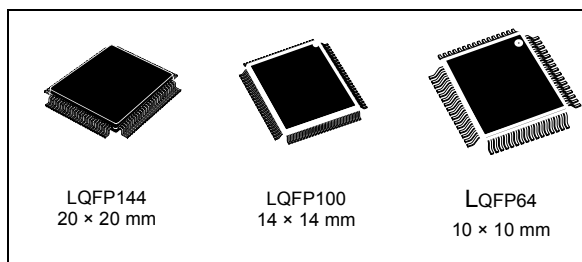


XL-density access line, ARM<sup>®</sup>-based 32-bit MCU with 768 KB to 1 MB Flash, 15 timers, 1 ADC and 10 communication interfaces

Datasheet - production data

## Features

- Core: ARM<sup>®</sup> 32-bit Cortex<sup>®</sup>-M3 CPU with MPU
  - 36 MHz maximum frequency, 1.25 DMIPS/MHz (Dhrystone 2.1) performance
  - Single-cycle multiplication and hardware division
- Memories
  - 768 Kbytes to 1 Mbyte of Flash memory (dual bank with read-while-write capability)
  - 80 Kbytes of SRAM
  - Flexible static memory controller with 4 Chip Select. Supports Compact Flash, SRAM, PSRAM, NOR and NAND memories
  - LCD parallel interface, 8080/6800 modes
- Clock, reset and supply management
  - 2.0 to 3.6 V application supply and I/Os
  - POR, PDR, and programmable voltage detector (PVD)
  - 4-to-16 MHz crystal oscillator
  - Internal 8 MHz factory-trimmed RC
  - Internal 40 kHz RC with calibration capability
  - 32 kHz oscillator for RTC with calibration
- Low power
  - Sleep, Stop and Standby modes
  - V<sub>BAT</sub> supply for RTC and backup registers
- 1 x 12-bit, 1  $\mu$ s A/D converters (up to 16 channels)
  - Conversion range: 0 to 3.6 V
  - Temperature sensor
- 2 x 12-bit D/A converters
- DMA
  - 12-channel DMA controller
  - Peripherals supported: timers, ADC, DAC, SPIs, I<sup>2</sup>Cs and USARTs
- Up to 112 fast I/O ports



- 51/80/112 I/Os, all mappable on 16 external interrupt vectors and almost all 5 V-tolerant
- Debug mode
  - Serial wire debug (SWD) & JTAG interfaces
  - Cortex-M3 Embedded Trace Macrocell™
- Up to 15 timers
  - Up to ten 16-bit timers, with up to 4 IC/OC/PWM or pulse counters
  - 2 x watchdog timers (Independent and Window)
  - SysTick timer: a 24-bit downcounter
  - 2 x 16-bit basic timers to drive the DAC
- Up to 10 communication interfaces
  - Up to 2 x I<sup>2</sup>C interfaces (SM7816 interface, LIN, IrDA capability, modem control)
  - Up to 3 SPIs (18 Mbit/s)
- CRC calculation unit, 96-bit unique ID
- ECOPACK<sup>®</sup> packages

**Table 1. Device summary**

| Reference   | Part number                            |
|-------------|----------------------------------------|
| STM32F101xF | STM32F101RF STM32F101VF<br>STM32F101ZF |
| STM32F101xG | STM32F101RG STM32F101VG<br>STM32F101ZG |

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# 1 Introduction

This datasheet provides the ordering information and mechanical device characteristics of the STM32F101xF and STM32F101xG XL-density access line microcontrollers. For more details on the whole STMicroelectronics STM32F101xx family, please refer to [Section 2.2: Full compatibility throughout the family](#).

The XL-density STM32F101xx datasheet should be read in conjunction with the STM32F10xxx reference manual.

For information on programming, erasing and protection of the internal Flash memory please refer to the *STM32F10xxx Flash programming manual*.

The reference and Flash programming manuals are both available from the STMicroelectronics website [www.st.com](http://www.st.com).

For information on the Cortex<sup>®</sup>-M3 core please refer to the Cortex<sup>®</sup>-M3 Technical Reference Manual, available from the [www.arm.com](http://www.arm.com) website.



## 2 Description

The STM32F101xF and STM32F101xG access line family incorporates the high-performance ARM® Cortex®-M3 32-bit RISC core operating at a 36 MHz frequency, high-speed embedded memories (Flash memory up to 1 Mbyte and SRAM of 80 Kbytes), and an extensive range of enhanced I/Os and peripherals connected to two APB buses. All devices offer one 12-bit ADC, ten general-purpose 16-bit timers, as well as standard and advanced communication interfaces: up to two I<sup>2</sup>Cs, three SPIs and five USARTs.

The STM32F101xx XL-density access line family operates in the –40 to +85 °C temperature range, from a 2.0 to 3.6 V power supply. A comprehensive set of power-saving mode allows the design of low-power applications.

These features make the STM32F101xx XL-density access line microcontroller family suitable for a wide range of applications such as medical and handheld equipment, PC peripherals and gaming, GPS platforms, industrial applications, PLC, printers, scanners alarm systems , power meters, and video intercom.

## 2.1 Device overview

The STM32F101xx XL-density access line family offers devices in 3 different package types: from 64 pins to 144 pins. Depending on the device chosen, different sets of peripherals are included, the description below gives an overview of the complete range of peripherals proposed in this family.

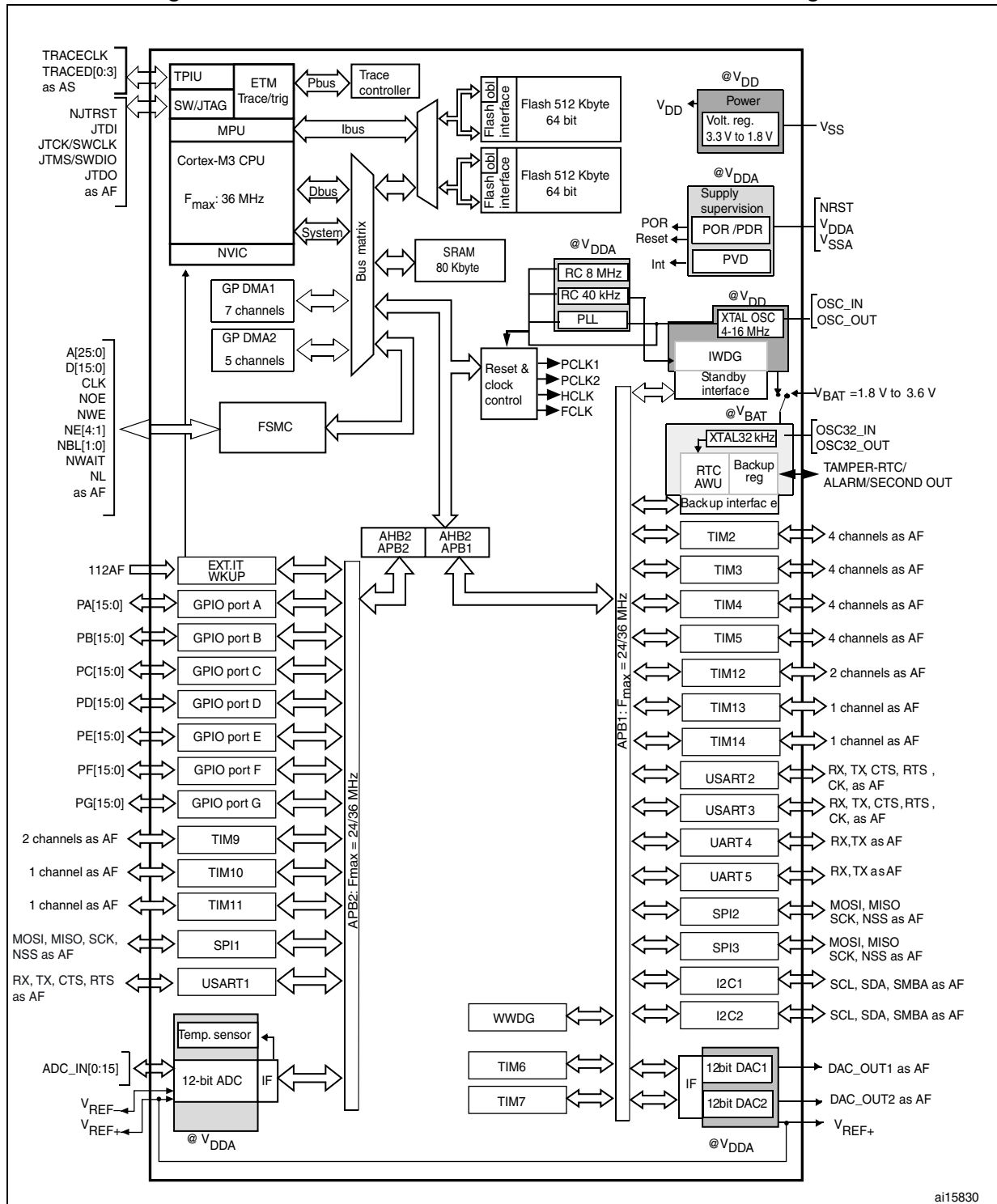
[Figure 1](#) shows the general block diagram of the device family.

**Table 2. STM32F101xF and STM32F101xG features and peripheral counts**

| Peripherals              |                  | STM32F101Rx                                                                                                                                |      | STM32F101Vx            |      | STM32F101Zx |      |
|--------------------------|------------------|--------------------------------------------------------------------------------------------------------------------------------------------|------|------------------------|------|-------------|------|
| Flash memory             |                  | 768 KB                                                                                                                                     | 1 MB | 768 KB                 | 1 MB | 768 KB      | 1 MB |
| SRAM in Kbytes           |                  | 80                                                                                                                                         |      | 80                     |      | 80          |      |
| FSMC                     |                  | No                                                                                                                                         |      | Yes                    |      | Yes         |      |
| Timers                   | General-purpose  | 10                                                                                                                                         |      |                        |      |             |      |
|                          | Basic            | 2                                                                                                                                          |      |                        |      |             |      |
| Communication interfaces | SPI              | 3                                                                                                                                          |      |                        |      |             |      |
|                          | I <sup>2</sup> C | 2                                                                                                                                          |      |                        |      |             |      |
|                          | USART            | 5                                                                                                                                          |      |                        |      |             |      |
| GPIOs                    |                  | 51                                                                                                                                         |      | 80                     |      | 112         |      |
| 12-bit ADC               |                  | 1                                                                                                                                          |      |                        |      |             |      |
| Number of channels       |                  | 16                                                                                                                                         |      |                        |      |             |      |
| 12-bit DAC               |                  | YES                                                                                                                                        |      |                        |      |             |      |
| Number of channels       |                  | 2                                                                                                                                          |      |                        |      |             |      |
| CPU frequency            |                  | 36 MHz                                                                                                                                     |      |                        |      |             |      |
| Operating voltage        |                  | 2.0 to 3.6 V                                                                                                                               |      |                        |      |             |      |
| Operating temperatures   |                  | Ambient temperature: −40 to +85 °C (see <a href="#">Table 10</a> )<br>Junction temperature: −40 to +105 °C (see <a href="#">Table 10</a> ) |      |                        |      |             |      |
| Package                  |                  | LQFP64                                                                                                                                     |      | LQFP100 <sup>(1)</sup> |      | LQFP144     |      |

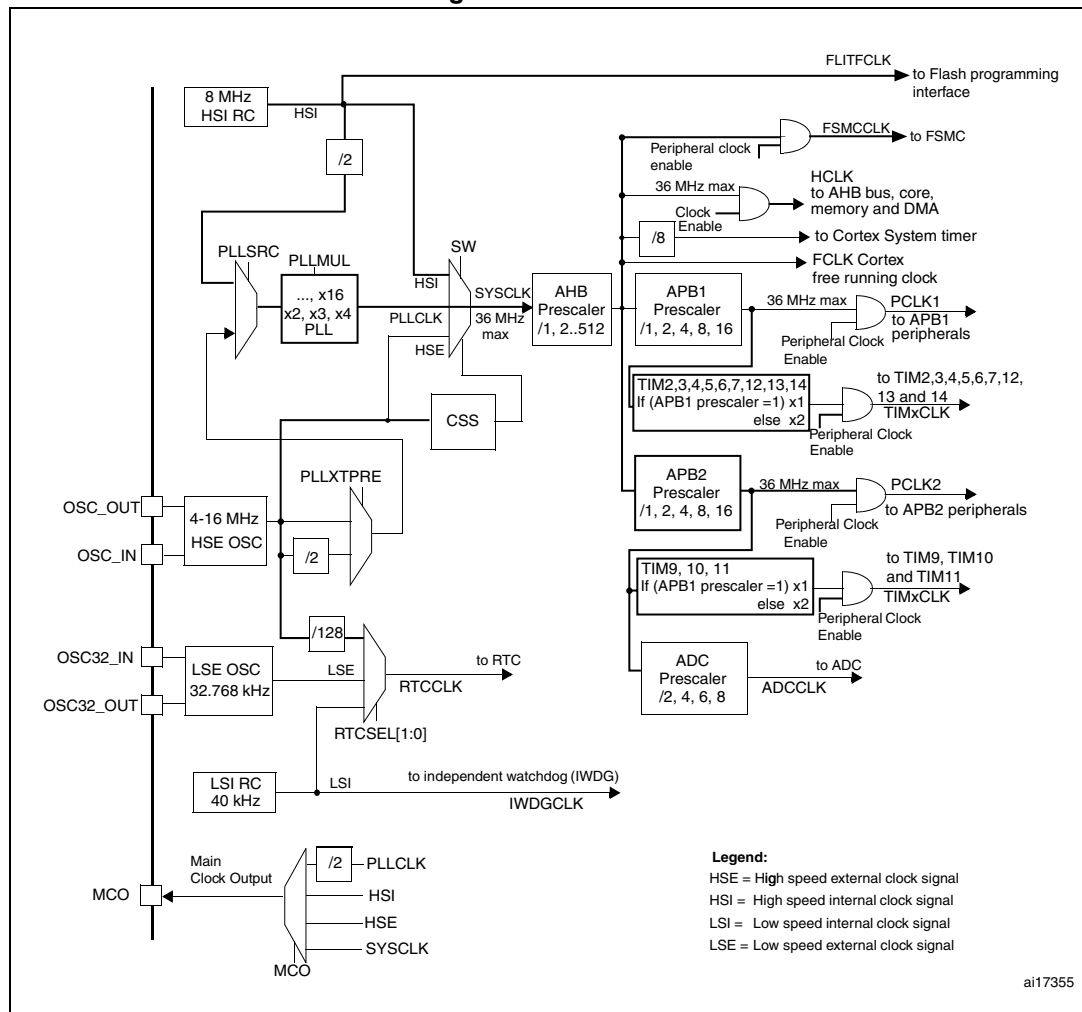
1. For the LQFP100 package, only FSMC Bank1 and Bank2 are available. Bank1 can only support a multiplexed NOR/PSRAM memory using the NE1 Chip Select. Bank2 can only support a 16- or 8-bit NAND Flash memory using the NCE2 Chip Select. The interrupt line cannot be used since Port G is not available in this package.

Figure 1. STM32F101xF and STM32F101xG access line block diagram



1.  $T_A = -40\text{ }^{\circ}\text{C}$  to  $+85\text{ }^{\circ}\text{C}$  (junction temperature up to  $105\text{ }^{\circ}\text{C}$ ).
2. AF = alternate function on I/O port pin.

Figure 2. Clock tree



1. When the HSI is used as a PLL clock input, the maximum system clock frequency that can be achieved is 36 MHz.
2. To have an ADC conversion time of 1  $\mu$ s, APB2 must be at 14 MHz or 28 MHz.

## 2.2 Full compatibility throughout the family

The STM32F101xx is a complete family whose members are fully pin-to-pin, software and feature compatible. In the reference manual, the STM32F101x4 and STM32F101x6 are identified as low-density devices, the STM32F101x8 and STM32F101xB are referred to as medium-density devices, the STM32F101xC, STM32F101xD and STM32F101xE are referred to as high-density devices, and the STM32F101xF and STM32F101xG are referred to as XL-density devices.

Low-, high-density and XL-density devices are an extension of the STM32F101x8/B medium-density devices, they are specified in the STM32F101x4/6, STM32F101xC/D/E and STM32F101xF/G datasheets, respectively.

Low-density devices feature lower Flash memory and RAM capacities, less timers and peripherals. High-density devices have higher Flash memory and RAM densities, and additional peripherals like FSMC and DAC. XL-density devices bring greater Flash and RAM capacities, and more features, namely an MPU, a higher number of timers and a dual bank Flash memory, while remaining fully compatible with the other members of the family.

The STM32F101x4, STM32F101x6, STM32F101xC, STM32F101xD, STM32F101xE, STM32F101xF and STM32F101xG are a drop-in replacement for the STM32F101x8/B devices, allowing the user to try different memory densities and providing a greater degree of freedom during the development cycle.

Moreover, the STM32F101xx access line family is fully compatible with all existing STM32F103xx performance line and STM32F102xx USB access line devices.

**Table 3. STM32F101xx family**

| Pinout | Memory size                                                                 |                            |                                                                                |              |                                                                                                                                         |              |              |                                                                                                                                                                                      |            |
|--------|-----------------------------------------------------------------------------|----------------------------|--------------------------------------------------------------------------------|--------------|-----------------------------------------------------------------------------------------------------------------------------------------|--------------|--------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
|        | Low-density devices                                                         |                            | Medium-density devices                                                         |              | High-density devices                                                                                                                    |              |              | XL-density devices                                                                                                                                                                   |            |
|        | 16 KB Flash                                                                 | 32 KB Flash <sup>(1)</sup> | 64 KB Flash                                                                    | 128 KB Flash | 256 KB Flash                                                                                                                            | 384 KB Flash | 512 KB Flash | 768 KB Flash                                                                                                                                                                         | 1 MB Flash |
|        | 4 KB RAM                                                                    | 6 KB RAM                   | 10 KB RAM                                                                      | 16 KB RAM    | 32 KB RAM                                                                                                                               | 48 KB RAM    | 48 KB RAM    | 80 KB RAM                                                                                                                                                                            | 80 KB RAM  |
| 144    | 2 × USARTs<br>2 × 16-bit timers<br>1 × SPI, 1 × I <sup>2</sup> C<br>1 × ADC |                            | 3 × USARTs<br>3 × 16-bit timers<br>2 × SPIs, 2 × I <sup>2</sup> Cs,<br>1 × ADC |              | 5 × USARTs<br>4 × 16-bit timers,<br>2 × basic timers<br>3 × SPIs, 2 × I <sup>2</sup> Cs,<br>1 × ADC, 1 × DAC<br>FSMC (100 and 144 pins) |              |              | 5 × USARTs<br>10 × 16-bit timers,<br>2 × basic timers<br>3 × SPIs, 2 × I <sup>2</sup> Cs,<br>1 × ADC, 1 × DAC<br>FSMC (100 and 144 pins), Cortex-M3 with MPU, Dual bank Flash memory |            |
| 100    |                                                                             |                            |                                                                                |              |                                                                                                                                         |              |              |                                                                                                                                                                                      |            |
| 64     |                                                                             |                            |                                                                                |              |                                                                                                                                         |              |              |                                                                                                                                                                                      |            |
| 48     |                                                                             |                            |                                                                                |              |                                                                                                                                         |              |              |                                                                                                                                                                                      |            |
| 36     |                                                                             |                            |                                                                                |              |                                                                                                                                         |              |              |                                                                                                                                                                                      |            |

1. For orderable part numbers that do not show the A internal code after the temperature range code (6), the reference datasheet for electrical characteristics is that of the STM32F101x8/B medium-density devices.

## 2.3 Overview

### 2.3.1 ARM® Cortex®-M3 core with embedded Flash and SRAM

The ARM® Cortex®-M3 processor is the latest generation of ARM® processors for embedded systems. It has been developed to provide a low-cost platform that meets the needs of MCU implementation, with a reduced pin count and low-power consumption, while delivering outstanding computational performance and an advanced system response to interrupts.

The ARM® Cortex®-M3 32-bit RISC processor features exceptional code-efficiency, delivering the high-performance expected from an ARM® core in the memory size usually associated with 8- and 16-bit devices.

The STM32F101xF and STM32F101xG access line family having an embedded ARM® core, is therefore compatible with all ARM® tools and software.

*Figure 1* shows the general block diagram of the device family.

### 2.3.2 Memory protection unit

The memory protection unit (MPU) is used to separate the processing of tasks from the data protection. The MPU can manage up to 8 protection areas that can all be further divided up into 8 subareas. The protection area sizes are between 32 bytes and the whole 4 gigabytes of addressable memory.

The memory protection unit is especially helpful for applications where some critical or certified code has to be protected against the misbehavior of other tasks. It is usually managed by an RTOS (real-time operating system). If a program accesses a memory location that is prohibited by the MPU, the RTOS can detect it and take action. In an RTOS environment, the kernel can dynamically update the MPU area setting, based on the process to be executed.

The MPU is optional and can be bypassed for applications that do not need it.

### 2.3.3 Embedded Flash memory

768 Kbytes to 1 Mbyte of embedded Flash are available for storing programs and data. The Flash memory is organized as two banks. The first bank has a size of 512 Kbytes. The second bank is either 256 or 512 Kbytes depending on the device. This gives the device the capability of writing to one bank while executing code from the other bank (read-while-write capability).

### 2.3.4 CRC (cyclic redundancy check) calculation unit

The CRC (cyclic redundancy check) calculation unit is used to get a CRC code from a 32-bit data word and a fixed generator polynomial.

Among other applications, CRC-based techniques are used to verify data transmission or storage integrity. In the scope of the EN/IEC 60335-1 standard, they offer a means of verifying the Flash memory integrity. The CRC calculation unit helps compute a signature of the software during runtime, to be compared with a reference signature generated at link-time and stored at a given memory location.

### 2.3.5 Embedded SRAM

80 Kbytes of embedded SRAM accessed (read/write) at CPU clock speed with 0 wait states.

### 2.3.6 FSMC (flexible static memory controller)

The FSMC is embedded in the STM32F101xF and STM32F101xG access line family. It has four Chip Select outputs supporting the following modes: PC Card/Compact Flash, SRAM, PSRAM, NOR and NAND.

Functionality overview:

- The three FSMC interrupt lines are ORed in order to be connected to the NVIC
- Write FIFO
- Code execution from external memory except for NAND Flash and PC Card
- The targeted frequency is HCLK/2, so external access is at 18 MHz when HCLK is at 36 MHz

### 2.3.7 LCD parallel interface

The FSMC can be configured to interface seamlessly with most graphic LCD controllers. It supports the Intel 8080 and Motorola 6800 modes, and is flexible enough to adapt to specific LCD interfaces. This LCD parallel interface capability makes it easy to build cost-effective graphic applications using LCD modules with embedded controllers or high-performance solutions using external controllers with dedicated acceleration.

### 2.3.8 Nested vectored interrupt controller (NVIC)

The STM32F101xF and STM32F101xG access line embeds a nested vectored interrupt controller able to handle up to 60 maskable interrupt channels (not including the 16 interrupt lines of Cortex<sup>®</sup>-M3) and 16 priority levels.

- Closely coupled NVIC gives low-latency interrupt processing
- Interrupt entry vector table address passed directly to the core
- Closely coupled NVIC core interface
- Allows early processing of interrupts
- Processing of *late arriving* higher priority interrupts
- Support for tail-chaining
- Processor state automatically saved
- Interrupt entry restored on interrupt exit with no instruction overhead

This hardware block provides flexible interrupt management features with minimal interrupt latency.

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

The external interrupt/event controller consists of 19 edge detector lines used to generate interrupt/event requests. Each line can be independently configured to select the trigger event (rising edge, falling edge, both) and can be masked independently. A pending register maintains the status of the interrupt requests. The EXTI can detect an external line with a pulse width shorter than the Internal APB2 clock period. Up to 112 GPIOs can be connected to the 16 external interrupt lines.

### 2.3.10 Clocks and startup

System clock selection is performed on startup, however the internal RC 8 MHz oscillator is selected as default CPU clock on reset. An external 4-16 MHz clock can be selected, in which case it is monitored for failure. If failure is detected, the system automatically switches back to the internal RC oscillator. A software interrupt is generated if enabled. Similarly, full interrupt management of the PLL clock is available when necessary (for example with failure of an indirectly used external oscillator).

Several prescalers are used to configure the AHB frequency, the high-speed APB (APB2) domain and the low-speed APB (APB1) domain. The maximum frequency of the AHB and APB domains is 36 MHz. See [Figure 2](#) for details on the clock tree.

### 2.3.11 Boot modes

At startup, boot pins are used to select one of three boot options:

- Boot from user Flash: you have an option to boot from any of two memory banks. By default, boot from Flash memory bank 1 is selected. You can choose to boot from Flash memory bank 2 by setting a bit in the option bytes.
- Boot from system memory
- Boot from embedded SRAM

The bootloader is located in system memory. It is used to reprogram the Flash memory by using USART1.

### 2.3.12 Power supply schemes

- $V_{DD} = 2.0$  to  $3.6$  V: external power supply for I/Os and the internal regulator. Provided externally through  $V_{DD}$  pins.
- $V_{SSA}$ ,  $V_{DDA} = 2.0$  to  $3.6$  V: external analog power supplies for ADC, DAC, Reset blocks, RCs and PLL (minimum voltage to be applied to  $V_{DDA}$  is  $2.4$  V when the ADC or DAC is used).  $V_{DDA}$  and  $V_{SSA}$  must be connected to  $V_{DD}$  and  $V_{SS}$ , respectively.
- $V_{BAT} = 1.8$  to  $3.6$  V: power supply for RTC, external clock 32 kHz oscillator and backup registers (through power switch) when  $V_{DD}$  is not present.

For more details on how to connect power pins, refer to [Figure 9: Power supply scheme](#).

### 2.3.13 Power supply supervisor

The device has an integrated power-on reset (POR)/power-down reset (PDR) circuitry. It is always active, and ensures proper operation starting from/down to  $2$  V. The device remains in reset mode when  $V_{DD}$  is below a specified threshold,  $V_{POR/PDR}$ , without the need for an external reset circuit.

The device features an embedded programmable voltage detector (PVD) that monitors the  $V_{DD}/V_{DDA}$  power supply and compares it to the  $V_{PVD}$  threshold. An interrupt can be generated when  $V_{DD}/V_{DDA}$  drops below the  $V_{PVD}$  threshold and/or when  $V_{DD}/V_{DDA}$  is higher than the  $V_{PVD}$  threshold. The interrupt service routine can then generate a warning message and/or put the MCU into a safe state. The PVD is enabled by software. Refer to [Table 12: Embedded reset and power control block characteristics](#) for the values of  $V_{POR/PDR}$  and  $V_{PVD}$ .

### 2.3.14 Voltage regulator

The regulator has three operation modes: main (MR), low power (LPR) and power down.

- MR is used in the nominal regulation mode (Run)
- LPR is used in the Stop modes.
- Power down is used in Standby mode: the regulator output is in high impedance: the kernel circuitry is powered down, inducing zero consumption (but the contents of the registers and SRAM are lost)

This regulator is always enabled after reset. It is disabled in Standby mode.

### 2.3.15 Low-power modes

The STM32F101xF and STM32F101xG access line supports three low-power modes to achieve the best compromise between low-power consumption, short startup time and available wakeup sources:

- **Sleep mode**  
In Sleep mode, only the CPU is stopped. All peripherals continue to operate and can wake up the CPU when an interrupt/event occurs.
- **Stop mode**  
Stop mode achieves the lowest power consumption while retaining the content of SRAM and registers. All clocks in the 1.8 V domain are stopped, the PLL, the HSI RC and the HSE crystal oscillators are disabled. The voltage regulator can also be put either in normal or in low-power mode.  
The device can be woken up from Stop mode by any of the EXTI line. The EXTI line source can be one of the 16 external lines, the PVD output or the RTC alarm.
- **Standby mode**  
The Standby mode is used to achieve the lowest power consumption. The internal voltage regulator is switched off so that the entire 1.8 V domain is powered off. The PLL, the HSI RC and the HSE crystal oscillators are also switched off. After entering Standby mode, SRAM and register contents are lost except for registers in the Backup domain and Standby circuitry.  
The device exits Standby mode when an external reset (NRST pin), a IWDG reset, a rising edge on the WKUP pin, or an RTC alarm occurs.

*Note: The RTC, the IWDG, and the corresponding clock sources are not stopped by entering Stop or Standby mode.*

### 2.3.16 DMA

The flexible 12-channel general-purpose DMAs (7 channels for DMA1 and 5 channels for DMA2) are able to manage memory-to-memory, peripheral-to-memory and memory-to-peripheral transfers.

The two DMA controllers support circular buffer management, removing the need for user code intervention when the controller reaches the end of the buffer.

Each channel is connected to dedicated hardware DMA requests, with support for software trigger on each channel. Configuration is made by software and transfer sizes between source and destination are independent.

DMA can be used with the main peripherals: SPI, I<sup>2</sup>C, USART, general-purpose and basic timers TIMx, DAC and ADC.

### 2.3.17 RTC (real-time clock) and backup registers

The RTC and the backup registers are supplied through a switch that takes power either on  $V_{DD}$  supply when present or through the  $V_{BAT}$  pin. The backup registers are forty-two 16-bit registers used to store 84 bytes of user application data when  $V_{DD}$  power is not present. They are not reset by a system or power reset, and they are not reset when the device wakes up from the Standby mode.

The real-time clock provides a set of continuously running counters which can be used with suitable software to provide a clock calendar function, and provides an alarm interrupt and a periodic interrupt. It is clocked by a 32.768 kHz external crystal, resonator or oscillator, the internal low-power RC oscillator or the high speed external clock divided by 128. The internal low-speed RC has a typical frequency of 40 kHz. The RTC can be calibrated using an external 512 Hz output to compensate for any natural quartz deviation. The RTC features a 32-bit programmable counter for long term measurement using the Compare register to generate an alarm. A 20-bit prescaler is used for the time base clock and is by default configured to generate a time base of 1 second from a clock at 32.768 kHz.

### 2.3.18 Timers and watchdogs

The XL-density STM32F101xx access line devices include up to ten general-purpose timers, two basic timers, two watchdog timers and a SysTick timer.

*Table 4: STM32F101xF and STM32F101xG timer feature comparison* compares the features of the general-purpose and basic timers.

**Table 4. STM32F101xF and STM32F101xG timer feature comparison**

| Timer                      | Counter resolution | Counter type      | Prescaler factor                | DMA request generation | Capture/compare channels | Complementary outputs |
|----------------------------|--------------------|-------------------|---------------------------------|------------------------|--------------------------|-----------------------|
| TIM2, TIM3, TIM4, TIM5     | 16-bit             | Up, down, up/down | Any integer between 1 and 65536 | Yes                    | 4                        | No                    |
| TIM9, TIM12                | 16-bit             | Up                | Any integer between 1 and 65536 | No                     | 2                        | No                    |
| TIM10, TIM11, TIM13, TIM14 | 16-bit             | Up                | Any integer between 1 and 65536 | No                     | 1                        | No                    |
| TIM6, TIM7                 | 16-bit             | Up                | Any integer between 1 and 65536 | Yes                    | 0                        | No                    |

#### General-purpose timers (TIMx)

There are 10 synchronizable general-purpose timers embedded in the STM32F101xF and STM32F101xG XL-density access line devices (see [Table 4](#) for differences).

- **TIM2, TIM3, TIM4, TIM5**

There are up to 4 synchronizable general-purpose timers (TIM2, TIM3, TIM4 and TIM5) embedded in the STM32F101xF and STM32F101xG access line devices.

These timers are based on a 16-bit auto-reload up/down counter, a 16-bit prescaler and feature 4 independent channels each for input capture/output compare, PWM or

one-pulse mode output. This gives up to 16 input captures / output compares / PWMs on the largest packages.

Their counter can be frozen in debug mode. Any of the general-purpose timers can be used to generate PWM outputs. They all have independent DMA request generation.

These timers are capable of handling quadrature (incremental) encoder signals and the digital outputs from 1 to 3 hall-effect sensors.

- **TIM10, TIM11 and TIM9**

These timers are based on a 16-bit auto-reload upcounter and a 16-bit prescaler. TIM10 and TIM11 feature one independent channel, whereas TIM9 has two independent channels for input capture/output compare, PWM or one-pulse mode output. They can be synchronized with the TIM2, TIM3, TIM4, TIM5 full-featured general-purpose timers. They can also be used as simple time bases.

- **TIM13, TIM14 and TIM12**

These timers are based on a 16-bit auto-reload upcounter and a 16-bit prescaler. TIM13 and TIM14 feature one independent channel, whereas TIM12 has two independent channels for input capture/output compare, PWM or one-pulse mode output. They can be synchronized with the TIM2, TIM3, TIM4, TIM5 full-featured general-purpose timers. They can also be used as simple time bases.

### **Basic timers TIM6 and TIM7**

These timers are mainly used for DAC trigger generation. They can also be used as a generic 16-bit time base.

### **Independent watchdog**

The independent watchdog is based on a 12-bit downcounter and 8-bit prescaler. It is clocked from an independent 40 kHz internal RC and as it operates independently from the main clock, it can operate in Stop and Standby modes. It can be used either as a watchdog to reset the device when a problem occurs, or as a free running timer for application timeout management. It is hardware or software configurable through the option bytes. The counter can be frozen in debug mode.

### **Window watchdog**

The window watchdog is based on a 7-bit downcounter that can be set as free running. It can be used as a watchdog to reset the device when a problem occurs. It is clocked from the main clock. It has an early warning interrupt capability and the counter can be frozen in debug mode.

### **SysTick timer**

This timer is dedicated to real-time operating systems, but could also be used as a standard down counter. It features:

- A 24-bit down counter
- Autoreload capability
- Maskable system interrupt generation when the counter reaches 0.
- Programmable clock source

### 2.3.19 I<sup>2</sup>C bus

Up to two I<sup>2</sup>C bus interfaces can operate in multi-master and slave modes. They support standard and fast modes.

They support 7/10-bit addressing mode and 7-bit dual addressing mode (as slave). A hardware CRC generation/verification is embedded.

They can be served by DMA and they support SMBus 2.0/PMBus.

### 2.3.20 Universal synchronous/asynchronous receiver transmitters (USARTs)

The STM32F101xF and STM32F101xG access line embeds three universal synchronous/asynchronous receiver transmitters (USART1, USART2 and USART3) and two universal asynchronous receiver transmitters (UART4 and UART5).

These five interfaces provide asynchronous communication, IrDA SIR ENDEC support, multiprocessor communication mode, single-wire half-duplex communication mode and have LIN Master/Slave capability. The five interfaces are able to communicate at speeds of up to 2.25 Mbit/s.

USART1, USART2 and USART3 also provide hardware management of the CTS and RTS signals, Smart Card mode (ISO 7816 compliant) and SPI-like communication capability. All interfaces can be served by the DMA controller except for UART5.

### 2.3.21 Serial peripheral interface (SPI)

Up to three SPIs are able to communicate up to 18 Mbits/s in slave and master modes in full-duplex and simplex communication modes. The 3-bit prescaler gives 8 master mode frequencies and the frame is configurable to 8 bits or 16 bits. The hardware CRC generation/verification supports basic SD Card/MMC modes.

All SPIs can be served by the DMA controller.

### 2.3.22 GPIOs (general-purpose inputs/outputs)

Each of the GPIO pins can be configured by software as output (push-pull or open-drain), as input (with or without pull-up or pull-down) or as peripheral alternate function. Most of the GPIO pins are shared with digital or analog alternate functions. All GPIOs are high current-capable.

The I/Os alternate function configuration can be locked if needed following a specific sequence in order to avoid spurious writing to the I/Os registers.

### 2.3.23 ADC (analog to digital converter)

A 12-bit analog-to-digital converter is embedded into STM32F101xF and STM32F101xG access line devices. It has up to 16 external channels, performing conversions in single-shot or scan modes. In scan mode, automatic conversion is performed on a selected group of analog inputs.

The ADC can be served by the DMA controller.

An analog watchdog feature allows very precise monitoring of the converted voltage of one, some or all selected channels. An interrupt is generated when the converted voltage is outside the programmed thresholds.

The events generated by the general-purpose timers (TIMx) can be internally connected to the ADC start trigger and injection trigger, respectively, to allow the application to synchronize A/D conversion and timers.

### 2.3.24 DAC (digital-to-analog converter)

The two 12-bit buffered DAC channels can be used to convert two digital signals into two analog voltage signal outputs. The chosen design structure is composed of integrated resistor strings and an amplifier in inverting configuration.

This dual digital Interface supports the following features:

- two DAC converters: one for each output channel
- 8-bit or 12-bit monotonic output
- left or right data alignment in 12-bit mode
- synchronized update capability
- noise-wave generation
- triangular-wave generation
- dual DAC channel independent or simultaneous conversions
- DMA capability for each channel
- external triggers for conversion
- input voltage reference  $V_{REF+}$

Seven DAC trigger inputs are used in the STM32F101xF and STM32F101xG access line family. The DAC channels are triggered through the timer update outputs that are also connected to different DMA channels.

### 2.3.25 Temperature sensor

The temperature sensor has to generate a voltage that varies linearly with temperature. The conversion range is between  $2\text{ V} < V_{DDA} < 3.6\text{ V}$ . The temperature sensor is internally connected to the ADC\_IN16 input channel which is used to convert the sensor output voltage into a digital value.

### 2.3.26 Serial wire JTAG debug port (SWJ-DP)

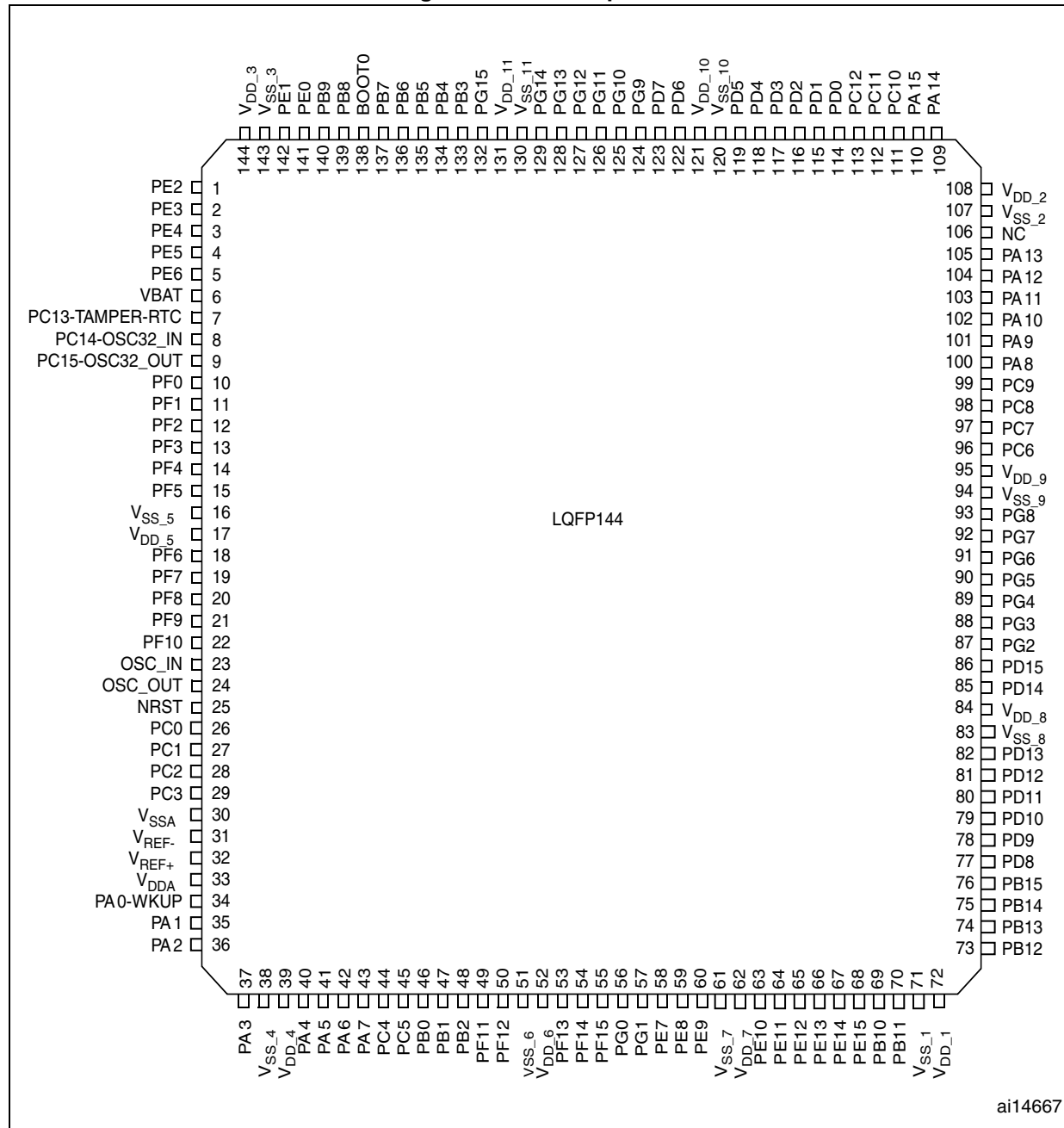
The ARM® SWJ-DP Interface is embedded, and is a combined JTAG and serial wire debug port that enables either a serial wire debug or a JTAG probe to be connected to the target. The JTAG TMS and TCK pins are shared respectively with SWDIO and SWCLK and a specific sequence on the TMS pin is used to switch between JTAG-DP and SW-DP.

### 2.3.27 Embedded Trace Macrocell™

The ARM® Embedded Trace Macrocell provides a greater visibility of the instruction and data flow inside the CPU core by streaming compressed data at a very high rate from the STM32F10xxx through a small number of ETM pins to an external hardware trace port analyzer (TPA) device. The TPA is connected to a host computer using Ethernet, or any other high-speed channel. Real-time instruction and data flow activity can be recorded and then formatted for display on the host computer running debugger software. TPA hardware is commercially available from common development tool vendors. It operates with third party debugger software tools.

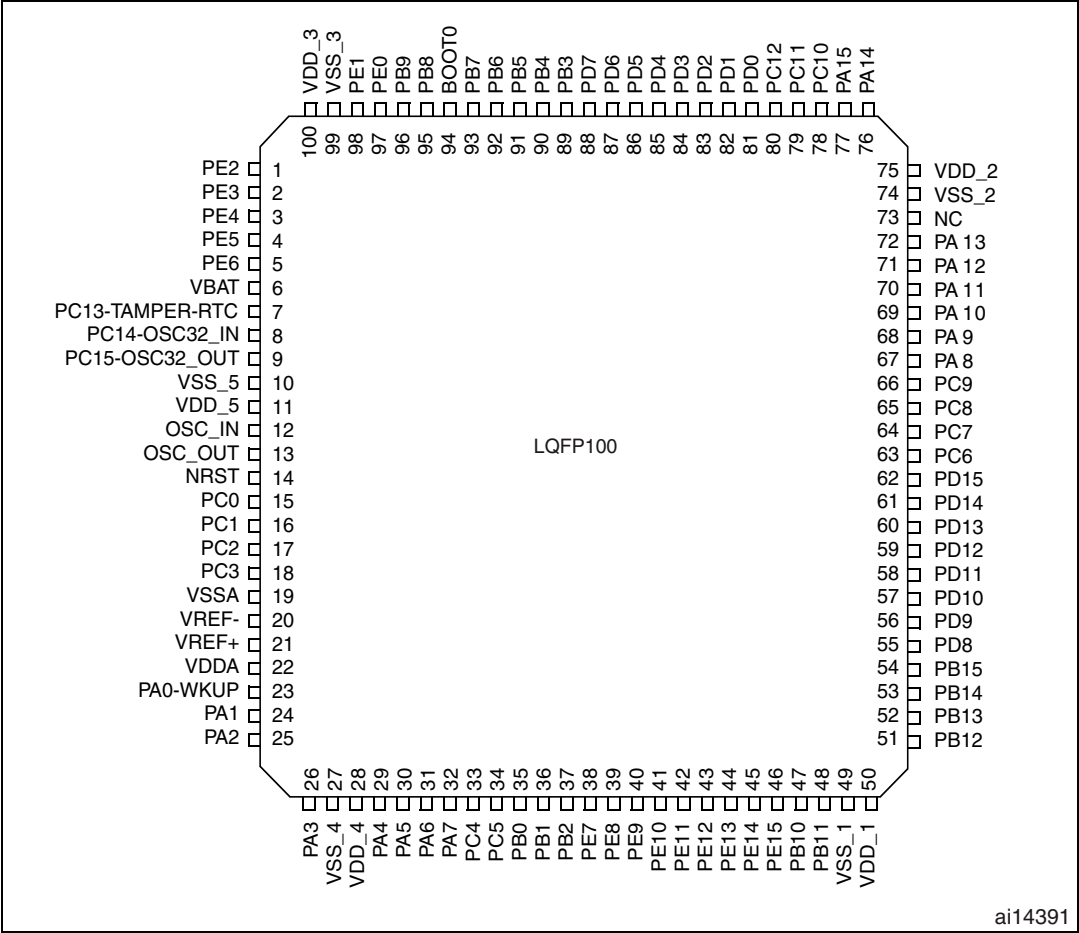
### 3 Pinouts and pin descriptions

Figure 3. LQFP144 pinout



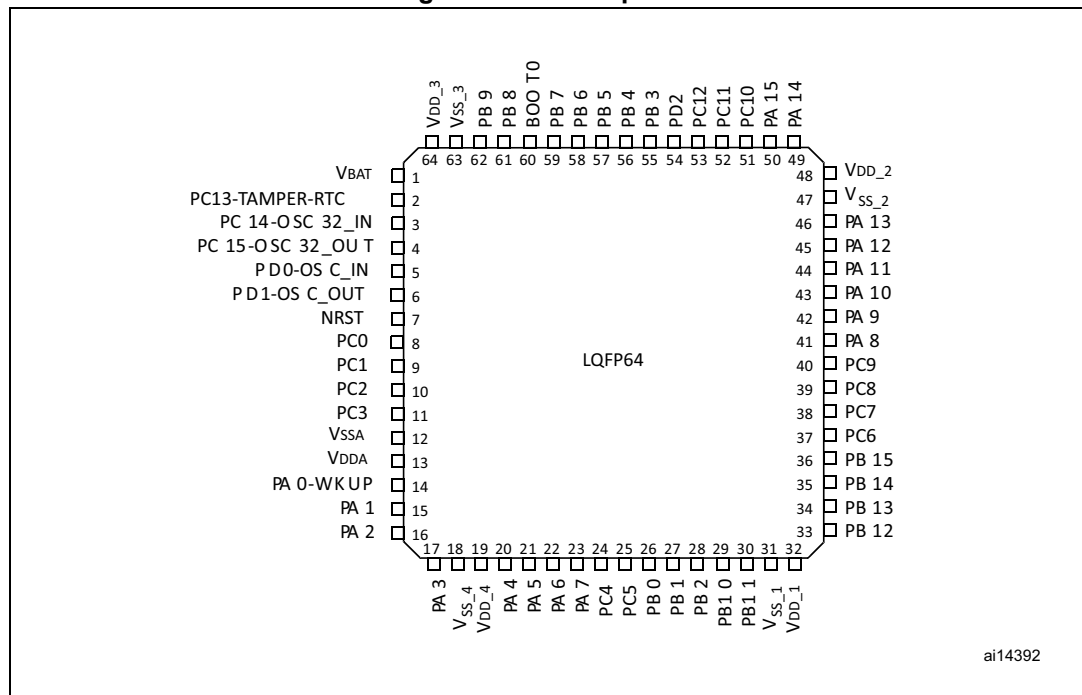
1. The above figure shows the package top view.

