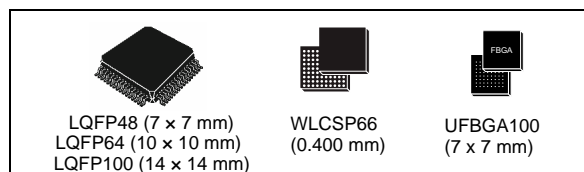


ARM® Cortex®-M4 32b MCU+FPU, up to 256KB Flash+32KB SRAM, timers, 4 ADCs(16-bit Sig. Delta / 12-bit SAR), 3 DACs, 2 comp., 1.8 V

Datasheet - production data

## Features

- Core: ARM® 32-bit Cortex®-M4 CPU (72 MHz max), single-cycle multiplication and HW division, DSP instruction with FPU (floating-point unit) and MPU (memory protection unit)
- 1.25 DMIPS/MHz (Dhrystone 2.1)
- Memories
  - 256 Kbytes of Flash memory
  - 32 Kbytes of SRAM with HW parity check
- CRC calculation unit
- Reset and power management
  - Supply:  $V_{DD} = 1.8\text{ V} \pm 8\%$ ,  $V_{DDA} = 1.65 - 3.6\text{ V}$
  - External POR pin
  - Low power modes: Sleep and Stop
- Clock management
  - 4 to 32 MHz crystal oscillator
  - 32 kHz oscillator for RTC with calibration
  - Internal 8 MHz RC with x16 PLL option
  - Internal 40 kHz oscillator
- Up to 84 fast I/Os
  - All mappable on external interrupt vectors
  - Up to 45 I/Os with 5 V tolerant capability
- 12-channel DMA controller
- One 12-bit, 1.0  $\mu\text{s}$  ADC (up to 16 channels)
  - Conversion range: 0 to 3.6 V
  - Separate analog supply from 2.4 up to 3.6
- Up to three 16-bit Sigma Delta ADC
  - Separate analog supply from 2.2 to 3.6 V, up to 21 single/ 11 diff channels
- Up to three 12-bit DAC channels
  - Separate analog supply from 2.2 to 3.6 V
- Two fast rail-to-rail analog comparators with programmable input and output with analog supply from 1.65 to 3.6 V
- Up to 24 capacitive sensing channels



- 17 timers
  - Two 32-bit timers and three 16-bit timers with up to 4 IC/OC/PWM or pulse counters
  - Two 16-bit timers with up to 2 IC/OC/PWM or pulse counters
  - Four 16-bit timers with up to 1 IC/OC/PWM or pulse counter
  - Independent and system watchdog timers
  - SysTick timer: 24-bit down counter
  - Three 16-bit basic timers to drive the DAC
- Calendar RTC with Alarm and periodic wakeup from Stop
- Communication interfaces
  - CAN interface (2.0B Active)
  - Two I<sup>2</sup>Cs supporting Fast Mode Plus (1 Mbit/s) with 20 mA current sink, SMBus/PMBus, wakeup from STOP
  - Three USARTs supporting synchronous mode, modem control, ISO/IEC 7816, LIN, IrDA, auto baud rate, wakeup feature
  - Three SPIs (18 Mbit/s) with 4 to 16 programmable bit frames, muxed I2S
  - HDMI-CEC bus interface
- Serial wire devices, JTAG, Cortex®-M4 ETM
- 96-bit unique ID

Table 1. Device summary

| Reference   | Part numbers                          |
|-------------|---------------------------------------|
| STM32F378xx | STM32F378CC, STM32F378RC, STM32F378VC |

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# 1 Introduction

This datasheet provides the ordering information and mechanical device characteristics of the STM32F378xx microcontrollers.

This STM32F378xx datasheet should be read in conjunction with the RM0313 reference manual. The reference manual is available from the STMicroelectronics website [www.st.com](http://www.st.com).

For information on the Cortex<sup>®</sup>-M4 with FPU core, please refer to:

- Cortex<sup>®</sup>-M4 with FPU Technical Reference Manual, available from [www.arm.com](http://www.arm.com).
- STM32F3xxx and STM32F4xxx Cortex<sup>®</sup>-M4 programming manual (PM0214) available from [www.st.com](http://www.st.com).



