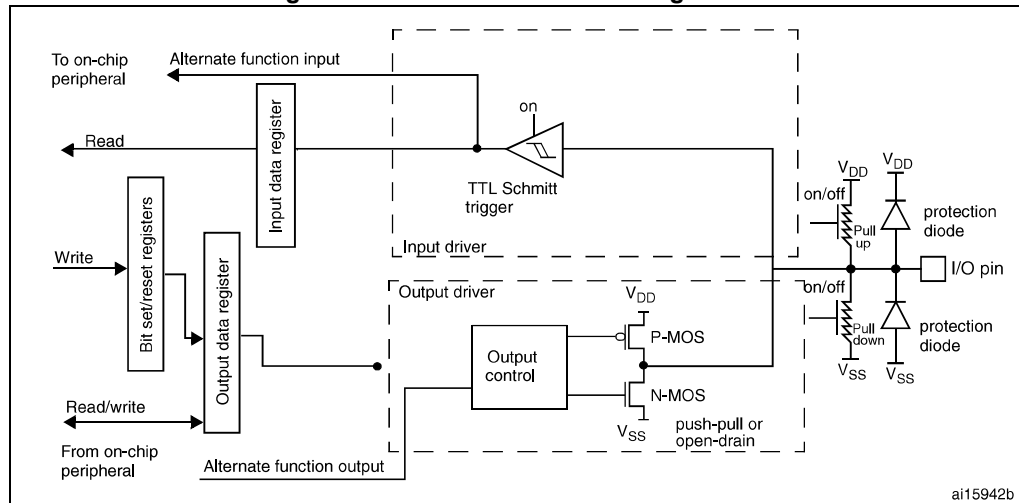
### 8.3.11 Alternate function configuration

When the I/O port is programmed as alternate function:

- The output buffer can be configured as open-drain or push-pull
- The output buffer is driven by the signal coming from the peripheral (transmitter enable and data)
- The Schmitt trigger input is activated
- The weak pull-up and pull-down resistors are activated or not depending on the value in the GPIOx\_PUPDR register
- The data present on the I/O pin are sampled into the input data register every AHB clock cycle
- A read access to the input data register gets the I/O state

Figure 20 shows the Alternate function configuration of the I/O port bit.

Figure 20. Alternate function configuration



### 8.3.12 Analog configuration

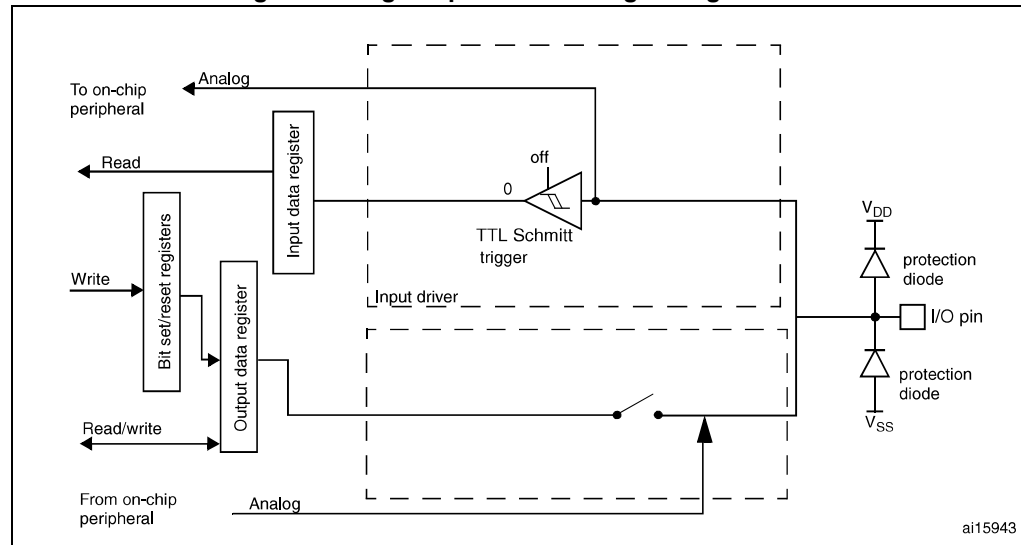
When the I/O port is programmed as analog configuration:

- The output buffer is disabled
- The Schmitt trigger input is deactivated, providing zero consumption for every analog value of the I/O pin. The output of the Schmitt trigger is forced to a constant value (0).
- The weak pull-up and pull-down resistors are disabled
- Read access to the input data register gets the value “0”

**Note:** *In the analog configuration, the I/O pins cannot be 5 Volt tolerant.*

*Figure 21* shows the high-impedance, analog-input configuration of the I/O port bit.

**Figure 21. High impedance-analog configuration**



### 8.3.13 Using the OSC32\_IN/OSC32\_OUT pins as GPIO PC14/PC15 port pins

The LSE oscillator pins OSC32\_IN and OSC32\_OUT can be used as general-purpose PC14 and PC15 I/Os, respectively, when the LSE oscillator is off. The PC14 and PC15 I/Os are only configured as LSE oscillator pins OSC32\_IN and OSC32\_OUT when the LSE oscillator is ON. This is done by setting the LSEON bit in the RCC\_BDCR register. The LSE has priority over the GPIO function.