Figure 4. LQFP100 pinout



1. The above figure shows the package top view.

Figure 5. LQFP64 pinout



ai14392

1. The above figure shows the package top view.

Table 5. STM32F101xF/STM32F101xG pin definitions

| Pins    |        |         | Pin name                       | Type <sup>(1)</sup> | I / O level <sup>(2)</sup> | Main function <sup>(3)</sup><br>(after reset) | Alternate functions <sup>(4)</sup> |          |
|---------|--------|---------|--------------------------------|---------------------|----------------------------|-----------------------------------------------|------------------------------------|----------|
| LQFP144 | LQFP64 | LQFP100 |                                |                     |                            |                                               | Default                            | Remap    |
| 1       | -      | 1       | PE2                            | I/O                 | FT                         | PE2                                           | TRACECLK / FSMC_A23                | -        |
| 2       | -      | 2       | PE3                            | I/O                 | FT                         | PE3                                           | TRACED0 / FSMC_A19                 | -        |
| 3       | -      | 3       | PE4                            | I/O                 | FT                         | PE4                                           | TRACED1 / FSMC_A20                 | -        |
| 4       | -      | 4       | PE5                            | I/O                 | FT                         | PE5                                           | TRACED2 / FSMC_A21                 | TIM9_CH1 |
| 5       | -      | 5       | PE6                            | I/O                 | FT                         | PE6                                           | TRACED3 / FSMC_A22                 | TIM9_CH2 |
| 6       | 1      | 6       | V <sub>BAT</sub>               | S                   | -                          | V <sub>BAT</sub>                              | -                                  | -        |
| 7       | 2      | 7       | PC13-TAMPER-RTC <sup>(5)</sup> | I/O                 | -                          | PC13 <sup>(6)</sup>                           | TAMPER-RTC                         | -        |
| 8       | 3      | 8       | PC14-OSC32_IN <sup>(5)</sup>   | I/O                 | -                          | PC14 <sup>(6)</sup>                           | OSC32_IN                           | -        |
| 9       | 4      | 9       | PC15-OSC32_OUT <sup>(5)</sup>  | I/O                 | -                          | PC15 <sup>(6)</sup>                           | OSC32_OUT                          | -        |
| 10      | -      | -       | PF0                            | I/O                 | FT                         | PF0                                           | FSMC_A0                            | -        |
| 11      | -      | -       | PF1                            | I/O                 | FT                         | PF1                                           | FSMC_A1                            | -        |

Table 5. STM32F101xF/STM32F101xG pin definitions (continued)

| Pins    |        |         | Pin name          | Type <sup>(1)</sup> | I / O level <sup>(2)</sup> | Main function <sup>(3)</sup><br>(after reset) | Alternate functions <sup>(4)</sup>                                                      |                    |
|---------|--------|---------|-------------------|---------------------|----------------------------|-----------------------------------------------|-----------------------------------------------------------------------------------------|--------------------|
| LQFP144 | LQFP64 | LQFP100 |                   |                     |                            |                                               | Default                                                                                 | Remap              |
| 12      | -      | -       | PF2               | I/O                 | FT                         | PF2                                           | FSMC_A2                                                                                 | -                  |
| 13      | -      | -       | PF3               | I/O                 | FT                         | PF3                                           | FSMC_A3                                                                                 | -                  |
| 14      | -      | -       | PF4               | I/O                 | FT                         | PF4                                           | FSMC_A4                                                                                 | -                  |
| 15      | -      | -       | PF5               | I/O                 | FT                         | PF5                                           | FSMC_A5                                                                                 | -                  |
| 16      | -      | 10      | V <sub>SS_5</sub> | S                   | -                          | V <sub>SS_5</sub>                             | -                                                                                       | -                  |
| 17      | -      | 11      | V <sub>DD_5</sub> | S                   | -                          | V <sub>DD_5</sub>                             | -                                                                                       | -                  |
| 18      | -      | -       | PF6               | I/O                 | -                          | PF6                                           | FSMC_NIORD                                                                              | TIM10_CH1          |
| 19      | -      | -       | PF7               | I/O                 | -                          | PF7                                           | FSMC_NREG                                                                               | TIM11_CH1          |
| 20      | -      | -       | PF8               | I/O                 | -                          | PF8                                           | FSMC_NIOWR                                                                              | TIM13_CH1          |
| 21      | -      | -       | PF9               | I/O                 | -                          | PF9                                           | FSMC_CD                                                                                 | TIM14_CH1          |
| 22      | -      | -       | PF10              | I/O                 | -                          | PF10                                          | FSMC_INTR                                                                               | -                  |
| 23      | 5      | 12      | OSC_IN            | I                   | -                          | OSC_IN                                        | -                                                                                       | PD0 <sup>(7)</sup> |
| 24      | 6      | 13      | OSC_OUT           | O                   | -                          | OSC_OUT                                       | -                                                                                       | PD1 <sup>(7)</sup> |
| 25      | 7      | 14      | NRST              | I/O                 | -                          | NRST                                          | -                                                                                       | -                  |
| 26      | 8      | 15      | PC0               | I/O                 | -                          | PC0                                           | ADC_IN10                                                                                | -                  |
| 27      | 9      | 16      | PC1               | I/O                 | -                          | PC1                                           | ADC_IN11                                                                                | -                  |
| 28      | 10     | 17      | PC2               | I/O                 | -                          | PC2                                           | ADC_IN12                                                                                | -                  |
| 29      | 11     | 18      | PC3               | I/O                 | -                          | PC3                                           | ADC_IN13                                                                                | -                  |
| 30      | 12     | 19      | V <sub>SSA</sub>  | S                   | -                          | V <sub>SSA</sub>                              | -                                                                                       | -                  |
| 31      | -      | 20      | V <sub>REF-</sub> | S                   | -                          | V <sub>REF-</sub>                             | -                                                                                       | -                  |
| 32      | -      | 21      | V <sub>REF+</sub> | S                   | -                          | V <sub>REF+</sub>                             | -                                                                                       | -                  |
| 33      | 13     | 22      | V <sub>DDA</sub>  | S                   | -                          | V <sub>DDA</sub>                              | -                                                                                       | -                  |
| 34      | 14     | 23      | PA0-WKUP          | I/O                 | -                          | PA0                                           | WKUP/ USART2_CTS <sup>(8)</sup> /<br>ADC_IN0 / TIM5_CH1/<br>TIM2_CH1_ETR <sup>(8)</sup> | -                  |
| 35      | 15     | 24      | PA1               | I/O                 | -                          | PA1                                           | USART2_RTS <sup>(8)</sup> /<br>ADC_IN1 / TIM5_CH2<br>TIM2_CH2 <sup>(8)</sup>            | -                  |
| 36      | 16     | 25      | PA2               | I/O                 | -                          | PA2                                           | USART2_TX <sup>(8)</sup> /<br>TIM5_CH3 / ADC_IN2/<br>TIM2_CH3 <sup>(8)</sup> / TIM9_CH1 | -                  |

Table 5. STM32F101xF/STM32F101xG pin definitions (continued)

| Pins    |        |         | Pin name          | Type <sup>(1)</sup> | I / O level <sup>(2)</sup> | Main function <sup>(3)</sup><br>(after reset) | Alternate functions <sup>(4)</sup>                                                       |       |
|---------|--------|---------|-------------------|---------------------|----------------------------|-----------------------------------------------|------------------------------------------------------------------------------------------|-------|
| LQFP144 | LQFP64 | LQFP100 |                   |                     |                            |                                               | Default                                                                                  | Remap |
| 37      | 17     | 26      | PA3               | I/O                 | -                          | PA3                                           | USART2_RX <sup>(8)</sup> / TIM5_CH4 /<br>ADC_IN3 / TIM2_CH4 <sup>(8)</sup> /<br>TIM9_CH2 | -     |
| 38      | 18     | 27      | V <sub>SS_4</sub> | S                   | -                          | V <sub>SS_4</sub>                             | -                                                                                        | -     |
| 39      | 19     | 28      | V <sub>DD_4</sub> | S                   | -                          | V <sub>DD_4</sub>                             | -                                                                                        | -     |
| 40      | 20     | 29      | PA4               | I/O                 | -                          | PA4                                           | SPI1_NSS / DAC_OUT1 /<br>ADC_IN4 / USART2_CK <sup>(8)</sup>                              | -     |
| 41      | 21     | 30      | PA5               | I/O                 | -                          | PA5                                           | SPI1_SCK / DAC_OUT2 /<br>ADC_IN5                                                         | -     |
| 42      | 22     | 31      | PA6               | I/O                 | -                          | PA6                                           | SPI1_MISO / ADC_IN6 /<br>TIM3_CH1 <sup>(8)</sup> / TIM13_CH1                             | -     |
| 43      | 23     | 32      | PA7               | I/O                 | -                          | PA7                                           | SPI1_MOSI / ADC_IN7 /<br>TIM3_CH2 <sup>(8)</sup> / TIM14_CH1                             | -     |
| 44      | 24     | 33      | PC4               | I/O                 | -                          | PC4                                           | ADC_IN14                                                                                 | -     |
| 45      | 25     | 34      | PC5               | I/O                 | -                          | PC5                                           | ADC_IN15                                                                                 | -     |
| 46      | 26     | 35      | PB0               | I/O                 | -                          | PB0                                           | ADC_IN8 / TIM3_CH3 <sup>(8)</sup>                                                        | -     |
| 47      | 27     | 36      | PB1               | I/O                 | -                          | PB1                                           | ADC_IN9 / TIM3_CH4 <sup>(8)</sup>                                                        | -     |
| 48      | 28     | 37      | PB2               | I/O                 | FT                         | PB2/BOOT1                                     | -                                                                                        | -     |
| 49      | -      | -       | PF11              | I/O                 | FT                         | PF11                                          | FSMC_NIOS16                                                                              | -     |
| 50      | -      | -       | PF12              | I/O                 | FT                         | PF12                                          | FSMC_A6                                                                                  | -     |
| 51      | -      | -       | V <sub>SS_6</sub> | S                   | -                          | V <sub>SS_6</sub>                             | -                                                                                        | -     |
| 52      | -      | -       | V <sub>DD_6</sub> | S                   | -                          | V <sub>DD_6</sub>                             | -                                                                                        | -     |
| 53      | -      | -       | PF13              | I/O                 | FT                         | PF13                                          | FSMC_A7                                                                                  | -     |
| 54      | -      | -       | PF14              | I/O                 | FT                         | PF14                                          | FSMC_A8                                                                                  | -     |
| 55      | -      | -       | PF15              | I/O                 | FT                         | PF15                                          | FSMC_A9                                                                                  | -     |
| 56      | -      | -       | PG0               | I/O                 | FT                         | PG0                                           | FSMC_A10                                                                                 | -     |
| 57      | -      | -       | PG1               | I/O                 | FT                         | PG1                                           | FSMC_A11                                                                                 | -     |
| 58      | -      | 38      | PE7               | I/O                 | FT                         | PE7                                           | FSMC_D4                                                                                  | -     |
| 59      | -      | 39      | PE8               | I/O                 | FT                         | PE8                                           | FSMC_D5                                                                                  | -     |
| 60      | -      | 40      | PE9               | I/O                 | FT                         | PE9                                           | FSMC_D6                                                                                  | -     |
| 61      | -      | -       | V <sub>SS_7</sub> | S                   | -                          | V <sub>SS_7</sub>                             | -                                                                                        | -     |

Table 5. STM32F101xF/STM32F101xG pin definitions (continued)

| Pins    |        |         | Pin name          | Type <sup>(1)</sup> | I / O level <sup>(2)</sup> | Main function <sup>(3)</sup><br>(after reset) | Alternate functions <sup>(4)</sup>                                     |                          |
|---------|--------|---------|-------------------|---------------------|----------------------------|-----------------------------------------------|------------------------------------------------------------------------|--------------------------|
| LQFP144 | LQFP64 | LQFP100 |                   |                     |                            |                                               | Default                                                                | Remap                    |
| 62      | -      | -       | V <sub>DD_7</sub> | S                   | -                          | V <sub>DD_7</sub>                             | -                                                                      | -                        |
| 63      | -      | 41      | PE10              | I/O                 | FT                         | PE10                                          | FSMC_D7                                                                | -                        |
| 64      | -      | 42      | PE11              | I/O                 | FT                         | PE11                                          | FSMC_D8                                                                | -                        |
| 65      | -      | 43      | PE12              | I/O                 | FT                         | PE12                                          | FSMC_D9                                                                | -                        |
| 66      | -      | 44      | PE13              | I/O                 | FT                         | PE13                                          | FSMC_D10                                                               | -                        |
| 67      | -      | 45      | PE14              | I/O                 | FT                         | PE14                                          | FSMC_D11                                                               | -                        |
| 68      | -      | 46      | PE15              | I/O                 | FT                         | PE15                                          | FSMC_D12                                                               | -                        |
| 69      | 29     | 47      | PB10              | I/O                 | FT                         | PB10                                          | I2C2_SCL / USART3_TX <sup>(8)</sup>                                    | TIM2_CH3                 |
| 70      | 30     | 48      | PB11              | I/O                 | FT                         | PB11                                          | I2C2_SDA / USART3_RX <sup>(8)</sup>                                    | TIM2_CH4                 |
| 71      | 31     | 49      | V <sub>SS_1</sub> | S                   | -                          | V <sub>SS_1</sub>                             | -                                                                      | -                        |
| 72      | 32     | 50      | V <sub>DD_1</sub> | S                   | -                          | V <sub>DD_1</sub>                             | -                                                                      | -                        |
| 73      | 33     | 51      | PB12              | I/O                 | FT                         | PB12                                          | SPI2_NSS <sup>(8)</sup> / I2C2_SMBA /<br>USART3_CK <sup>(8)</sup>      | -                        |
| 74      | 34     | 52      | PB13              | I/O                 | FT                         | PB13                                          | SPI2_SCK <sup>(8)</sup> /<br>USART3_CTS <sup>(8)</sup>                 | -                        |
| 75      | 35     | 53      | PB14              | I/O                 | FT                         | PB14                                          | SPI2_MISO <sup>(8)</sup> /<br>USART3_RTS <sup>(8)</sup> /<br>TIM12_CH1 | -                        |
| 76      | 36     | 54      | PB15              | I/O                 | FT                         | PB15                                          | SPI2_MOSI <sup>(8)</sup> / TIM12_CH2                                   | -                        |
| 77      | -      | 55      | PD8               | I/O                 | FT                         | PD8                                           | FSMC_D13                                                               | USART3_TX                |
| 78      | -      | 56      | PD9               | I/O                 | FT                         | PD9                                           | FSMC_D14                                                               | USART3_RX                |
| 79      | -      | 57      | PD10              | I/O                 | FT                         | PD10                                          | FSMC_D15                                                               | USART3_CK                |
| 80      | -      | 58      | PD11              | I/O                 | FT                         | PD11                                          | FSMC_A16                                                               | USART3_CTS               |
| 81      | -      | 59      | PD12              | I/O                 | FT                         | PD12                                          | FSMC_A17                                                               | TIM4_CH1 /<br>USART3_RTS |
| 82      | -      | 60      | PD13              | I/O                 | FT                         | PD13                                          | FSMC_A18                                                               | TIM4_CH2                 |
| 83      | -      | -       | V <sub>SS_8</sub> | S                   | -                          | V <sub>SS_8</sub>                             | -                                                                      | -                        |
| 84      | -      | -       | V <sub>DD_8</sub> | S                   | -                          | V <sub>DD_8</sub>                             | -                                                                      | -                        |
| 85      | -      | 61      | PD14              | I/O                 | FT                         | PD14                                          | FSMC_D0                                                                | TIM4_CH3                 |
| 86      | -      | 62      | PD15              | I/O                 | FT                         | PD15                                          | FSMC_D1                                                                | TIM4_CH4                 |
| 87      | -      | -       | PG2               | I/O                 | FT                         | PG2                                           | FSMC_A12                                                               | -                        |

Table 5. STM32F101xF/STM32F101xG pin definitions (continued)

| Pins    |        |         | Pin name          | Type <sup>(1)</sup> | I / O level <sup>(2)</sup> | Main function <sup>(3)</sup><br>(after reset) | Alternate functions <sup>(4)</sup> |                                 |
|---------|--------|---------|-------------------|---------------------|----------------------------|-----------------------------------------------|------------------------------------|---------------------------------|
| LQFP144 | LQFP64 | LQFP100 |                   |                     |                            |                                               | Default                            | Remap                           |
| 88      | -      | -       | PG3               | I/O                 | FT                         | PG3                                           | FSMC_A13                           | -                               |
| 89      | -      | -       | PG4               | I/O                 | FT                         | PG4                                           | FSMC_A14                           | -                               |
| 90      | -      | -       | PG5               | I/O                 | FT                         | PG5                                           | FSMC_A15                           | -                               |
| 91      | -      | -       | PG6               | I/O                 | FT                         | PG6                                           | FSMC_INT2                          | -                               |
| 92      | -      | -       | PG7               | I/O                 | FT                         | PG7                                           | FSMC_INT3                          | -                               |
| 93      | -      | -       | PG8               | I/O                 | FT                         | PG8                                           | -                                  | -                               |
| 94      | -      | -       | V <sub>SS_9</sub> | S                   | -                          | V <sub>SS_9</sub>                             | -                                  | -                               |
| 95      | -      | -       | V <sub>DD_9</sub> | S                   | -                          | V <sub>DD_9</sub>                             | -                                  | -                               |
| 96      | 37     | 63      | PC6               | I/O                 | FT                         | PC6                                           | -                                  | TIM3_CH1                        |
| 97      | 38     | 64      | PC7               | I/O                 | FT                         | PC7                                           | -                                  | TIM3_CH2                        |
| 98      | 39     | 65      | PC8               | I/O                 | FT                         | PC8                                           | -                                  | TIM3_CH3                        |
| 99      | 40     | 66      | PC9               | I/O                 | FT                         | PC9                                           | -                                  | TIM3_CH4                        |
| 100     | 41     | 67      | PA8               | I/O                 | FT                         | PA8                                           | USART1_CK / MCO                    | -                               |
| 101     | 42     | 68      | PA9               | I/O                 | FT                         | PA9                                           | USART1_TX <sup>(8)</sup>           | -                               |
| 102     | 43     | 69      | PA10              | I/O                 | FT                         | PA10                                          | USART1_RX <sup>(8)</sup>           | -                               |
| 103     | 44     | 70      | PA11              | I/O                 | FT                         | PA11                                          | USART1_CTS                         | -                               |
| 104     | 45     | 71      | PA12              | I/O                 | FT                         | PA12                                          | USART1_RTS                         | -                               |
| 105     | 46     | 72      | PA13              | I/O                 | FT                         | JTMS-SWDIO                                    | -                                  | PA13                            |
| 106     | -      | 73      | Not connected     |                     |                            |                                               |                                    |                                 |
| 107     | 47     | 74      | V <sub>SS_2</sub> | S                   | -                          | V <sub>SS_2</sub>                             | -                                  | -                               |
| 108     | 48     | 75      | V <sub>DD_2</sub> | S                   | -                          | V <sub>DD_2</sub>                             | -                                  | -                               |
| 109     | 49     | 76      | PA14              | I/O                 | FT                         | JTCK-SWCLK                                    | -                                  | PA14                            |
| 110     | 50     | 77      | PA15              | I/O                 | FT                         | JTDI                                          | SPI3_NSS                           | TIM2_CH1_ETR/<br>PA15 /SPI1_NSS |
| 111     | 51     | 78      | PC10              | I/O                 | FT                         | PC10                                          | UART4_TX                           | USART3_TX                       |
| 112     | 52     | 79      | PC11              | I/O                 | FT                         | PC11                                          | UART4_RX                           | USART3_RX                       |
| 113     | 53     | 80      | PC12              | I/O                 | FT                         | PC12                                          | UART5_TX                           | USART3_CK                       |
| 114     | -      | 81      | PD0               | I/O                 | FT                         | -                                             | FSMC_D2 <sup>(9)</sup>             | -                               |
| 115     | -      | 82      | PD1               | I/O                 | FT                         | -                                             | FSMC_D3 <sup>(9)</sup>             | -                               |

Table 5. STM32F101xF/STM32F101xG pin definitions (continued)

| Pins    |        |         | Pin name           | Type <sup>(1)</sup> | I / O level <sup>(2)</sup> | Main function <sup>(3)</sup><br>(after reset) | Alternate functions <sup>(4)</sup>                |                                        |
|---------|--------|---------|--------------------|---------------------|----------------------------|-----------------------------------------------|---------------------------------------------------|----------------------------------------|
| LQFP144 | LQFP64 | LQFP100 |                    |                     |                            |                                               | Default                                           | Remap                                  |
| 116     | 54     | 83      | PD2                | I/O                 | FT                         | PD2                                           | TIM3_ETR / UART5_RX                               | -                                      |
| 117     | -      | 84      | PD3                | I/O                 | FT                         | PD3                                           | FSMC_CLK                                          | USART2_CTS                             |
| 118     | -      | 85      | PD4                | I/O                 | FT                         | PD4                                           | FSMC_NOE                                          | USART2_RTS                             |
| 119     | -      | 86      | PD5                | I/O                 | FT                         | PD5                                           | FSMC_NWE                                          | USART2_TX                              |
| 120     | -      | -       | V <sub>SS_10</sub> | S                   | -                          | V <sub>SS_10</sub>                            | -                                                 | -                                      |
| 121     | -      | -       | V <sub>DD_10</sub> | S                   | -                          | V <sub>DD_10</sub>                            | -                                                 | -                                      |
| 122     | -      | 87      | PD6                | I/O                 | FT                         | PD6                                           | FSMC_NWAIT                                        | USART2_RX                              |
| 123     | -      | 88      | PD7                | I/O                 | FT                         | PD7                                           | FSMC_NE1 / FSMC_NCE2                              | USART2_CK                              |
| 124     | -      | -       | PG9                | I/O                 | FT                         | PG9                                           | FSMC_NE2 / FSMC_NCE3                              | -                                      |
| 125     | -      | -       | PG10               | I/O                 | FT                         | PG10                                          | FSMC_NE3 /<br>FSMC_NCE4_1                         | -                                      |
| 126     | -      | -       | PG11               | I/O                 | FT                         | PG11                                          | FSMC_NCE4_2                                       | -                                      |
| 127     | -      | -       | PG12               | I/O                 | FT                         | PG12                                          | FSMC_NE4                                          | -                                      |
| 128     | -      | -       | PG13               | I/O                 | FT                         | PG13                                          | FSMC_A24                                          | -                                      |
| 129     | -      | -       | PG14               | I/O                 | FT                         | PG14                                          | FSMC_A25                                          | -                                      |
| 130     | -      | -       | V <sub>SS_11</sub> | S                   | -                          | V <sub>SS_11</sub>                            | -                                                 | -                                      |
| 131     | -      | -       | V <sub>DD_11</sub> | S                   | -                          | V <sub>DD_11</sub>                            | -                                                 | -                                      |
| 132     | -      | -       | PG15               | I/O                 | FT                         | PG15                                          | -                                                 | -                                      |
| 133     | 55     | 89      | PB3                | I/O                 | FT                         | JTDO                                          | SPI3_SCK                                          | TIM2_CH2 / PB3<br>TRACESWO<br>SPI1_SCK |
| 134     | 56     | 90      | PB4                | I/O                 | FT                         | NJTRST                                        | SPI3_MISO                                         | PB4 / TIM3_CH1<br>SPI1_MISO            |
| 135     | 57     | 91      | PB5                | I/O                 | -                          | PB5                                           | I2C1_SMBA/ SPI3_MOSI                              | TIM3_CH2 /<br>SPI1_MOSI                |
| 136     | 58     | 92      | PB6                | I/O                 | FT                         | PB6                                           | I2C1_SCL / TIM4_CH1 <sup>(8)</sup>                | USART1_TX                              |
| 137     | 59     | 93      | PB7                | I/O                 | FT                         | PB7                                           | I2C1_SDA / FSMC_NADV /<br>TIM4_CH2 <sup>(8)</sup> | USART1_RX                              |
| 138     | 60     | 94      | BOOT0              | I                   | -                          | BOOT0                                         | -                                                 | -                                      |
| 139     | 61     | 95      | PB8                | I/O                 | FT                         | PB8                                           | TIM4_CH3 <sup>(8)</sup> / TIM10_CH1               | I2C1_SCL                               |
| 140     | 62     | 96      | PB9                | I/O                 | FT                         | PB9                                           | TIM4_CH4 <sup>(8)</sup> / TIM11_CH1               | I2C1_SDA                               |

Table 5. STM32F101xF/STM32F101xG pin definitions (continued)

| Pins    |        |         | Pin name          | Type <sup>(1)</sup> | I / O level <sup>(2)</sup> | Main function <sup>(3)</sup><br>(after reset) | Alternate functions <sup>(4)</sup>  |       |
|---------|--------|---------|-------------------|---------------------|----------------------------|-----------------------------------------------|-------------------------------------|-------|
| LQFP144 | LQFP64 | LQFP100 |                   |                     |                            |                                               | Default                             | Remap |
| 141     | -      | 97      | PE0               | I/O                 | FT                         | PE0                                           | TIM4_ETR <sup>(8)</sup> / FSMC_NBL0 | -     |
| 142     | -      | 98      | PE1               | I/O                 | FT                         | PE1                                           | FSMC_NBL1                           | -     |
| 143     | 63     | 99      | V <sub>SS_3</sub> | S                   | -                          | V <sub>SS_3</sub>                             | -                                   | -     |
| 144     | 64     | 100     | V <sub>DD_3</sub> | S                   | -                          | V <sub>DD_3</sub>                             | -                                   | -     |

1. I = input, O = output, S = supply.

2. FT = 5 V tolerant.

3. Function availability depends on the chosen device.

4. If several peripherals share the same I/O pin, to avoid conflict between these alternate functions only one peripheral should be enabled at a time through the peripheral clock enable bit (in the corresponding RCC peripheral clock enable register).

5. PC13, PC14 and PC15 are supplied through the power switch. Since the switch only sinks a limited amount of current (3 mA), the use of GPIOs PC13 to PC15 in output mode is limited: the speed should not exceed 2 MHz with a maximum load of 30 pF and these IOs must not be used as a current source (e.g. to drive an LED).

6. Main function after the first backup domain power-up. Later on, it depends on the contents of the Backup registers even after reset (because these registers are not reset by the main reset). For details on how to manage these IOs, refer to the Battery backup domain and BKP register description sections in the STM32F10xxx reference manual, available from the STMicroelectronics website: [www.st.com](http://www.st.com).

7. For the LQFP64 package, the pins number 5 and 6 are configured as OSC\_IN/OSC\_OUT after reset, however the functionality of PD0 and PD1 can be remapped by software on these pins. For the LQFP100 and LQFP144 packages, PD0 and PD1 are available by default, so there is no need for remapping. For more details, refer to Alternate function I/O and debug configuration section in the STM32F10xxx reference manual.

8. This alternate function can be remapped by software to some other port pins (if available on the used package). For more details, refer to the Alternate function I/O and debug configuration section in the STM32F10xxx reference manual, available from the STMicroelectronics website: [www.st.com](http://www.st.com).

9. For devices delivered in LQFP64 packages, the FSMC function is not available.

Table 6. FSMC pin definition

| Pins | FSMC   |        |                    |                  |             | LQFP100 <sup>(1)</sup> |
|------|--------|--------|--------------------|------------------|-------------|------------------------|
|      | CF     | CF/IDE | NOR/PSRAM/<br>SRAM | NOR/PSRAM<br>Mux | NAND 16 bit |                        |
| PE2  | -      | -      | A23                | A23              | -           | Yes                    |
| PE3  | -      | -      | A19                | A19              | -           | Yes                    |
| PE4  | -      | -      | A20                | A20              | -           | Yes                    |
| PE5  | -      | -      | A21                | A21              | -           | Yes                    |
| PE6  | -      | -      | A22                | A22              | -           | Yes                    |
| PF0  | A0     | A0     | A0                 | -                | -           | -                      |
| PF1  | A1     | A1     | A1                 | -                | -           | -                      |
| PF2  | A2     | A2     | A2                 | -                | -           | -                      |
| PF3  | A3     | -      | A3                 | -                | -           | -                      |
| PF4  | A4     | -      | A4                 | -                | -           | -                      |
| PF5  | A5     | -      | A5                 | -                | -           | -                      |
| PF6  | NIORD  | NIORD  | -                  | -                | -           | -                      |
| PF7  | NREG   | NREG   | -                  | -                | -           | -                      |
| PF8  | NIOWR  | NIOWR  | -                  | -                | -           | -                      |
| PF9  | CD     | CD     | -                  | -                | -           | -                      |
| PF10 | INTR   | INTR   | -                  | -                | -           | -                      |
| PF11 | NIOS16 | NIOS16 | -                  | -                | -           | -                      |
| PF12 | A6     | -      | A6                 | -                | -           | -                      |
| PF13 | A7     | -      | A7                 | -                | -           | -                      |
| PF14 | A8     | -      | A8                 | -                | -           | -                      |
| PF15 | A9     | -      | A9                 | -                | -           | -                      |
| PG0  | A10    | -      | A10                | -                | -           | -                      |
| PG1  | -      | -      | A11                | -                | -           | -                      |
| PE7  | D4     | D4     | D4                 | DA4              | D4          | Yes                    |
| PE8  | D5     | D5     | D5                 | DA5              | D5          | Yes                    |
| PE9  | D6     | D6     | D6                 | DA6              | D6          | Yes                    |
| PE10 | D7     | D7     | D7                 | DA7              | D7          | Yes                    |
| PE11 | D8     | D8     | D8                 | DA8              | D8          | Yes                    |
| PE12 | D9     | D9     | D9                 | DA9              | D9          | Yes                    |
| PE13 | D10    | D10    | D10                | DA10             | D10         | Yes                    |
| PE14 | D11    | D11    | D11                | DA11             | D11         | Yes                    |
| PE15 | D12    | D12    | D12                | DA12             | D12         | Yes                    |
| PD8  | D13    | D13    | D13                | DA13             | D13         | Yes                    |

Table 6. FSMC pin definition (continued)

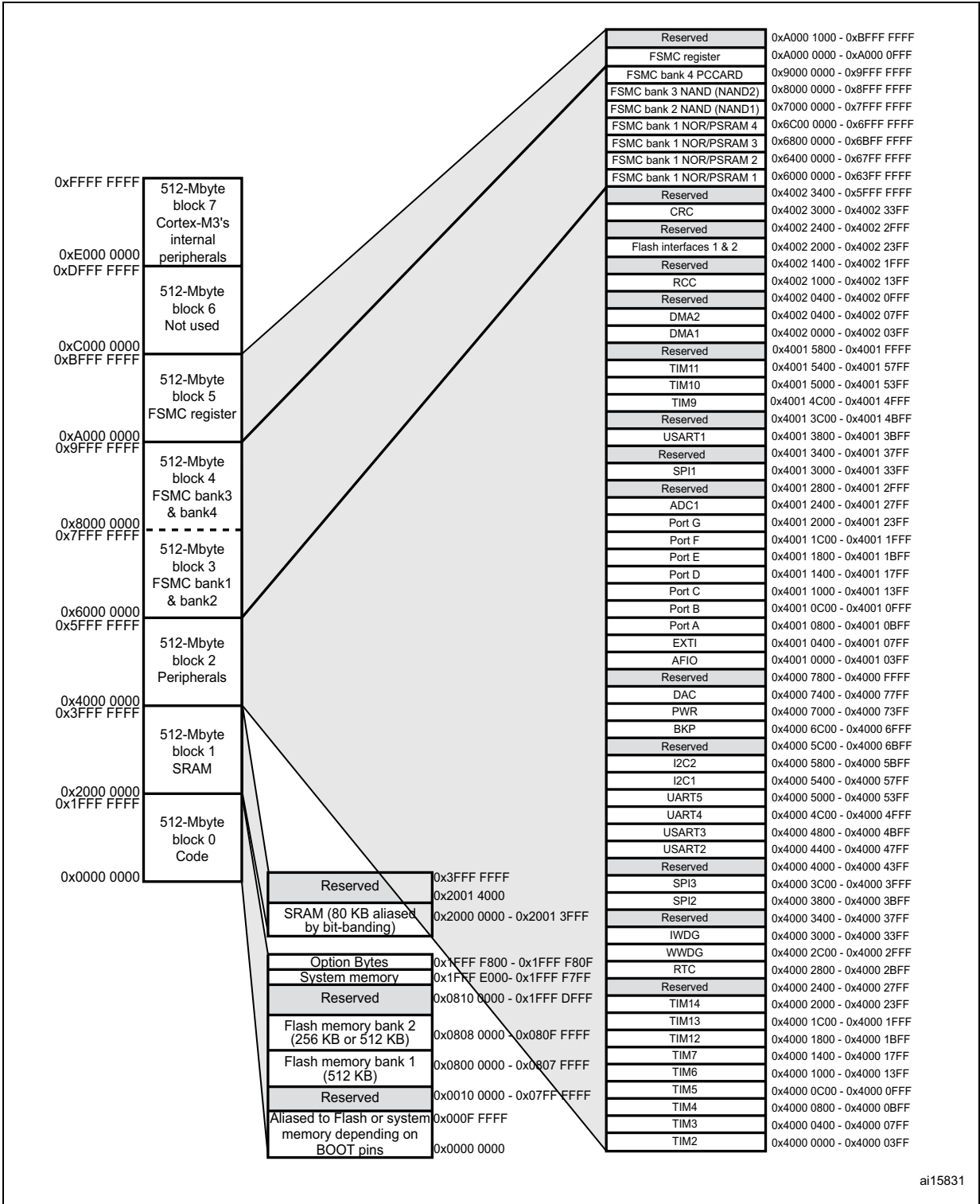
| Pins | FSMC   |        |                    |                  |             | LQFP100 <sup>(1)</sup> |
|------|--------|--------|--------------------|------------------|-------------|------------------------|
|      | CF     | CF/IDE | NOR/PSRAM/<br>SRAM | NOR/PSRAM<br>Mux | NAND 16 bit |                        |
| PD9  | D14    | D14    | D14                | DA14             | D14         | Yes                    |
| PD10 | D15    | D15    | D15                | DA15             | D15         | Yes                    |
| PD11 | -      | -      | A16                | A16              | CLE         | Yes                    |
| PD12 | -      | -      | A17                | A17              | ALE         | Yes                    |
| PD13 | -      | -      | A18                | A18              |             | Yes                    |
| PD14 | D0     | D0     | D0                 | DA0              | D0          | Yes                    |
| PD15 | D1     | D1     | D1                 | DA1              | D1          | Yes                    |
| PG2  | -      | -      | A12                | -                | -           | -                      |
| PG3  | -      | -      | A13                | -                | -           | -                      |
| PG4  | -      | -      | A14                | -                | -           | -                      |
| PG5  | -      | -      | A15                | -                | -           | -                      |
| PG6  | -      | -      | -                  | -                | INT2        | -                      |
| PG7  | -      | -      | -                  | -                | INT3        | -                      |
| PD0  | D2     | D2     | D2                 | DA2              | D2          | Yes                    |
| PD1  | D3     | D3     | D3                 | DA3              | D3          | Yes                    |
| PD3  | -      | -      | CLK                | CLK              | -           | Yes                    |
| PD4  | NOE    | NOE    | NOE                | NOE              | NOE         | Yes                    |
| PD5  | NWE    | NWE    | NWE                | NWE              | NWE         | Yes                    |
| PD6  | NWAIT  | NWAIT  | NWAIT              | NWAIT            | NWAIT       | Yes                    |
| PD7  | -      | -      | NE1                | NE1              | NCE2        | Yes                    |
| PG9  | -      | -      | NE2                | NE2              | NCE3        | -                      |
| PG10 | NCE4_1 | NCE4_1 | NE3                | NE3              | -           | -                      |
| PG11 | NCE4_2 | NCE4_2 | -                  | -                | -           | -                      |
| PG12 | -      | -      | NE4                | NE4              | -           | -                      |
| PG13 | -      | -      | A24                | A24              | -           | -                      |
| PG14 | -      | -      | A25                | A25              | -           | -                      |
| PB7  | -      | -      | NADV               | NADV             | -           | Yes                    |
| PE0  | -      | -      | NBL0               | NBL0             | -           | Yes                    |
| PE1  | -      | -      | NBL1               | NBL1             | -           | Yes                    |

1. Ports F and G are not available in devices delivered in 100-pin packages.

## 4 Memory mapping

The memory map is shown in [Figure 6](#).

Figure 6. Memory map



ai15831

## 5 Electrical characteristics

### 5.1 Parameter conditions

Unless otherwise specified, all voltages are referenced to  $V_{SS}$ .

#### 5.1.1 Minimum and maximum values

Unless otherwise specified the minimum and maximum values are guaranteed in the worst conditions of ambient temperature, supply voltage and frequencies by tests in production on 100% of the devices with an ambient temperature at  $T_A = 25\text{ }^{\circ}\text{C}$  and  $T_A = T_{A\text{max}}$  (given by the selected temperature range).

Data based on characterization results, design simulation and/or technology characteristics are indicated in the table footnotes and are not tested in production. Based on characterization, the minimum and maximum values refer to sample tests and represent the mean value plus or minus three times the standard deviation ( $\text{mean} \pm 3\Sigma$ ).

#### 5.1.2 Typical values

Unless otherwise specified, typical data are based on  $T_A = 25\text{ }^{\circ}\text{C}$ ,  $V_{DD} = 3.3\text{ V}$  (for the  $2\text{ V} \leq V_{DD} \leq 3.6\text{ V}$  voltage range). They are given only as design guidelines and are not tested.

Typical ADC accuracy values are determined by characterization of a batch of samples from a standard diffusion lot over the full temperature range, where 95% of the devices have an error less than or equal to the value indicated ( $\text{mean} \pm 2\Sigma$ ).

#### 5.1.3 Typical curves

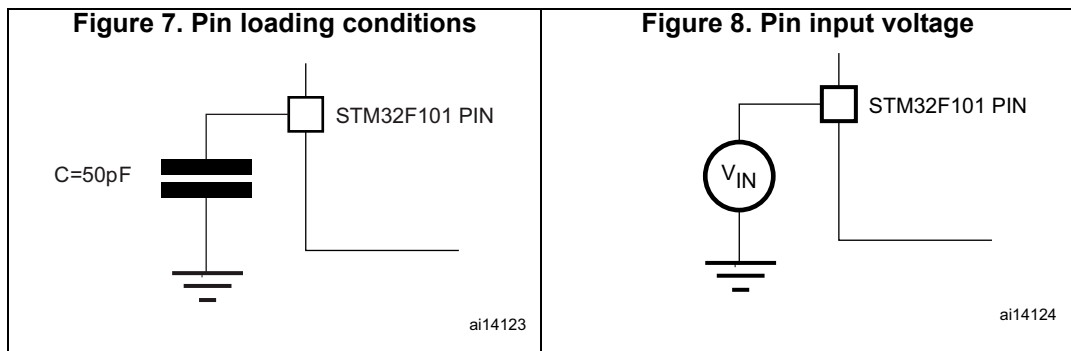
Unless otherwise specified, all typical curves are given only as design guidelines and are not tested.

#### 5.1.4 Loading capacitor

The loading conditions used for pin parameter measurement are shown in [Figure 7](#).

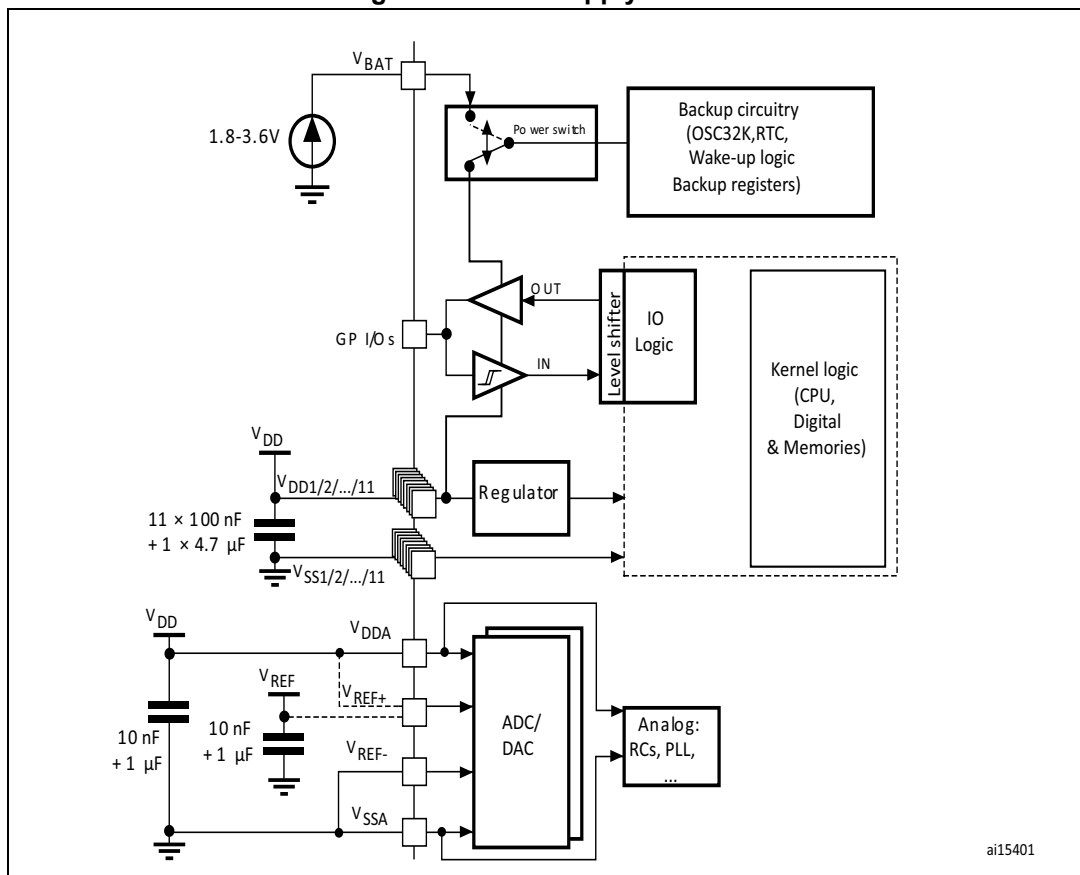
### 5.1.5 Pin input voltage

The input voltage measurement on a pin of the device is described in [Figure 8](#).