## 2 Description

The STM32F378xx family is based on the high-performance ARM® Cortex®-M4 32-bit RISC core operating at a frequency of up to 72 MHz, and embedding a floating point unit (FPU), a memory protection unit (MPU) and an Embedded Trace Macrocell™ (ETM). The family incorporates high-speed embedded memories (up to 256 Kbyte of Flash memory, up to 32 Kbytes of SRAM), and an extensive range of enhanced I/Os and peripherals connected to two APB buses.

The STM32F378xx devices offer one fast 12-bit ADC (1 Msps), up to three 16-bit Sigma delta ADCs, up to two comparators, up to two DACs (DAC1 with 2 channels and DAC2 with 1 channel), a low-power RTC, 9 general-purpose 16-bit timers, two general-purpose 32-bit timers, three basic timers.

They also feature standard and advanced communication interfaces: up to two I2Cs, three SPIs, all with muxed I2Ss, three USARTs and CAN.

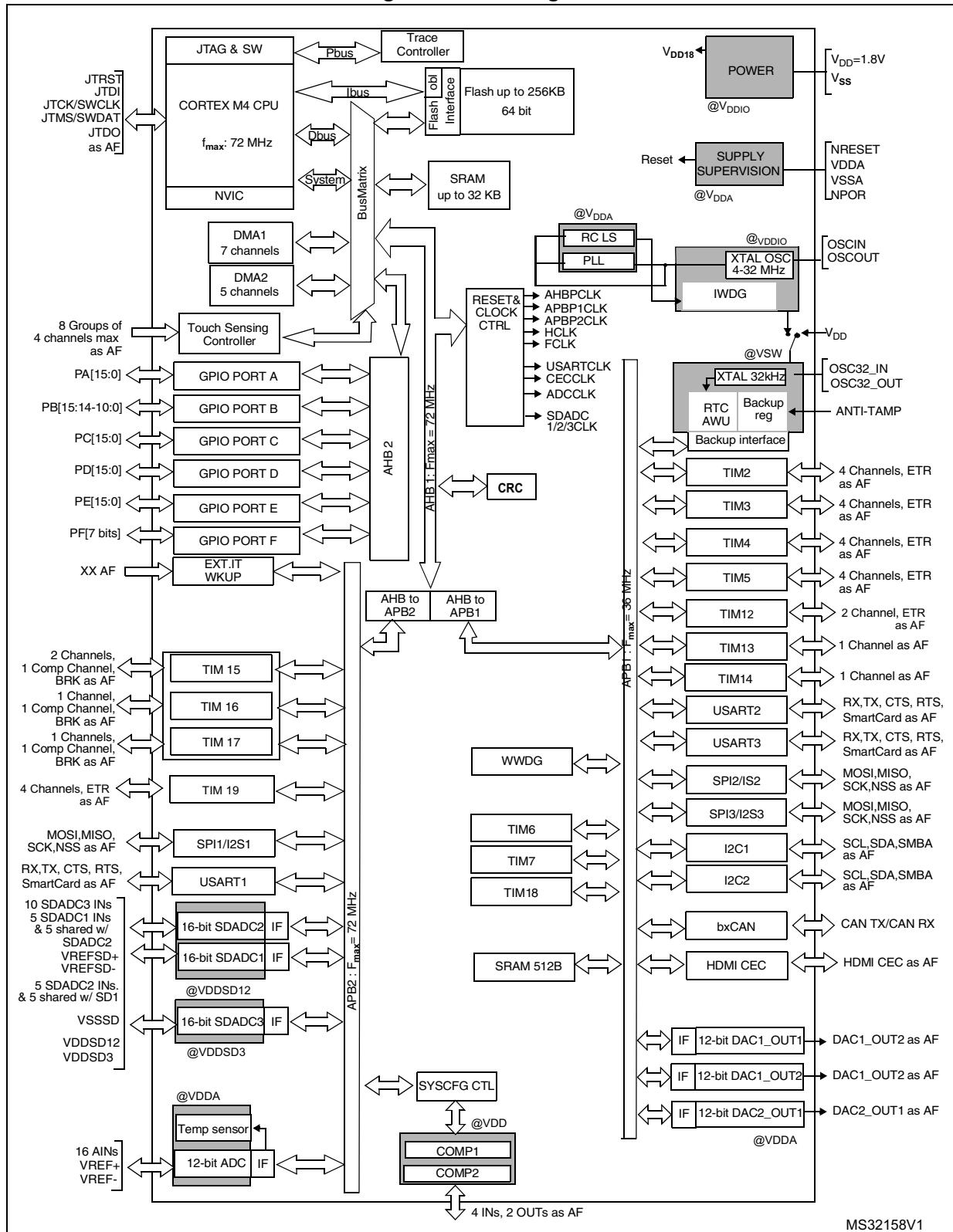
The STM32F378xx family operates in the -40 to +85 °C and -40 to +105 °C temperature ranges from a 1.8 V  $\pm$  8% power supply. A comprehensive set of power-saving mode allows the design of low-power applications.