**Note:** *The PC14/PC15 GPIO functionality is lost when the 1.2 V domain is powered off (by the device entering the standby mode) or when the backup domain is supplied by V<sub>BAT</sub> (V<sub>DD</sub> no more supplied). In this case the I/Os are set in analog input mode.*

### 8.3.14 Using the OSC\_IN/OSC\_OUT pins as GPIO PH0/PH1 port pins

The HSE oscillator pins OSC\_IN/OSC\_OUT can be used as general-purpose PH0/PH1 I/Os, respectively, when the HSE oscillator is OFF. (after reset, the HSE oscillator is off). The PH0/PH1 I/Os are only configured as OSC\_IN/OSC\_OUT HSE oscillator pins when the HSE oscillator is ON. This is done by setting the HSEON bit in the RCC\_CR register. The HSE has priority over the GPIO function.

### 8.3.15 Selection of RTC functions

The STM32F4xx feature one GPIO pins RTC\_AF1 that can be used for the detection of a tamper or time stamp event, or RTC\_ALARM, or RTC\_CALIB RTC outputs.

- The RTC\_AF1 (PC13) can be used for the following purposes:

RTC\_ALARM output: this output can be RTC Alarm A, RTC Alarm B or RTC Wakeup depending on the OSEL[1:0] bits in the RTC\_CR register

- RTC\_CALIB output: this feature is enabled by setting the COE[23] in the RTC\_CR register
- RTC\_TAMP1: tamper event detection
- RTC\_TS: time stamp event detection

The selection of the corresponding pin is performed through the RTC\_TAFCR register as follows:

- TAMP1INSEL is used to select which pin is used as the RTC\_TAMP1 tamper input
- TSINSEL is used to select which pin is used as the RTC\_TS time stamp input
- ALARMOUTTYPE is used to select whether the RTC\_ALARM is output in push-pull or open-drain mode

The output mechanism follows the priority order listed in [Table 26](#).

**Table 26. RTC additional functions<sup>(1)</sup>**

Pin configuration and function	RTC_ALARM enabled	RTC_CALIB enabled	Tamper enabled	Time stamp enabled	TAMP1INSEL TAMPER1 pin selection	TSINSEL TIMESTAMP pin selection	ALARMOUTTYPE RTC_ALARM configuration
Alarm out output OD	1	Don't care	Don't care	Don't care	Don't care	Don't care	0
Alarm out output PP	1	Don't care	Don't care	Don't care	Don't care	Don't care	1
Calibration out output PP	0	1	Don't care	Don't care	Don't care	Don't care	Don't care
TAMPER1 input floating	0	0	1	0	0	Don't care	Don't care
TIMESTAMP and TAMPER1 input floating	0	0	1	1	0	0	Don't care
TIMESTAMP input floating	0	0	0	1	Don't care	0	Don't care
Standard GPIO	0	0	0	0	Don't care	Don't care	Don't care

1. OD: open drain; PP: push-pull.

## 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 27](#).

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:

- 0x0C00 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]	
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
MODER7[1:0]		MODER6[1:0]		MODER5[1:0]		MODER4[1:0]		MODER3[1:0]		MODER2[1:0]		MODER1[1:0]		MODER0[1:0]	
rW	rW	rW	rW	rW	rW	rW	rW	rW	rW	rW	rW	rW	rW	rW	rW

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
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 **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 **8MHz**  
 01: Medium speed **50**  
 10: High speed **80**  
 11: Very high speed **150**

*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 *فلا دىنج*

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
															r/w
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
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 31:17 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]			
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
AFRL3[3:0]				AFRL2[3:0]				AFRL1[3:0]				AFRL0[3:0]			
rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw

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]			
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
AFRH11[3:0]				AFRH10[3:0]				AFRH9[3:0]				AFRH8[3:0]			
rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw

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 27. 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	GPIOA_MODER	MODER15[1:0]		MODER14[1:0]		MODER13[1:0]		MODER12[1:0]		MODER11[1:0]		MODER10[1:0]		MODER9[1:0]		MODER8[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]	
	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	GPIOB_MODER	MODER15[1:0]		MODER14[1:0]		MODER13[1:0]		MODER12[1:0]		MODER11[1:0]		MODER10[1:0]		MODER9[1:0]		MODER8[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]	
	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	GPIOx_MODER (where x = C..E and H)	MODER15[1:0]		MODER14[1:0]		MODER13[1:0]		MODER12[1:0]		MODER11[1:0]		MODER10[1:0]		MODER9[1:0]		MODER8[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]	
	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
0x04	GPIOx_OTYPER (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	GPIOx_OSPEEDR (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	GPIOA_OSPEEDER	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	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
0x08	GPIOB_OSPEEDR	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	1	1	0	0	0	0	0	0
0x0C	GPIOA_PUPDR	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	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

Table 27. 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	
0x0C	GPIOB_PUPDR	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	GPIOx_PUPDR (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	GPIOx_IDR (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	x
0x14	GPIOx_ODR (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	0
0x18	GPIOx_BSRR (where x = A..E and H)	BR15	BR14	BR13	BR12	BR11	BR10	BR9	BR8	BR7	BR6	BR5	BR4	BR3	BR2	BR1	BR0	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	0
0x1C	GPIOx_LCKR (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	GPIOx_AFRL (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	0	0
0x24	GPIOx_AFRH (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	0	0

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