### 5.1.6 Power supply scheme

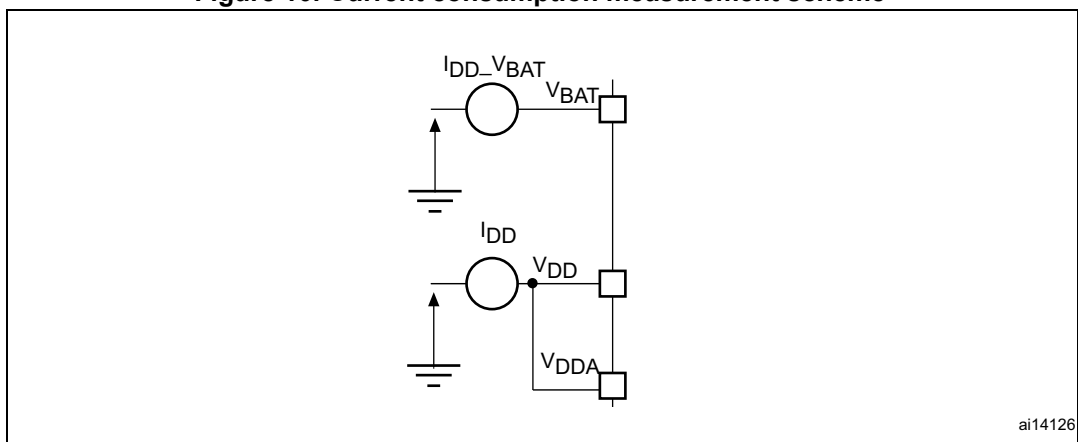
**Figure 9. Power supply scheme**



**Caution:** In [Figure 9](#), the 4.7  $\mu\text{F}$  capacitor must be connected to  $V_{DD3}$ .

### 5.1.7 Current consumption measurement

Figure 10. Current consumption measurement scheme



## 5.2 Absolute maximum ratings

Stresses above the absolute maximum ratings listed in [Table 7: Voltage characteristics](#), [Table 8: Current characteristics](#), and [Table 9: Thermal characteristics](#) may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these conditions is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.

Table 7. Voltage characteristics

| Symbol               | Ratings                                                                         | Min                                                                                   | Max            | Unit |
|----------------------|---------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|----------------|------|
| $V_{DD} - V_{SS}$    | External main supply voltage (including $V_{DDA}$ and $V_{DD}$ ) <sup>(1)</sup> | -0.3                                                                                  | 4.0            | V    |
| $V_{IN}^{(2)}$       | Input voltage on five volt tolerant pin                                         | $V_{SS} - 0.3$                                                                        | $V_{DD} + 4.0$ |      |
|                      | Input voltage on any other pin                                                  | $V_{SS} - 0.3$                                                                        | 4.0            |      |
| $ \Delta V_{DDx} $   | Variations between different $V_{DD}$ power pins                                | -                                                                                     | 50             | mV   |
| $ V_{SSx} - V_{SS} $ | Variations between all the different ground pins including $V_{REF-}$           | -                                                                                     | 50             |      |
| $V_{ESD(HBM)}$       | Electrostatic discharge voltage (human body model)                              | see <a href="#">Section 5.3.12: Absolute maximum ratings (electrical sensitivity)</a> |                | -    |

1. All main power ( $V_{DD}$ ,  $V_{DDA}$ ) and ground ( $V_{SS}$ ,  $V_{SSA}$ ) pins must always be connected to the external power supply, in the permitted range.
2.  $V_{IN}$  maximum must always be respected. Refer to [Table 8: Current characteristics](#) for the maximum allowed injected current values.

Table 8. Current characteristics

| Symbol                | Ratings                                                                 | Max.  | Unit |
|-----------------------|-------------------------------------------------------------------------|-------|------|
| $\Sigma I_{VDD}$      | Total current into $V_{DD}/V_{DDA}$ power lines (source) <sup>(1)</sup> | 150   | mA   |
| $\Sigma I_{VSS}$      | Total current out of $V_{SS}$ ground lines (sink) <sup>(1)</sup>        | 150   |      |
| $I_{IO}$              | Output current sunk by any I/O and control pin                          | 25    |      |
|                       | Output current source by any I/Os and control pin                       | -25   |      |
| $I_{INJ(PIN)}^{(2)}$  | Injected current on five volt tolerant pins <sup>(3)</sup>              | -5/+0 |      |
|                       | Injected current on any other pin <sup>(4)</sup>                        | ± 5   |      |
| $\Sigma I_{INJ(PIN)}$ | Total injected current (sum of all I/O and control pins) <sup>(5)</sup> | ± 25  |      |

1. All main power ( $V_{DD}$ ,  $V_{DDA}$ ) and ground ( $V_{SS}$ ,  $V_{SSA}$ ) pins must always be connected to the external power supply, in the permitted range.
2. Negative injection disturbs the analog performance of the device. See note 3 below [Table 59 on page 95](#).
3. Positive injection is not possible on these I/Os. A negative injection is induced by  $V_{IN} < V_{SS}$ .  $I_{INJ(PIN)}$  must never be exceeded. Refer to [Table 7: Voltage characteristics](#) for the maximum allowed input voltage values.
4. A positive injection is induced by  $V_{IN} > V_{DD}$  while a negative injection is induced by  $V_{IN} < V_{SS}$ .  $I_{INJ(PIN)}$  must never be exceeded. Refer to [Table 7: Voltage characteristics](#) for the maximum allowed input voltage values.
5. When several inputs are submitted to a current injection, the maximum  $\Sigma I_{INJ(PIN)}$  is the absolute sum of the positive and negative injected currents (instantaneous values).

Table 9. Thermal characteristics

| Symbol    | Ratings                      | Value       | Unit |
|-----------|------------------------------|-------------|------|
| $T_{STG}$ | Storage temperature range    | -65 to +150 | °C   |
| $T_J$     | Maximum junction temperature | 150         | °C   |

## 5.3 Operating conditions

### 5.3.1 General operating conditions

**Table 10. General operating conditions**

| Symbol          | Parameter                                                     | Conditions                                   | Min | Max | Unit               |
|-----------------|---------------------------------------------------------------|----------------------------------------------|-----|-----|--------------------|
| $f_{HCLK}$      | Internal AHB clock frequency                                  | -                                            | 0   | 36  | MHz                |
| $f_{PCLK1}$     | Internal APB1 clock frequency                                 | -                                            | 0   | 36  |                    |
| $f_{PCLK2}$     | Internal APB2 clock frequency                                 | -                                            | 0   | 36  |                    |
| $V_{DD}$        | Standard operating voltage                                    | -                                            | 2   | 3.6 | V                  |
| $V_{DDA}^{(1)}$ | Analog operating voltage (ADC not used)                       | Must be the same potential as $V_{DD}^{(2)}$ | 2   | 3.6 | V                  |
|                 | Analog operating voltage (ADC used)                           |                                              | 2.4 | 3.6 |                    |
| $V_{BAT}$       | Backup operating voltage                                      | -                                            | 1.8 | 3.6 | V                  |
| $P_D$           | Power dissipation at $T_A = 85\text{ }^{\circ}\text{C}^{(3)}$ | LQFP144                                      | -   | 666 | mW                 |
|                 |                                                               | LQFP100                                      | -   | 434 |                    |
|                 |                                                               | LQFP64                                       | -   | 444 |                    |
| $T_A$           | Ambient temperature                                           | Maximum power dissipation                    | -40 | 85  | $^{\circ}\text{C}$ |
|                 |                                                               | low-power dissipation <sup>(4)</sup>         | -40 | 105 | $^{\circ}\text{C}$ |
| $T_J$           | Junction temperature range                                    | -                                            | -40 | 105 | $^{\circ}\text{C}$ |

1. When the ADC is used, refer to [Table 56: ADC characteristics](#).
2. It is recommended to power  $V_{DD}$  and  $V_{DDA}$  from the same source. A maximum difference of 300 mV between  $V_{DD}$  and  $V_{DDA}$  can be tolerated during power-up and operation.
3. If  $T_A$  is lower, higher  $P_D$  values are allowed as long as  $T_J$  does not exceed  $T_{Jmax}$  (see [Section 6.4: Thermal characteristics](#)).
4. In low-power dissipation state,  $T_A$  can be extended to this range as long as  $T_J$  does not exceed  $T_{Jmax}$  (see [Section 6.4: Thermal characteristics](#)).

### 5.3.2 Operating conditions at power-up / power-down

The parameters given in [Table 11](#) are derived from tests performed under the ambient temperature condition summarized in [Table 10](#).

**Table 11. Operating conditions at power-up / power-down**

| Symbol    | Parameter               | Conditions | Min | Max      | Unit            |
|-----------|-------------------------|------------|-----|----------|-----------------|
| $t_{VDD}$ | $V_{DD}$ rise time rate | -          | 0   | $\infty$ | $\mu\text{s/V}$ |
|           | $V_{DD}$ fall time rate |            | 20  | $\infty$ |                 |

### 5.3.3 Embedded reset and power control block characteristics

The parameters given in [Table 12](#) are derived from tests performed under ambient temperature and  $V_{DD}$  supply voltage conditions summarized in [Table 10](#).

**Table 12. Embedded reset and power control block characteristics**

| Symbol               | Parameter                                     | Conditions                  | Min                | Typ  | Max  | Unit |
|----------------------|-----------------------------------------------|-----------------------------|--------------------|------|------|------|
| $V_{PVD}$            | Programmable voltage detector level selection | PLS[2:0]=000 (rising edge)  | 2.1                | 2.18 | 2.26 | V    |
|                      |                                               | PLS[2:0]=000 (falling edge) | 2                  | 2.08 | 2.16 | V    |
|                      |                                               | PLS[2:0]=001 (rising edge)  | 2.19               | 2.28 | 2.37 | V    |
|                      |                                               | PLS[2:0]=001 (falling edge) | 2.09               | 2.18 | 2.27 | V    |
|                      |                                               | PLS[2:0]=010 (rising edge)  | 2.28               | 2.38 | 2.48 | V    |
|                      |                                               | PLS[2:0]=010 (falling edge) | 2.18               | 2.28 | 2.38 | V    |
|                      |                                               | PLS[2:0]=011 (rising edge)  | 2.38               | 2.48 | 2.58 | V    |
|                      |                                               | PLS[2:0]=011 (falling edge) | 2.28               | 2.38 | 2.48 | V    |
|                      |                                               | PLS[2:0]=100 (rising edge)  | 2.47               | 2.58 | 2.69 | V    |
|                      |                                               | PLS[2:0]=100 (falling edge) | 2.37               | 2.48 | 2.59 | V    |
|                      |                                               | PLS[2:0]=101 (rising edge)  | 2.57               | 2.68 | 2.79 | V    |
|                      |                                               | PLS[2:0]=101 (falling edge) | 2.47               | 2.58 | 2.69 | V    |
|                      |                                               | PLS[2:0]=110 (rising edge)  | 2.66               | 2.78 | 2.9  | V    |
|                      |                                               | PLS[2:0]=110 (falling edge) | 2.56               | 2.68 | 2.8  | V    |
|                      |                                               | PLS[2:0]=111 (rising edge)  | 2.76               | 2.88 | 3    | V    |
|                      |                                               | PLS[2:0]=111 (falling edge) | 2.66               | 2.78 | 2.9  | V    |
| $V_{PVDhyst}^{(2)}$  | PVD hysteresis                                | -                           | -                  | 100  | -    | mV   |
| $V_{POR/PDR}$        | Power on/power down reset threshold           | Falling edge                | 1.8 <sup>(1)</sup> | 1.88 | 1.96 | V    |
|                      |                                               | Rising edge                 | 1.84               | 1.92 | 2.0  | V    |
| $V_{PDRhyst}^{(2)}$  | PDR hysteresis                                | -                           | -                  | 40   | -    | mV   |
| $t_{RSTTEMPO}^{(2)}$ | Reset temporization                           | -                           | 1.5                | 2.5  | 3.5  | ms   |

1. The product behavior is guaranteed by design down to the minimum  $V_{POR/PDR}$  value.

2. Guaranteed by design.

### 5.3.4 Embedded reference voltage

The parameters given in [Table 13](#) are derived from tests performed under ambient temperature and  $V_{DD}$  supply voltage conditions summarized in [Table 10](#).

**Table 13. Embedded internal reference voltage**

| Symbol                 | Parameter                                                     | Conditions                                                        | Min  | Typ  | Max                 | Unit                    |
|------------------------|---------------------------------------------------------------|-------------------------------------------------------------------|------|------|---------------------|-------------------------|
| $V_{REFINT}$           | Internal reference voltage                                    | $-40\text{ }^{\circ}\text{C} < T_A < +85\text{ }^{\circ}\text{C}$ | 1.16 | 1.20 | 1.24                | V                       |
| $T_{S\_vrefint}^{(1)}$ | ADC sampling time when reading the internal reference voltage | -                                                                 | -    | 5.1  | 17.1 <sup>(2)</sup> | $\mu\text{s}$           |
| $V_{RERINT}^{(2)}$     | Internal reference voltage spread over the temperature range  | $V_{DD} = 3\text{ V} \pm 10\text{ mV}$                            | -    | -    | 10                  | mV                      |
| $T_{Coeff}^{(2)}$      | Temperature coefficient                                       | -                                                                 | -    | -    | 100                 | ppm/ $^{\circ}\text{C}$ |

1. Shortest sampling time can be determined in the application by multiple iterations.

2. Guaranteed by design.

### 5.3.5 Supply current characteristics

The current consumption is a function of several parameters and factors such as the operating voltage, ambient temperature, I/O pin loading, device software configuration, operating frequencies, I/O pin switching rate, program location in memory and executed binary code.

The current consumption is measured as described in [Figure 10: Current consumption measurement scheme](#).

All Run-mode current consumption measurements given in this section are performed with a reduced code that gives a consumption equivalent to Dhrystone 2.1 code.

#### Maximum current consumption

The MCU is placed under the following conditions:

- All I/O pins are in input mode with a static value at  $V_{DD}$  or  $V_{SS}$  (no load)
- All peripherals are disabled except if it is explicitly mentioned
- The Flash access time is adjusted to  $f_{HCLK}$  frequency (0 wait state from 0 to 24 MHz, 1 wait state from 24 to 36 MHz)
- Prefetch in on (reminder: this bit must be set before clock setting and bus prescaling)
- When the peripherals are enabled  $f_{PCLK1} = f_{HCLK}/2$ ,  $f_{PCLK2} = f_{HCLK}$

The parameters given in [Table 14](#) are derived from tests performed under ambient temperature and  $V_{DD}$  supply voltage conditions summarized in [Table 10](#).

**Table 14. Maximum current consumption in Run mode, code with data processing running from Flash**

| Symbol   | Parameter                  | Conditions                                               | $f_{HCLK}$ | Max <sup>(1)</sup>                 | Unit |
|----------|----------------------------|----------------------------------------------------------|------------|------------------------------------|------|
|          |                            |                                                          |            | $T_A = 85\text{ }^{\circ}\text{C}$ |      |
| $I_{DD}$ | Supply current in Run mode | External clock <sup>(2)</sup> , all peripherals enabled  | 36 MHz     | 41                                 | mA   |
|          |                            |                                                          | 24 MHz     | 29                                 |      |
|          |                            |                                                          | 16 MHz     | 22                                 |      |
|          |                            |                                                          | 8 MHz      | 12.5                               |      |
|          |                            | External clock <sup>(2)</sup> , all peripherals disabled | 36 MHz     | 24                                 |      |
|          |                            |                                                          | 24 MHz     | 17.5                               |      |
|          |                            |                                                          | 16 MHz     | 14                                 |      |
|          |                            |                                                          | 8 MHz      | 8.5                                |      |

1. Guaranteed by characterization results.

2. External clock is 8 MHz and PLL is on when  $f_{HCLK} > 8\text{ MHz}$ .

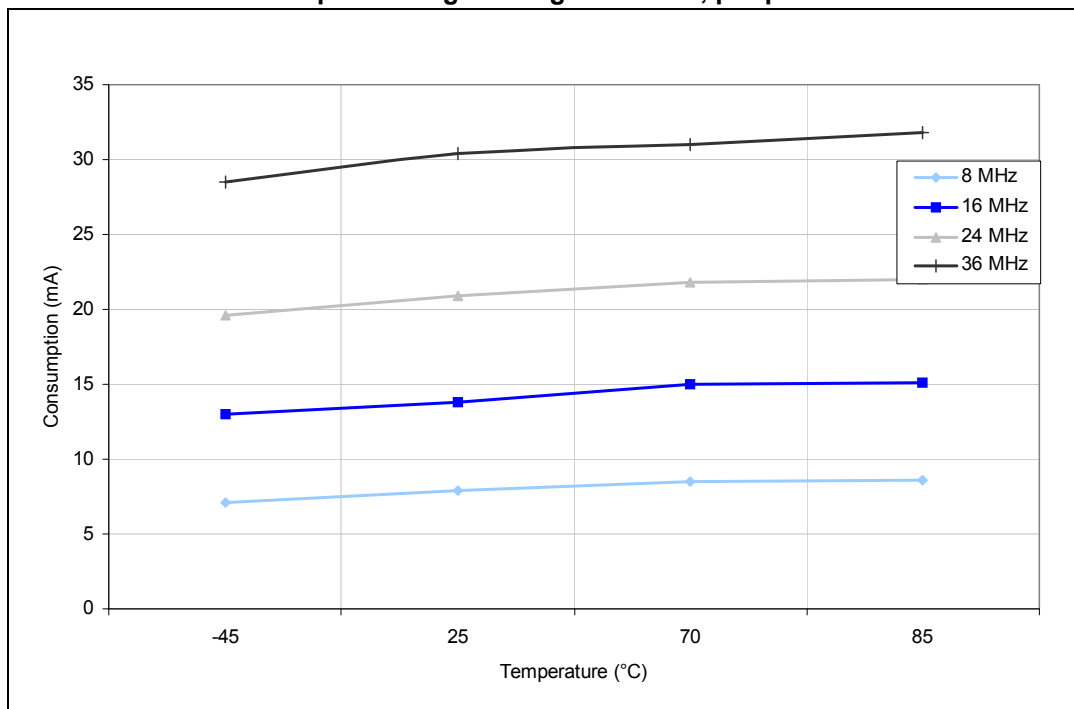
**Table 15. Maximum current consumption in Run mode, code with data processing running from RAM**

| Symbol   | Parameter                  | Conditions                                              | $f_{HCLK}$ | Max <sup>(1)</sup>                 | Unit |
|----------|----------------------------|---------------------------------------------------------|------------|------------------------------------|------|
|          |                            |                                                         |            | $T_A = 85\text{ }^{\circ}\text{C}$ |      |
| $I_{DD}$ | Supply current in Run mode | External clock <sup>(2)</sup> , all peripherals enabled | 36 MHz     | 37                                 | mA   |
|          |                            |                                                         | 24 MHz     | 26.5                               |      |
|          |                            |                                                         | 16 MHz     | 19                                 |      |
|          |                            |                                                         | 8 MHz      | 11.5                               |      |
|          |                            | External clock <sup>(2)</sup> all peripherals disabled  | 36 MHz     | 20.5                               |      |
|          |                            |                                                         | 24 MHz     | 15                                 |      |
|          |                            |                                                         | 16 MHz     | 11                                 |      |
|          |                            |                                                         | 8 MHz      | 7.5                                |      |

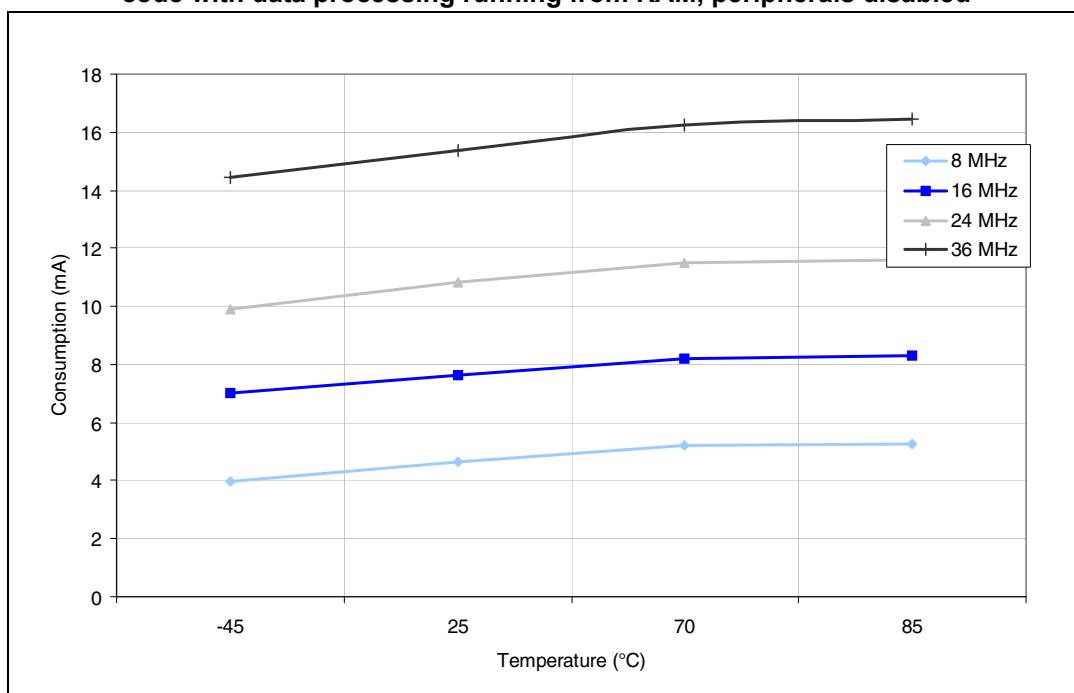
1. Guaranteed by characterization results, tested in production at  $V_{DD}\text{ max}$ ,  $f_{HCLK}\text{ max}$ .

2. External clock is 8 MHz and PLL is on when  $f_{HCLK} > 8\text{ MHz}$ .

**Figure 11. Typical current consumption in Run mode versus frequency (at 3.6 V) - code with data processing running from RAM, peripherals enabled**



**Figure 12. Typical current consumption in Run mode versus frequency (at 3.6 V) - code with data processing running from RAM, peripherals disabled**



**Table 16. Maximum current consumption in Sleep mode, code running from Flash or RAM**

| Symbol          | Parameter                    | Conditions                                               | f <sub>HCLK</sub> | Max <sup>(1)</sup>     | Unit |
|-----------------|------------------------------|----------------------------------------------------------|-------------------|------------------------|------|
|                 |                              |                                                          |                   | T <sub>A</sub> = 85 °C |      |
| I <sub>DD</sub> | Supply current in Sleep mode | External clock <sup>(2)</sup> all peripherals enabled    | 36 MHz            | 27.5                   | mA   |
|                 |                              |                                                          | 24 MHz            | 20                     |      |
|                 |                              |                                                          | 16 MHz            | 15                     |      |
|                 |                              |                                                          | 8 MHz             | 9                      |      |
|                 |                              | External clock <sup>(2)</sup> , all peripherals disabled | 36 MHz            | 6.9                    |      |
|                 |                              |                                                          | 24 MHz            | 5.9                    |      |
|                 |                              |                                                          | 16 MHz            | 5.4                    |      |
|                 |                              |                                                          | 8 MHz             | 4.7                    |      |

1. Guaranteed by characterization results, tested in production at V<sub>DD</sub> max, f<sub>HCLK</sub> max with peripherals enabled.

2. External clock is 8 MHz and PLL is on when f<sub>HCLK</sub> > 8 MHz.

**Table 17. Typical and maximum current consumptions in Stop and Standby modes**

| Symbol          | Parameter                      | Conditions                                                                                                                            | Typ <sup>(1)</sup>                               |                                                  |                                                  | Max                       | Unit |
|-----------------|--------------------------------|---------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------|--------------------------------------------------|--------------------------------------------------|---------------------------|------|
|                 |                                |                                                                                                                                       | V <sub>DD</sub> /<br>V <sub>BAT</sub> =<br>2.0 V | V <sub>DD</sub> /<br>V <sub>BAT</sub> =<br>2.4 V | V <sub>DD</sub> /V <sub>BA</sub><br>T<br>= 3.3 V | T <sub>A</sub> =<br>85 °C |      |
| I <sub>DD</sub> | Supply current in Stop mode    | Regulator in Run mode, Low-speed and high-speed internal RC oscillators and high-speed oscillator OFF (no independent watchdog)       | -                                                | 34.5                                             | 35                                               | 379                       | μA   |
|                 |                                | Regulator in Low-power mode, Low-speed and high-speed internal RC oscillators and high-speed oscillator OFF (no independent watchdog) | -                                                | 24.5                                             | 25                                               | 365                       |      |
|                 | Supply current in Standby mode | Low-speed internal RC oscillator and independent watchdog ON                                                                          | -                                                | 3                                                | 3.8                                              | -                         |      |
|                 |                                | Low-speed internal RC oscillator ON, independent watchdog OFF                                                                         | -                                                | 2.8                                              | 3.6                                              | -                         |      |
|                 |                                | Low-speed internal RC oscillator and independent watchdog OFF, low-speed oscillator and RTC OFF                                       | -                                                | 1.9                                              | 2.1                                              | 5 <sup>(2)</sup>          |      |
|                 | I <sub>DD_VBAT</sub>           | Backup domain supply current                                                                                                          | 1.05                                             | 1.1                                              | 1.4                                              | 2 <sup>(2)</sup>          |      |

1. Typical values are measured at T<sub>A</sub> = 25 °C.

2. Guaranteed by characterization results.

Figure 13. Typical current consumption on  $V_{BAT}$  with RTC on vs. temperature at different  $V_{BAT}$  values

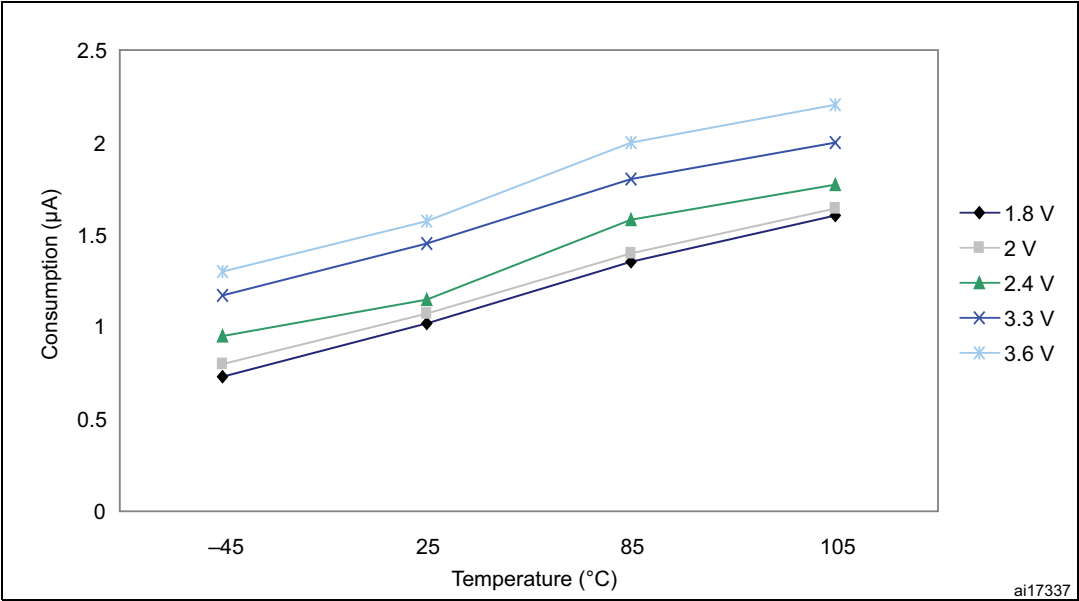
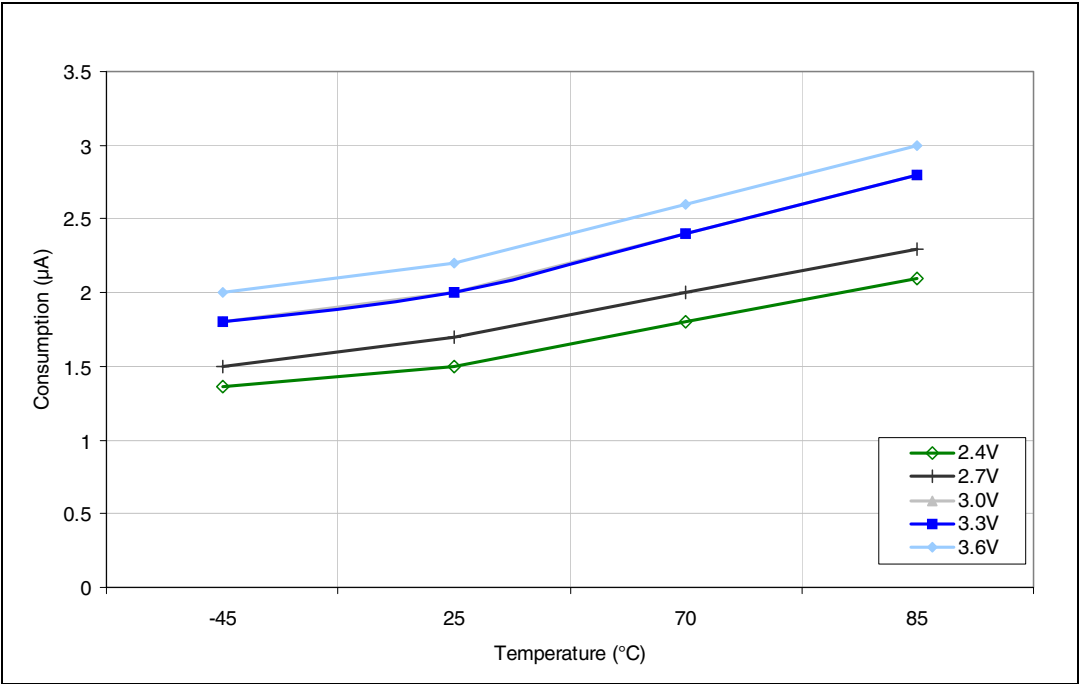


Figure 14. Typical current consumption in Standby mode versus temperature at different  $V_{DD}$  values



### Typical current consumption

The MCU is placed under the following conditions:

- All I/O pins are in input mode with a static value at  $V_{DD}$  or  $V_{SS}$  (no load)
- All peripherals are disabled except if it is explicitly mentioned
- The Flash access time is adjusted to  $f_{HCLK}$  frequency (0 wait state from 0 to 24 MHz, 1 wait state from 24 to 36 MHz)
- Prefetch is on (reminder: this bit must be set before clock setting and bus prescaling)
- When the peripherals are enabled  $f_{PCLK1} = f_{HCLK}/4$ ,  $f_{PCLK2} = f_{HCLK}/2$ ,  $f_{ADCCLK} = f_{PCLK2}/4$
- When the peripherals are enabled  $f_{PCLK1} = f_{HCLK}$ ,  $f_{PCLK2} = f_{HCLK}$ ,  $f_{ADCCLK} = f_{PCLK2}/2$

The parameters given in [Table 18](#) are derived from tests performed under ambient temperature and  $V_{DD}$  supply voltage conditions summarized in [Table 10](#).

**Table 18. Typical current consumption in Run mode, code with data processing running from Flash**

| Symbol   | Parameter                  | Conditions                                                                          | $f_{HCLK}$ | Typ <sup>(1)</sup>                     | Typ <sup>(1)</sup>       | Unit |
|----------|----------------------------|-------------------------------------------------------------------------------------|------------|----------------------------------------|--------------------------|------|
|          |                            |                                                                                     |            | All peripherals enabled <sup>(2)</sup> | All peripherals disabled |      |
| $I_{DD}$ | Supply current in Run mode | External clock <sup>(3)</sup>                                                       | 36 MHz     | 28.5                                   | 18.7                     | mA   |
|          |                            |                                                                                     | 24 MHz     | 24.1                                   | 12.8                     |      |
|          |                            |                                                                                     | 16 MHz     | 14                                     | 9.2                      |      |
|          |                            |                                                                                     | 8 MHz      | 7.7                                    | 5.4                      |      |
|          |                            |                                                                                     | 4 MHz      | 4.6                                    | 3.4                      |      |
|          |                            |                                                                                     | 2 MHz      | 3                                      | 2.3                      |      |
|          |                            |                                                                                     | 1 MHz      | 2.2                                    | 1.8                      |      |
|          |                            |                                                                                     | 500 kHz    | 1.7                                    | 1.5                      |      |
|          |                            |                                                                                     | 125 kHz    | 1.4                                    | 1.3                      |      |
|          |                            | Running on high speed internal RC (HSI), AHB prescaler used to reduce the frequency | 36 MHz     | 27.5                                   | 17.5                     |      |
|          |                            |                                                                                     | 24 MHz     | 18.9                                   | 11.6                     |      |
|          |                            |                                                                                     | 16 MHz     | 12.2                                   | 8.2                      |      |
|          |                            |                                                                                     | 8 MHz      | 7.2                                    | 4.8                      |      |
|          |                            |                                                                                     | 4 MHz      | 4                                      | 2.7                      |      |
|          |                            |                                                                                     | 2 MHz      | 2.3                                    | 1.7                      |      |
|          |                            |                                                                                     | 1 MHz      | 1.5                                    | 1.2                      |      |
|          |                            |                                                                                     | 500 kHz    | 1.1                                    | 0.9                      |      |
|          |                            |                                                                                     | 125 kHz    | 0.75                                   | 0.7                      |      |

1. Typical values are measures at  $T_A = 25\text{ }^{\circ}\text{C}$ ,  $V_{DD} = 3.3\text{ V}$ .

2. Add an additional power consumption of 0.8 mA per ADC for the analog part. In applications, this consumption occurs only while the ADC is on (ADON bit is set in the ADC\_CR2 register).

3. External clock is 8 MHz and PLL is on when  $f_{HCLK} > 8\text{ MHz}$ .

**Table 19. Typical current consumption in Sleep mode, code running from Flash or RAM**

| Symbol          | Parameter                    | Conditions                                                                          | f <sub>HCLK</sub> | Typ <sup>(1)</sup>                     | Typ <sup>(1)</sup>       | Unit |
|-----------------|------------------------------|-------------------------------------------------------------------------------------|-------------------|----------------------------------------|--------------------------|------|
|                 |                              |                                                                                     |                   | All peripherals enabled <sup>(2)</sup> | All peripherals disabled |      |
| I <sub>DD</sub> | Supply current in Sleep mode | External clock <sup>(3)</sup>                                                       | 36 MHz            | 17.7                                   | 4                        | mA   |
|                 |                              |                                                                                     | 24 MHz            | 12.2                                   | 3.1                      |      |
|                 |                              |                                                                                     | 16 MHz            | 8.4                                    | 2.3                      |      |
|                 |                              |                                                                                     | 8 MHz             | 4.6                                    | 1.5                      |      |
|                 |                              |                                                                                     | 4 MHz             | 3                                      | 1.3                      |      |
|                 |                              |                                                                                     | 2 MHz             | 2.15                                   | 1.25                     |      |
|                 |                              |                                                                                     | 1 MHz             | 1.7                                    | 1.2                      |      |
|                 |                              |                                                                                     | 500 kHz           | 1.5                                    | 1.15                     |      |
|                 |                              |                                                                                     | 125 kHz           | 1.35                                   | 1.15                     |      |
|                 |                              | Running on High Speed Internal RC (HSI), AHB prescaler used to reduce the frequency | 36 MHz            | 17                                     | 3.35                     |      |
|                 |                              |                                                                                     | 24 MHz            | 11.6                                   | 2.3                      |      |
|                 |                              |                                                                                     | 16 MHz            | 7.7                                    | 1.6                      |      |
|                 |                              |                                                                                     | 8 MHz             | 3.9                                    | 0.8                      |      |
|                 |                              |                                                                                     | 4 MHz             | 2.3                                    | 0.7                      |      |
|                 |                              |                                                                                     | 2 MHz             | 1.5                                    | 0.6                      |      |
|                 |                              |                                                                                     | 1 MHz             | 1.1                                    | 0.5                      |      |
|                 |                              |                                                                                     | 500 kHz           | 0.9                                    | 0.5                      |      |
|                 |                              |                                                                                     | 125 kHz           | 0.7                                    | 0.5                      |      |

1. Typical values are measures at T<sub>A</sub> = 25 °C, V<sub>DD</sub> = 3.3 V.

2. Add an additional power consumption of 0.8 mA per ADC for the analog part. In applications, this consumption occurs only while the ADC is on (ADON bit is set in the ADC\_CR2 register).

3. External clock is 8 MHz and PLL is on when f<sub>HCLK</sub> > 8 MHz.

### On-chip peripheral current consumption

The current consumption of the on-chip peripherals is given in [Table 20](#). The MCU is placed under the following conditions:

- all I/O pins are in input mode with a static value at V<sub>DD</sub> or V<sub>SS</sub> (no load)
- all peripherals are disabled unless otherwise mentioned
- the given value is calculated by measuring the current consumption
  - with all peripherals clocked off
  - with only one peripheral clocked on
- ambient operating temperature and V<sub>DD</sub> supply voltage conditions summarized in [Table 7](#).

Table 20. Peripheral current consumption<sup>(1)</sup>

| Peripherals         |                          | μA/MHz |
|---------------------|--------------------------|--------|
| AHB (up to 36MHz)   | DMA1                     | 23.06  |
|                     | DMA2                     | 18.47  |
|                     | FSMC                     | 55.14  |
|                     | CRC                      | 2.08   |
|                     | BusMatrix <sup>(2)</sup> | 11.67  |
| APB1 (up to 18 MHz) | APB1-Bridge              | 8.61   |
|                     | TIM2                     | 37.22  |
|                     | TIM3                     | 36.39  |
|                     | TIM4                     | 35.56  |
|                     | TIM5                     | 33.61  |
|                     | TIM6                     | 7.78   |
|                     | TIM7                     | 7.78   |
|                     | TIM12                    | 19.17  |
|                     | TIM13                    | 12.22  |
|                     | TIM14                    | 13.33  |
|                     | SPI2/I2S2 <sup>(3)</sup> | 8.33   |
|                     | SPI3/I2S3 <sup>(3)</sup> | 8.33   |
|                     | USART2                   | 12.22  |
|                     | USART3                   | 12.22  |
|                     | UART4                    | 12.22  |
|                     | UART5                    | 12.22  |
|                     | I2C1                     | 10.28  |
|                     | I2C2                     | 10.28  |
|                     | DAC <sup>(4)</sup>       | 9.17   |
|                     | WWDG                     | 3.06   |
|                     | PWR                      | 2.50   |
|                     | BKP                      | 2.78   |
|                     | IWDG                     | 4.44   |

Table 20. Peripheral current consumption<sup>(1)</sup> (continued)

| Peripherals        |                        | $\mu\text{A}/\text{MHz}$ |
|--------------------|------------------------|--------------------------|
| APB2 (up to 36MHz) | APB2-Bridge            | 2.78                     |
|                    | GPIOA                  | 7.64                     |
|                    | GPIOB                  | 7.64                     |
|                    | GPIOC                  | 7.64                     |
|                    | GIOD                   | 8.47                     |
|                    | GPIOE                  | 8.47                     |
|                    | GPIOF                  | 8.19                     |
|                    | GPIOG                  | 8.19                     |
|                    | SPI1                   | 5.14                     |
|                    | USART1                 | 16.67                    |
|                    | TIM9                   | 11.81                    |
|                    | TIM10                  | 8.47                     |
|                    | TIM11                  | 8.47                     |
|                    | ADC1 <sup>(5)(6)</sup> | 17.68                    |

1.  $f_{\text{HCLK}} = 36 \text{ MHz}$ ,  $f_{\text{APB1}} = f_{\text{HCLK}}/2$ ,  $f_{\text{APB2}} = f_{\text{HCLK}}$ , default prescaler value for each peripheral.
2. The BusMatrix is automatically active when at least one master peripheral is ON.
3. When the I2S is enabled, a current consumption of 0.02 mA must be added.
4. When DAC\_OUT1 or DAC\_OUT2 is enabled, a current consumption of 0.36 mA must be added.
5. Specific conditions for ADC:  $f_{\text{HCLK}} = 28 \text{ MHz}$ ,  $f_{\text{APB1}} = f_{\text{HCLK}}/2$ ,  $f_{\text{APB2}} = f_{\text{HCLK}}$ ,  $f_{\text{ADCCLK}} = f_{\text{APB2}}/2$ . When ADON bit in the ADC\_CR2 register is set to 1, the current consumption is equal to 0.59 mA.
6. When the ADC is enabled, a current consumption of 0,1 mA must be added.

### 5.3.6 External clock source characteristics

#### High-speed external user clock generated from an external source

The characteristics given in [Table 21](#) result from tests performed using an high-speed external clock source, and under ambient temperature and supply voltage conditions summarized in [Table 10](#).

Table 21. High-speed external user clock characteristics

| Symbol                       | Parameter                                           | Conditions                       | Min         | Typ | Max         | Unit    |
|------------------------------|-----------------------------------------------------|----------------------------------|-------------|-----|-------------|---------|
| $f_{HSE\_ext}$               | User external clock source frequency <sup>(1)</sup> | -                                | 1           | 8   | 25          | MHz     |
| $V_{HSEH}$                   | OSC_IN input pin high level voltage                 |                                  | $0.7V_{DD}$ | -   | $V_{DD}$    | V       |
| $V_{HSEL}$                   | OSC_IN input pin low level voltage                  |                                  | $V_{SS}$    | -   | $0.3V_{DD}$ |         |
| $t_{w(HSE)}$<br>$t_{w(HSE)}$ | OSC_IN high or low time <sup>(1)</sup>              |                                  | 5           | -   | -           | ns      |
| $t_{r(HSE)}$<br>$t_{f(HSE)}$ | OSC_IN rise or fall time <sup>(1)</sup>             |                                  | -           | -   | 20          |         |
| $C_{in(HSE)}$                | OSC_IN input capacitance <sup>(1)</sup>             | -                                | -           | 5   | -           | pF      |
| $DuCy_{(HSE)}$               | Duty cycle                                          | -                                | 45          | -   | 55          | %       |
| $I_L$                        | OSC_IN Input leakage current                        | $V_{SS} \leq V_{IN} \leq V_{DD}$ | -           | -   | $\pm 1$     | $\mu A$ |

1. Guaranteed by design.

### Low-speed external user clock generated from an external source

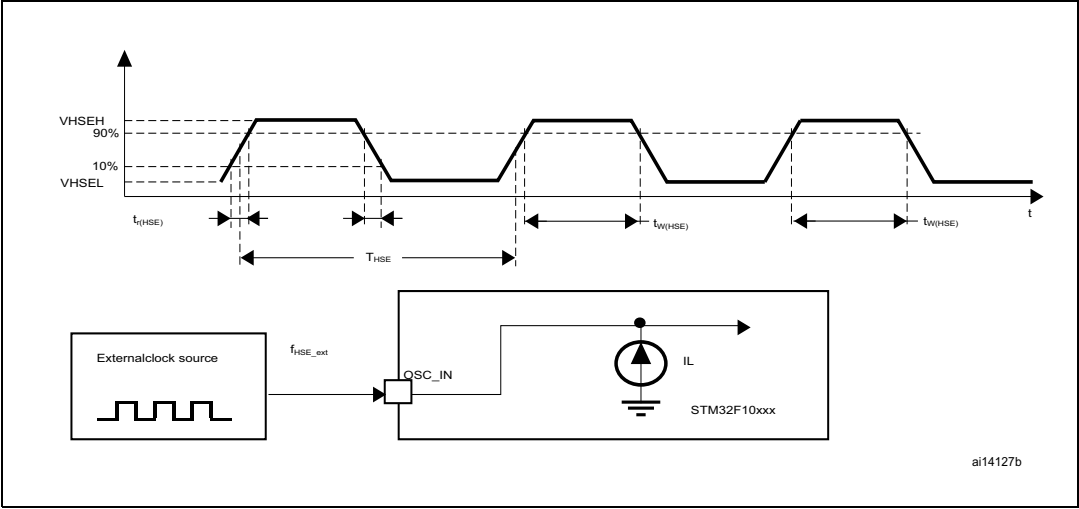
The characteristics given in [Table 22](#) result from tests performed using an low-speed external clock source, and under ambient temperature and supply voltage conditions summarized in [Table 10](#).