The STM32F378xx family offers devices in five packages ranging from 48 pins to 100 pins. The set of included peripherals changes with the device chosen.

Table 2. Device overview

| Peripheral                     |                  | STM32F378Cx  | STM32F378Rx        | STM32F378Vx          |
|--------------------------------|------------------|--|--------------------|----------------------|
| Flash (Kbytes)                 |                  | 256  |                    |                      |
| SRAM (Kbytes)                  |                  | 32   |                    |                      |
| Timers                         | General purpose  | 9 (16-bit)<br>2 (32 bit)   |                    |                      |
|                                | Basic            | 3 (16-bit)   |                    |                      |
| Comm. interfaces               | SPI/I2S          | 3  |                    |                      |
|                                | I <sup>2</sup> C | 2  |                    |                      |
|                                | USART            | 3  |                    |                      |
|                                | CAN              | 1  |                    |                      |
| Capacitive sensing channels    |                  | 14   | 17                 | 24                   |
| 12-bit ADCs                    |                  | 1  |                    |                      |
| 16-bit ADCs Sigma- Delta       |                  | 3  |                    |                      |
| 12-bit DACs outputs            |                  | 3  |                    |                      |
| Analog comparator              |                  | 2  |                    |                      |
| Max. CPU frequency             |                  | 72 MHz   |                    |                      |
| Main operating voltage         |                  | 1.8 V +/- 8%   |                    |                      |
| 16-bit SDADC operating voltage |                  | 2.2 to 3.6 V   |                    |                      |
| Operating temperature          |                  | Ambient operating temperature:<br>-40 to 85 °C / -40 to 105 °C<br>Junction temperature:<br>-40 to 105 °C / -40 to 125 °C |                    |                      |
| Packages                       |                  | LQFP48   | LQFP64,<br>WLCSP66 | LQFP100,<br>UFBGA100 |

Figure 1. Block diagram



1. AF: alternate function on I/O pins.

## 3 Functional overview

### 3.1 ARM® Cortex®-M4 core with embedded Flash and SRAM

The ARM Cortex-M4 processor is the latest generation of ARM processors for embedded systems. It was 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 response to interrupts.

The ARM Cortex-M4 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 processor supports a set of DSP instructions which allow efficient signal processing and complex algorithm execution.

Its single precision FPU speeds up software development by using metalanguage development tools, while avoiding saturation.

With its embedded ARM core, the STM32F378xx family is compatible with all ARM tools and software.

*Figure 1* shows the general block diagram of the STM32F378xx family.

### 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.

The Cortex-M4 processor is a high performance 32-bit processor designed for the microcontroller market. It offers significant benefits to developers, including:

- Outstanding processing performance combined with fast interrupt handling
- Enhanced system debug with extensive breakpoint and trace capabilities
- Efficient processor core, system and memories
- Ultralow power consumption with integrated sleep modes
- Platform security robustness with optional integrated memory protection unit (MPU).

With its embedded ARM core, the STM32F378xx devices are compatible with all ARM development tools and software.

### 3.3 Embedded Flash memory

All STM32F378xx devices feature up to 256 Kbytes of embedded Flash memory available for storing programs and data. The Flash memory access time is adjusted to the CPU clock frequency (0 wait state from 0 to 24 MHz, 1 wait state from 24 to 48 MHz and 2 wait states above).

### 3.4 Cyclic redundancy check (CRC) calculation unit

The CRC (cyclic redundancy check) calculation unit is used to get a CRC code using a configurable generator polynomial value and size.

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 linktime and stored at a given memory location.