Table 22. Low-speed user external clock characteristics

| Symbol                       | Parameter                                           | Conditions                       | Min         | Typ    | Max         | Unit    |
|------------------------------|-----------------------------------------------------|----------------------------------|-------------|--------|-------------|---------|
| $f_{LSE\_ext}$               | User external clock source frequency <sup>(1)</sup> | -                                | -           | 32.768 | 1000        | kHz     |
| $V_{LSEH}$                   | OSC32_IN input pin high level voltage               | -                                | $0.7V_{DD}$ | -      | $V_{DD}$    | V       |
| $V_{LSEL}$                   | OSC32_IN input pin low level voltage                | -                                | $V_{SS}$    | -      | $0.3V_{DD}$ |         |
| $t_{w(LSE)}$<br>$t_{w(LSE)}$ | OSC32_IN high or low time <sup>(1)</sup>            | -                                | 450         | -      | -           | ns      |
| $t_{r(LSE)}$<br>$t_{f(LSE)}$ | OSC32_IN rise or fall time <sup>(1)</sup>           | -                                | -           | -      | 50          |         |
| $C_{in(LSE)}$                | OSC32_IN input capacitance <sup>(1)</sup>           | -                                | -           | 5      | -           | pF      |
| $DuCy_{(LSE)}$               | Duty cycle                                          | -                                | 30          | -      | 70          | %       |
| $I_L$                        | OSC32_IN Input leakage current                      | $V_{SS} \leq V_{IN} \leq V_{DD}$ | -           | -      | $\pm 1$     | $\mu A$ |

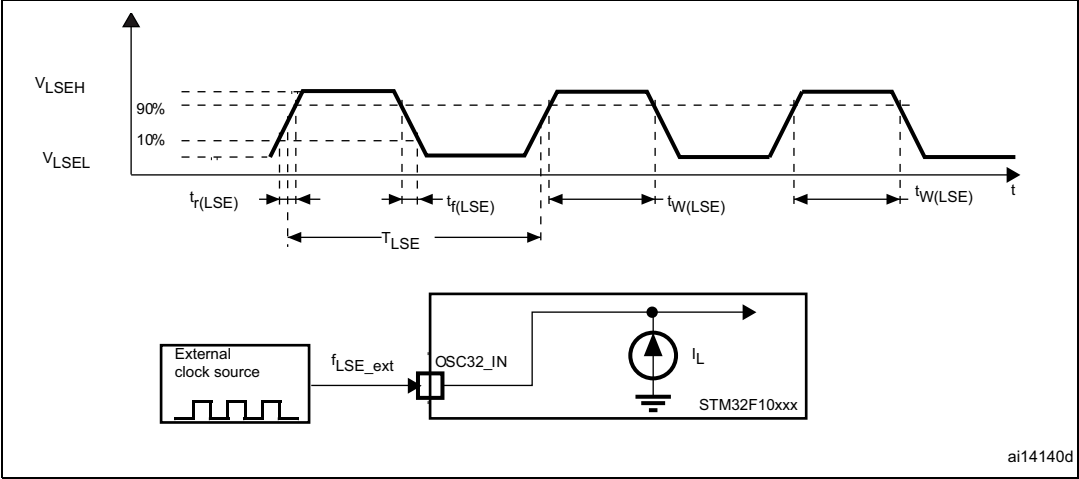
1. Guaranteed by design.

Figure 15. High-speed external clock source AC timing diagram



ai14127b

Figure 16. Low-speed external clock source AC timing diagram



ai14140d

### High-speed external clock generated from a crystal/ceramic resonator

The high-speed external (HSE) clock can be supplied with a 4 to 16 MHz crystal/ceramic resonator oscillator. All the information given in this paragraph are based on characterization results obtained with typical external components specified in [Table 23](#). In the application, the resonator and the load capacitors have to be placed as close as possible to the oscillator pins in order to minimize output distortion and startup stabilization time. Refer to the crystal resonator manufacturer for more details on the resonator characteristics (frequency, package, accuracy).

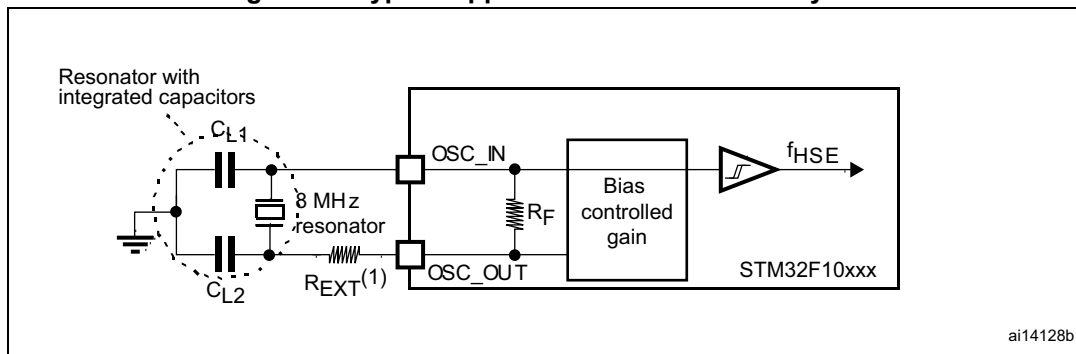
**Table 23. HSE 4-16 MHz oscillator characteristics<sup>(1)(2)</sup>**

| Symbol                       | Parameter                                                                                                | Conditions                                            | Min | Typ | Max | Unit       |
|------------------------------|----------------------------------------------------------------------------------------------------------|-------------------------------------------------------|-----|-----|-----|------------|
| $f_{OSC\_IN}$                | Oscillator frequency                                                                                     | -                                                     | 4   | 8   | 16  | MHz        |
| $R_F$                        | Feedback resistor                                                                                        | -                                                     | -   | 200 | -   | k $\Omega$ |
| C                            | Recommended load capacitance versus equivalent serial resistance of the crystal ( $R_S$ ) <sup>(3)</sup> | $R_S = 30 \Omega$                                     | -   | 30  | -   | pF         |
| $i_2$                        | HSE driving current                                                                                      | $V_{DD} = 3.3 V$<br>$V_{IN} = V_{SS}$ with 30 pF load | -   | -   | 1   | mA         |
| $g_m$                        | Oscillator transconductance                                                                              | Startup                                               | 25  | -   | -   | mA/V       |
| $t_{SU(HSE)}$ <sup>(4)</sup> | Startup time                                                                                             | $V_{DD}$ is stabilized                                | -   | 2   | -   | ms         |

1. Resonator characteristics given by the crystal/ceramic resonator manufacturer.
2. Guaranteed by characterization results.
3. The relatively low value of the RF resistor offers a good protection against issues resulting from use in a humid environment, due to the induced leakage and the bias condition change. However, it is recommended to take this point into account if the MCU is used in tough humidity conditions.
4.  $t_{SU(HSE)}$  is the startup time measured from the moment it is enabled (by software) to a stabilized 8 MHz oscillation is reached. This value is measured for a standard crystal resonator and it can vary significantly with the crystal manufacturer

For  $C_{L1}$  and  $C_{L2}$ , it is recommended to use high-quality external ceramic capacitors in the 5 pF to 25 pF range (typ.), designed for high-frequency applications, and selected to match the requirements of the crystal or resonator (see [Figure 17](#)).  $C_{L1}$  and  $C_{L2}$  are usually the same size. The crystal manufacturer typically specifies a load capacitance which is the series combination of  $C_{L1}$  and  $C_{L2}$ . PCB and MCU pin capacitance must be included (10 pF can be used as a rough estimate of the combined pin and board capacitance) when sizing  $C_{L1}$  and  $C_{L2}$ . Refer to the application note AN2867 "Oscillator design guide for ST microcontrollers" available from the ST website [www.st.com](http://www.st.com).

Figure 17. Typical application with an 8 MHz crystal



1.  $R_{EXT}$  value depends on the crystal characteristics.

### Low-speed external clock generated from a crystal/ceramic resonator

The low-speed external (LSE) clock can be supplied with a 32.768 kHz crystal/ceramic resonator oscillator. All the information given in this paragraph are based on characterization results obtained with typical external components specified in [Table 24](#). In the application, the resonator and the load capacitors have to be placed as close as possible to the oscillator pins in order to minimize output distortion and startup stabilization time. Refer to the crystal resonator manufacturer for more details on the resonator characteristics (frequency, package, accuracy).

**Table 24. LSE oscillator characteristics ( $f_{LSE} = 32.768 \text{ kHz}$ )<sup>(1) (2)</sup>**

| Symbol              | Parameter                                                                                 | Conditions                                    |                                    | Min | Typ | Max | Unit            |
|---------------------|-------------------------------------------------------------------------------------------|-----------------------------------------------|------------------------------------|-----|-----|-----|-----------------|
| $R_F$               | Feedback resistor                                                                         | -                                             | -                                  | -   | 5   | -   | M $\Omega$      |
| C                   | Recommended load capacitance versus equivalent serial resistance of the crystal ( $R_S$ ) | $R_S = 30 \text{ K}\Omega$                    | -                                  | -   | -   | 15  | pF              |
| $I_2$               | LSE driving current                                                                       | $V_{DD} = 3.3 \text{ V}$<br>$V_{IN} = V_{SS}$ | -                                  | -   | -   | 1.4 | $\mu\text{A}$   |
| $g_m$               | Oscillator transconductance                                                               | -                                             | -                                  | 5   | -   | -   | $\mu\text{A/V}$ |
| $t_{SU(LSE)}^{(3)}$ | Startup time                                                                              | $V_{DD}$ is stabilized                        | $T_A = 50 \text{ }^\circ\text{C}$  | -   | 1.5 | -   | s               |
|                     |                                                                                           |                                               | $T_A = 25 \text{ }^\circ\text{C}$  | -   | 2.5 | -   |                 |
|                     |                                                                                           |                                               | $T_A = 10 \text{ }^\circ\text{C}$  | -   | 4   | -   |                 |
|                     |                                                                                           |                                               | $T_A = 0 \text{ }^\circ\text{C}$   | -   | 6   | -   |                 |
|                     |                                                                                           |                                               | $T_A = -10 \text{ }^\circ\text{C}$ | -   | 10  | -   |                 |
|                     |                                                                                           |                                               | $T_A = -20 \text{ }^\circ\text{C}$ | -   | 17  | -   |                 |
|                     |                                                                                           |                                               | $T_A = -30 \text{ }^\circ\text{C}$ | -   | 32  | -   |                 |
|                     |                                                                                           |                                               | $T_A = -40 \text{ }^\circ\text{C}$ | -   | 60  | -   |                 |

1. Guaranteed by characterization results.

2. Refer to the note and caution paragraphs below the table, and to the application note AN2867 "Oscillator design guide for ST microcontrollers".

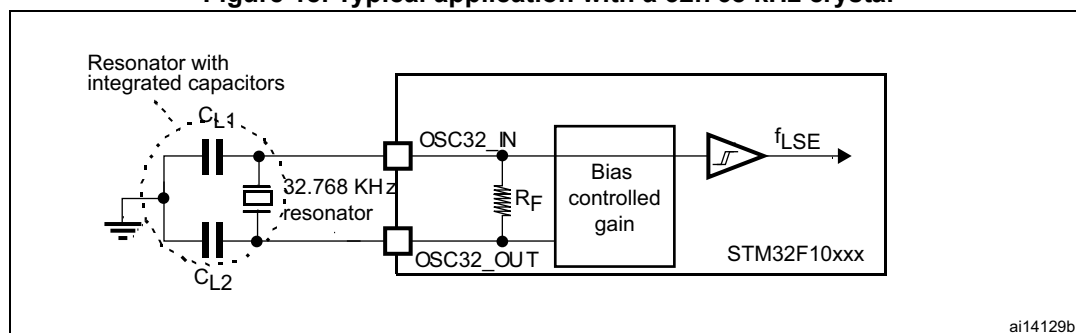
3.  $t_{SU(LSE)}$  is the startup time measured from the moment it is enabled (by software) to a stabilized 32.768 kHz oscillation is reached. This value is measured for a standard crystal and it can vary significantly with the crystal manufacturer

**Note:** For  $C_{L1}$  and  $C_{L2}$ , it is recommended to use high-quality ceramic capacitors in the 5 pF to 15 pF range selected to match the requirements of the crystal or resonator.  $C_{L1}$  and  $C_{L2}$  are usually the same size. The crystal manufacturer typically specifies a load capacitance which is the series combination of  $C_{L1}$  and  $C_{L2}$ . Load capacitance  $C_L$  has the following formula:  $C_L = C_{L1} \times C_{L2} / (C_{L1} + C_{L2}) + C_{stray}$  where  $C_{stray}$  is the pin capacitance and board or trace PCB-related capacitance. Typically, it is between 2 pF and 7 pF.

**Caution:** To avoid exceeding the maximum value of  $C_{L1}$  and  $C_{L2}$  (15 pF) it is strongly recommended to use a resonator with a load capacitance  $C_L \leq 7$  pF. Never use a resonator with a load capacitance of 12.5 pF.

**Example:** if you choose a resonator with a load capacitance of  $C_L = 6$  pF, and  $C_{stray} = 2$  pF, then  $C_{L1} = C_{L2} = 8$  pF.

**Figure 18. Typical application with a 32.768 kHz crystal**



### 5.3.7 Internal clock source characteristics

The parameters given in [Table 25](#) are derived from tests performed under ambient temperature and  $V_{DD}$  supply voltage conditions summarized in [Table 10](#).

#### High-speed internal (HSI) RC oscillator

**Table 25. HSI oscillator characteristics<sup>(1)</sup>**

| Symbol                              | Parameter                        | Conditions                                           |                                | Min  | Typ | Max              | Unit |
|-------------------------------------|----------------------------------|------------------------------------------------------|--------------------------------|------|-----|------------------|------|
| f <sub>HSI</sub>                    | Frequency                        | -                                                    |                                | -    | 8   | -                | MHz  |
| DuCy <sub>(HSI)</sub>               | Duty cycle                       | -                                                    |                                | 45   | -   | 55               | %    |
| ACC <sub>HSI</sub>                  | Accuracy of the HSI oscillator   | User-trimmed with the RCC_CR register <sup>(2)</sup> |                                | -    | -   | 1 <sup>(3)</sup> | %    |
|                                     |                                  | Factory-calibrated <sup>(4)</sup>                    | T <sub>A</sub> = −40 to 105 °C | −2   | -   | 2.5              | %    |
|                                     |                                  |                                                      | T <sub>A</sub> = −10 to 85 °C  | −1.5 | -   | 2.2              | %    |
|                                     |                                  |                                                      | T <sub>A</sub> = 0 to 70 °C    | −1.3 | -   | 2                | %    |
|                                     |                                  |                                                      | T <sub>A</sub> = 25 °C         | −1.1 | -   | 1.8              | %    |
| t <sub>su(HSI)</sub> <sup>(4)</sup> | HSI oscillator startup time      | -                                                    |                                | 1    | -   | 2                | μs   |
| I <sub>DD(HSI)</sub> <sup>(4)</sup> | HSI oscillator power consumption | -                                                    |                                | -    | 80  | 100              | μA   |

1.  $V_{DD} = 3.3$  V,  $T_A = -40$  to  $85$  °C unless otherwise specified.

2. Refer to application note AN2868 "STM32F10xxx internal RC oscillator (HSI) calibration" available from the ST website [www.st.com](http://www.st.com)
3. Guaranteed by design.
4. Guaranteed by characterization results.

### Low-speed internal (LSI) RC oscillator

**Table 26. LSI oscillator characteristics <sup>(1)</sup>**

| Symbol              | Parameter                        | Min | Typ  | Max | Unit    |
|---------------------|----------------------------------|-----|------|-----|---------|
| $f_{LSI}^{(2)}$     | Frequency                        | 30  | 40   | 60  | kHz     |
| $t_{su(LSI)}^{(3)}$ | LSI oscillator startup time      | -   | -    | 85  | $\mu s$ |
| $I_{DD(LSI)}^{(3)}$ | LSI oscillator power consumption | -   | 0.65 | 1.2 | $\mu A$ |

1.  $V_{DD} = 3 V$ ,  $T_A = -40$  to  $85$  °C unless otherwise specified.
2. Guaranteed by characterization results.
3. Guaranteed by design.

### Wakeup time from low-power mode

The wakeup times given in [Table 27](#) are measured on a wakeup phase with an 8-MHz HSI RC oscillator. The clock source used to wake up the device depends from the current operating mode:

- Stop or Standby mode: the clock source is the RC oscillator
- Sleep mode: the clock source is the clock that was set before entering Sleep mode.

All timings are derived from tests performed under ambient temperature and  $V_{DD}$  supply voltage conditions summarized in [Table 10](#).

**Table 27. Low-power mode wakeup timings**

| Symbol              | Parameter                                           | Typ | Unit    |
|---------------------|-----------------------------------------------------|-----|---------|
| $t_{WUSLEEP}^{(1)}$ | Wakeup from Sleep mode                              | 1.8 | $\mu s$ |
| $t_{WUSTOP}^{(1)}$  | Wakeup from Stop mode (regulator in run mode)       | 3.6 | $\mu s$ |
|                     | Wakeup from Stop mode (regulator in low-power mode) | 5.4 |         |
| $t_{WUSTDBY}^{(1)}$ | Wakeup from Standby mode                            | 50  | $\mu s$ |

1. The wakeup times are measured from the wakeup event to the point at which the user application code reads the first instruction.

### 5.3.8 PLL characteristics

The parameters given in [Table 28](#) are derived from tests performed under ambient temperature and  $V_{DD}$  supply voltage conditions summarized in [Table 10](#).

**Table 28. PLL characteristics**

| Symbol         | Parameter                      | Value              |     |                    | Unit |
|----------------|--------------------------------|--------------------|-----|--------------------|------|
|                |                                | Min <sup>(1)</sup> | Typ | Max <sup>(1)</sup> |      |
| $f_{PLL\_IN}$  | PLL input clock <sup>(2)</sup> | 1                  | 8.0 | 25                 | MHz  |
|                | PLL input clock duty cycle     | 40                 | -   | 60                 | %    |
| $f_{PLL\_OUT}$ | PLL multiplier output clock    | 16                 | -   | 36                 | MHz  |
| $t_{LOCK}$     | PLL lock time                  | -                  | -   | 200                | μs   |
| Jitter         | Cycle-to-cycle jitter          | -                  | -   | 300                | ps   |

1. Guaranteed by characterization results.
2. Take care of using the appropriate multiplier factors so as to have PLL input clock values compatible with the range defined by  $f_{PLL\_OUT}$ .

### 5.3.9 Memory characteristics

#### Flash memory

The characteristics are given at  $T_A = -40$  to  $+85$  °C unless otherwise specified.

**Table 29. Flash memory characteristics**

| Symbol      | Parameter               | Conditions                                                           | Min | Typ  | Max <sup>(1)</sup> | Unit |
|-------------|-------------------------|----------------------------------------------------------------------|-----|------|--------------------|------|
| $t_{prog}$  | 16-bit programming time | $T_A = -40$ to $+85$ °C                                              | 40  | 52.5 | 70                 | μs   |
| $t_{ERASE}$ | Page (2 KB) erase time  | $T_A = -40$ to $+85$ °C                                              | 20  | -    | 40                 | ms   |
| $t_{ME}$    | Mass erase time         | $T_A = -40$ to $+85$ °C                                              | 20  | -    | 40                 | ms   |
| $I_{DD}$    | Supply current          | Read mode<br>$f_{HCLK} = 36$ MHz with 1 wait state, $V_{DD} = 3.3$ V | -   | -    | 28                 | mA   |
|             |                         | Write mode<br>$f_{HCLK} = 36$ MHz, $V_{DD} = 3.3$ V                  | -   | -    | 7                  | mA   |
|             |                         | Erase mode<br>$f_{HCLK} = 36$ MHz, $V_{DD} = 3.3$ V                  | -   | -    | 5                  | mA   |
|             |                         | Power-down mode / Halt,<br>$V_{DD} = 3.0$ to $3.6$ V                 | -   | -    | 50                 | μA   |
| $V_{prog}$  | Programming voltage     | -                                                                    | 2   | -    | 3.6                | V    |

1. Guaranteed by design.

Table 30. Flash memory endurance and data retention

| Symbol           | Parameter      | Conditions                                       | Value              | Unit    |
|------------------|----------------|--------------------------------------------------|--------------------|---------|
|                  |                |                                                  | Min <sup>(1)</sup> |         |
| N <sub>END</sub> | Endurance      | T <sub>A</sub> = -40 °C to 85 °C                 | 10                 | kcycles |
| t <sub>RET</sub> | Data retention | T <sub>A</sub> = 85 °C, 1 kcycle <sup>(2)</sup>  | 30                 | Years   |
|                  |                | T <sub>A</sub> = 55 °C, 10 kcycle <sup>(2)</sup> | 20                 |         |

1. Guaranteed by characterization results.

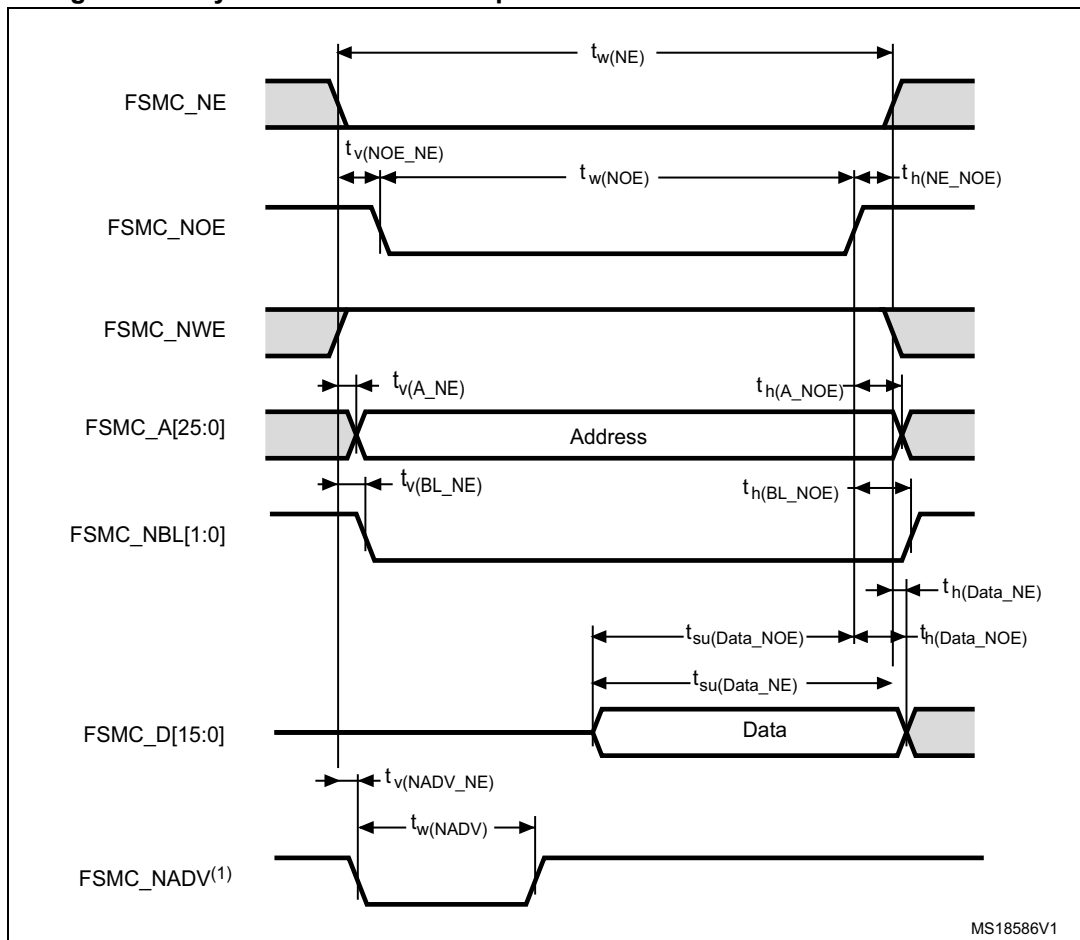
2. Cycling performed over the whole temperature range.

### 5.3.10 FSMC characteristics

#### Asynchronous waveforms and timings

[Figure 19](#) through [Figure 22](#) represent asynchronous waveforms and [Table 31](#) through [Table 34](#) provide the corresponding timings. The results shown in these tables are obtained with the following FSMC configuration:

- AddressSetupTime = 0
- AddressHoldTime = 1
- DataSetupTime = 1

**Figure 19. Asynchronous non-multiplexed SRAM/PSRAM/NOR read waveforms**

1. Mode 2/B, C and D only. In Mode 1, FSMC\_NADV is not used.

**Note:**  $FSMC\_BusTurnAroundDuration = 0$ .

**Table 31. Asynchronous non-multiplexed SRAM/PSRAM/NOR read timings<sup>(1) (2)</sup>**

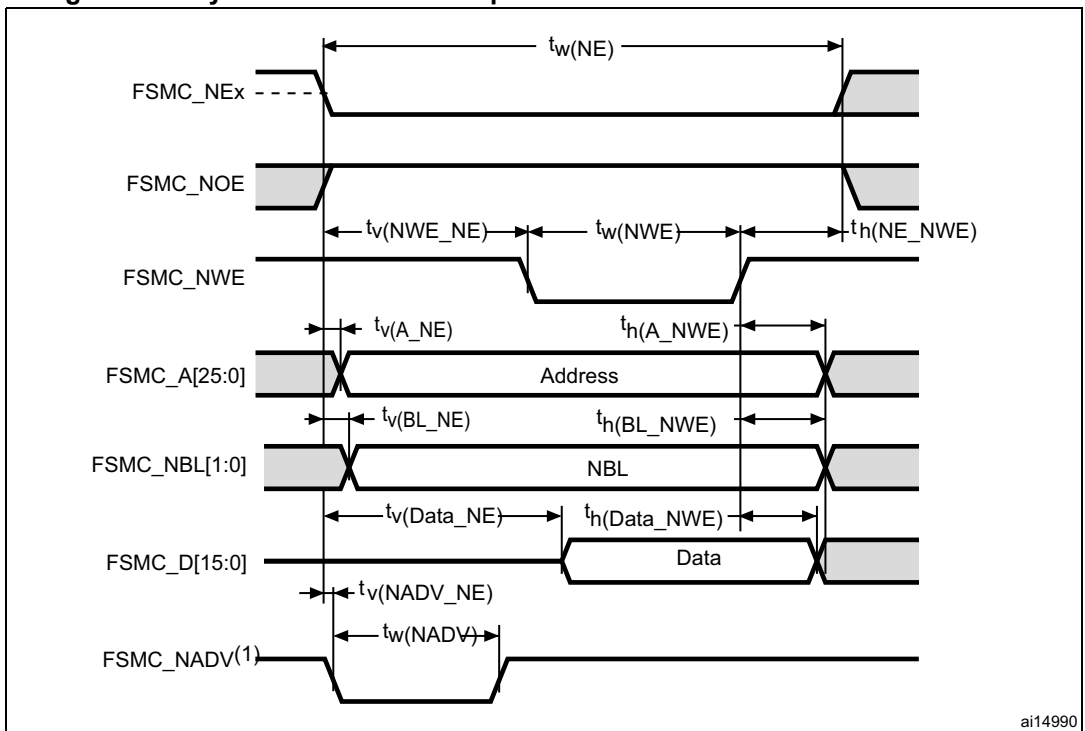
| Symbol              | Parameter                               | Min               | Max             | Unit |
|---------------------|-----------------------------------------|-------------------|-----------------|------|
| $t_{w(NE)}$         | FSMC_NE low time                        | $5t_{HCLK} + 0.5$ | $5t_{HCLK} + 2$ | ns   |
| $t_{v(NOE\_NE)}$    | FSMC_NEx low to FSMC_NOE low            | 0.5               | 1.5             | ns   |
| $t_{w(NOE)}$        | FSMC_NOE low time                       | $5t_{HCLK} - 1$   | $5t_{HCLK} + 1$ | ns   |
| $t_{h(NE\_NOE)}$    | FSMC_NOE high to FSMC_NE high hold time | 0                 | -               | ns   |
| $t_{v(A\_NE)}$      | FSMC_NEx low to FSMC_A valid            | -                 | 3               | ns   |
| $t_{h(A\_NOE)}$     | Address hold time after FSMC_NOE high   | 0                 | -               | ns   |
| $t_{v(BL\_NE)}$     | FSMC_NEx low to FSMC_BL valid           | -                 | 0               | ns   |
| $t_{h(BL\_NOE)}$    | FSMC_BL hold time after FSMC_NOE high   | 0.5               | -               | ns   |
| $t_{su(Data\_NE)}$  | Data to FSMC_NEx high setup time        | $2t_{HCLK} - 1$   | -               | ns   |
| $t_{su(Data\_NOE)}$ | Data to FSMC_NOEx high setup time       | $2t_{HCLK} - 1$   | -               | ns   |
| $t_{h(Data\_NOE)}$  | Data hold time after FSMC_NOE high      | 0                 | -               | ns   |

**Table 31. Asynchronous non-multiplexed SRAM/PSRAM/NOR read timings<sup>(1) (2)</sup>**

| Symbol            | Parameter                          | Min | Max            | Unit |
|-------------------|------------------------------------|-----|----------------|------|
| $t_{h(Data\_NE)}$ | Data hold time after FSMC_NEx high | 0   | -              | ns   |
| $t_{v(NADV\_NE)}$ | FSMC_NEx low to FSMC_NADV low      | -   | 0              | ns   |
| $t_w(NADV)$       | FSMC_NADV low time                 | -   | $t_{HCLK} + 2$ | ns   |

1.  $C_L = 15$  pF.

2. Guaranteed by characterization results.

**Figure 20. Asynchronous non-multiplexed SRAM/PSRAM/NOR write waveforms**

1. Mode 2/B, C and D only. In Mode 1, FSMC\_NADV is not used.

**Table 32. Asynchronous non-multiplexed SRAM/PSRAM/NOR write timings<sup>(1)(2)</sup>**

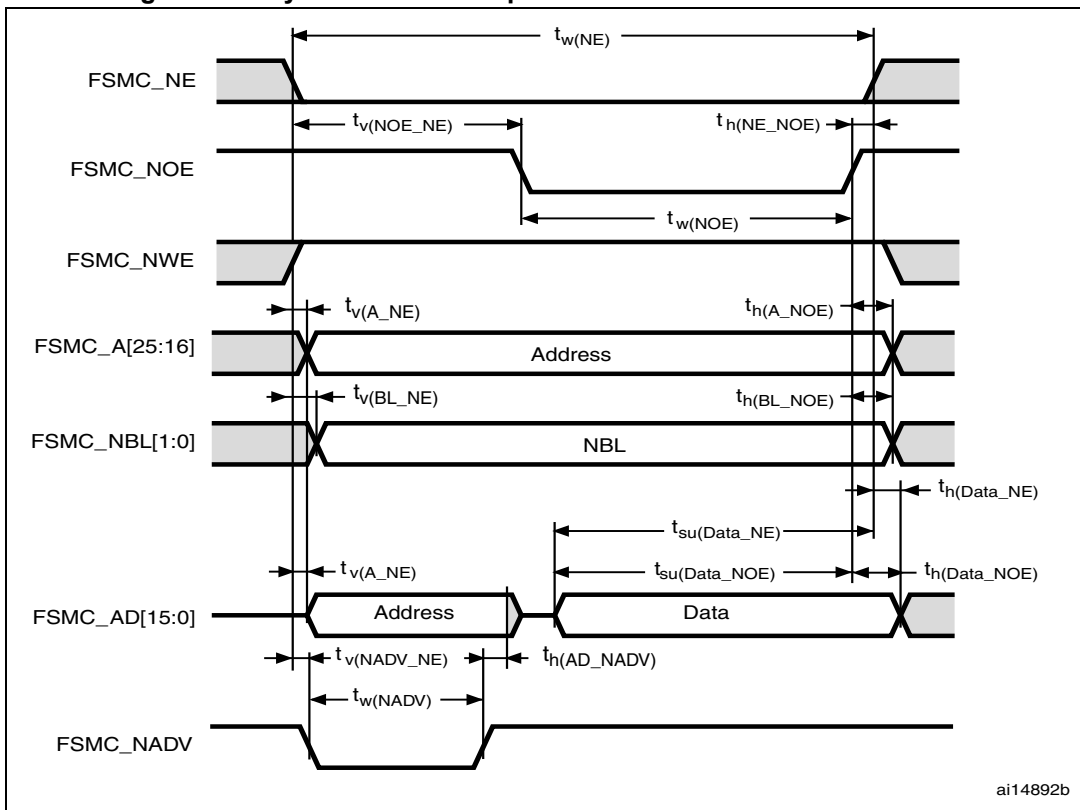
| Symbol            | Parameter                               | Min               | Max               | Unit |
|-------------------|-----------------------------------------|-------------------|-------------------|------|
| $t_w(NE)$         | FSMC_NE low time                        | $3t_{HCLK} + 0.5$ | $3t_{HCLK} + 1.5$ | ns   |
| $t_{v(NWE\_NE)}$  | FSMC_NEx low to FSMC_NWE low            | $t_{HCLK} + 0.5$  | $t_{HCLK} + 1.5$  | ns   |
| $t_w(NWE)$        | FSMC_NWE low time                       | $t_{HCLK} - 0.5$  | $t_{HCLK} + 1$    | ns   |
| $t_h(NE\_NWE)$    | FSMC_NWE high to FSMC_NE high hold time | $t_{HCLK} - 0.5$  | -                 | ns   |
| $t_{v(A\_NE)}$    | FSMC_NEx low to FSMC_A valid            | -                 | 0                 | ns   |
| $t_h(A\_NWE)$     | Address hold time after FSMC_NWE high   | $t_{HCLK}$        | -                 | ns   |
| $t_{v(BL\_NE)}$   | FSMC_NEx low to FSMC_NBL valid          | -                 | 1.5               | ns   |
| $t_h(BL\_NWE)$    | FSMC_NBL hold time after FSMC_NWE high  | $t_{HCLK} - 1.5$  | -                 | ns   |
| $t_{v(Data\_NE)}$ | FSMC_NEx low to Data valid              | -                 | $t_{HCLK}$        | ns   |

**Table 32. Asynchronous non-multiplexed SRAM/PSRAM/NOR write timings<sup>(1)(2)</sup>**

| Symbol             | Parameter                          | Min        | Max              | Unit |
|--------------------|------------------------------------|------------|------------------|------|
| $t_{h(Data\_NWE)}$ | Data hold time after FSMC_NWE high | $t_{HCLK}$ | -                | ns   |
| $t_{v(NADV\_NE)}$  | FSMC_NEx low to FSMC_NADV low      | -          | 0                | ns   |
| $t_{w(NADV)}$      | FSMC_NADV low time                 | -          | $t_{HCLK} + 1.5$ | ns   |

1.  $C_L = 15$  pF.

2. Guaranteed by characterization results.

**Figure 21. Asynchronous multiplexed NOR/PSRAM read waveforms**

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**Table 33. Asynchronous multiplexed NOR/PSRAM read timings<sup>(1)(2)</sup>**

| Symbol            | Parameter                                              | Min               | Max               | Unit |
|-------------------|--------------------------------------------------------|-------------------|-------------------|------|
| $t_{w(NE)}$       | FSMC_NE low time                                       | $7t_{HCLK} + 0.5$ | $7t_{HCLK} + 2$   | ns   |
| $t_{v(NOE\_NE)}$  | FSMC_NEx low to FSMC_NOE low                           | $3t_{HCLK} + 0.5$ | $3t_{HCLK} + 1.5$ | ns   |
| $t_{w(NOE)}$      | FSMC_NOE low time                                      | $4t_{HCLK} - 1$   | $4t_{HCLK} + 1$   | ns   |
| $t_{h(NE\_NOE)}$  | FSMC_NOE high to FSMC_NE high hold time                | 0.5               | -                 | ns   |
| $t_{v(A\_NE)}$    | FSMC_NEx low to FSMC_A valid                           | -                 | 0                 | ns   |
| $t_{v(NADV\_NE)}$ | FSMC_NEx low to FSMC_NADV low                          | 0                 | 1                 | ns   |
| $t_{w(NADV)}$     | FSMC_NADV low time                                     | $t_{HCLK} + 0.5$  | $t_{HCLK} + 2$    | ns   |
| $t_{h(AD\_NADV)}$ | FSMC_AD (address) valid hold time after FSMC_NADV high | $t_{HCLK}$        | -                 | ns   |

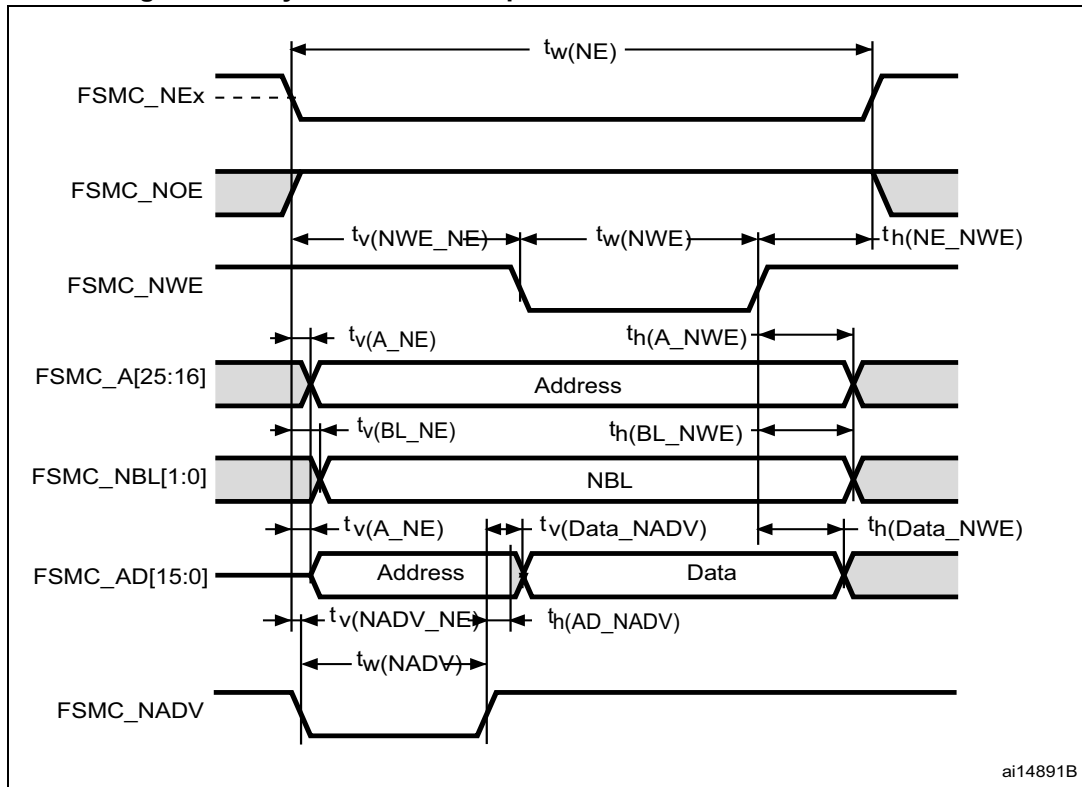
**Table 33. Asynchronous multiplexed NOR/PSRAM read timings<sup>(1)(2)</sup> (continued)**

| Symbol              | Parameter                             | Min               | Max | Unit |
|---------------------|---------------------------------------|-------------------|-----|------|
| $t_{h(A\_NOE)}$     | Address hold time after FSMC_NOE high | $t_{HCLK} - 2$    | -   | ns   |
| $t_{h(BL\_NOE)}$    | FSMC_BL hold time after FSMC_NOE high | 0.5               | -   | ns   |
| $t_{v(BL\_NE)}$     | FSMC_NEx low to FSMC_BL valid         | -                 | 0   | ns   |
| $t_{su(Data\_NE)}$  | Data to FSMC_NEx high setup time      | $4t_{HCLK} - 0.5$ | -   | ns   |
| $t_{su(Data\_NOE)}$ | Data to FSMC_NOE high setup time      | $4t_{HCLK} - 1$   | -   | ns   |
| $t_{h(Data\_NE)}$   | Data hold time after FSMC_NEx high    | 0                 | -   | ns   |
| $t_{h(Data\_NOE)}$  | Data hold time after FSMC_NOE high    | 0                 | -   | ns   |

1.  $C_L = 15$  pF.

2. Guaranteed by characterization results.

Figure 22. Asynchronous multiplexed NOR/PSRAM write waveforms



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Table 34. Asynchronous multiplexed NOR/PSRAM write timings<sup>(1)(2)</sup>

| Symbol              | Parameter                                              | Min               | Max              | Unit |
|---------------------|--------------------------------------------------------|-------------------|------------------|------|
| $t_{w(NE)}$         | FSMC_NEx low time                                      | $5t_{HCLK} + 0.5$ | $5t_{HCLK} + 2$  | ns   |
| $t_{v(NWE\_NE)}$    | FSMC_NEx low to FSMC_NWE low                           | $t_{HCLK} + 1$    | $t_{HCLK} + 1.5$ | ns   |
| $t_{w(NWE)}$        | FSMC_NWE low time                                      | $3t_{HCLK} - 1$   | $3t_{HCLK} + 2$  | ns   |
| $t_{h(NE\_NWE)}$    | FSMC_NWE high to FSMC_NEx high hold time               | $t_{HCLK} - 0.5$  | -                | ns   |
| $t_{v(A\_NE)}$      | FSMC_NEx low to FSMC_A valid                           | -                 | 3.5              | ns   |
| $t_{v(NADV\_NE)}$   | FSMC_NEx low to FSMC_NADV low                          | 0                 | 1                | ns   |
| $t_{w(NADV)}$       | FSMC_NADV low time                                     | $t_{HCLK} + 0.5$  | $t_{HCLK} + 1.5$ | ns   |
| $t_{h(AD\_NADV)}$   | FSMC_AD (address) valid hold time after FSMC_NADV high | $t_{HCLK} - 0.5$  | -                | ns   |
| $t_{h(A\_NWE)}$     | Address hold time after FSMC_NWE high                  | $4t_{HCLK} - 2$   | -                | ns   |
| $t_{v(BL\_NE)}$     | FSMC_NEx low to FSMC_NBL valid                         | -                 | 0.5              | ns   |
| $t_{h(BL\_NWE)}$    | FSMC_NBL hold time after FSMC_NWE high                 | $t_{HCLK} - 1.5$  | -                | ns   |
| $t_{v(Data\_NADV)}$ | FSMC_NADV high to Data valid                           | -                 | $t_{HCLK} + 6$   | ns   |
| $t_{h(Data\_NWE)}$  | Data hold time after FSMC_NWE high                     | $t_{HCLK} - 0.5$  | -                | ns   |

1.  $C_L = 15$  pF.

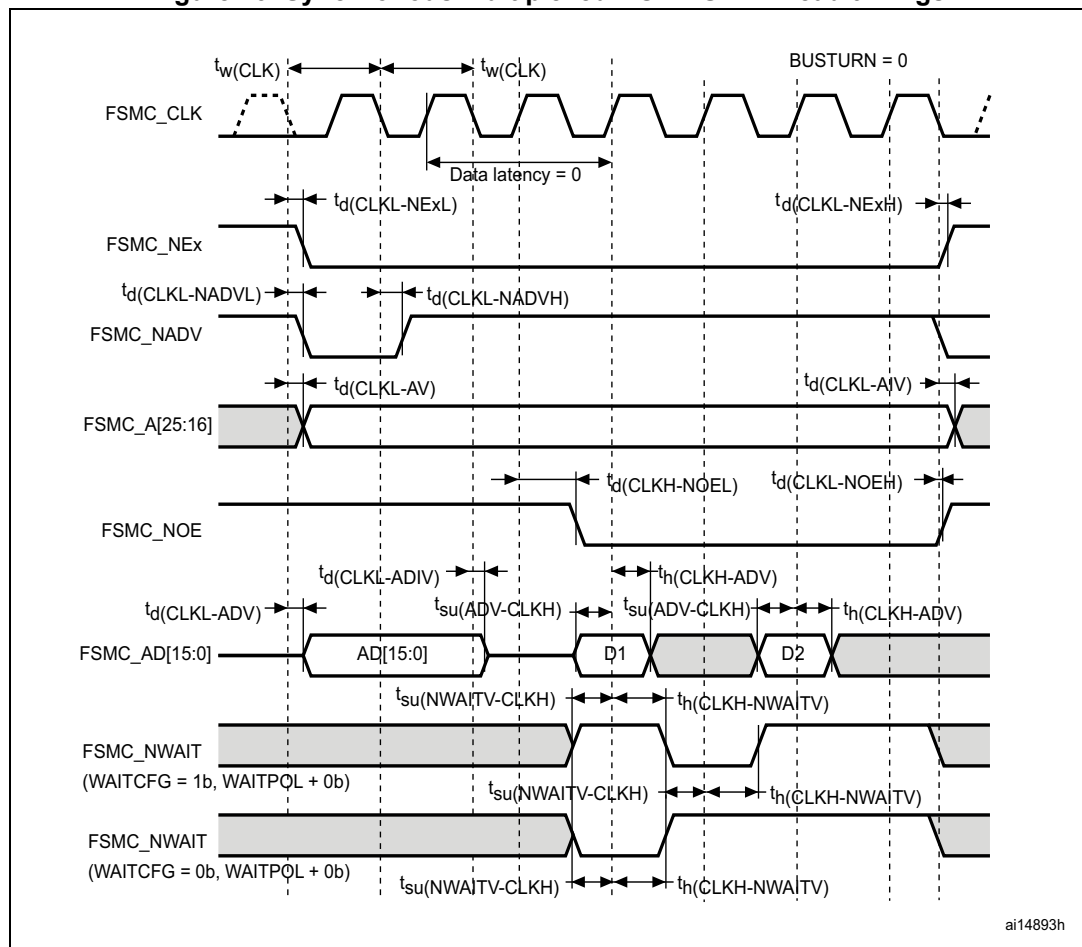
2. Guaranteed by characterization results.

### Synchronous waveforms and timings

Figure 23 through Figure 26 represent synchronous waveforms and Table 36 through Table 38 provide the corresponding timings. The results shown in these tables are obtained with the following FSMC configuration:

- BurstAccessMode = FSMC\_BurstAccessMode\_Enable;
- MemoryType = FSMC\_MemoryType\_CRAM;
- WriteBurst = FSMC\_WriteBurst\_Enable;
- CLKDivision = 1; (0 is not supported, see the STM32F10xxx reference manual)
- DataLatency = 1 for NOR Flash; DataLatency = 0 for PSRAM

**Figure 23. Synchronous multiplexed NOR/PSRAM read timings**



**Table 35. Synchronous multiplexed NOR/PSRAM read timings<sup>(1)(2)</sup>**

| Symbol                | Parameter                                         | Min  | Max | Unit |
|-----------------------|---------------------------------------------------|------|-----|------|
| $t_{w(CLK)}$          | FSMC_CLK period                                   | 55.5 | -   | ns   |
| $t_{d(CLKL-NExL)}$    | FSMC_CLK low to FSMC_NEx low ( $x = 0...2$ )      | -    | 0.5 | ns   |
| $t_{d(CLKL-NExH)}$    | FSMC_CLK low to FSMC_NEx high ( $x = 0...2$ )     | 1    | -   | ns   |
| $t_{d(CLKL-NADV_L)}$  | FSMC_CLK low to FSMC_NADV low                     | -    | 1   | ns   |
| $t_{d(CLKL-NADV_H)}$  | FSMC_CLK low to FSMC_NADV high                    | 0.5  | -   | ns   |
| $t_{d(CLKL-AV)}$      | FSMC_CLK low to FSMC_Ax valid ( $x = 16...25$ )   | -    | 0   | ns   |
| $t_{d(CLKL-AIV)}$     | FSMC_CLK low to FSMC_Ax invalid ( $x = 16...25$ ) | 1.5  | -   | ns   |
| $t_{d(CLKL-NOEL)}$    | FSMC_CLK low to FSMC_NOE low                      | -    | 14  | ns   |
| $t_{d(CLKL-NOEH)}$    | FSMC_CLK low to FSMC_NOE high                     | 1    | -   | ns   |
| $t_{d(CLKL-ADV)}$     | FSMC_CLK low to FSMC_AD[15:0] valid               | -    | 11  | ns   |
| $t_{d(CLKL-ADIV)}$    | FSMC_CLK low to FSMC_AD[15:0] invalid             | 0.5  | -   | ns   |
| $t_{su(ADV-CLKH)}$    | FSMC_A/D[15:0] valid data before FSMC_CLK high    | 2    | -   | ns   |
| $t_h(CLKH-ADV)$       | FSMC_A/D[15:0] valid data after FSMC_CLK high     | 0    | -   | ns   |
| $t_{su(NWAITV-CLKH)}$ | FSMC_NWAIT valid before FSMC_CLK high             | 8    | -   | ns   |
| $t_h(CLKH-NWAITV)$    | FSMC_NWAIT valid after FSMC_CLK high              | 2    | -   | ns   |

1.  $C_L = 15$  pF.

2. Guaranteed by characterization results.

Figure 24. Synchronous multiplexed PSRAM write timings

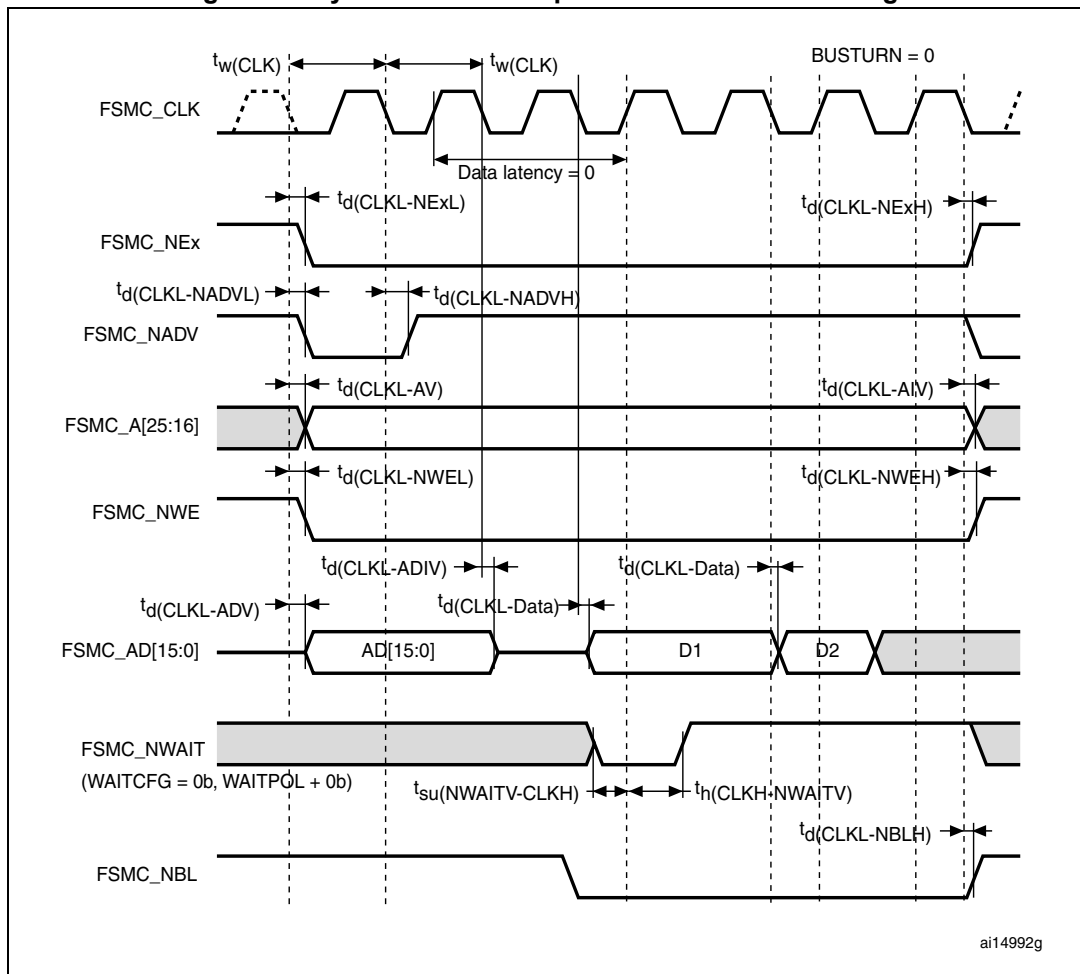


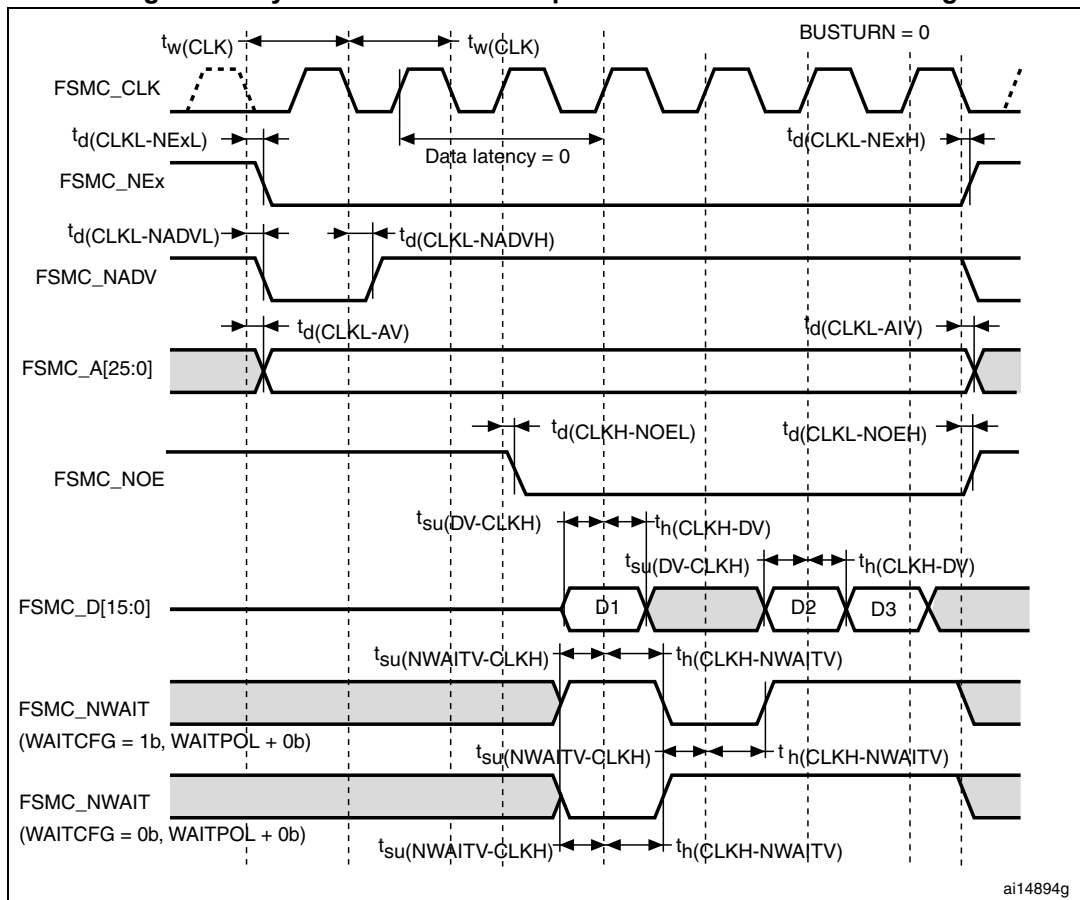
Table 36. Synchronous multiplexed PSRAM write timings<sup>(1)(2)</sup>

| Symbol                | Parameter                                     | Min  | Max | Unit |
|-----------------------|-----------------------------------------------|------|-----|------|
| $t_{w(CLK)}$          | FSMC_CLK period                               | 27.5 | -   | ns   |
| $t_{d(CLKL-NEXL)}$    | FSMC_CLK low to FSMC_Nex low (x = 0...2)      | -    | 0   | ns   |
| $t_{d(CLKL-NEXH)}$    | FSMC_CLK low to FSMC_NEx high (x = 0...2)     | 1    | -   | ns   |
| $t_{d(CLKL-NADVL)}$   | FSMC_CLK low to FSMC_NADV low                 | -    | 1   | ns   |
| $t_{d(CLKL-NADVH)}$   | FSMC_CLK low to FSMC_NADV high                | 1    | -   | ns   |
| $t_{d(CLKL-AV)}$      | FSMC_CLK low to FSMC_Ax valid (x = 16...25)   | -    | 0   | ns   |
| $t_{d(CLKL-AIV)}$     | FSMC_CLK low to FSMC_Ax invalid (x = 16...25) | 1    | -   | ns   |
| $t_{d(CLKL-NWEL)}$    | FSMC_CLK low to FSMC_NWE low                  | -    | 1   | ns   |
| $t_{d(CLKL-NWEH)}$    | FSMC_CLK low to FSMC_NWE high                 | 1.5  | -   | ns   |
| $t_{d(CLKL-ADV)}$     | FSMC_CLK low to FSMC_AD[15:0] valid           | -    | 10  | ns   |
| $t_{d(CLKL-ADIV)}$    | FSMC_CLK low to FSMC_AD[15:0] invalid         | 1    | -   | ns   |
| $t_{d(CLKL-Data)}$    | FSMC_A/D[15:0] valid after FSMC_CLK low       | -    | 6   | ns   |
| $t_{d(CLKL-NBLH)}$    | FSMC_CLK low to FSMC_NBL high                 | 1    | -   | ns   |
| $t_{su(NWAITV-CLKH)}$ | FSMC_NWAIT valid before FSMC_CLK high         | 7    | -   | ns   |
| $t_h(CLKH-NWAITV)$    | FSMC_NWAIT valid after FSMC_CLK high          | 2    | -   | ns   |

1.  $C_L = 15$  pF.

2. Guaranteed by characterization results.

Figure 25. Synchronous non-multiplexed NOR/PSRAM read timings

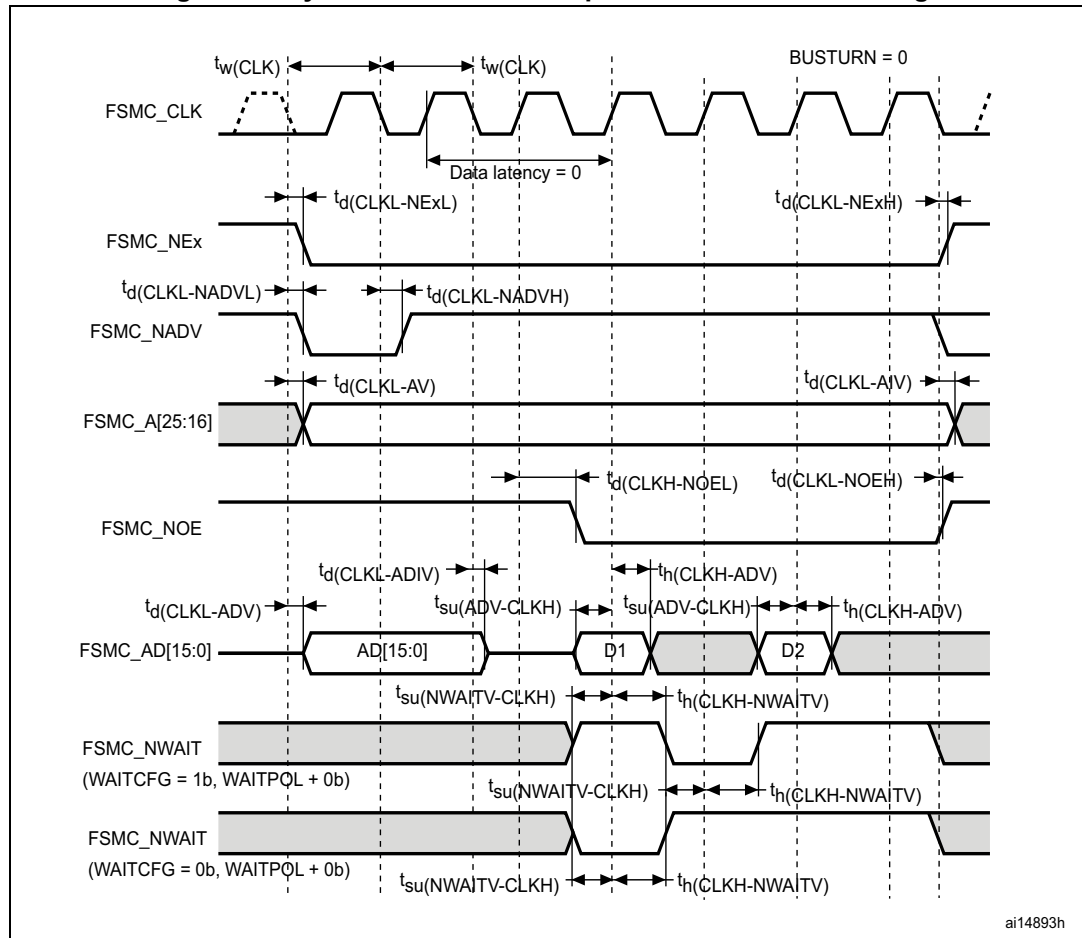
Table 37. Synchronous non-multiplexed NOR/PSRAM read timings<sup>(1)(2)</sup>

| Symbol                              | Parameter                                            | Min  | Max                   | Unit |
|-------------------------------------|------------------------------------------------------|------|-----------------------|------|
| $t_w(\text{CLK})$                   | FSMC_CLK period                                      | 27.6 | -                     | ns   |
| $t_d(\text{CLKL-NExL})$             | FSMC_CLK low to FSMC_NEx low ( $x = 0 \dots 2$ )     | -    | 1.5                   | ns   |
| $t_d(\text{CLKL-NExH})$             | FSMC_CLK low to FSMC_NEx high ( $x = 0 \dots 2$ )    | 2    | -                     | ns   |
| $t_d(\text{CLKL-NADV})$             | FSMC_CLK low to FSMC_NADV low                        | -    | 0.5                   | ns   |
| $t_d(\text{CLKL-NADVH})$            | FSMC_CLK low to FSMC_NADV high                       | 1    | -                     | ns   |
| $t_d(\text{CLKL-AV})$               | FSMC_CLK low to FSMC_Ax valid ( $x = 0 \dots 25$ )   | -    | 0                     | ns   |
| $t_d(\text{CLKL-AIV})$              | FSMC_CLK low to FSMC_Ax invalid ( $x = 0 \dots 25$ ) | 2    | -                     | ns   |
| $t_d(\text{CLKL-NOEL})$             | FSMC_CLK low to FSMC_NOE low                         | -    | $t_{\text{HCLK}} + 1$ | ns   |
| $t_d(\text{CLKL-NOEH})$             | FSMC_CLK low to FSMC_NOE high                        | 1.5  | -                     | ns   |
| $t_{\text{su}}(\text{DV-CLKH})$     | FSMC_D[15:0] valid data before FSMC_CLK high         | 3.5  | -                     | ns   |
| $t_{\text{h}}(\text{CLKH-DV})$      | FSMC_D[15:0] valid data after FSMC_CLK high          | 0    | -                     | ns   |
| $t_{\text{su}}(\text{NWAITV-CLKH})$ | FSMC_NWAIT valid before FSMC_SMCLK high              | 7    | -                     | ns   |
| $t_{\text{h}}(\text{CLKH-NWAITV})$  | FSMC_NWAIT valid after FSMC_CLK high                 | 2    | -                     | ns   |

1.  $C_L = 15 \text{ pF}$ .

2. Guaranteed by characterization results.

**Figure 26. Synchronous non-multiplexed PSRAM write timings**



**Table 38. Synchronous non-multiplexed PSRAM write timings<sup>(1)(2)</sup>**

| Symbol                   | Parameter                                     | Min  | Max | Unit |
|--------------------------|-----------------------------------------------|------|-----|------|
| $t_w(\text{CLK})$        | FSMC_CLK period                               | 27.6 | -   | ns   |
| $t_d(\text{CLKL-NExL})$  | FSMC_CLK low to FSMC_NEx low (x = 0...2)      | -    | 0.5 | ns   |
| $t_d(\text{CLKL-NExH})$  | FSMC_CLK low to FSMC_NEx high (x = 0...2)     | 1.5  | -   | ns   |
| $t_d(\text{CLKL-NADV})$  | FSMC_CLK low to FSMC_NADV low                 | -    | 1   | ns   |
| $t_d(\text{CLKL-NADVH})$ | FSMC_CLK low to FSMC_NADV high                | 0.5  | -   | ns   |
| $t_d(\text{CLKL-AV})$    | FSMC_CLK low to FSMC_Ax valid (x = 16...25)   | -    | 0   | ns   |
| $t_d(\text{CLKL-AIV})$   | FSMC_CLK low to FSMC_Ax invalid (x = 16...25) | 1.5  | -   | ns   |
| $t_d(\text{CLKL-NWEL})$  | FSMC_CLK low to FSMC_NWE low                  | -    | 1   | ns   |
| $t_d(\text{CLKL-NWEH})$  | FSMC_CLK low to FSMC_NWE high                 | 1.5  | -   | ns   |
| $t_d(\text{CLKL-Data})$  | FSMC_D[15:0] valid data after FSMC_CLK low    | -    | 2.5 | ns   |
| $t_d(\text{CLKL-NBLH})$  | FSMC_CLK low to FSMC_NBL high                 | 0.5  | -   | ns   |

**Table 38. Synchronous non-multiplexed PSRAM write timings<sup>(1)(2)</sup> (continued)**

| Symbol                | Parameter                             | Min | Max | Unit |
|-----------------------|---------------------------------------|-----|-----|------|
| $t_{su(NWAITV-CLKH)}$ | FSMC_NWAIT valid before FSMC_CLK high | 7   | -   | ns   |
| $t_{h(CLKH-NWAITV)}$  | FSMC_NWAIT valid after FSMC_CLK high  | 2   | -   | ns   |

1.  $C_L = 15$  pF.

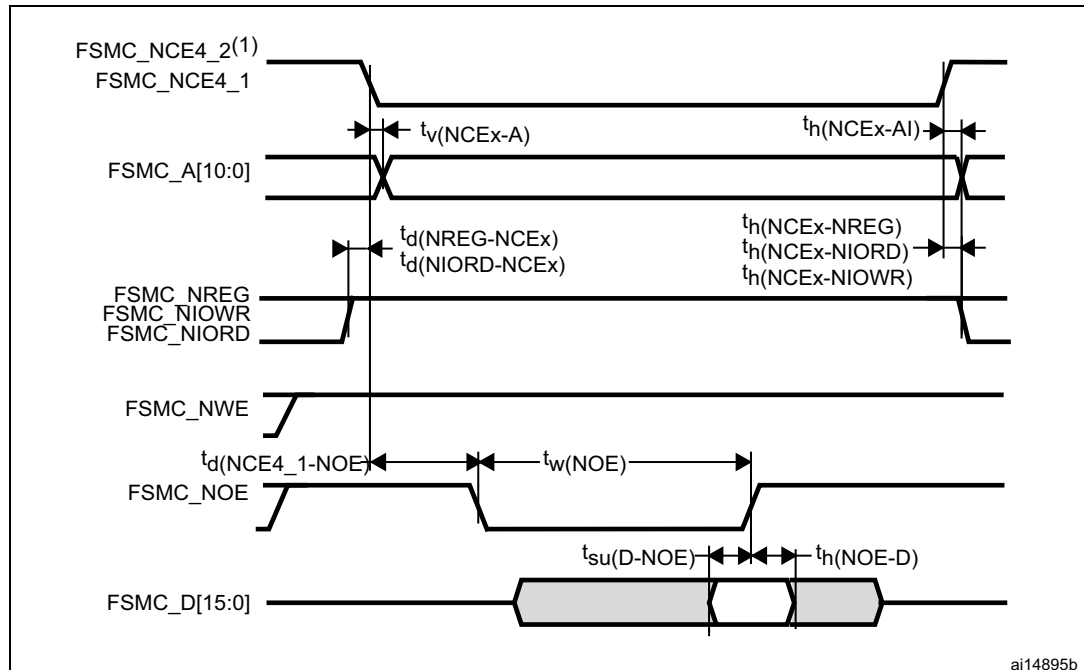
2. Guaranteed by characterization results.

### PC Card/CompactFlash controller waveforms and timings

[Figure 27](#) through [Figure 32](#) represent synchronous waveforms and [Table 40](#) and [Table 41](#) provide the corresponding timings. The results shown in this table are obtained with the following FSMC configuration:

- COM.FSMC\_SetupTime = 0x04;
- COM.FSMC\_WaitSetupTime = 0x07;
- COM.FSMC\_HoldSetupTime = 0x04;
- COM.FSMC\_HiZSetupTime = 0x00;
- ATT.FSMC\_SetupTime = 0x04;
- ATT.FSMC\_WaitSetupTime = 0x07;
- ATT.FSMC\_HoldSetupTime = 0x04;
- ATT.FSMC\_HiZSetupTime = 0x00;
- IO.FSMC\_SetupTime = 0x04;
- IO.FSMC\_WaitSetupTime = 0x07;
- IO.FSMC\_HoldSetupTime = 0x04;
- IO.FSMC\_HiZSetupTime = 0x00;
- TCLRSetupTime = 0;
- TARSetupTime = 0;

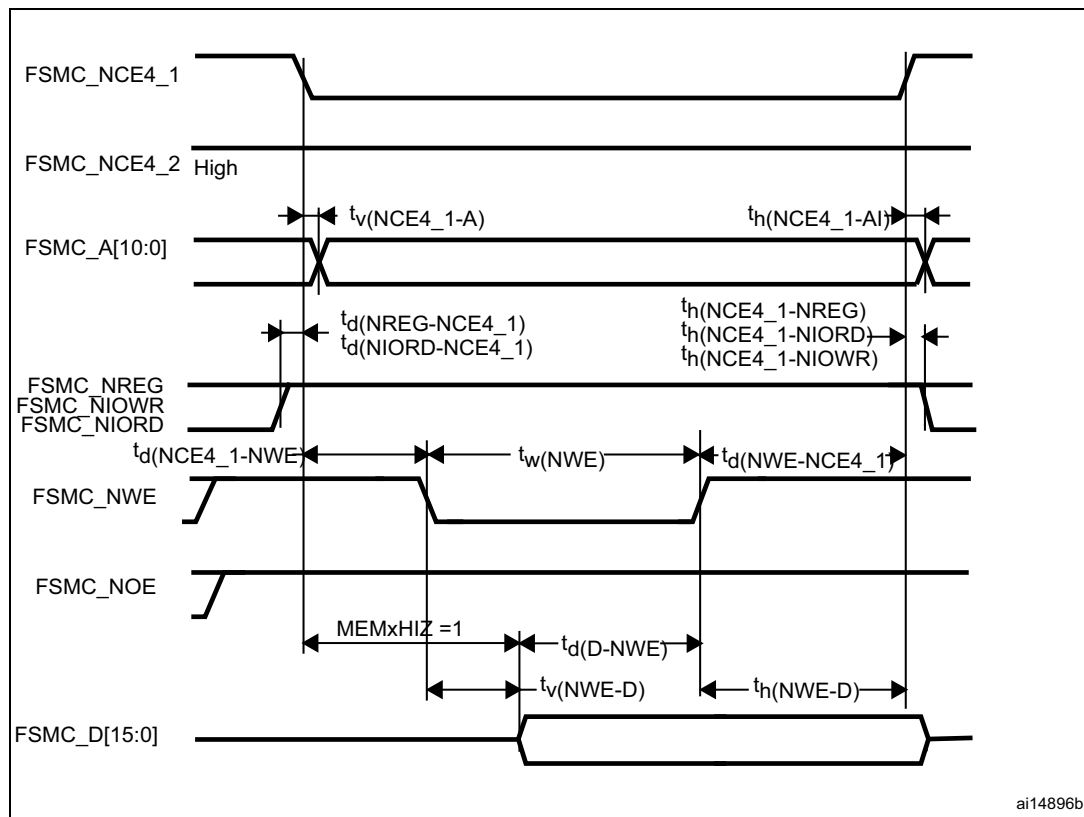
**Figure 27. PC Card/CompactFlash controller waveforms for common memory read access**



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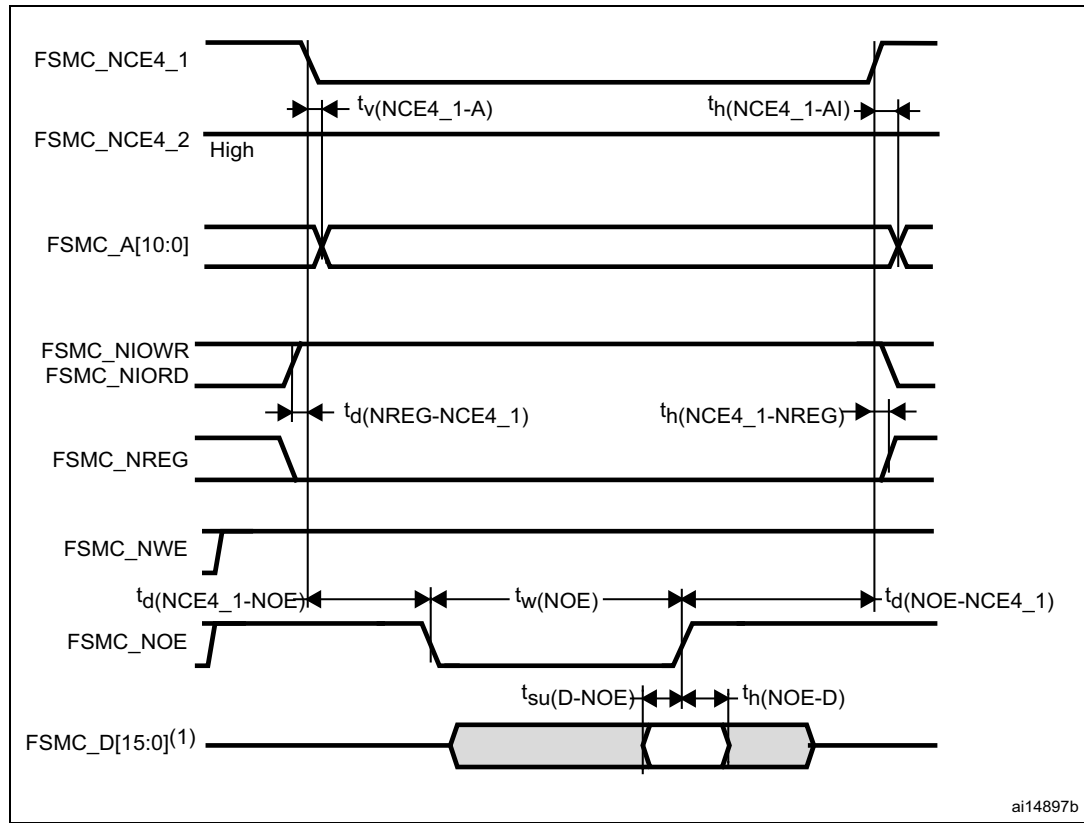
1. FSMC\_NCE4\_2 remains high (inactive during 8-bit access).

**Figure 28. PC Card/CompactFlash controller waveforms for common memory write access**

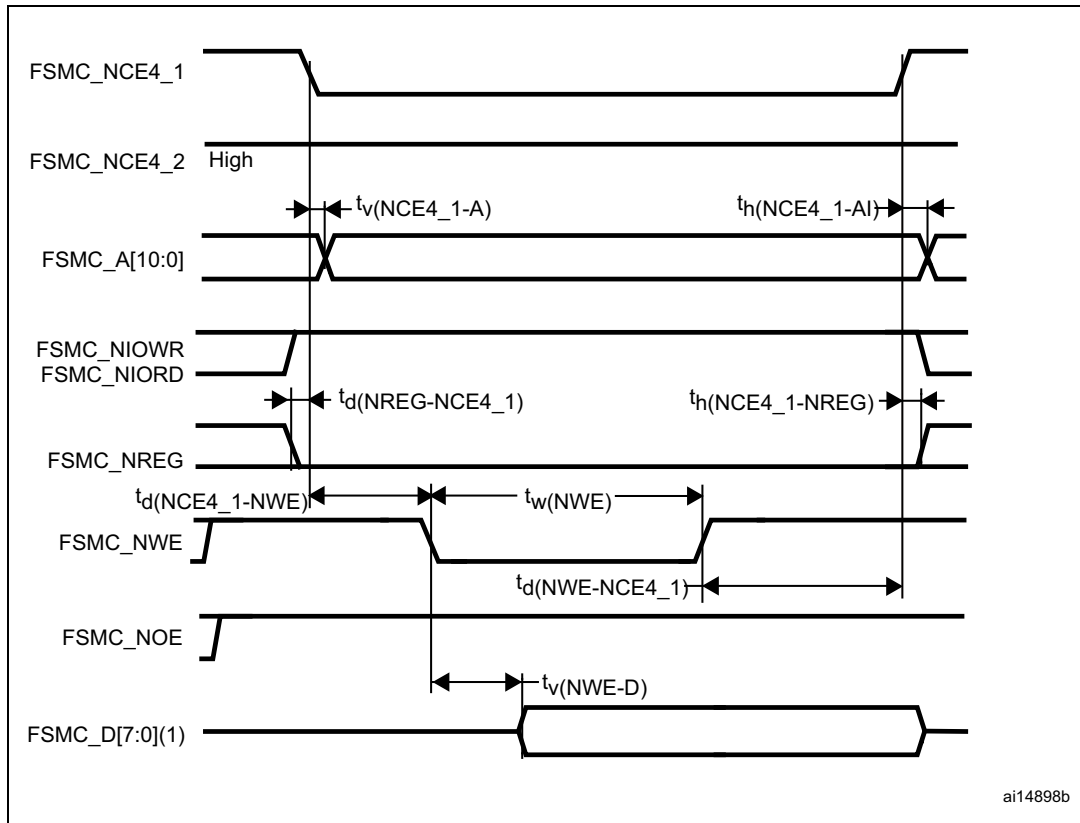


ai14896b

**Figure 29. PC Card/CompactFlash controller waveforms for attribute memory read access**



1. Only data bits 0...7 are read (bits 8...15 are disregarded).

**Figure 30. PC Card/CompactFlash controller waveforms for attribute memory write access**

1. Only data bits 0...7 are driven (bits 8...15 remains HiZ).

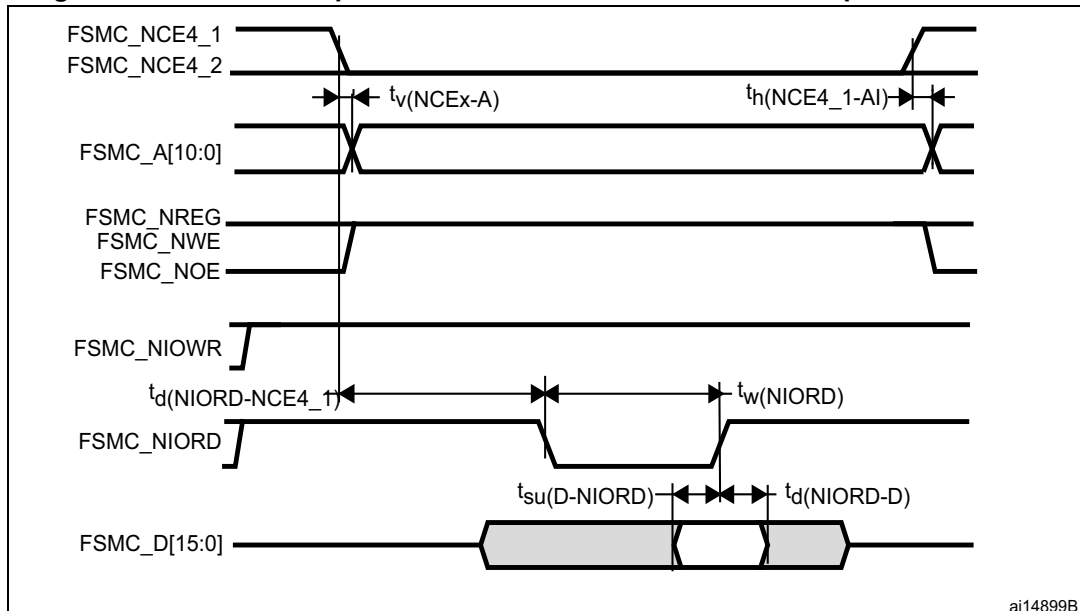
**Figure 31. PC Card/CompactFlash controller waveforms for I/O space read access**

Figure 32. PC Card/CompactFlash controller waveforms for I/O space write access

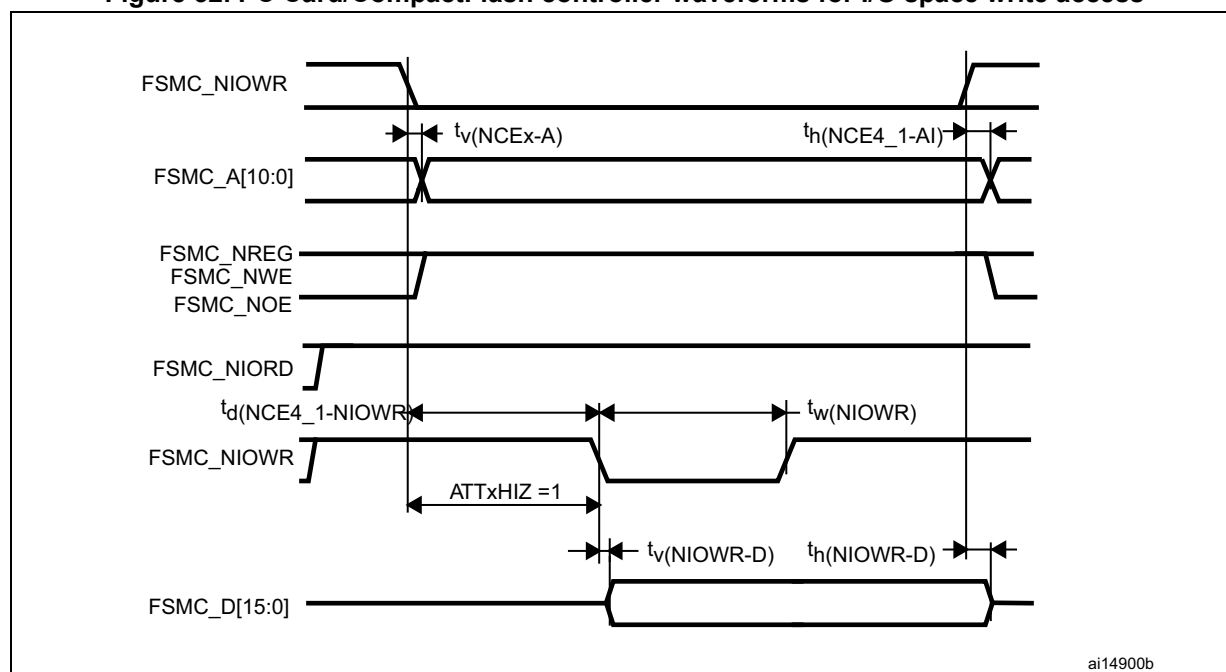


Table 39. Switching characteristics for PC Card/CF read and write cycles in attribute/common space

| Symbol             | Parameter                                    | Min                | Max             | Unit |
|--------------------|----------------------------------------------|--------------------|-----------------|------|
| $t_{v(NCEx-A)}$    | FSMC_NCEx low to FSMC_Ay valid               | -                  | 0               | ns   |
| $t_{h(NCEx-AI)}$   | FSMC_NCEx high to FSMC_Ax invalid            | 0                  | -               |      |
| $t_{d(NREG-NCEx)}$ | FSMC_NCEx low to FSMC_NREG valid             | -                  | 2               |      |
| $t_{h(NCEx-NREG)}$ | FSMC_NCEx high to FSMC_NREG invalid          | $t_{HCLK} + 4$     | -               |      |
| $t_{d(NCEx\_NWE)}$ | FSMC_NCEx low to FSMC_NWE low                | -                  | $5t_{HCLK} + 1$ |      |
| $t_{d(NCEx\_NOE)}$ | FSMC_NCEx low to FSMC_NOE low                | -                  | $5t_{HCLK} + 1$ |      |
| $t_{w(NOE)}$       | FSMC_NOE low width                           | $8t_{HCLK} - 0.5$  | $8t_{HCLK} + 1$ |      |
| $t_{d(NOE-NCEx)}$  | FSMC_NOE high to FSMC_NCEx high              | $5t_{HCLK} - 0.5$  | -               |      |
| $t_{su(D-NOE)}$    | FSMC_D[15:0] valid data before FSMC_NOE high | 32                 | -               |      |
| $t_{h(NOE-D)}$     | FSMC_NOE high to FSMC_D[15:0] invalid        | $t_{HCLK}$         | -               |      |
| $t_{w(NWE)}$       | FSMC_NWE low width                           | $8t_{HCLK} - 1$    | $8t_{HCLK} + 4$ |      |
| $t_{d(NWE\_NCEx)}$ | FSMC_NWE high to FSMC_NCEx high              | $5t_{HCLK} + 1.5$  | -               |      |
| $t_{d(NCEx-NWE)}$  | FSMC_NCEx low to FSMC_NWE low                | -                  | $5t_{HCLK} + 1$ |      |
| $t_{v(NWE-D)}$     | FSMC_NWE low to FSMC_D[15:0] valid           | -                  | 0               |      |
| $t_{h(NWE-D)}$     | FSMC_NWE high to FSMC_D[15:0] invalid        | $11t_{HCLK}$       | -               |      |
| $t_{d(D-NWE)}$     | FSMC_D[15:0] valid before FSMC_NWE high      | $13t_{HCLK} + 2.5$ | -               |      |

**Table 40. Switching characteristics for PC Card/CF read and write cycles in I/O space**

| Symbol                 | Parameter                                 | Min           | Max           | Unit |
|------------------------|-------------------------------------------|---------------|---------------|------|
| $t_{w(NIOWR)}$         | FSMC_NIOWR low width                      | 8 THCLK       | -             | ns   |
| $t_{v(NIOWR-D)}$       | FSMC_NIOWR low to FSMC_D[15:0] valid      | -             | 5 THCLK - 4   | ns   |
| $t_{h(NIOWR-D)}$       | FSMC_NIOWR high to FSMC_D[15:0] invalid   | 11 THCLK - 7  | -             | ns   |
| $t_{d(NCE4\_1-NIOWR)}$ | FSMC_NCE4_1 low to FSMC_NIOWR valid       | -             | 5 THCLK + 1   | ns   |
| $t_{h(NCEx-NIOWR)}$    | FSMC_NCEx high to FSMC_NIOWR invalid      | 5 THCLK - 2.5 | -             | ns   |
| $t_{d(NIORD-NCEx)}$    | FSMC_NCEx low to FSMC_NIORD valid         | -             | 5 THCLK - 0.5 | ns   |
| $t_{h(NCEx-NIORD)}$    | FSMC_NCEx high to FSMC_NIORD valid        | 5 THCLK - 0.5 | -             | ns   |
| $t_{w(NIORD)}$         | FSMC_NIORD low width                      | 8 THCLK       | -             | ns   |
| $t_{su(D-NIORD)}$      | FSMC_D[15:0] valid before FSMC_NIORD high | 28            | -             | ns   |
| $t_{d(NIORD-D)}$       | FSMC_D[15:0] valid after FSMC_NIORD high  | 3             | -             | ns   |

### NAND controller waveforms and timings

*Figure 33* through *Figure 36* represent synchronous waveforms and *Table 40* and *Table 41* provide the corresponding timings. The results shown in this table are obtained with the following FSMC configuration:

- COM.FSMC\_SetupTime = 0x00;
- COM.FSMC\_WaitSetupTime = 0x02;
- COM.FSMC\_HoldSetupTime = 0x02;
- COM.FSMC\_HiZSetupTime = 0x00;
- ATT.FSMC\_SetupTime = 0x01;
- ATT.FSMC\_WaitSetupTime = 0x02;
- ATT.FSMC\_HoldSetupTime = 0x01;
- ATT.FSMC\_HiZSetupTime = 0x00;
- Bank = FSMC\_Bank\_NAND;
- MemoryDataWidth = FSMC\_MemoryDataWidth\_16b;
- ECC = FSMC\_ECC\_Enable;
- ECCPageSize = FSMC\_ECCPageSize\_512Bytes;
- TCLRSetupTime = 0;
- TARSetupTime = 0;

Figure 33. NAND controller waveforms for read access

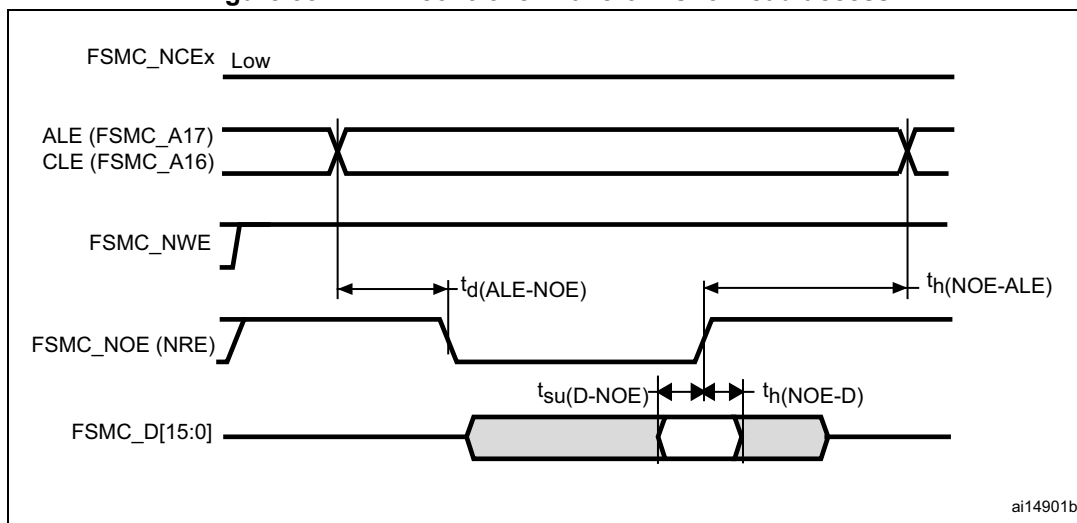


Figure 34. NAND controller waveforms for write access

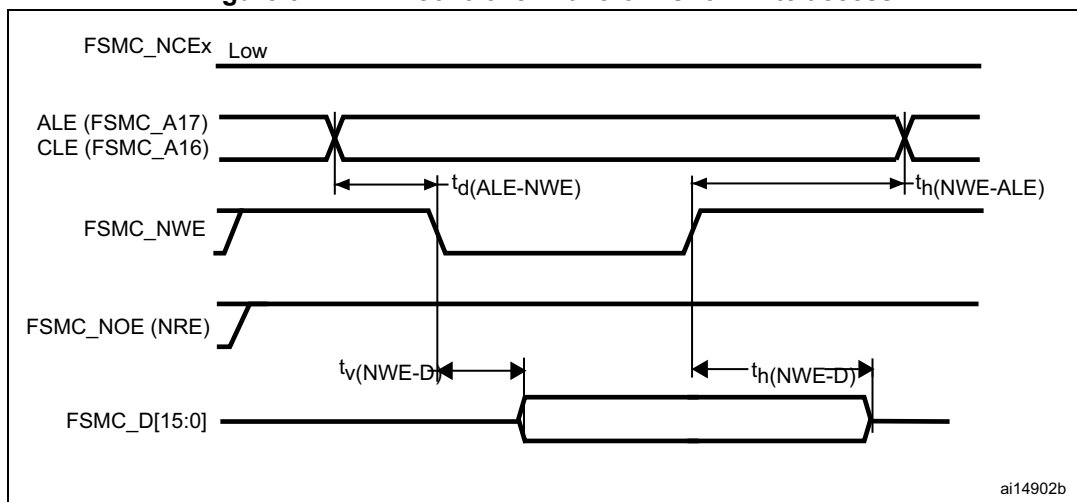


Figure 35. NAND controller waveforms for common memory read access

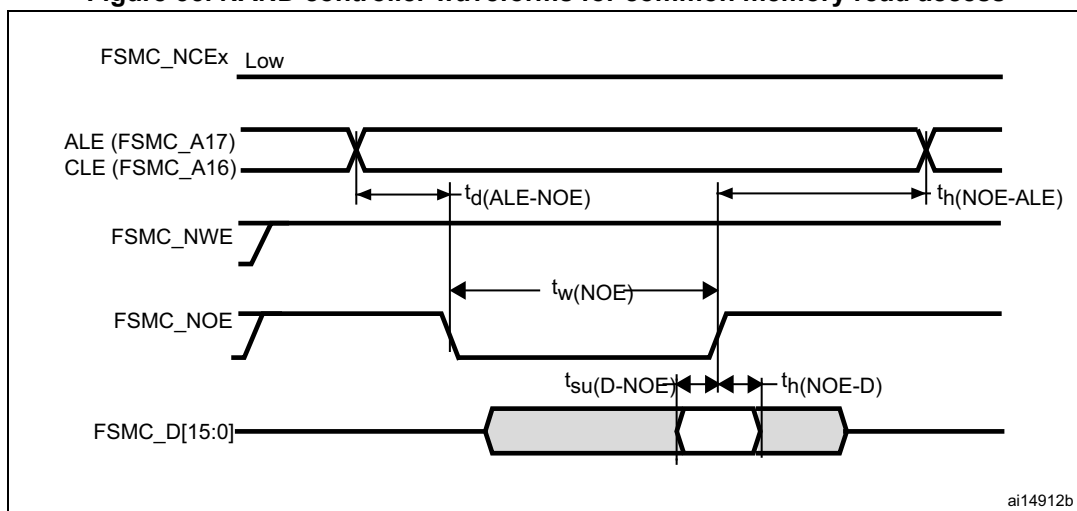
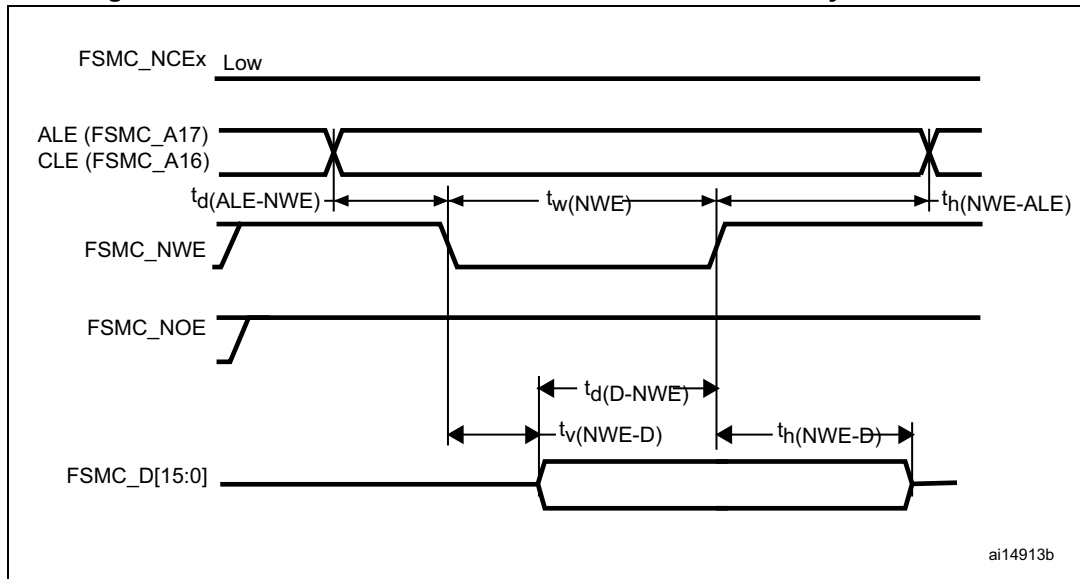


Figure 36. NAND controller waveforms for common memory write access

Table 41. Switching characteristics for NAND Flash write cycles<sup>(1)</sup>

| Symbol         | Parameter                             | Min             | Max               | Unit |
|----------------|---------------------------------------|-----------------|-------------------|------|
| $t_w(NWE)$     | FSMC_NWE low width                    | $3t_{HCLK}$     | $3t_{HCLK}$       | ns   |
| $t_v(NWE-D)$   | FSMC_NWE low to FSMC_D[15:0] valid    | -               | 0                 | ns   |
| $t_h(NWE-D)$   | FSMC_NWE high to FSMC_D[15:0] invalid | $2t_{HCLK} + 2$ | -                 | ns   |
| $t_d(ALE-NWE)$ | FSMC_ALE valid before FSMC_NWE low    | -               | $3t_{HCLK} + 1.5$ | ns   |
| $t_h(NWE-ALE)$ | FSMC_NWE high to FSMC_ALE invalid     | $3t_{HCLK} + 8$ | -                 | ns   |
| $t_d(ALE-NOE)$ | FSMC_ALE valid before FSMC_NOE low    | -               | $2t_{HCLK}$       | ns   |
| $t_h(NOE-ALE)$ | FSMC_NWE high to FSMC_ALE invalid     | $2t_{HCLK}$     | -                 | ns   |

1.  $C_L = 15$  pF.

### 5.3.11 EMC characteristics

Susceptibility tests are performed on a sample basis during device characterization.

#### Functional EMS (Electromagnetic susceptibility)

While a simple application is executed on the device (toggling 2 LEDs through I/O ports), the device is stressed by two electromagnetic events until a failure occurs. The failure is indicated by the LEDs:

- **Electrostatic discharge (ESD)** (positive and negative) is applied to all device pins until a functional disturbance occurs. This test is compliant with the IEC 61000-4-2 standard.
- **FTB**: A Burst of Fast Transient voltage (positive and negative) is applied to  $V_{DD}$  and  $V_{SS}$  through a 100 pF capacitor, until a functional disturbance occurs. This test is compliant with the IEC 61000-4-4 standard.

A device reset allows normal operations to be resumed.

The test results are given in [Table 42](#). They are based on the EMS levels and classes defined in application note AN1709.

**Table 42. EMS characteristics**

| Symbol     | Parameter                                                                                                                         | Conditions                                                                                                                          | Level/Class |
|------------|-----------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------|-------------|
| $V_{FESD}$ | Voltage limits to be applied on any I/O pin to induce a functional disturbance                                                    | $V_{DD} = 3.3\text{ V}$ , LQFP144,<br>$T_A = +25\text{ }^{\circ}\text{C}$ , $f_{HCLK} = 36\text{ MHz}$<br>conforms to IEC 61000-4-2 | 2B          |
| $V_{EFTB}$ | Fast transient voltage burst limits to be applied through 100 pF on $V_{DD}$ and $V_{SS}$ pins to induce a functional disturbance | $V_{DD} = 3.3\text{ V}$ , LQFP144,<br>$T_A = +25\text{ }^{\circ}\text{C}$ , $f_{HCLK} = 36\text{ MHz}$<br>conforms to IEC 61000-4-4 | 4A          |

### Designing hardened software to avoid noise problems

EMC characterization and optimization are performed at component level with a typical application environment and simplified MCU software. It should be noted that good EMC performance is highly dependent on the user application and the software in particular.

Therefore it is recommended that the user applies EMC software optimization and pre qualification tests in relation with the EMC level requested for his application.

#### Software recommendations

The software flowchart must include the management of runaway conditions such as:

- Corrupted program counter
- Unexpected reset
- Critical Data corruption (control registers...)

#### Prequalification trials

Most of the common failures (unexpected reset and program counter corruption) can be reproduced by manually forcing a low state on the NRST pin or the Oscillator pins for 1 second. To complete these trials, ESD stress can be applied directly on the device, over the range of specification values. When unexpected behavior is detected, the software can be hardened to prevent unrecoverable errors occurring (see application note AN1015).

### Electromagnetic Interference (EMI)

The electromagnetic field emitted by the device is monitored while a simple application is executed (toggling 2 LEDs through the I/O ports). This emission test is compliant with IEC 61967-2 standard which specifies the test board and the pin loading.

**Table 43. EMI characteristics**

| Symbol    | Parameter  | Conditions                                                                                                         | Monitored frequency band | Max vs. $[f_{HSE}/f_{HCLK}]$ | Unit       |
|-----------|------------|--------------------------------------------------------------------------------------------------------------------|--------------------------|------------------------------|------------|
|           |            |                                                                                                                    |                          | 8/36 MHz                     |            |
| $S_{EMI}$ | Peak level | $V_{DD} = 3.3\text{ V}$ , $T_A = 25\text{ }^{\circ}\text{C}$ ,<br>LQFP144 package<br>compliant with<br>IEC 61967-2 | 0.1 MHz to 30 MHz        | 8                            | dB $\mu$ V |
|           |            |                                                                                                                    | 30 MHz to 130 MHz        | 27                           |            |
|           |            |                                                                                                                    | 130 MHz to 1 GHz         | 26                           |            |
|           |            |                                                                                                                    | SAE EMI Level            | 4                            | -          |

### 5.3.12 Absolute maximum ratings (electrical sensitivity)

Based on three different tests (ESD, LU) using specific measurement methods, the device is stressed in order to determine its performance in terms of electrical sensitivity.

#### Electrostatic discharge (ESD)

Electrostatic discharges (a positive then a negative pulse separated by 1 second) are applied to the pins of each sample according to each pin combination. The sample size depends on the number of supply pins in the device (3 parts × (n+1) supply pins). This test conforms to the JESD22-A114/JESD22-C101 standard.

**Table 44. ESD absolute maximum ratings**

| Symbol                | Ratings                                               | Conditions                                                      | Class | Maximum value <sup>(1)</sup> | Unit |
|-----------------------|-------------------------------------------------------|-----------------------------------------------------------------|-------|------------------------------|------|
| $V_{\text{ESD(HBM)}}$ | Electrostatic discharge voltage (human body model)    | $T_A = +25\text{ }^{\circ}\text{C}$ , conforming to JESD22-A114 | 2     | 2000                         | V    |
| $V_{\text{ESD(CDM)}}$ | Electrostatic discharge voltage (charge device model) | $T_A = +25\text{ }^{\circ}\text{C}$ , conforming to JESD22-C101 | III   | 500                          |      |

1. Guaranteed by characterization results.

#### Static latch-up

Two complementary static tests are required on six parts to assess the latch-up performance:

- A supply overvoltage is applied to each power supply pin
- A current injection is applied to each input, output and configurable I/O pin

These tests are compliant with EIA/JESD 78 IC latch-up standard.

**Table 45. Electrical sensitivities**

| Symbol | Parameter             | Conditions                                                | Class      |
|--------|-----------------------|-----------------------------------------------------------|------------|
| LU     | Static latch-up class | $T_A = +85\text{ }^{\circ}\text{C}$ conforming to JESD78A | II level A |

### 5.3.13 I/O current injection characteristics

As a general rule, current injection to the I/O pins, due to external voltage below  $V_{\text{SS}}$  or above  $V_{\text{DD}}$  (for standard, 3 V-capable I/O pins) should be avoided during normal product operation. However, in order to give an indication of the robustness of the microcontroller in cases when abnormal injection accidentally happens, susceptibility tests are performed on a sample basis during device characterization.

#### Functional susceptibility to I/O current injection

While a simple application is executed on the device, the device is stressed by injecting current into the I/O pins programmed in floating input mode. While current is injected into the I/O pin, one at a time, the device is checked for functional failures.

The failure is indicated by an out of range parameter: ADC error above a certain limit (>5 LSB TUE), out of spec current injection on adjacent pins or other functional failure (for example reset, oscillator frequency deviation).

The test results are given in [Table 46](#)

**Table 46. I/O current injection susceptibility**

| Symbol           | Description                                             | Functional susceptibility |                    | Unit |
|------------------|---------------------------------------------------------|---------------------------|--------------------|------|
|                  |                                                         | Negative injection        | Positive injection |      |
| I <sub>INJ</sub> | Injected current on OSC_IN32, OSC_OUT32, PA4, PA5, PC13 | -0                        | +0                 | mA   |
|                  | Injected current on all FT pins                         | -5                        | +0                 |      |
|                  | Injected current on any other pin                       | -5                        | +5                 |      |

### 5.3.14 I/O port characteristics

#### General input/output characteristics

Unless otherwise specified, the parameters given in [Table 47](#) are derived from tests performed under the conditions summarized in [Table 10](#). All I/Os are CMOS and TTL compliant.

**Table 47. I/O static characteristics**

| Symbol    | Parameter                                                     | Conditions                                        | Min                                                 | Typ | Max                                                  | Unit          |
|-----------|---------------------------------------------------------------|---------------------------------------------------|-----------------------------------------------------|-----|------------------------------------------------------|---------------|
| $V_{IL}$  | Standard IO input low level voltage                           | -                                                 | -0.3                                                | -   | $0.28 \cdot (V_{DD} - 2 \text{ V}) + 0.8 \text{ V}$  | V             |
|           | IO FT <sup>(1)</sup> input low level voltage                  |                                                   | -0.3                                                | -   | $0.32 \cdot (V_{DD} - 2 \text{ V}) + 0.75 \text{ V}$ | V             |
| $V_{IH}$  | Standard IO input high level voltage                          |                                                   | $0.41 \cdot (V_{DD} - 2 \text{ V}) + 1.3 \text{ V}$ | -   | $V_{DD} + 0.3$                                       | V             |
|           | IO FT <sup>(1)</sup> input high level voltage                 | $V_{DD} > 2 \text{ V}$                            | $0.42 \cdot (V_{DD} - 2 \text{ V}) + 1 \text{ V}$   | -   | 5.5                                                  | V             |
|           |                                                               | $V_{DD} \leq 2 \text{ V}$                         |                                                     |     | 5.2                                                  |               |
| $V_{hys}$ | Standard IO Schmitt trigger voltage hysteresis <sup>(2)</sup> | -                                                 | 200                                                 | -   | -                                                    | mV            |
|           | IO FT Schmitt trigger voltage hysteresis <sup>(2)</sup>       |                                                   | $5\% V_{DD}^{(3)}$                                  | -   | -                                                    | mV            |
| $I_{lkg}$ | Input leakage current <sup>(4)</sup>                          | $V_{SS} \leq V_{IN} \leq V_{DD}$<br>Standard I/Os | -                                                   | -   | $\pm 1$                                              | $\mu\text{A}$ |
|           |                                                               | $V_{IN} = 5 \text{ V}$<br>I/O FT                  | -                                                   | -   | 3                                                    |               |
| $R_{PU}$  | Weak pull-up equivalent resistor <sup>(5)</sup>               | $V_{IN} = V_{SS}$                                 | 30                                                  | 40  | 50                                                   | k $\Omega$    |
| $R_{PD}$  | Weak pull-down equivalent resistor <sup>(5)</sup>             | $V_{IN} = V_{DD}$                                 | 30                                                  | 40  | 50                                                   | k $\Omega$    |
| $C_{IO}$  | I/O pin capacitance                                           | -                                                 | -                                                   | 5   | -                                                    | pF            |

1. FT = Five-volt tolerant. In order to sustain a voltage higher than  $V_{DD} + 0.3$  the internal pull-up/pull-down resistors must be disabled.
2. Hysteresis voltage between Schmitt trigger switching levels. Guaranteed by characterization results.
3. With a minimum of 100 mV.
4. Leakage could be higher than maximum value if negative current is injected on adjacent pins.
5. Pull-up and pull-down resistors are designed with a true resistance in series with a switchable PMOS/NMOS. This PMOS/NMOS contribution to the series resistance is minimum (~10% order).

All I/Os are CMOS and TTL compliant (no software configuration required). Their characteristics cover more than the strict CMOS-technology or TTL parameters. The coverage of these requirements is shown in [Figure 37](#) and [Figure 38](#) for standard I/Os, and in [Figure 39](#) and [Figure 40](#) for 5 V tolerant I/Os.

Figure 37. Standard I/O input characteristics - CMOS port

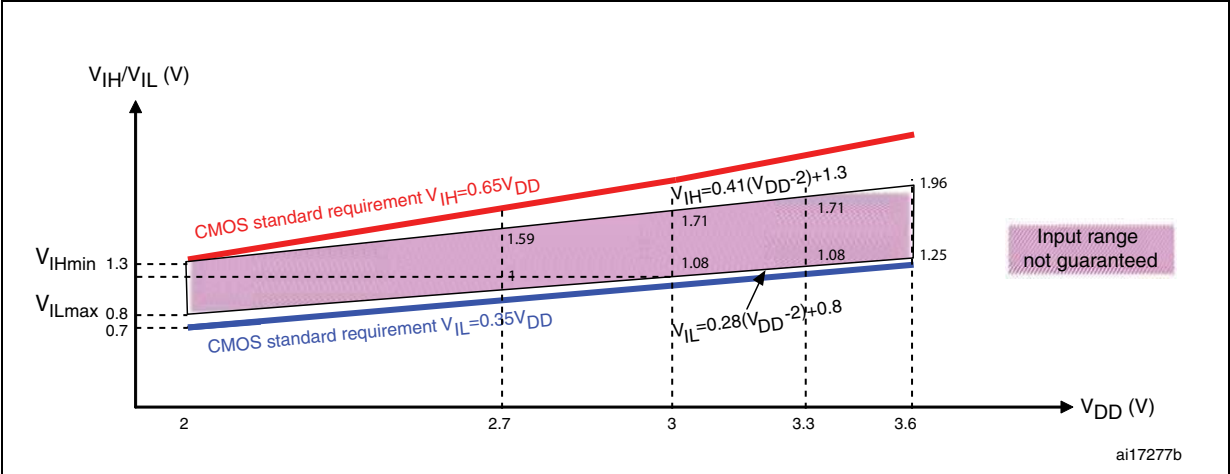


Figure 38. Standard I/O input characteristics - TTL port

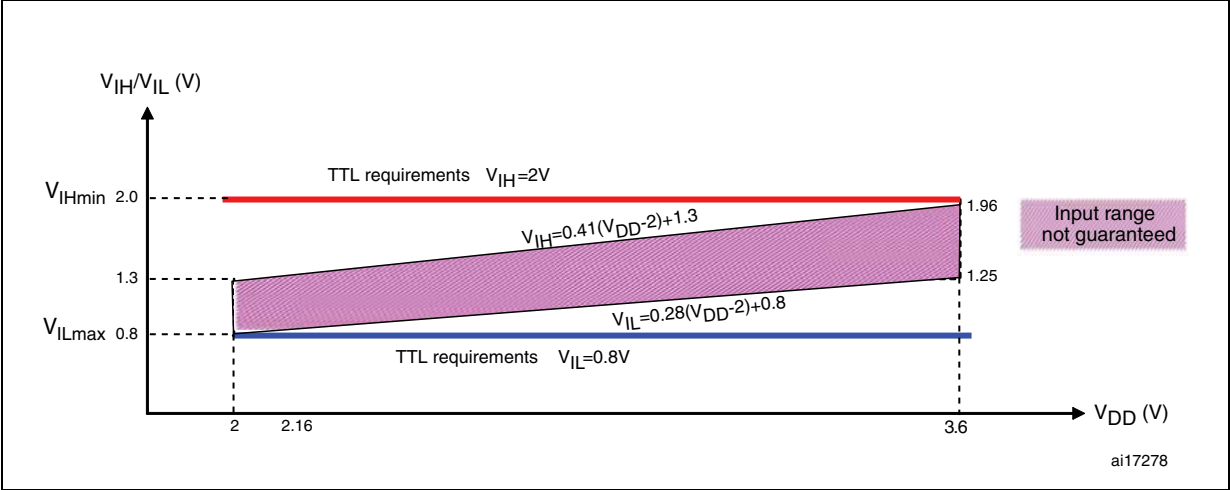


Figure 39. 5 V tolerant I/O input characteristics - CMOS port

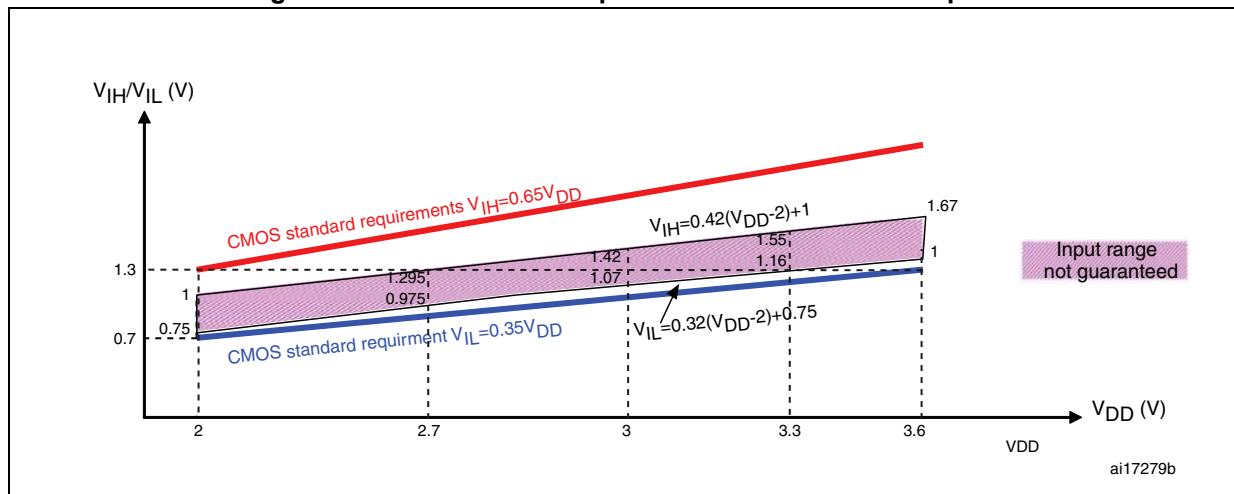
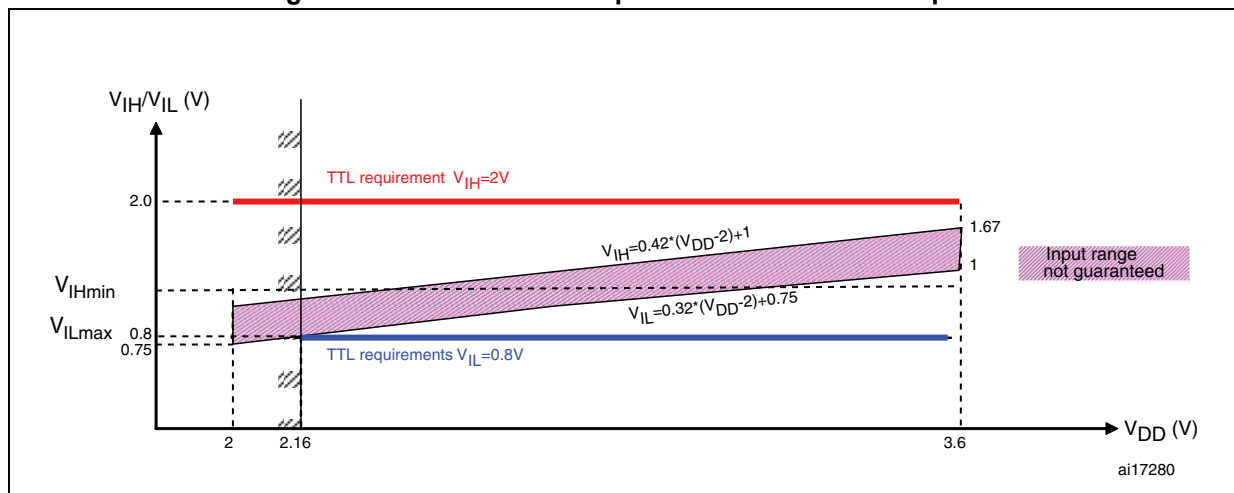


Figure 40. 5 V tolerant I/O input characteristics - TTL port



### Output driving current

The GPIOs (general purpose input/outputs) can sink or source up to  $\pm 8$  mA, and sink or source up to  $\pm 20$  mA (with a relaxed  $V_{OL}/V_{OH}$ ) except PC13, PC14 and PC15 which can sink or source up to  $\pm 3$  mA. When using the GPIOs PC13 to PC15 in output mode, the speed should not exceed 2 MHz with a maximum load of 30 pF.

In the user application, the number of I/O pins which can drive current must be limited to respect the absolute maximum rating specified in [Section 5.2](#):

- The sum of the currents sourced by all the I/Os on  $V_{DD}$ , plus the maximum Run consumption of the MCU sourced on  $V_{DD}$ , cannot exceed the absolute maximum rating  $I_{VDD}$  (see [Table 8](#)).
- The sum of the currents sunk by all the I/Os on  $V_{SS}$  plus the maximum Run consumption of the MCU sunk on  $V_{SS}$  cannot exceed the absolute maximum rating  $I_{VSS}$  (see [Table 8](#)).

## Output voltage levels

Unless otherwise specified, the parameters given in [Table 48](#) are derived from tests performed under ambient temperature and  $V_{DD}$  supply voltage conditions summarized in [Table 10](#). All I/Os are CMOS and TTL compliant.

**Table 48. Output voltage characteristics**

| Symbol         | Parameter                                                                         | Conditions                                                                                           | Min          | Max | Unit |
|----------------|-----------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------|--------------|-----|------|
| $V_{OL}^{(1)}$ | Output Low level voltage for an I/O pin when 8 pins are sunk at the same time     | CMOS port <sup>(2)</sup> ,<br>$I_{IO} = +8 \text{ mA}$ ,<br>$2.7 \text{ V} < V_{DD} < 3.6 \text{ V}$ | -            | 0.4 | V    |
| $V_{OH}^{(3)}$ | Output High level voltage for an I/O pin when 8 pins are sourced at the same time |                                                                                                      | $V_{DD}-0.4$ | -   |      |
| $V_{OL}^{(1)}$ | Output low level voltage for an I/O pin when 8 pins are sunk at the same time     | TTL port <sup>(2)</sup><br>$I_{IO} = +8 \text{ mA}$<br>$2.7 \text{ V} < V_{DD} < 3.6 \text{ V}$      | -            | 0.4 | V    |
| $V_{OH}^{(3)}$ | Output high level voltage for an I/O pin when 8 pins are sourced at the same time |                                                                                                      | 2.4          | -   |      |
| $V_{OL}^{(1)}$ | Output low level voltage for an I/O pin when 8 pins are sunk at the same time     | $I_{IO} = +20 \text{ mA}^{(4)}$<br>$2.7 \text{ V} < V_{DD} < 3.6 \text{ V}$                          | -            | 1.3 | V    |
| $V_{OH}^{(3)}$ | Output high level voltage for an I/O pin when 8 pins are sourced at the same time |                                                                                                      | $V_{DD}-1.3$ | -   |      |
| $V_{OL}^{(1)}$ | Output low level voltage for an I/O pin when 8 pins are sunk at the same time     | $I_{IO} = +6 \text{ mA}^{(4)}$<br>$2 \text{ V} < V_{DD} < 2.7 \text{ V}$                             | -            | 0.4 | V    |
| $V_{OH}^{(3)}$ | Output high level voltage for an I/O pin when 8 pins are sourced at the same time |                                                                                                      | $V_{DD}-0.4$ | -   |      |

1. The  $I_{IO}$  current sunk by the device must always respect the absolute maximum rating specified in [Table 8](#) and the sum of  $I_{IO}$  (I/O ports and control pins) must not exceed  $I_{VSS}$ .
2. TTL and CMOS outputs are compatible with JEDEC standards JESD36 and JESD52.
3. The  $I_{IO}$  current sourced by the device must always respect the absolute maximum rating specified in [Table 8](#) and the sum of  $I_{IO}$  (I/O ports and control pins) must not exceed  $I_{VDD}$ .
4. Guaranteed by characterization results.

### Input/output AC characteristics

The definition and values of input/output AC characteristics are given in [Figure 41](#) and [Table 49](#), respectively.

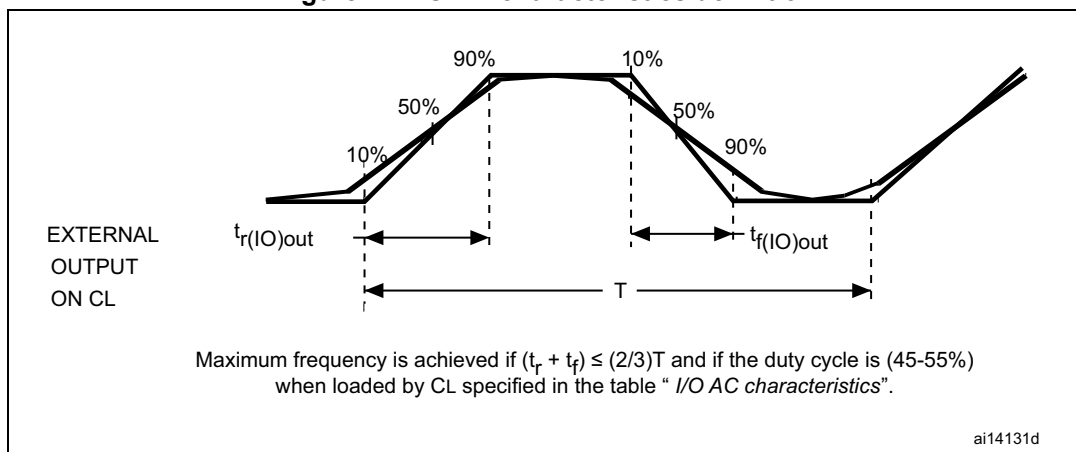
Unless otherwise specified, the parameters given in [Table 49](#) are derived from tests performed under ambient temperature and  $V_{DD}$  supply voltage conditions summarized in [Table 10](#).

**Table 49. I/O AC characteristics<sup>(1)</sup>**

| MODEx<br>[1:0] bit<br>value <sup>(1)</sup> | Symbol                          | Parameter                                                       | Conditions                                                         | Max                | Unit |
|--------------------------------------------|---------------------------------|-----------------------------------------------------------------|--------------------------------------------------------------------|--------------------|------|
| 10                                         | $f_{\max(\text{IO})\text{out}}$ | Maximum frequency <sup>(2)</sup>                                | $C_L = 50 \text{ pF}$ , $V_{DD} = 2 \text{ V to } 3.6 \text{ V}$   | 2                  | MHz  |
|                                            | $t_{f(\text{IO})\text{out}}$    | Output high to low level fall time                              | $C_L = 50 \text{ pF}$ , $V_{DD} = 2 \text{ V to } 3.6 \text{ V}$   | 125 <sup>(3)</sup> | ns   |
|                                            | $t_{r(\text{IO})\text{out}}$    | Output low to high level rise time                              |                                                                    | 125 <sup>(3)</sup> |      |
| 01                                         | $f_{\max(\text{IO})\text{out}}$ | Maximum frequency <sup>(2)</sup>                                | $C_L = 50 \text{ pF}$ , $V_{DD} = 2 \text{ V to } 3.6 \text{ V}$   | 10                 | MHz  |
|                                            | $t_{f(\text{IO})\text{out}}$    | Output high to low level fall time                              | $C_L = 50 \text{ pF}$ , $V_{DD} = 2 \text{ V to } 3.6 \text{ V}$   | 25 <sup>(3)</sup>  | ns   |
|                                            | $t_{r(\text{IO})\text{out}}$    | Output low to high level rise time                              |                                                                    | 25 <sup>(3)</sup>  |      |
| 11                                         | $F_{\max(\text{IO})\text{out}}$ | Maximum Frequency <sup>(2)</sup>                                | $C_L = 30 \text{ pF}$ , $V_{DD} = 2.7 \text{ V to } 3.6 \text{ V}$ | 50                 | MHz  |
|                                            |                                 |                                                                 | $C_L = 50 \text{ pF}$ , $V_{DD} = 2.7 \text{ V to } 3.6 \text{ V}$ | 30                 | MHz  |
|                                            |                                 |                                                                 | $C_L = 50 \text{ pF}$ , $V_{DD} = 2 \text{ V to } 2.7 \text{ V}$   | 20                 | MHz  |
|                                            | $t_{f(\text{IO})\text{out}}$    | Output high to low level fall time                              | $C_L = 30 \text{ pF}$ , $V_{DD} = 2.7 \text{ V to } 3.6 \text{ V}$ | 5 <sup>(3)</sup>   | ns   |
|                                            |                                 |                                                                 | $C_L = 50 \text{ pF}$ , $V_{DD} = 2.7 \text{ V to } 3.6 \text{ V}$ | 8 <sup>(3)</sup>   |      |
|                                            |                                 |                                                                 | $C_L = 50 \text{ pF}$ , $V_{DD} = 2 \text{ V to } 2.7 \text{ V}$   | 12 <sup>(3)</sup>  |      |
|                                            | $t_{r(\text{IO})\text{out}}$    | Output low to high level rise time                              | $C_L = 30 \text{ pF}$ , $V_{DD} = 2.7 \text{ V to } 3.6 \text{ V}$ | 5 <sup>(3)</sup>   |      |
|                                            |                                 |                                                                 | $C_L = 50 \text{ pF}$ , $V_{DD} = 2.7 \text{ V to } 3.6 \text{ V}$ | 8 <sup>(3)</sup>   |      |
|                                            |                                 |                                                                 | $C_L = 50 \text{ pF}$ , $V_{DD} = 2 \text{ V to } 2.7 \text{ V}$   | 12 <sup>(3)</sup>  |      |
| -                                          | $t_{\text{EXTI}pw}$             | Pulse width of external signals detected by the EXTI controller | -                                                                  | 10                 | ns   |

1. The I/O speed is configured using the MODEx[1:0] bits. Refer to the STM32F10xxx reference manual for a description of GPIO Port configuration register.
2. The maximum frequency is defined in [Figure 41](#).
3. Guaranteed by design.

Figure 41. I/O AC characteristics definition



### 5.3.15 NRST pin characteristics

The NRST pin input driver uses CMOS technology. It is connected to a permanent pull-up resistor,  $R_{PU}$  (see [Table 47](#)).

Unless otherwise specified, the parameters given in [Table 50](#) are derived from tests performed under ambient temperature and  $V_{DD}$  supply voltage conditions summarized in [Table 10](#).

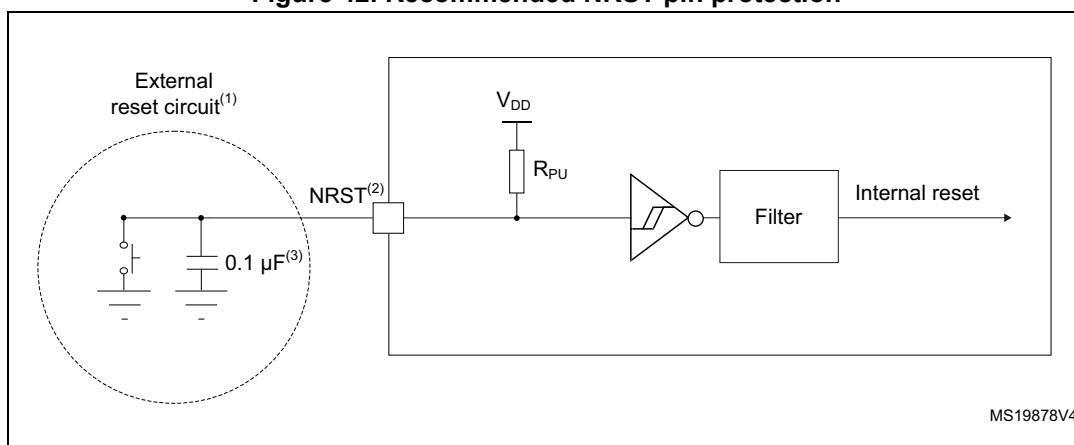
Table 50. NRST pin characteristics

| Symbol               | Parameter                                       | Conditions        | Min  | Typ | Max          | Unit       |
|----------------------|-------------------------------------------------|-------------------|------|-----|--------------|------------|
| $V_{IL(NRST)}^{(1)}$ | NRST Input low level voltage                    | -                 | -0.5 | -   | 0.8          | V          |
| $V_{IH(NRST)}^{(1)}$ | NRST Input high level voltage                   | -                 | 2    | -   | $V_{DD}+0.5$ |            |
| $V_{hys(NRST)}$      | NRST Schmitt trigger voltage hysteresis         | -                 | -    | 200 | -            | mV         |
| $R_{PU}$             | Weak pull-up equivalent resistor <sup>(2)</sup> | $V_{IN} = V_{SS}$ | 30   | 40  | 50           | k $\Omega$ |
| $V_{F(NRST)}^{(1)}$  | NRST Input filtered pulse                       | -                 | -    | -   | 100          | ns         |
| $V_{NF(NRST)}^{(1)}$ | NRST Input not filtered pulse                   | -                 | 300  | -   | -            | ns         |

1. Guaranteed by design.

2. The pull-up is designed with a true resistance in series with a switchable PMOS. This PMOS contribution to the series resistance must be minimum (~10% order).

Figure 42. Recommended NRST pin protection



1. The reset network protects the device against parasitic resets.
2. The user must ensure that the level on the NRST pin can go below the  $V_{IL(NRST)}$  max level specified in [Table 50](#). Otherwise the reset will not be taken into account by the device.
3. The external capacitor on NRST must be placed as close as possible to the device.

### 5.3.16 TIM timer characteristics

The parameters given in [Table 51](#) are guaranteed by design.

Refer to [Section 5.3.13: I/O current injection characteristics](#) for details on the input/output alternate function characteristics (output compare, input capture, external clock, PWM output).

Table 51. TIMx<sup>(1)</sup> characteristics

| Symbol           | Parameter                                                   | Conditions                     | Min    | Max                  | Unit          |
|------------------|-------------------------------------------------------------|--------------------------------|--------|----------------------|---------------|
| $t_{res(TIM)}$   | Timer resolution time                                       | -                              | 1      | -                    | $t_{TIMxCLK}$ |
|                  |                                                             | $f_{TIMxCLK} = 36 \text{ MHz}$ | 27.8   | -                    | ns            |
| $f_{EXT}$        | Timer external clock frequency on CH1 to CH4                | -                              | 0      | $f_{TIMxCLK}/2$      | MHz           |
|                  |                                                             | $f_{TIMxCLK} = 36 \text{ MHz}$ | 0      | 18                   | MHz           |
| $Res_{TIM}$      | Timer resolution                                            | -                              | -      | 16                   | bit           |
| $t_{COUNTER}$    | 16-bit counter clock period when internal clock is selected | -                              | 1      | 65536                | $t_{TIMxCLK}$ |
|                  |                                                             | $f_{TIMxCLK} = 36 \text{ MHz}$ | 0.0278 | 1820                 | µs            |
| $t_{MAX\_COUNT}$ | Maximum possible count                                      | -                              | -      | $65536 \times 65536$ | $t_{TIMxCLK}$ |
|                  |                                                             | $f_{TIMxCLK} = 36 \text{ MHz}$ | -      | 119.2                | s             |

1. TIMx is used as a general term to refer to the TIM1, TIM2, TIM3 and TIM4 timers.

### 5.3.17 Communications interfaces

#### I<sup>2</sup>C interface characteristics

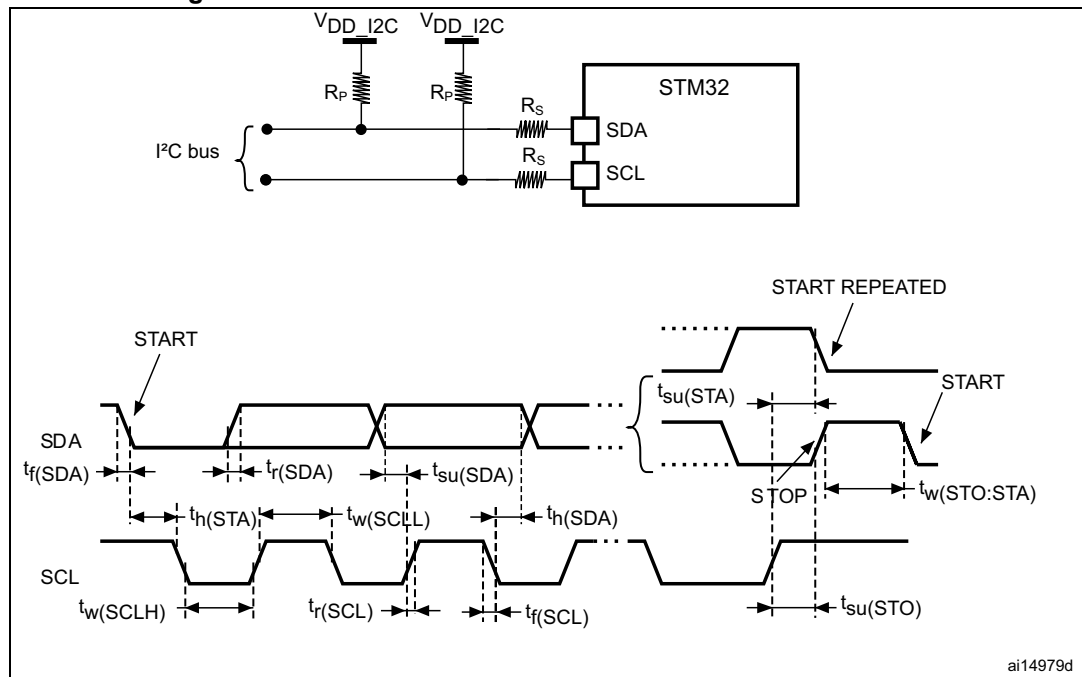
The STM32F101xF and STM32F101xG access line I<sup>2</sup>C interface meets the requirements of the standard I<sup>2</sup>C communication protocol with the following restrictions: the I/O pins SDA and SCL are mapped to are not “true” open-drain. When configured as open-drain, the PMOS connected between the I/O pin and V<sub>DD</sub> is disabled, but is still present.

The I<sup>2</sup>C characteristics are described in [Table 52](#). Refer also to [Section 5.3.13: I/O current injection characteristics](#) for more details on the input/output alternate function characteristics (SDA and SCL).

**Table 52. I<sup>2</sup>C characteristics**

| Symbol                                       | Parameter                                                                                     | Standard mode<br>I <sup>2</sup> C <sup>(1)(2)</sup> |                     | Fast mode I <sup>2</sup> C <sup>(1)(2)</sup> |                    | Unit |
|----------------------------------------------|-----------------------------------------------------------------------------------------------|-----------------------------------------------------|---------------------|----------------------------------------------|--------------------|------|
|                                              |                                                                                               | Min                                                 | Max                 | Min                                          | Max                |      |
| t <sub>w</sub> (SCLL)                        | SCL clock low time                                                                            | 4.7                                                 | -                   | 1.3                                          | -                  | μs   |
| t <sub>w</sub> (SCLH)                        | SCL clock high time                                                                           | 4.0                                                 | -                   | 0.6                                          | -                  |      |
| t <sub>su</sub> (SDA)                        | SDA setup time                                                                                | 250                                                 | -                   | 100                                          | -                  | ns   |
| t <sub>h</sub> (SDA)                         | SDA data hold time                                                                            | -                                                   | 3450 <sup>(3)</sup> | -                                            | 900 <sup>(3)</sup> |      |
| t <sub>r</sub> (SDA)<br>t <sub>r</sub> (SCL) | SDA and SCL rise time                                                                         | -                                                   | 1000                | -                                            | 300                |      |
| t <sub>f</sub> (SDA)<br>t <sub>f</sub> (SCL) | SDA and SCL fall time                                                                         | -                                                   | 300                 | -                                            | 300                |      |
| t <sub>h</sub> (STA)                         | Start condition hold time                                                                     | 4.0                                                 | -                   | 0.6                                          | -                  | μs   |
| t <sub>su</sub> (STA)                        | Repeated Start condition setup time                                                           | 4.7                                                 | -                   | 0.6                                          | -                  |      |
| t <sub>su</sub> (STO)                        | Stop condition setup time                                                                     | 4.0                                                 | -                   | 0.6                                          | -                  | μs   |
| t <sub>w</sub> (STO:STA)                     | Stop to Start condition time (bus free)                                                       | 4.7                                                 | -                   | 1.3                                          | -                  | μs   |
| C <sub>b</sub>                               | Capacitive load for each bus line                                                             | -                                                   | 400                 | -                                            | 400                | pF   |
| t <sub>SP</sub>                              | Pulse width of the spikes that are suppressed by the analog filter for standard and fast mode | 0                                                   | 50 <sup>(4)</sup>   | 0                                            | 50 <sup>(4)</sup>  | μs   |

1. Guaranteed by design.
2. f<sub>PCLK1</sub> must be at least 2 MHz to achieve standard mode I<sup>2</sup>C frequencies. It must be at least 4 MHz to achieve the fast mode I<sup>2</sup>C frequencies and it must be a multiple of 10 MHz in order to reach the I<sup>2</sup>C fast mode maximum clock speed of 400 kHz.
3. The maximum data hold time has only to be met if the interface does not stretch the low period of SCL signal.
4. The minimum width of the spikes filtered by the analog filter is above t<sub>SP</sub>(max).

Figure 43. I<sup>2</sup>C bus AC waveforms and measurement circuit<sup>(1)</sup>

1. Measurement points are done at CMOS levels:  $0.3V_{DD}$  and  $0.7V_{DD}$ .
1.  $R_S$  = series protection resistor.
2.  $R_P$  = external pull-up resistor.
3.  $V_{DD\_I2C}$  is the I<sup>2</sup>C bus power supply.

Table 53. SCL frequency ( $f_{PCLK1} = 36 \text{ MHz}$ ,  $V_{DD} = V_{DD\_I2C} = 3.3 \text{ V}$ )<sup>(1)(2)</sup>

| $f_{SCL}$<br>(kHz) | I2C_CCR value               |
|--------------------|-----------------------------|
|                    | $R_P = 4.7 \text{ k}\Omega$ |
| 400                | 0x801E                      |
| 300                | 0x8028                      |
| 200                | 0x803C                      |
| 100                | 0x00B4                      |
| 50                 | 0x0168                      |
| 20                 | 0x0384                      |

1.  $R_P$  = External pull-up resistance,  $f_{SCL}$  = I<sup>2</sup>C speed.
2. For speeds around 200 kHz, the tolerance on the achieved speed is of  $\pm 5\%$ . For other speed ranges, the tolerance on the achieved speed  $\pm 2\%$ . These variations depend on the accuracy of the external components used to design the application.

### SPI interface characteristics

Unless otherwise specified, the parameters given in [Table 54](#)[Table 55](#) are derived from tests performed under ambient temperature,  $f_{PCLKx}$  frequency and  $V_{DD}$  supply voltage conditions summarized in [Table 10](#).

Refer to [Section 5.3.13: I/O current injection characteristics](#) for more details on the input/output alternate function characteristics (NSS, SCK, MOSI, MISO).

**Table 54. STM32F10xxx SPI characteristics**

| Symbol                                     | Parameter                    | Conditions                                  | Min         | Max         | Unit |
|--------------------------------------------|------------------------------|---------------------------------------------|-------------|-------------|------|
| $f_{SCK}$<br>$1/t_{c(SCK)}$                | SPI clock frequency          | Master mode                                 | -           | 10          | MHz  |
|                                            |                              | Slave mode                                  | -           | 10          |      |
| $t_{r(SCK)}$<br>$t_{f(SCK)}$               | SPI clock rise and fall time | Capacitive load: C = 30 pF                  | -           | 8           | ns   |
| $t_{su(NSS)}^{(1)}$                        | NSS setup time               | Slave mode                                  | $4t_{PCLK}$ | -           |      |
| $t_{h(NSS)}^{(1)}$                         | NSS hold time                | Slave mode                                  | 73          | -           |      |
| $t_{w(SCKH)}^{(1)}$<br>$t_{w(SCKL)}^{(1)}$ | SCK high and low time        | Master mode, $f_{PCLK} = 36$ MHz, presc = 4 | 50          | 60          |      |
| $t_{su(MI)}^{(1)}$<br>$t_{su(SI)}^{(1)}$   | Data input setup time        | Master mode - SPI1                          | 3           | -           |      |
|                                            |                              | Master mode - SPI2                          | 5           | -           |      |
|                                            |                              | Slave mode                                  | 4           | -           |      |
| $t_{h(MI)}^{(1)}$<br>$t_{h(SI)}^{(1)}$     | Data input hold time         | Master mode - SPI1                          | 4           | -           |      |
|                                            |                              | Master mode - SPI2                          | 6           | -           |      |
|                                            |                              | Slave mode                                  | 5           | -           |      |
| $t_{a(SO)}^{(1)(2)}$                       | Data output access time      | Slave mode, $f_{PCLK} = 36$ MHz, presc = 4  | 0           | 55          |      |
|                                            |                              | Slave mode, $f_{PCLK} = 20$ MHz             | -           | $4t_{PCLK}$ |      |
| $t_{dis(SO)}^{(1)(3)}$                     | Data output disable time     | Slave mode                                  | 10          | -           |      |
| $t_{v(SO)}^{(1)}$                          | Data output valid time       | Slave mode (after enable edge)              | -           | 25          |      |
| $t_{v(MO)}^{(1)}$                          | Data output valid time       | Master mode (after enable edge)             | -           | 6           |      |
| $t_{h(SO)}^{(1)}$<br>$t_{h(MO)}^{(1)}$     | Data output hold time        | Slave mode (after enable edge)              | 25          | -           |      |
|                                            |                              | Master mode (after enable edge)             | 6           | -           |      |

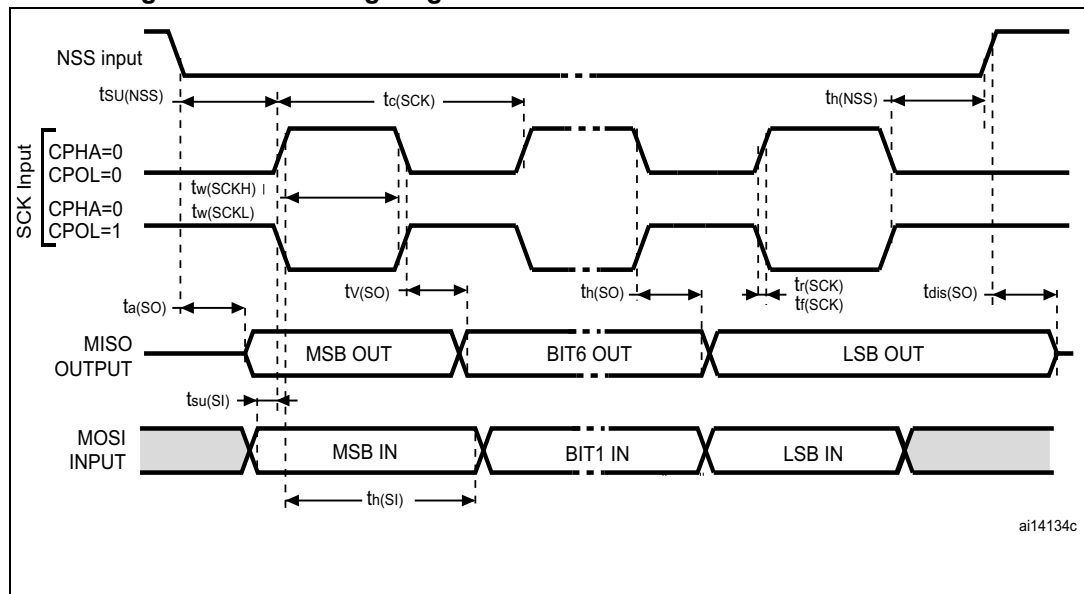
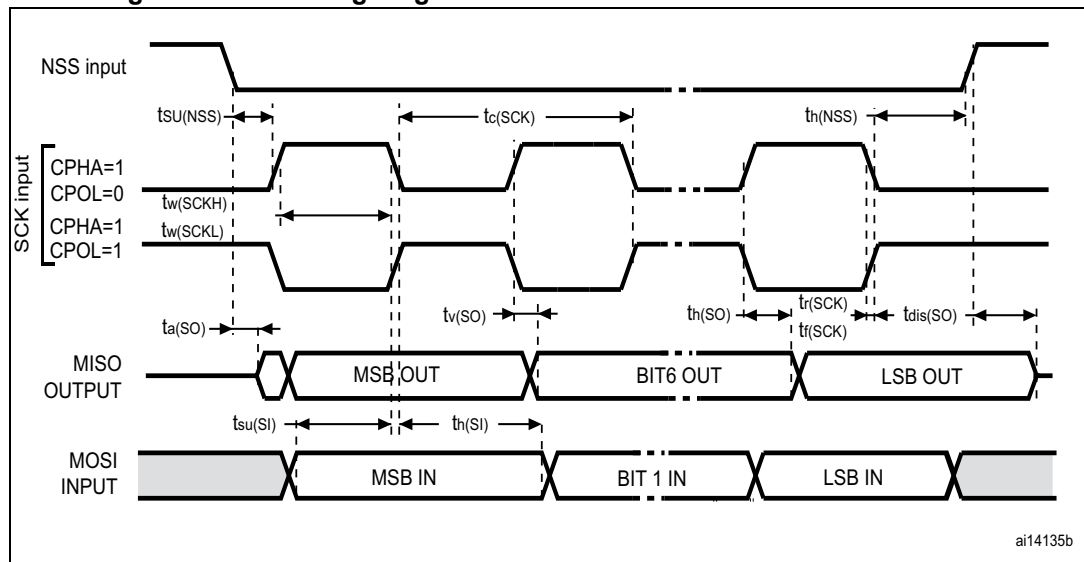
1. Guaranteed by characterization results.
2. Min time is for the minimum time to drive the output and the max time is for the maximum time to validate the data.
3. Min time is for the minimum time to invalidate the output and the max time is for the maximum time to put the data in Hi-Z

Table 55. SPI characteristics

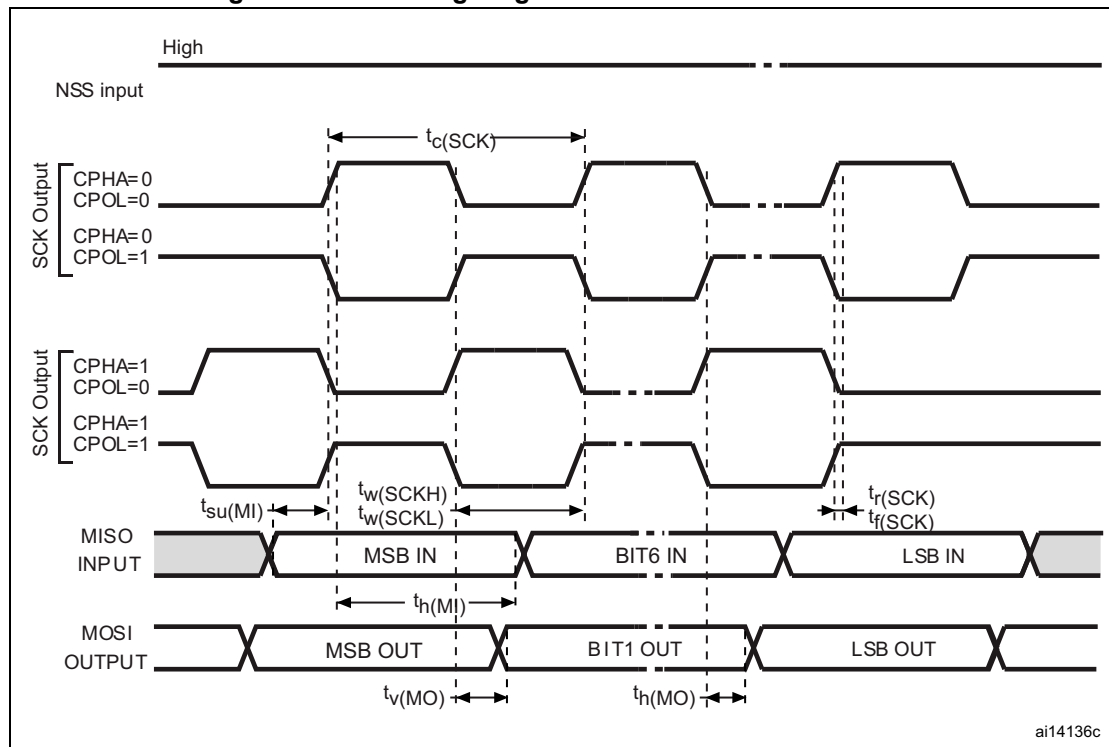
| Symbol                                     | Parameter                        | Conditions                                  | Min         | Max         | Unit |
|--------------------------------------------|----------------------------------|---------------------------------------------|-------------|-------------|------|
| $f_{SCK}$<br>$1/t_{c(SCK)}$                | SPI clock frequency              | Master mode                                 | -           | 18          | MHz  |
|                                            |                                  | Slave mode                                  | -           | 18          |      |
| $t_{r(SCK)}$<br>$t_{f(SCK)}$               | SPI clock rise and fall time     | Capacitive load: C = 30 pF                  | -           | 8           | ns   |
| DuCy(SCK)                                  | SPI slave input clock duty cycle | Slave mode                                  | 30          | 70          | %    |
| $t_{su(NSS)}^{(1)}$                        | NSS setup time                   | Slave mode                                  | $4t_{PCLK}$ | -           | ns   |
| $t_{h(NSS)}^{(1)}$                         | NSS hold time                    | Slave mode                                  | $2t_{PCLK}$ | -           |      |
| $t_{w(SCKH)}^{(1)}$<br>$t_{w(SCKL)}^{(1)}$ | SCK high and low time            | Master mode, $f_{PCLK} = 36$ MHz, presc = 4 | 50          | 60          |      |
| $t_{su(MI)}^{(1)}$<br>$t_{su(SI)}^{(1)}$   | Data input setup time            | Master mode                                 | 5           | -           |      |
|                                            |                                  | Slave mode                                  | 5           | -           |      |
| $t_{h(MI)}^{(1)}$<br>$t_{h(SI)}^{(1)}$     | Data input hold time             | Master mode                                 | 5           | -           |      |
|                                            |                                  | Slave mode                                  | 4           | -           |      |
| $t_{a(SO)}^{(1)(2)}$                       | Data output access time          | Slave mode, $f_{PCLK} = 20$ MHz             | 0           | $3t_{PCLK}$ |      |
| $t_{dis(SO)}^{(1)(3)}$                     | Data output disable time         | Slave mode                                  | 2           | 10          |      |
| $t_{v(SO)}^{(1)(1)}$                       | Data output valid time           | Slave mode (after enable edge)              | -           | 25          |      |
| $t_{v(MO)}^{(1)(1)}$                       | Data output valid time           | Master mode (after enable edge)             | -           | 5           |      |
| $t_{h(SO)}^{(1)}$<br>$t_{h(MO)}^{(1)}$     | Data output hold time            | Slave mode (after enable edge)              | 15          | -           |      |
|                                            |                                  | Master mode (after enable edge)             | 2           | -           |      |

1. Guaranteed by characterization results.
2. Min time is for the minimum time to drive the output and the max time is for the maximum time to validate the data.
3. Min time is for the minimum time to invalidate the output and the max time is for the maximum time to put the data in Hi-Z

Figure 44. SPI timing diagram - slave mode and CPHA=0

Figure 45. SPI timing diagram - slave mode and CPHA=1<sup>(1)</sup>

1. Measurement points are done at CMOS levels:  $0.3V_{DD}$  and  $0.7V_{DD}$ .

Figure 46. SPI timing diagram - master mode<sup>(1)</sup>

1. Measurement points are done at CMOS levels:  $0.3V_{DD}$  and  $0.7V_{DD}$ .

### 5.3.18 12-bit ADC characteristics

Unless otherwise specified, the parameters given in [Table 56](#) are preliminary values derived from tests performed under ambient temperature,  $f_{PCLK2}$  frequency and  $V_{DDA}$  supply voltage conditions summarized in [Table 10](#).

**Note:** *It is recommended to perform a calibration after each power-up.*

Table 56. ADC characteristics

| Symbol                           | Parameter                                       | Conditions                                                              | Min                                                                        | Typ | Max                | Unit               |
|----------------------------------|-------------------------------------------------|-------------------------------------------------------------------------|----------------------------------------------------------------------------|-----|--------------------|--------------------|
| V <sub>DDA</sub>                 | Power supply                                    | -                                                                       | 2.4                                                                        | -   | 3.6                | V                  |
| V <sub>REF+</sub>                | Positive reference voltage                      | -                                                                       | 2.4                                                                        | -   | V <sub>DDA</sub>   | V                  |
| V <sub>REF-</sub>                | Negative reference voltage                      | -                                                                       | -                                                                          | 0   | -                  | V                  |
| I <sub>VREF</sub>                | Current on the V <sub>REF</sub> input pin       | -                                                                       | -                                                                          | 160 | 220 <sup>(1)</sup> | μA                 |
| f <sub>ADC</sub>                 | ADC clock frequency                             | -                                                                       | 0.6                                                                        | -   | 14                 | MHz                |
| f <sub>S</sub> <sup>(2)</sup>    | Sampling rate                                   | -                                                                       | 0.05                                                                       | -   | 1                  | MHz                |
| f <sub>TRIG</sub> <sup>(2)</sup> | External trigger frequency                      | f <sub>ADC</sub> = 14 MHz                                               | -                                                                          | -   | 823                | kHz                |
|                                  |                                                 | -                                                                       | -                                                                          | -   | 17                 | 1/f <sub>ADC</sub> |
| V <sub>AIN</sub>                 | Conversion voltage range <sup>(3)</sup>         | -                                                                       | 0 (V <sub>SSA</sub> or V <sub>REF-</sub> tied to ground)                   | -   | V <sub>REF+</sub>  | V                  |
| R <sub>AIN</sub> <sup>(2)</sup>  | External input impedance                        | See <a href="#">Equation 1</a> and <a href="#">Table 57</a> for details | -                                                                          | -   | 50                 | kΩ                 |
| R <sub>ADC</sub> <sup>(2)</sup>  | Sampling switch resistance                      | -                                                                       | -                                                                          | -   | 1                  | kΩ                 |
| C <sub>ADC</sub> <sup>(2)</sup>  | Internal sample and hold capacitor              | -                                                                       | -                                                                          | -   | 8                  | pF                 |
| t <sub>CAL</sub> <sup>(2)</sup>  | Calibration time                                | f <sub>ADC</sub> = 14 MHz                                               | 5.9                                                                        |     |                    | μs                 |
|                                  |                                                 | -                                                                       | 83                                                                         |     |                    | 1/f <sub>ADC</sub> |
| t <sub>lat</sub> <sup>(2)</sup>  | Injection trigger conversion latency            | f <sub>ADC</sub> = 14 MHz                                               | -                                                                          | -   | 0.214              | μs                 |
|                                  |                                                 | -                                                                       | -                                                                          | -   | 3 <sup>(4)</sup>   | 1/f <sub>ADC</sub> |
| t <sub>latr</sub> <sup>(2)</sup> | Regular trigger conversion latency              | f <sub>ADC</sub> = 14 MHz                                               | -                                                                          | -   | 0.143              | μs                 |
|                                  |                                                 | -                                                                       | -                                                                          | -   | 2 <sup>(4)</sup>   | 1/f <sub>ADC</sub> |
| t <sub>S</sub> <sup>(2)</sup>    | Sampling time                                   | f <sub>ADC</sub> = 14 MHz                                               | 0.107                                                                      | -   | 17.1               | μs                 |
|                                  |                                                 | -                                                                       | 1.5                                                                        | -   | 239.5              | 1/f <sub>ADC</sub> |
| t <sub>STAB</sub> <sup>(2)</sup> | Power-up time                                   | -                                                                       | 0                                                                          | 0   | 1                  | μs                 |
| t <sub>CONV</sub> <sup>(2)</sup> | Total conversion time (including sampling time) | f <sub>ADC</sub> = 14 MHz                                               | 1                                                                          | -   | 18                 | μs                 |
|                                  |                                                 | -                                                                       | 14 to 252 (t <sub>S</sub> for sampling +12.5 for successive approximation) |     |                    | 1/f <sub>ADC</sub> |

1. Guaranteed by characterization results.

2. Guaranteed by design.

3. V<sub>REF+</sub> can be internally connected to V<sub>DDA</sub> and V<sub>REF-</sub> can be internally connected to V<sub>SSA</sub>, depending on the package. Refer to [Section 3: Pinouts and pin descriptions](#) for further details.

4. For external triggers, a delay of 1/f<sub>CLK2</sub> must be added to the latency specified in [Table 56](#).

**Equation 1: R<sub>AIN</sub> max formula:**

$$R_{AIN} < \frac{T_S}{f_{ADC} \times C_{ADC} \times \ln(2^{N+2})} - R_{ADC}$$

The formula above ([Equation 1](#)) is used to determine the maximum external impedance allowed for an error below 1/4 of LSB. Here N = 12 (from 12-bit resolution).

**Table 57.  $R_{AIN}$  max for  $f_{ADC} = 14$  MHz<sup>(1)</sup>**

| $T_s$ (cycles) | $t_s$ ( $\mu$ s) | $R_{AIN}$ max (k $\Omega$ ) |
|----------------|------------------|-----------------------------|
| 1.5            | 0.11             | 0.4                         |
| 7.5            | 0.54             | 5.9                         |
| 13.5           | 0.96             | 11.4                        |
| 28.5           | 2.04             | 25.2                        |
| 41.5           | 2.96             | 37.2                        |
| 55.5           | 3.96             | 50                          |
| 71.5           | 5.11             | NA                          |
| 239.5          | 17.1             | NA                          |

1. Guaranteed by design.

**Table 58. ADC accuracy - limited test conditions<sup>(1)(2)</sup>**

| Symbol | Parameter                    | Test conditions                                                                                                                                                                           | Typ       | Max <sup>(3)</sup> | Unit |
|--------|------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|--------------------|------|
| ET     | Total unadjusted error       | $f_{PCLK2} = 28$ MHz,<br>$f_{ADC} = 14$ MHz, $R_{AIN} < 10$ k $\Omega$ ,<br>$V_{DDA} = 3$ V to 3.6 V, $T_A = 25$ °C<br>Measurements made after<br>ADC calibration<br>$V_{REF+} = V_{DDA}$ | $\pm 1.3$ | $\pm 2$            | LSB  |
| EO     | Offset error                 |                                                                                                                                                                                           | $\pm 1$   | $\pm 1.5$          |      |
| EG     | Gain error                   |                                                                                                                                                                                           | $\pm 0.5$ | $\pm 1.5$          |      |
| ED     | Differential linearity error |                                                                                                                                                                                           | $\pm 0.7$ | $\pm 1$            |      |
| EL     | Integral linearity error     |                                                                                                                                                                                           | $\pm 0.8$ | $\pm 1.5$          |      |

- ADC DC accuracy values are measured after internal calibration.
- ADC Accuracy vs. Negative Injection Current: Injecting negative current on any of the standard analog input pins should be avoided as this significantly reduces the accuracy of the conversion being performed on another analog input. It is recommended to add a Schottky diode (pin to ground) to analog pins which may potentially inject negative current.  
Any positive injection current within the limits specified for  $I_{INJ(PIN)}$  and  $\Sigma I_{INJ(PIN)}$  in [Section 5.3.13](#) does not affect the ADC accuracy.
- Guaranteed by characterization results.

Table 59. ADC accuracy<sup>(1) (2)(3)</sup>

| Symbol | Parameter                    | Test conditions                                                                                                                                                                              | Typ       | Max <sup>(4)</sup> | Unit |
|--------|------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|--------------------|------|
| ET     | Total unadjusted error       | $f_{PCLK2} = 28 \text{ MHz}$ ,<br>$f_{ADC} = 14 \text{ MHz}$ , $R_{AIN} < 10 \text{ k}\Omega$ ,<br>$V_{DDA} = 2.4 \text{ V to } 3.6 \text{ V}$<br>Measurements made after<br>ADC calibration | $\pm 2$   | $\pm 5$            | LSB  |
| EO     | Offset error                 |                                                                                                                                                                                              | $\pm 1.5$ | $\pm 2.5$          |      |
| EG     | Gain error                   |                                                                                                                                                                                              | $\pm 1.5$ | $\pm 3$            |      |
| ED     | Differential linearity error |                                                                                                                                                                                              | $\pm 1$   | $\pm 2$            |      |
| EL     | Integral linearity error     |                                                                                                                                                                                              | $\pm 1.5$ | $\pm 3$            |      |

1. ADC DC accuracy values are measured after internal calibration.
2. Better performance could be achieved in restricted  $V_{DD}$ , frequency,  $V_{REF}$  and temperature ranges.
3. ADC accuracy vs. negative injection current: Injecting negative current on any of the standard (non-robust) analog input pins should be avoided as this significantly reduces the accuracy of the conversion being performed on another analog input. It is recommended to add a Schottky diode (pin to ground) to standard analog pins which may potentially inject negative current.  
Any positive injection current within the limits specified for  $I_{INJ(PIN)}$  and  $\Sigma I_{INJ(PIN)}$  in [Section 5.3.13](#) does not affect the ADC accuracy.
4. Preliminary values.

Figure 47. ADC accuracy characteristics

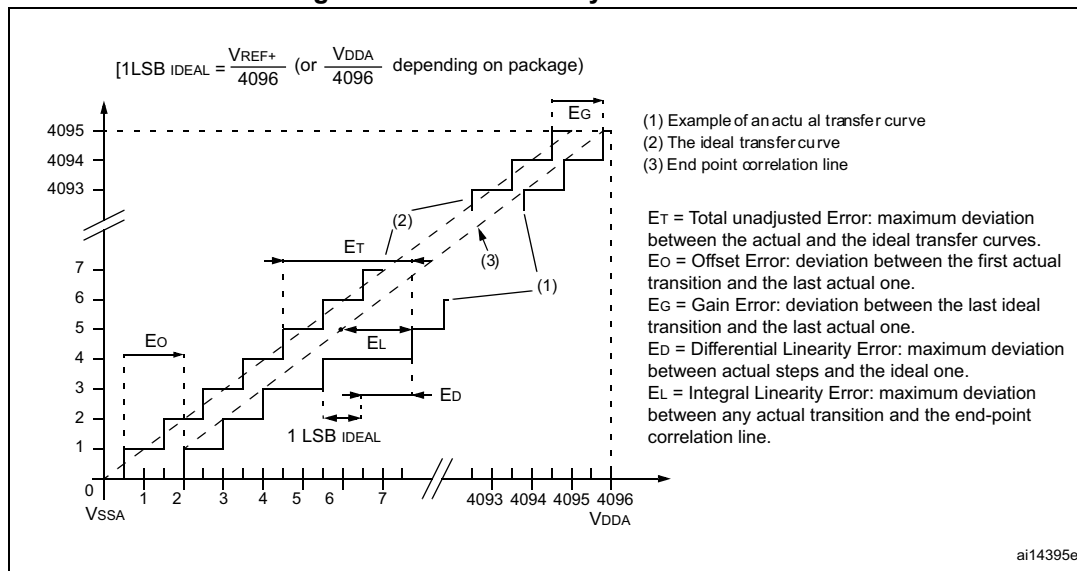
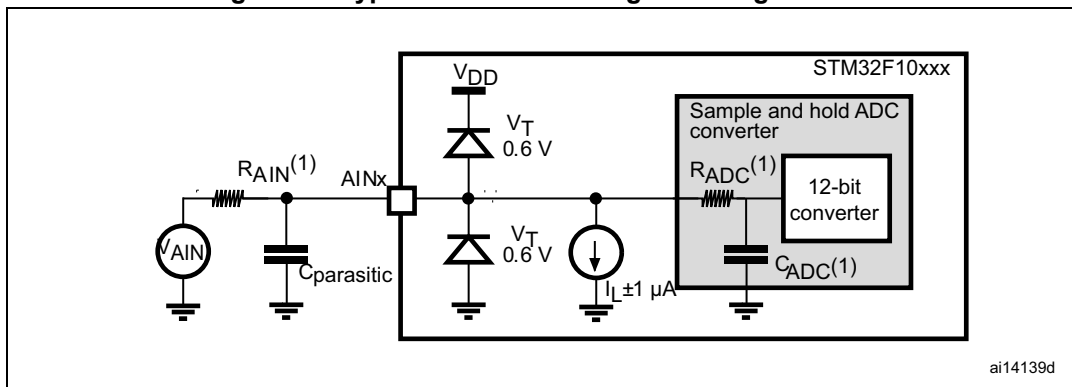


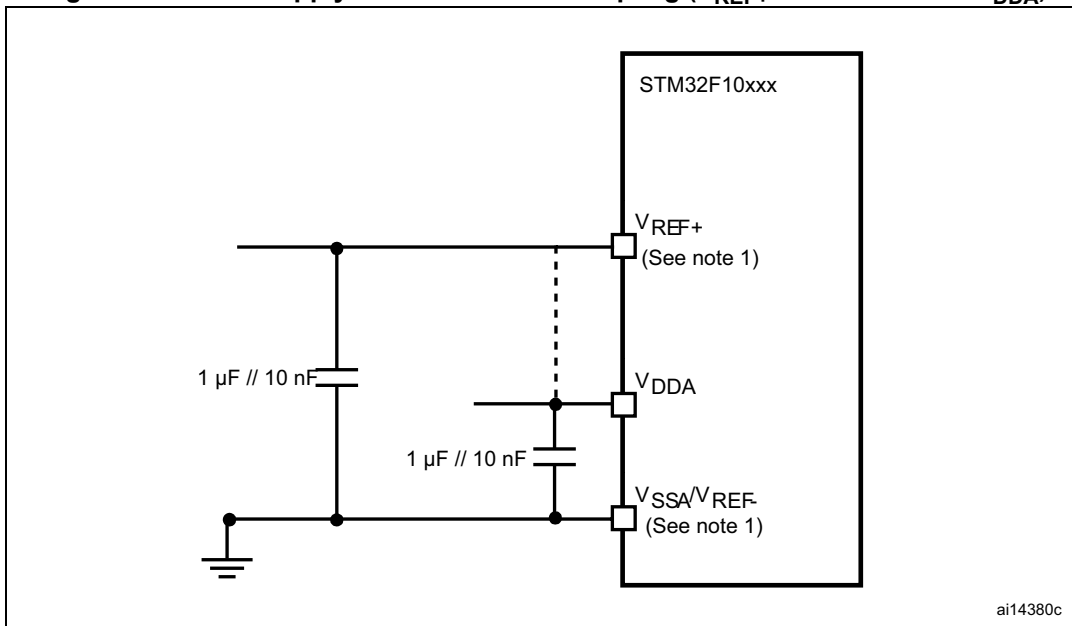
Figure 48. Typical connection diagram using the ADC



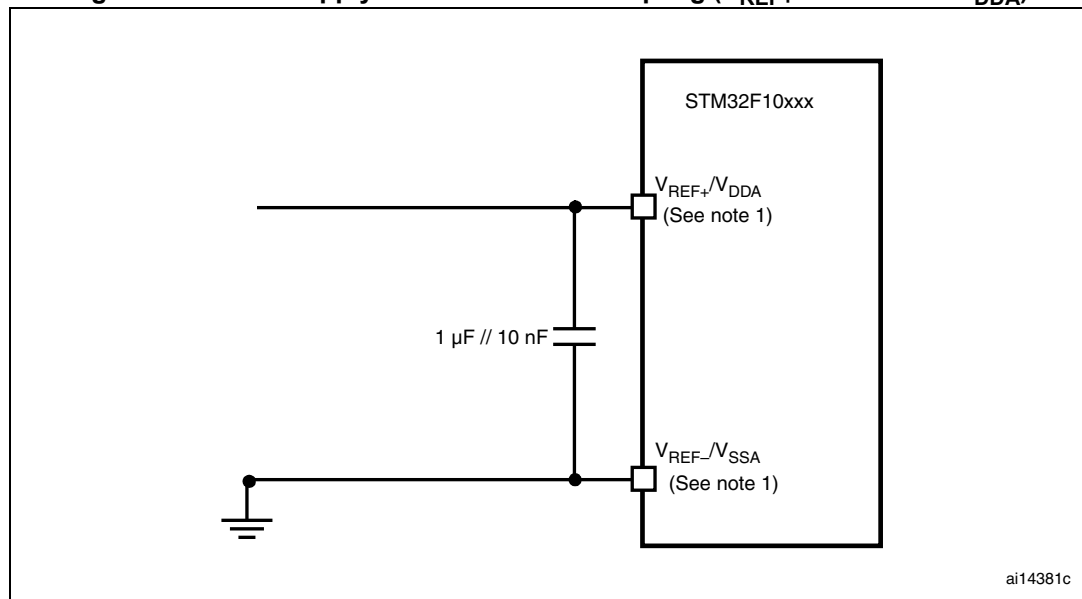
1. Refer to [Table 56](#) for the values of  $R_{AIN}$ ,  $R_{ADC}$  and  $C_{ADC}$ .
2.  $C_{parasitic}$  represents the capacitance of the PCB (dependent on soldering and PCB layout quality) plus the pad capacitance (roughly 7 pF). A high  $C_{parasitic}$  value will downgrade conversion accuracy. To remedy this,  $f_{ADC}$  should be reduced.

### General PCB design guidelines

Power supply decoupling should be performed as shown in [Figure 49](#) or [Figure 50](#), depending on whether  $V_{REF+}$  is connected to  $V_{DDA}$  or not. The 10 nF capacitors should be ceramic (good quality). They should be placed as close as possible to the chip.

Figure 49. Power supply and reference decoupling ( $V_{REF+}$  not connected to  $V_{DDA}$ )

1.  $V_{REF+}$  and  $V_{REF-}$  inputs are available only on 100-pin packages.

Figure 50. Power supply and reference decoupling ( $V_{REF+}$  connected to  $V_{DDA}$ )

1.  $V_{REF+}$  and  $V_{REF-}$  inputs are available only on 100-pin packages.

### 5.3.19 DAC electrical specifications

Table 60. DAC characteristics

| Symbol           | Parameter                        | Conditions           |                                   | Min | Typ | Max <sup>(1)</sup> | Unit       | Comments                                                                                                                |
|------------------|----------------------------------|----------------------|-----------------------------------|-----|-----|--------------------|------------|-------------------------------------------------------------------------------------------------------------------------|
| $V_{DDA}$        | Analog supply voltage            |                      |                                   | 2.4 | -   | 3.6                | V          | -                                                                                                                       |
| $V_{REF+}$       | Reference supply voltage         |                      |                                   | 2.4 | -   | 3.6                | V          | $V_{REF+}$ must always be below $V_{DDA}$                                                                               |
| $V_{SSA}$        | Ground                           |                      |                                   | 0   | -   | 0                  | V          | -                                                                                                                       |
| $R_{LOAD}^{(2)}$ | Resistive load with buffer ON    | DAC output buffer ON | $R_{LOAD}$ connected to $V_{SSA}$ | 5   | -   | -                  | k $\Omega$ | -                                                                                                                       |
|                  |                                  |                      | $R_{LOAD}$ connected to $V_{DDA}$ | 25  | -   | -                  |            | -                                                                                                                       |
| $R_O^{(2)}$      | Impedance output with buffer OFF |                      |                                   | -   | -   | 15                 | k $\Omega$ | When the buffer is OFF, the minimum resistive load between DAC_OUT and $V_{SS}$ to have a 1% accuracy is 1.5 M $\Omega$ |
| $C_{LOAD}^{(2)}$ | Capacitive load                  |                      |                                   | -   | -   | 50                 | pF         | Maximum capacitive load at DAC_OUT pin (when the buffer is ON).                                                         |

Table 60. DAC characteristics (continued)

| Symbol                                | Parameter                                                                                                                                      | Conditions |  | Min | Typ | Max <sup>(1)</sup>       | Unit | Comments                                                                                                                                                                                       |
|---------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------|------------|--|-----|-----|--------------------------|------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| DAC_OUT <sub>min</sub> <sup>(2)</sup> | Lower DAC_OUT voltage with buffer ON                                                                                                           |            |  | 0.2 | -   | -                        | V    | It gives the maximum output excursion of the DAC.<br>It corresponds to 12-bit input code (0x0E0) to (0xF1C) at V <sub>REF+</sub> = 3.6 V and (0x155) and (0xEAB) at V <sub>REF+</sub> = 2.4 V. |
| DAC_OUT <sub>max</sub> <sup>(2)</sup> | Higher DAC_OUT voltage with buffer ON                                                                                                          |            |  | -   | -   | V <sub>DDA</sub> - 0.2   | V    |                                                                                                                                                                                                |
| DAC_OUT <sub>min</sub> <sup>(2)</sup> | Lower DAC_OUT voltage with buffer OFF                                                                                                          |            |  | -   | 0.5 | -                        | mV   | It gives the maximum output excursion of the DAC.                                                                                                                                              |
| DAC_OUT <sub>max</sub> <sup>(2)</sup> | Higher DAC_OUT voltage with buffer OFF                                                                                                         |            |  | -   | -   | V <sub>REF+</sub> - 1LSB | V    |                                                                                                                                                                                                |
| I <sub>DDVREF+</sub>                  | DAC DC current consumption in quiescent mode (Standby mode)                                                                                    |            |  | -   | -   | 220                      | μA   | With no load, worst code (0xF1C) at V <sub>REF+</sub> = 3.6 V in terms of DC consumption on the inputs.                                                                                        |
| I <sub>DDA</sub>                      | DAC DC current consumption in quiescent mode <sup>(3)</sup>                                                                                    |            |  | -   | -   | 380                      | μA   | With no load, middle code (0x800) on the inputs.                                                                                                                                               |
|                                       |                                                                                                                                                |            |  | -   | -   | 480                      | μA   | With no load, worst code (0xF1C) at V <sub>REF+</sub> = 3.6 V in terms of DC consumption on the inputs.                                                                                        |
| DNL <sup>(1)</sup>                    | Differential non linearity Difference between two consecutive code-1LSB)                                                                       |            |  | -   | -   | ±0.5                     | LSB  | Given for the DAC in 10-bit configuration.                                                                                                                                                     |
|                                       |                                                                                                                                                |            |  | -   | -   | ±2                       | LSB  | Given for the DAC in 12-bit configuration.                                                                                                                                                     |
| INL <sup>(1)</sup>                    | Integral non linearity (difference between measured value at Code i and the value at Code i on a line drawn between Code 0 and last Code 1023) |            |  | -   | -   | ±1                       | LSB  | Given for the DAC in 10-bit configuration.                                                                                                                                                     |
|                                       |                                                                                                                                                |            |  | -   | -   | ±4                       | LSB  | Given for the DAC in 12-bit configuration.                                                                                                                                                     |
| Offset <sup>(1)</sup>                 | Offset error (difference between measured value at Code (0x800) and the ideal value = V <sub>REF+</sub> /2)                                    |            |  | -   | -   | ±10                      | mV   | -                                                                                                                                                                                              |
|                                       |                                                                                                                                                |            |  | -   | -   | ±3                       | LSB  | Given for the DAC in 10-bit at V <sub>REF+</sub> = 3.6 V.                                                                                                                                      |
|                                       |                                                                                                                                                |            |  | -   | -   | ±12                      | LSB  | Given for the DAC in 12-bit at V <sub>REF+</sub> = 3.6 V.                                                                                                                                      |
| Gain error <sup>(1)</sup>             | Gain error                                                                                                                                     |            |  | -   | -   | ±0.5                     | %    | Given for the DAC in 12bit configuration.                                                                                                                                                      |

Table 60. DAC characteristics (continued)

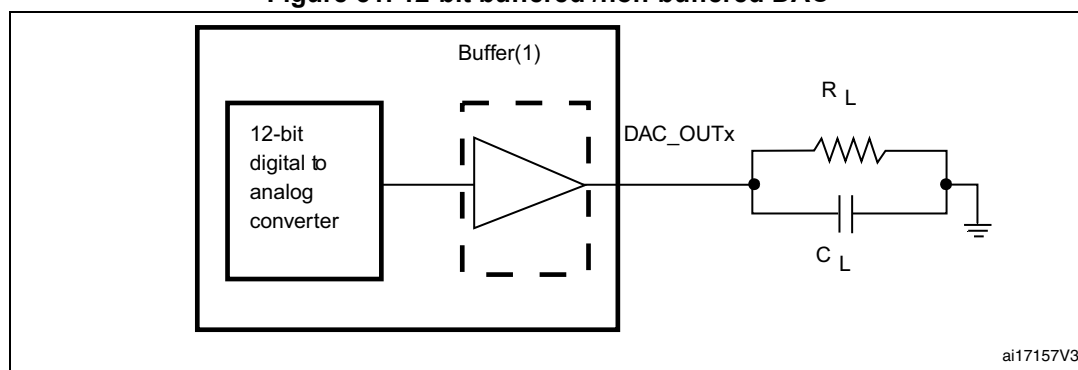
| Symbol                     | Parameter                                                                                                                                                         | Conditions | Min | Typ | Max <sup>(1)</sup> | Unit          | Comments                                                                                                                                |
|----------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|-----|-----|--------------------|---------------|-----------------------------------------------------------------------------------------------------------------------------------------|
| $t_{\text{SETTLING}}$      | Settling time (full scale: for a 10-bit input code transition between the lowest and the highest input codes when DAC_OUT reaches final value $\pm 1\text{LSB}$ ) |            | -   | 3   | 4                  | $\mu\text{s}$ | $C_{\text{LOAD}} \leq 50 \text{ pF}$ , $R_{\text{LOAD}} \geq 5 \text{ k}\Omega$                                                         |
| Update rate <sup>(1)</sup> | Max frequency for a correct DAC_OUT change when small variation in the input code (from code $i$ to $i+1\text{LSB}$ )                                             |            | -   | -   | 1                  | MS/s          | $C_{\text{LOAD}} \leq 50 \text{ pF}$ , $R_{\text{LOAD}} \geq 5 \text{ k}\Omega$                                                         |
| $t_{\text{WAKEUP}}^{(1)}$  | Wakeup time from off state (Setting the ENx bit in the DAC Control register)                                                                                      |            | -   | 6.5 | 10                 | $\mu\text{s}$ | $C_{\text{LOAD}} \leq 50 \text{ pF}$ , $R_{\text{LOAD}} \geq 5 \text{ k}\Omega$<br>input code between lowest and highest possible ones. |
| PSRR+ <sup>(2)</sup>       | Power supply rejection ratio (to $V_{\text{DDA}}$ ) (static DC measurement)                                                                                       |            | -   | -67 | -40                | dB            | No $R_{\text{LOAD}}$ , $C_{\text{LOAD}} = 50 \text{ pF}$                                                                                |

1. Preliminary values.

2. Guaranteed by design.

3. Quiescent mode refers to the state of the DAC when a steady value is kept on the output so that no dynamic consumption is involved.

Figure 51. 12-bit buffered /non-buffered DAC



1. The DAC integrates an output buffer that can be used to reduce the output impedance and to drive external loads directly without the use of an external operational amplifier. The buffer can be bypassed by configuring the BOFFx bit in the DAC\_CR register.

### 5.3.20 Temperature sensor characteristics

Table 61. TS characteristics

| Symbol                   | Parameter                                      | Min  | Typ     | Max     | Unit                   |
|--------------------------|------------------------------------------------|------|---------|---------|------------------------|
| $T_L^{(1)}$              | $V_{SENSE}$ linearity with temperature         | -    | $\pm 1$ | $\pm 2$ | $^{\circ}\text{C}$     |
| Avg_Slope <sup>(1)</sup> | Average slope                                  | 4.0  | 4.3     | 4.6     | mV/ $^{\circ}\text{C}$ |
| $V_{25}^{(1)}$           | Voltage at 25 $^{\circ}\text{C}$               | 1.34 | 1.43    | 1.52    | V                      |
| $t_{START}^{(2)}$        | Startup time                                   | 4    | -       | 10      | $\mu\text{s}$          |
| $T_{S\_temp}^{(3)(2)}$   | ADC sampling time when reading the temperature | -    | -       | 17.1    | $\mu\text{s}$          |

1. Preliminary values.

2. Guaranteed by design.

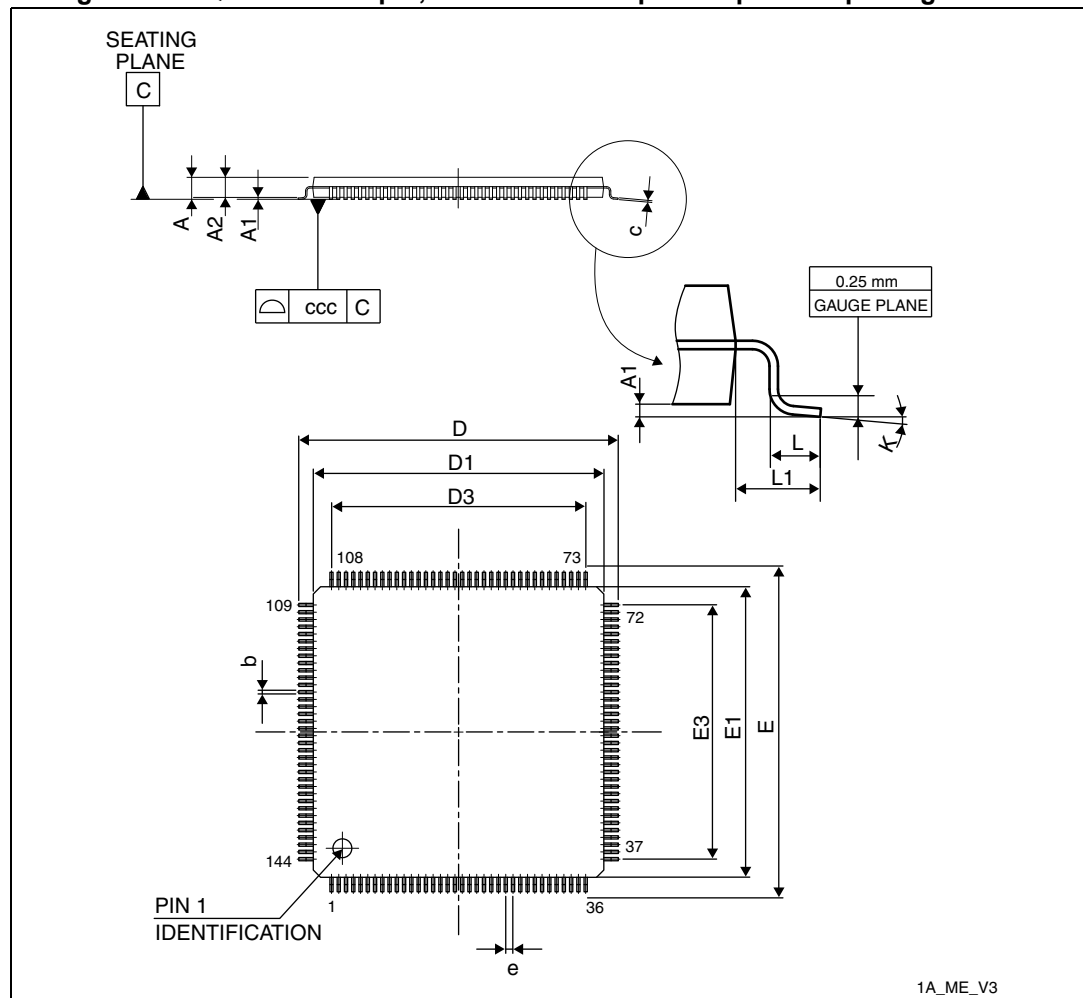
3. Shortest sampling time can be determined in the application by multiple iterations.

## 6 Package information

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK<sup>®</sup> packages, depending on their level of environmental compliance. ECOPACK<sup>®</sup> specifications, grade definitions and product status are available at: [www.st.com](http://www.st.com). ECOPACK<sup>®</sup> is an ST trademark.

### 6.1 LQFP144 package information

Figure 52. LQFP144 - 144-pin, 20 x 20 mm low-profile quad flat package outline



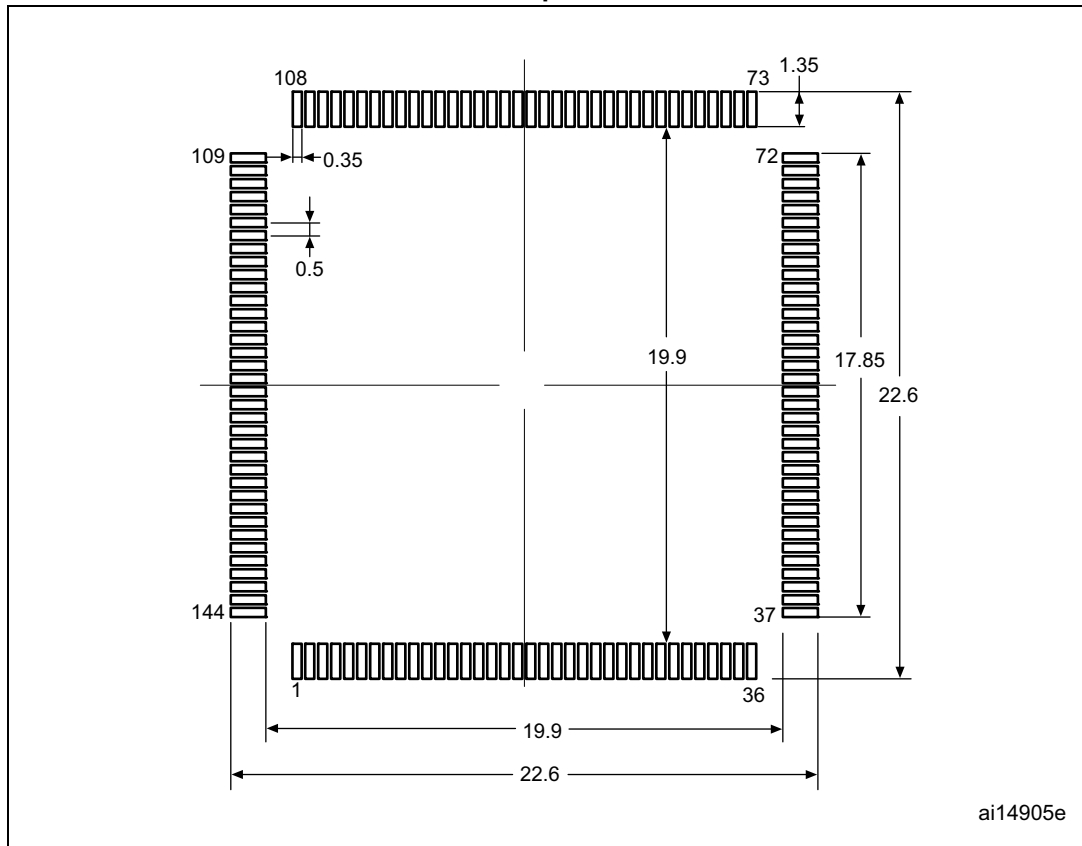
1. Drawing is not to scale.

**Table 62. LQFP144 - 144-pin, 20 x 20 mm low-profile quad flat package  
mechanical data**

| Symbol | millimeters |        |        | inches <sup>(1)</sup> |        |        |
|--------|-------------|--------|--------|-----------------------|--------|--------|
|        | Min         | Typ    | Max    | Min                   | Typ    | Max    |
| A      | -           | -      | 1.600  | -                     | -      | 0.0630 |
| A1     | 0.050       | -      | 0.150  | 0.0020                | -      | 0.0059 |
| A2     | 1.350       | 1.400  | 1.450  | 0.0531                | 0.0551 | 0.0571 |
| b      | 0.170       | 0.220  | 0.270  | 0.0067                | 0.0087 | 0.0106 |
| c      | 0.090       | -      | 0.200  | 0.0035                | -      | 0.0079 |
| D      | 21.800      | 22.000 | 22.200 | 0.8583                | 0.8661 | 0.874  |
| D1     | 19.800      | 20.000 | 20.200 | 0.7795                | 0.7874 | 0.7953 |
| D3     | -           | 17.500 | -      | -                     | 0.689  | -      |
| E      | 21.800      | 22.000 | 22.200 | 0.8583                | 0.8661 | 0.874  |
| E1     | 19.800      | 20.000 | 20.200 | 0.7795                | 0.7874 | 0.7953 |
| E3     | -           | 17.500 | -      |                       | 0.689  |        |
| e      | -           | 0.500  | -      |                       | 0.0197 |        |
| L      | 0.450       | 0.600  | 0.750  | 0.0177                | 0.0236 | 0.0295 |
| L1     | -           | 1.000  | -      |                       | 0.0394 |        |
| k      | 0°          | 3.5°   | 7°     | 0°                    | 3.5°   | 7°     |
| ccc    | -           | -      | 0.080  | -                     | -      | 0.0031 |

1. Values in inches are converted from mm and rounded to 4 decimal digits.

**Figure 53. LQFP144 - 144-pin, 20 x 20 mm low-profile quad flat package footprint**



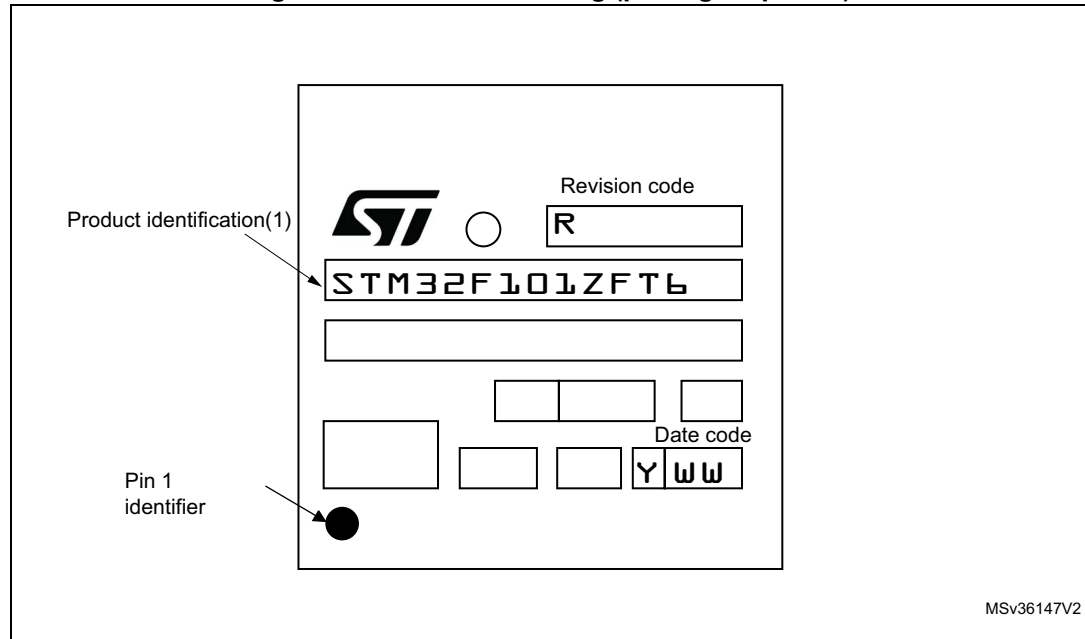
1. Dimensions are expressed in millimeters.

### Device marking for LQFP144

The following figure gives an example of topside marking versus pin 1 position identifier location.

Other optional marking or inset/upset marks, which identify the parts throughout supply chain operations, are not indicated below.

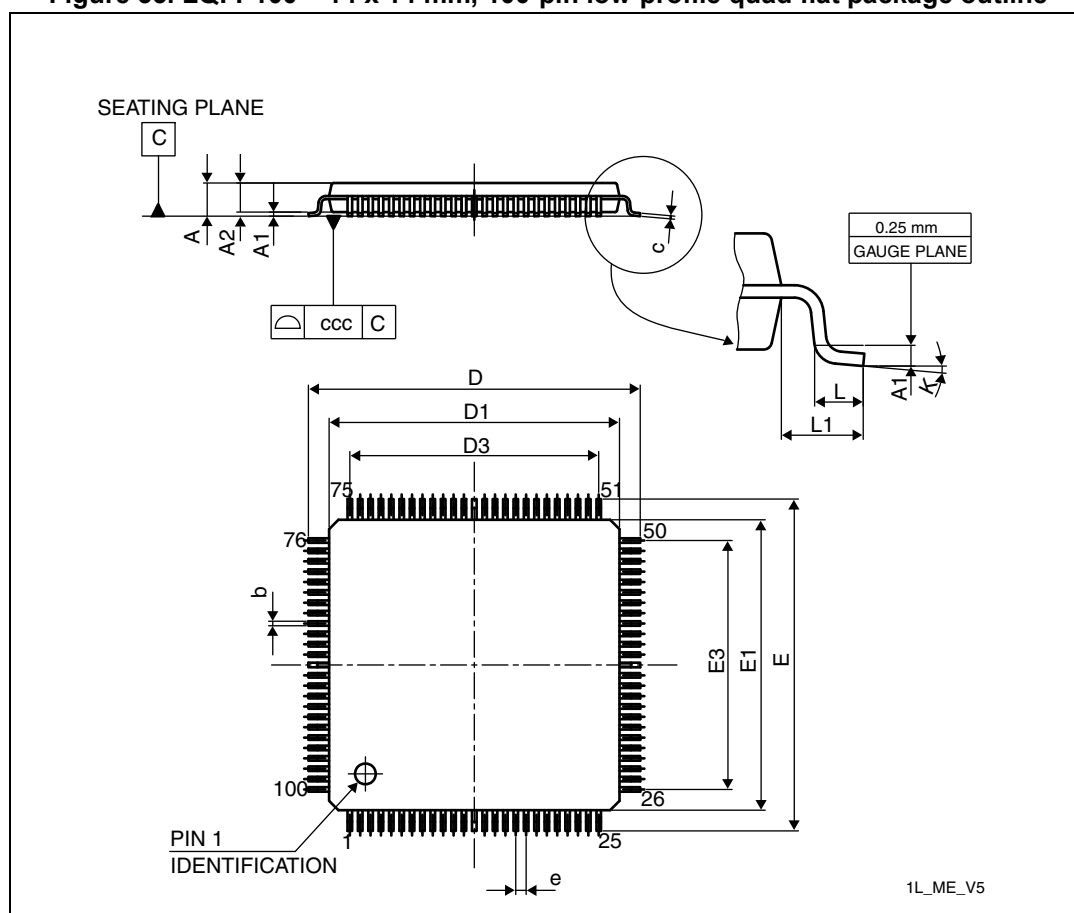
**Figure 54. LQFP144 marking (package top view)**



1. Parts marked as "ES", "E" or accompanied by an Engineering Sample notification letter, are not yet qualified and therefore not yet ready to be used in production and any consequences deriving from such usage will not be at ST charge. In no event, ST will be liable for any customer usage of these engineering samples in production. ST Quality has to be contacted prior to any decision to use these Engineering samples to run qualification activity.

## 6.2 LQFP100 package information

Figure 55. LQFP100 – 14 x 14 mm, 100-pin low-profile quad flat package outline



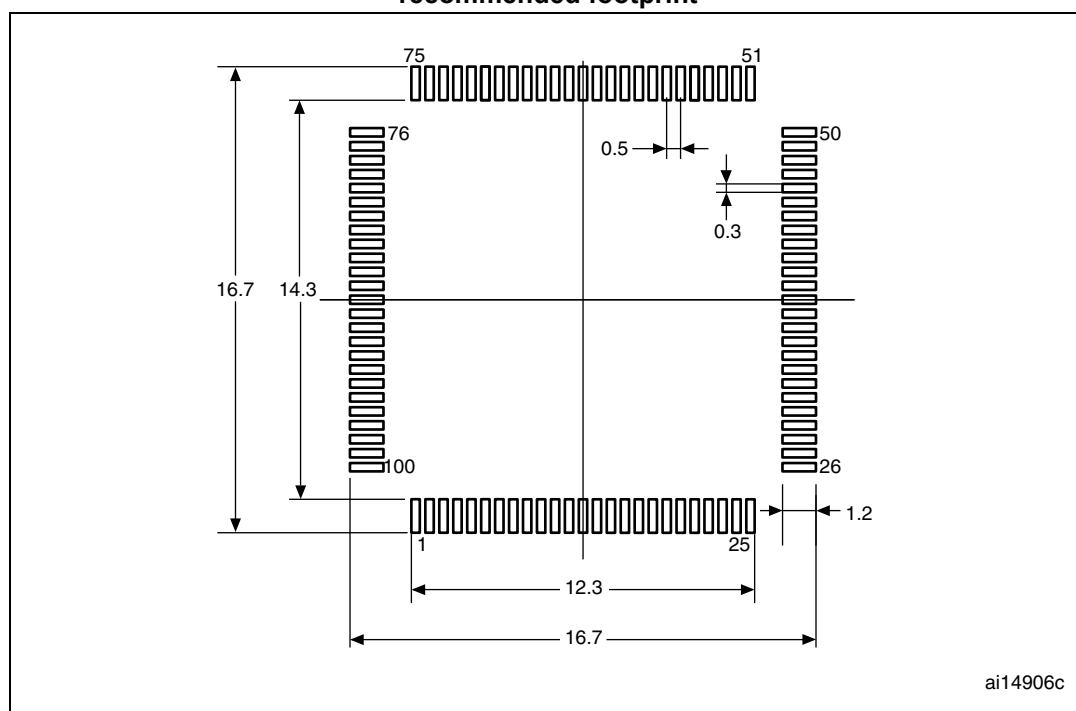
1. Drawing is not to scale.

Table 63. LQFP100 – 14 x 14 mm, 100-pin low-profile quad flat package mechanical data

| Symbol | millimeters |        |        | inches <sup>(1)</sup> |        |        |
|--------|-------------|--------|--------|-----------------------|--------|--------|
|        | Min         | Typ    | Max    | Min                   | Typ    | Max    |
| A      | -           | -      | 1.600  | -                     | -      | 0.0630 |
| A1     | 0.050       | -      | 0.150  | 0.0020                | -      | 0.0059 |
| A2     | 1.350       | 1.400  | 1.450  | 0.0531                | 0.0551 | 0.0571 |
| b      | 0.170       | 0.220  | 0.270  | 0.0067                | 0.0087 | 0.0106 |
| c      | 0.090       | -      | 0.200  | 0.0035                | -      | 0.0079 |
| D      | 15.800      | 16.000 | 16.200 | 0.622                 | 0.6299 | 0.6378 |
| D1     | 13.800      | 14.000 | 14.200 | 0.5433                | 0.5512 | 0.5591 |
| D3     | -           | 12.000 | -      | -                     | 0.4724 | -      |
| E      | 15.800      | 16.000 | 16.200 | 0.622                 | 0.6299 | 0.6378 |
| E1     | 13.800      | 14.000 | 14.200 | 0.5433                | 0.5512 | 0.5591 |

| Symbol | millimeters |        |       | inches <sup>(1)</sup> |        |        |
|--------|-------------|--------|-------|-----------------------|--------|--------|
|        | Min         | Typ    | Max   | Min                   | Typ    | Max    |
| E3     | -           | 12.000 | -     | -                     | 0.4724 | -      |
| e      | -           | 0.500  | -     | -                     | 0.0197 | -      |
| L      | 0.450       | 0.600  | 0.750 | 0.0177                | 0.0236 | 0.0295 |
| L1     | -           | 1.000  | -     | -                     | 0.0394 | -      |
| k      | 0°          | 3.5°   | 7°    | 0°                    | 3.5°   | 7°     |
| ccc    | -           | -      | 0.080 | -                     | -      | 0.0031 |

**Figure 56. LQFP100 - 100-pin, 14 x 14 mm low-profile quad flat recommended footprint**



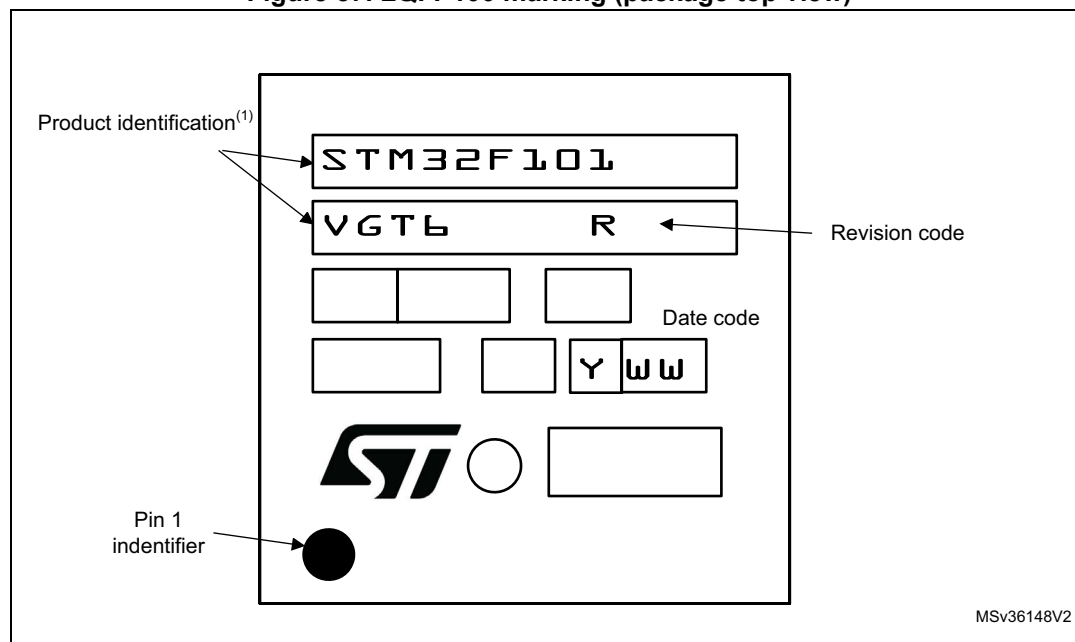
106/117

### Device marking for LQFP100

The following figure gives an example of topside marking versus pin 1 position identifier location.

Other optional marking or inset/upset marks, which identify the parts throughout supply chain operations, are not indicated below.

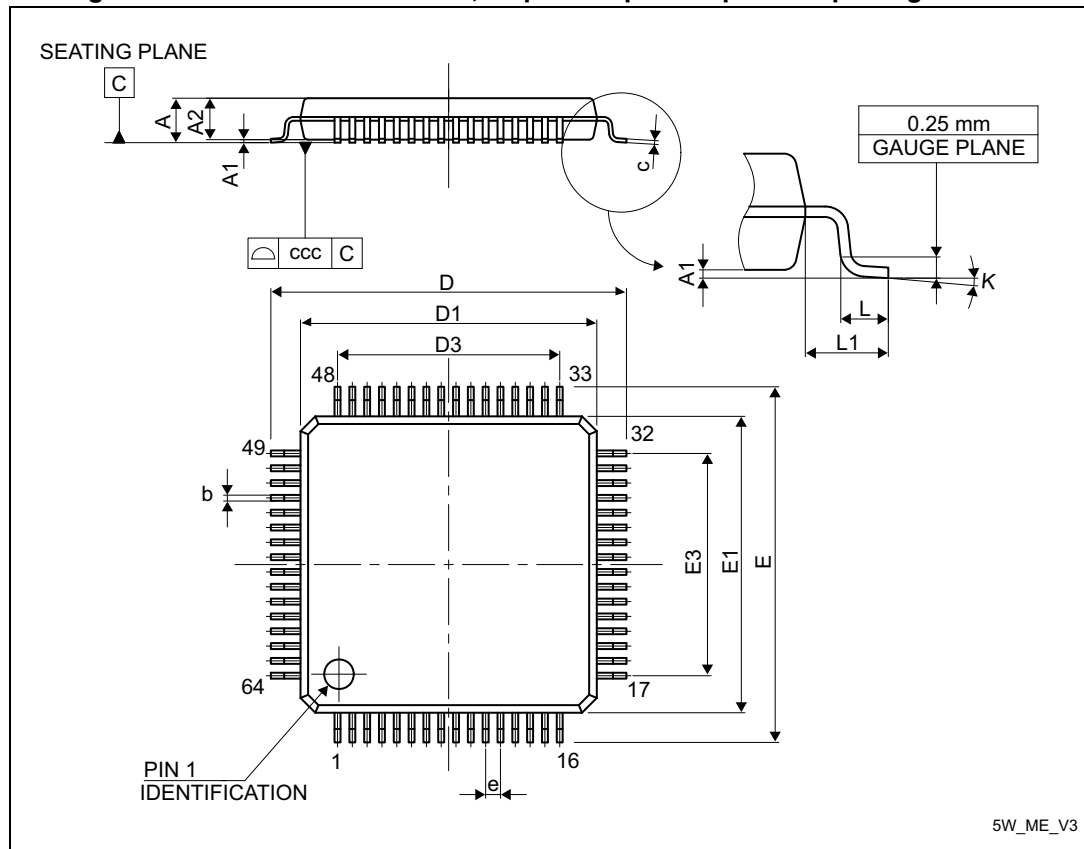
**Figure 57. LQFP100 marking (package top view)**



1. Parts marked as "ES", "E" or accompanied by an Engineering Sample notification letter, are not yet qualified and therefore not yet ready to be used in production and any consequences deriving from such usage will not be at ST charge. In no event, ST will be liable for any customer usage of these engineering samples in production. ST Quality has to be contacted prior to any decision to use these Engineering samples to run qualification activity.

### 6.3 LQFP64 information

Figure 58. LQFP64 – 10 x 10 mm, 64 pin low-profile quad flat package outline



1. Drawing is not to scale.

Table 64. LQFP64 – 10 x 10 mm, 64 pin low-profile quad flat package mechanical data

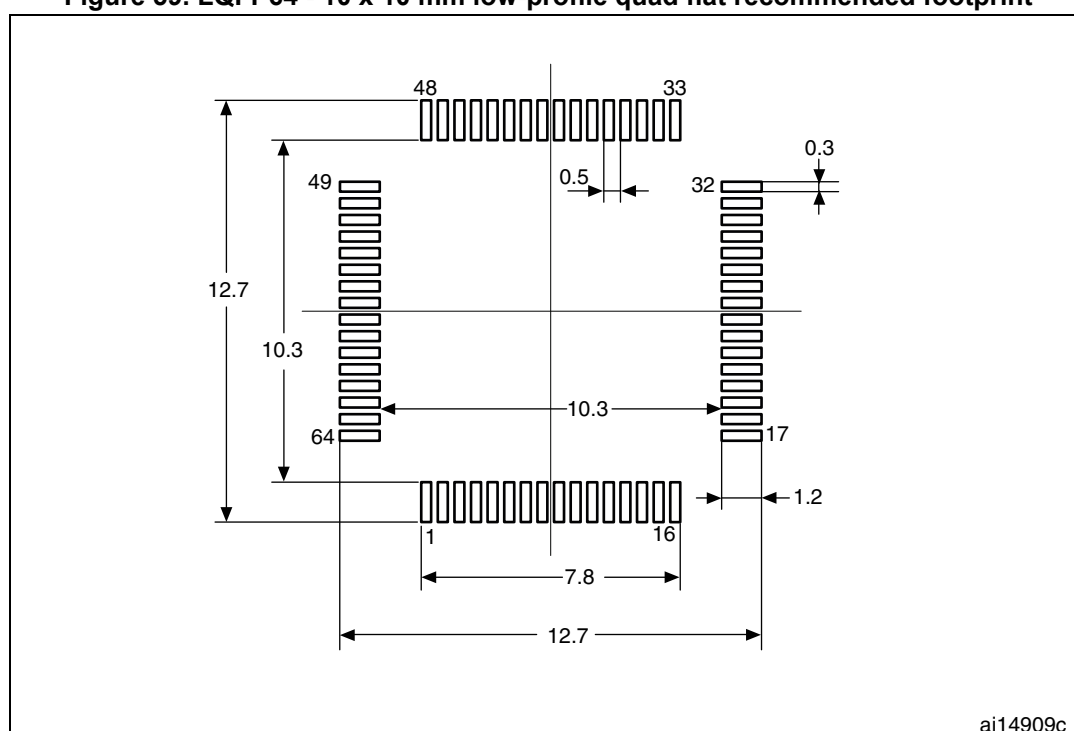
| Symbol | millimeters |        |       | inches <sup>(1)</sup> |        |        |
|--------|-------------|--------|-------|-----------------------|--------|--------|
|        | Min         | Typ    | Max   | Min                   | Typ    | Max    |
| A      | -           | -      | 1.600 | -                     | -      | 0.0630 |
| A1     | 0.050       | -      | 0.150 | 0.0020                | -      | 0.0059 |
| A2     | 1.350       | 1.400  | 1.450 | 0.0531                | 0.0551 | 0.0571 |
| b      | 0.170       | 0.220  | 0.270 | 0.0067                | 0.0087 | 0.0106 |
| c      | 0.090       | -      | 0.200 | 0.0035                | -      | 0.0079 |
| D      | -           | 12.000 | -     | -                     | 0.4724 | -      |
| D1     | -           | 10.000 | -     | -                     | 0.3937 | -      |
| D3     | -           | 7.500  | -     | -                     | 0.2953 | -      |
| E      | -           | 12.000 | -     | -                     | 0.4724 | -      |
| E1     | -           | 10.000 | -     | -                     | 0.3937 | -      |
| E3     | -           | 7.500  | -     | -                     | 0.2953 | -      |

**Table 64. LQFP64 – 10 x 10 mm, 64 pin low-profile quad flat package mechanical data (continued)**

| Symbol | millimeters |       |       | inches <sup>(1)</sup> |        |        |
|--------|-------------|-------|-------|-----------------------|--------|--------|
|        | Min         | Typ   | Max   | Min                   | Typ    | Max    |
| e      | -           | 0.500 | -     | -                     | 0.0197 | -      |
| θ      | 0°          | 3.5°  | 7°    | 0°                    | 3.5°   | 7°     |
| L      | 0.450       | 0.600 | 0.750 | 0.0177                | 0.0236 | 0.0295 |
| L1     | -           | 1.000 | -     | -                     | 0.0394 | -      |
| ccc    | -           | -     | 0.080 | -                     | -      | 0.0031 |

1. Values in inches are converted from mm and rounded to 4 decimal digits.

**Figure 59. LQFP64 - 10 x 10 mm low-profile quad flat recommended footprint**



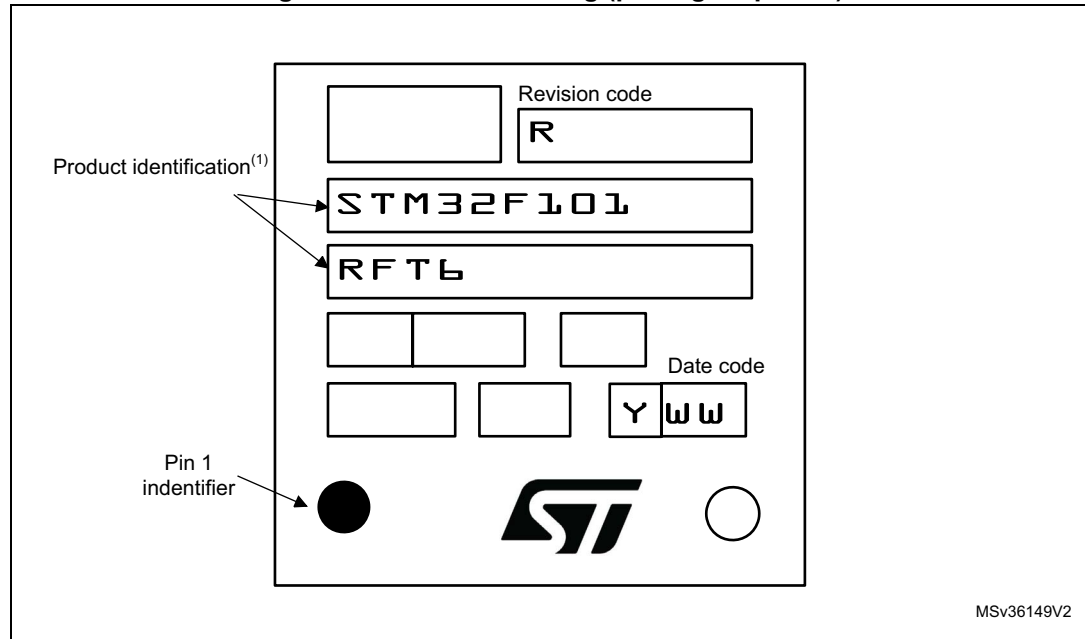
1. Dimensions are in millimeters.

### Device marking for LQFP64

The following figure gives an example of topside marking versus pin 1 position identifier location.

Other optional marking or inset/upset marks, which identify the parts throughout supply chain operations, are not indicated below.

**Figure 60. LQFP64 marking (package top view)**



1. Parts marked as "ES", "E" or accompanied by an Engineering Sample notification letter, are not yet qualified and therefore not yet ready to be used in production and any consequences deriving from such usage will not be at ST charge. In no event, ST will be liable for any customer usage of these engineering samples in production. ST Quality has to be contacted prior to any decision to use these Engineering samples to run qualification activity.

## 6.4 Thermal characteristics

The maximum chip junction temperature ( $T_{Jmax}$ ) must never exceed the values given in [Table 10: General operating conditions on page 39](#).

The maximum chip-junction temperature,  $T_J$  max, in degrees Celsius, may be calculated using the following equation:

$$T_J \text{ max} = T_A \text{ max} + (P_D \text{ max} \times \Theta_{JA})$$

Where:

- $T_A$  max is the maximum ambient temperature in °C,
- $\Theta_{JA}$  is the package junction-to-ambient thermal resistance, in °C/W,
- $P_D$  max is the sum of  $P_{INT}$  max and  $P_{I/O}$  max ( $P_D \text{ max} = P_{INT} \text{ max} + P_{I/O} \text{ max}$ ),
- $P_{INT}$  max is the product of  $I_{DD}$  and  $V_{DD}$ , expressed in Watts. This is the maximum chip internal power.

$P_{I/O}$  max represents the maximum power dissipation on output pins where:

$$P_{I/O} \text{ max} = \Sigma (V_{OL} \times I_{OL}) + \Sigma ((V_{DD} - V_{OH}) \times I_{OH}),$$

taking into account the actual  $V_{OL} / I_{OL}$  and  $V_{OH} / I_{OH}$  of the I/Os at low and high level in the application.

**Table 65. Package thermal characteristics**

| Symbol        | Parameter                                                                         | Value | Unit |
|---------------|-----------------------------------------------------------------------------------|-------|------|
| $\Theta_{JA}$ | <b>Thermal resistance junction-ambient</b><br>LQFP144 - 20 x 20 mm / 0.5 mm pitch | 30    | °C/W |
|               | <b>Thermal resistance junction-ambient</b><br>LQFP100 - 14 x 14 mm / 0.5 mm pitch | 46    |      |
|               | <b>Thermal resistance junction-ambient</b><br>LQFP64 - 10 x 10 mm / 0.5 mm pitch  | 45    |      |

### 6.4.1 Reference document

JESD51-2 Integrated Circuits Thermal Test Method Environment Conditions - Natural Convection (Still Air), available from [www.jedec.org](http://www.jedec.org).

### 6.4.2 Evaluating the maximum junction temperature for an application

When ordering the microcontroller, the temperature range is specified in the ordering information scheme shown in [Table 66: STM32F101xF and STM32F101xG ordering information scheme](#).

Each temperature range suffix corresponds to a specific guaranteed ambient temperature at maximum dissipation and, to a specific maximum junction temperature. Here, only temperature range 6 is available (–40 to 85 °C).

The following example shows how to calculate the temperature range needed for a given application, making it possible to check whether the required temperature range is compatible with the STM32F10xxx junction temperature range.

#### Example: High-performance application

Assuming the following application conditions:

Maximum ambient temperature  $T_{Amax} = 82\text{ °C}$  (measured according to JESD51-2),  
 $I_{DDmax} = 50\text{ mA}$ ,  $V_{DD} = 3.5\text{ V}$ , maximum 20 I/Os used at the same time in output at low level with  $I_{OL} = 8\text{ mA}$ ,  $V_{OL} = 0.4\text{ V}$  and maximum 8 I/Os used at the same time in output mode at low level with  $I_{OL} = 20\text{ mA}$ ,  $V_{OL} = 1.3\text{ V}$

$$P_{INTmax} = 50\text{ mA} \times 3.5\text{ V} = 175\text{ mW}$$

$$P_{IOmax} = 20 \times 8\text{ mA} \times 0.4\text{ V} + 8 \times 20\text{ mA} \times 1.3\text{ V} = 272\text{ mW}$$

This gives:  $P_{INTmax} = 175\text{ mW}$  and  $P_{IOmax} = 272\text{ mW}$

$$P_{Dmax} = 175 + 272 = 447\text{ mW}$$

Thus:  $P_{Dmax} = 447\text{ mW}$

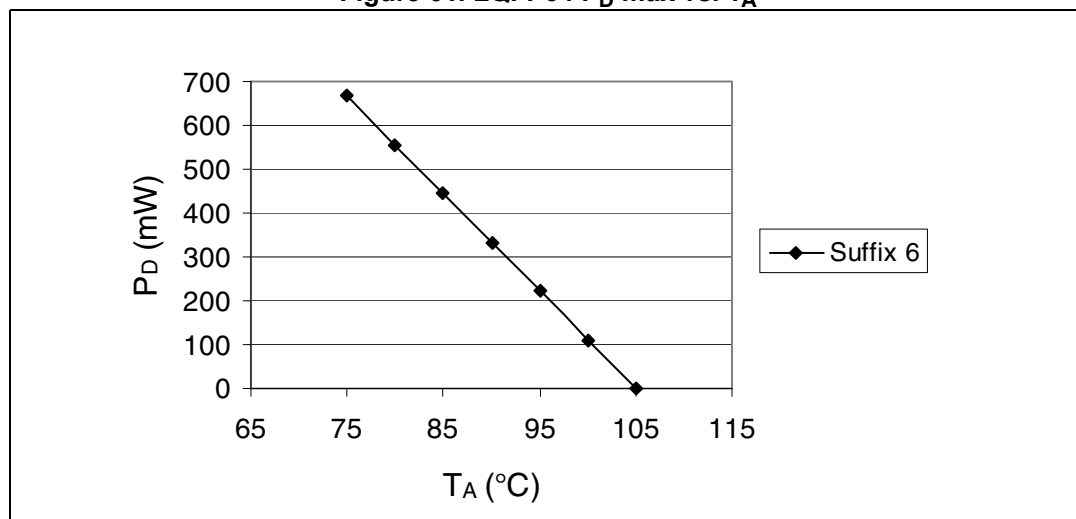
Using the values obtained in [Table 66](#)  $T_{Jmax}$  is calculated as follows:

– For LQFP64, 45 °C/W

$$T_{Jmax} = 82\text{ °C} + (45\text{ °C/W} \times 447\text{ mW}) = 82\text{ °C} + 20.1\text{ °C} = 102.1\text{ °C}$$

This is within the junction temperature range of the STM32F10xxx (–40 <  $T_J$  < 105 °C).

Figure 61. LQFP64  $P_D$  max vs.  $T_A$



7 Part numbering

Table 66. STM32F101xF and STM32F101xG ordering information scheme

|                                                 |       |   |     |   |   |   |   |     |
|-------------------------------------------------|-------|---|-----|---|---|---|---|-----|
| Example:                                        | STM32 | F | 101 | R | F | T | 6 | xxx |
| <b>Device family</b>                            |       |   |     |   |   |   |   |     |
| STM32 = ARM®-based 32-bit microcontroller       |       |   |     |   |   |   |   |     |
| <b>Product type</b>                             |       |   |     |   |   |   |   |     |
| F = general-purpose                             |       |   |     |   |   |   |   |     |
| <b>Device subfamily</b>                         |       |   |     |   |   |   |   |     |
| 101 = access line                               |       |   |     |   |   |   |   |     |
| <b>Pin count</b>                                |       |   |     |   |   |   |   |     |
| R = 64 pins                                     |       |   |     |   |   |   |   |     |
| V = 100 pins                                    |       |   |     |   |   |   |   |     |
| Z = 144 pins                                    |       |   |     |   |   |   |   |     |
| <b>Flash memory size</b>                        |       |   |     |   |   |   |   |     |
| F = 768 Kbytes of Flash memory                  |       |   |     |   |   |   |   |     |
| G = 1 Mbyte of Flash memory                     |       |   |     |   |   |   |   |     |
| <b>Package</b>                                  |       |   |     |   |   |   |   |     |
| T = LQFP                                        |       |   |     |   |   |   |   |     |
| <b>Temperature range</b>                        |       |   |     |   |   |   |   |     |
| 6 = Industrial temperature range, -40 to 85 °C. |       |   |     |   |   |   |   |     |
| <b>Options</b>                                  |       |   |     |   |   |   |   |     |
| xxx = programmed parts                          |       |   |     |   |   |   |   |     |
| TR = tape and real                              |       |   |     |   |   |   |   |     |

For a list of available options (speed, package, etc..) or for further information on any aspect of this device, please contact your nearest ST sales office.

## 8 Revision history

**Table 67. Document revision history**

| Date        | Revision | Changes                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|-------------|----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 27-Oct-2009 | 1        | Initial release.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| 15-Nov-2010 | 2        | <p>LQFP64 package mechanical data updated: see <a href="#">Figure 58: LQFP64 – 10 x 10 mm, 64 pin low-profile quad flat package outline</a> and <a href="#">Table 64: LQFP64 – 10 x 10 mm, 64 pin low-profile quad flat package mechanical data</a>.</p> <p>Internal code removed from <a href="#">Table 66: STM32F101xF and STM32F101xG ordering information scheme</a>.</p> <p>Updated note 2 below <a href="#">Table 52: I<sup>2</sup>C characteristics</a></p> <p>Updated <a href="#">Figure 43: I<sup>2</sup>C bus AC waveforms and measurement circuit<sup>(1)</sup></a></p> <p>Updated <a href="#">Figure 42: Recommended NRST pin protection</a></p> <p>Updated note 1 below <a href="#">Table 47: I/O static characteristics</a></p> <p>Updated <a href="#">Table 20: Peripheral current consumption</a></p> <p>Updated <a href="#">Table 14: Maximum current consumption in Run mode, code with data processing running from Flash</a></p> <p>Updated <a href="#">Table 15: Maximum current consumption in Run mode, code with data processing running from RAM</a></p> <p>Updated <a href="#">Table 16: Maximum current consumption in Sleep mode, code running from Flash or RAM</a></p> <p>Updated <a href="#">Table 17: Typical and maximum current consumptions in Stop and Standby modes</a></p> <p>Updated <a href="#">Table 18: Typical current consumption in Run mode, code with data processing running from Flash</a></p> <p>Updated <a href="#">Table 19: Typical current consumption in Sleep mode, code running from Flash or RAM</a></p> <p>Updated <a href="#">Table 24: LSE oscillator characteristics (f<sub>LSE</sub> = 32.768 kHz)</a></p> <p>Updated <a href="#">Figure 19: Asynchronous non-multiplexed SRAM/PSRAM/NOR read waveforms on page 58</a></p> <p>Added <a href="#">Section 5.3.13: I/O current injection characteristics on page 99</a>.</p> |

Table 67. Document revision history (continued)

| Date        | Revision | Changes                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|-------------|----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 25-Nov-2014 | 3        | <p>Updated number of ADCs in <a href="#">Table 2: STM32F101xF and STM32F101xG features and peripheral counts</a>.</p> <p>Modified <a href="#">Section 2.3.22: GPIOs (general-purpose inputs/outputs) on page 21</a>.</p> <p>Added note below <a href="#">Figure 3: LQFP144 pinout</a>, <a href="#">Figure 4: LQFP100 pinout</a>, and <a href="#">Figure 5: LQFP64 pinout</a>.</p> <p>Modified OSC_IN, OSC_OUT, PD0, PD1, PB8, PB9 and PF8 in <a href="#">Table 5: STM32F101xF/STM32F101xG pin definitions on page 25</a>.</p> <p>Updated notes related to parameters not tested in production in the whole document.</p> <p>Modified notes in <a href="#">Table 7: Voltage characteristics on page 37</a> and <a href="#">Table 8: Current characteristics on page 38</a>.</p> <p>Removed ADC2/3 and CAN from <a href="#">Table 20: Peripheral current consumption on page 48</a>.</p> <p>Modified <math>t_{w(HSE)}</math> value in <a href="#">Table 21: High-speed external user clock characteristics on page 50</a>.</p> <p>Updated <a href="#">Table 24: LSE oscillator characteristics (<math>f_{LSE} = 32.768</math> kHz) on page 53</a>.</p> <p>Changed JESD22-C101 to ANSI/ESD STM5.3.1 in <a href="#">Section : Electrostatic discharge (ESD)</a>.</p> <p>Updated <a href="#">Section 5.3.10: FSMC characteristics on page 57</a>.</p> <p>Updated <a href="#">Figure 41: I/O AC characteristics definition</a>. Updated conditions related to <a href="#">Section : I<sup>2</sup>C interface characteristics on page 87</a>.</p> <p>Modified <a href="#">Table 52: I<sup>2</sup>C characteristics on page 87</a>, updated <a href="#">Figure 43: I<sup>2</sup>C bus AC waveforms and measurement circuit<sup>(1)</sup></a> and <math>V_{DD}/V_{DD\_I2C}</math> conditions in <a href="#">Table 53: SCL frequency (<math>f_{PCLK1} = 36</math> MHz, <math>V_{DD} = V_{DD\_I2C} = 3.3</math> V) on page 88</a>.</p> <p>Modified <a href="#">Section : Output driving current on page 82</a>.</p> <p>Modified <a href="#">Table 52: I<sup>2</sup>C characteristics on page 87</a> and updated <a href="#">Figure 43: I<sup>2</sup>C bus AC waveforms and measurement circuit<sup>(1)</sup></a>.</p> <p>Modified <a href="#">Figure 46: SPI timing diagram - master mode<sup>(1)</sup> on page 92</a>.</p> <p>Modified notes in <a href="#">Table 56: ADC characteristics on page 93</a> and <a href="#">Table 59: ADC accuracy on page 95</a>.</p> <p>Updated <math>I_{DDA}</math> definition in <a href="#">Table 60: DAC characteristics on page 97</a> and removed comment related to the offset parameter for <math>\pm 10</math> mV.</p> <p>Added Device marking information for all packages.</p> |

Table 67. Document revision history (continued)

| Date        | Revision | Changes                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|-------------|----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 18-May-2015 | 4        | <p>Modified Cortex-M3 technical reference manual url in <a href="#">Section 1: Introduction</a>.</p> <p>Updated <a href="#">Table 20: Peripheral current consumption</a>.</p> <p>Restored CDM standard and class in <a href="#">Table 44: ESD absolute maximum ratings</a></p> <p>Updated ccc dimension in <a href="#">Table 62: LQFP144 - 144-pin, 20 x 20 mm low-profile quad flat package mechanical data</a> and <a href="#">Section : Device marking for LQFP144</a>.</p> <p>Updated <a href="#">Section : Device marking for LQFP100</a>.</p> <p>Updated <a href="#">Table 64: LQFP64 – 10 x 10 mm, 64 pin low-profile quad flat package mechanical data</a> and <a href="#">Section : Device marking for LQFP64</a>.</p> |
| 13-Dec-2016 | 5        | <p>Updated:</p> <ul style="list-style-type: none"> <li>– <a href="#">Table 5: STM32F101xF/STM32F101xG pin definitions</a></li> <li>– <math> V_{SSX} - V_{SS} </math> in <a href="#">Table 7: Voltage characteristics</a> to add <math>V_{REF-}</math>.</li> <li>– <math>R_{LOAD}</math> in <a href="#">Table 60: DAC characteristics</a></li> <li>– <a href="#">Figure 42: Recommended NRST pin protection</a></li> <li>– <a href="#">Section 6: Package information</a></li> </ul> <p>Added:</p> <ul style="list-style-type: none"> <li>– <math>V_{REF-}</math> in <a href="#">Table 56: ADC characteristics</a></li> </ul>                                                                                                    |

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