### 3.5 Embedded SRAM

All STM32F378xx devices feature up to 32 Kbytes of embedded SRAM with hardware parity check. The memory can be accessed in read/write at CPU clock speed with 0 wait states.

### 3.6 Boot modes

At startup, Boot0 pin and Boot1 option bit are used to select one of three boot options:

- Boot from user Flash
- Boot from system memory
- Boot from embedded SRAM

The boot loader is located in system memory. It is used to reprogram the Flash memory by using USART1 (PA9/PA10), USART2 (PD5/PD6) or I2C (PB6/PB7).

### 3.7 Power management

#### 3.7.1 Power supply schemes

- $V_{DD}$ : external power supply for I/Os and core. It is provided externally through  $V_{DD}$  pins, and can be 1.8 V +/- 8%.
- $V_{DDA}$  = 1.65 to 3.6 V:
  - external analog power supplies for Reset blocks, RCs and PLL
  - supply voltage for 12-bit ADC, DACs and comparators (minimum voltage to be applied to  $V_{DDA}$  is 2.4 V when the 12-bit ADC and DAC are used).
- $V_{DDSD12}$  and  $V_{DDSD3}$  = 2.2 to 3.6 V: supply voltages for SDADC1/2 and SDADC3 sigma delta ADCs. Independent from  $V_{DD}/V_{DDA}$ .
- $V_{BAT}$  = 1.65 to 3.6 V: power supply for RTC, external clock 32 kHz oscillator and backup registers when  $V_{DD}$  is not present.

### 3.7.2 Power supply supervisor

Device power on reset is controlled through the external NPOR pin. The device remains in reset mode when NPOR is held low. NPOR pin has an internal pull-up resistor so the external driver can be open drain type.

To guarantee a proper power-on reset, the NPOR pin must be held low until  $V_{DD}$  is stable.

When  $V_{DD}$  is stable, the reset state can be exited by:

- either putting the NPOR pin in high impedance. NPOR pin has an internal pull up.
- or forcing the pin to high level by connecting it to  $V_{DDA}$ .

### 3.7.3 Low-power modes

The STM32F378xx supports two 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 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, the USARTs, the I2Cs, the CEC the COMPx and the RTC alarm.

## 3.8 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 4-32 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 entry is available when necessary (for example with failure of an indirectly used external oscillator).

Several prescalers allow to configure the AHB frequency, the high speed APB (APB2) and the low speed APB (APB1) domains. The maximum frequency of the AHB and the high speed APB domains is 72 MHz, while the maximum allowed frequency of the low speed APB domain is 36 MHz.

## 3.9 General-purpose input/outputs (GPIOs)

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 except for analog inputs.

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.

Do not reconfigure GPIO pins which are not present on 48 and 64 pin packages to the analog mode. Additional current consumption in the range of tens of  $\mu\text{A}$  per pin can be observed if  $V_{\text{DDA}}$  is higher than  $V_{\text{DDIO}}$ .

### 3.10 Direct memory access (DMA)

The flexible 12-channel, general-purpose DMA is able to manage memory-to-memory, peripheral-to-memory and memory-to-peripheral transfers. The DMA controller supports circular buffer management, avoiding the generation of interrupts when the controller reaches the end of the buffer.

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

The two DMAs can be used with the main peripherals: SPIs, I2Cs, USARTs, DACs, ADC, SDADCs, general-purpose timers.

### 3.11 Interrupts and events

#### 3.11.1 Nested vectored interrupt controller (NVIC)

The STM32F378xx devices embed a nested vectored interrupt controller (NVIC) able to handle up to 60 maskable interrupt channels and 16 priority levels.

The NVIC benefits are the following:

- 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

The NVIC hardware block provides flexible interrupt management features with minimal interrupt latency.

#### 3.11.2 Extended interrupt/event controller (EXTI)

The extended interrupt/event controller consists of 29 edge detector lines used to generate interrupt/event requests and wake-up the system. 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 clock period. Up to 84 GPIOs can be connected to the 16 external interrupt lines.



## 3.12 12-bit analog-to-digital converter (ADC)

The 12-bit analog-to-digital converter is based on a successive approximation register (SAR) architecture. It has up to 16 external channels (AIN15:0) and 3 internal channels (temperature sensor, voltage reference,  $V_{BAT}$  voltage measurement) 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 timers (TIMx) can be internally connected to the ADC start and injection trigger, respectively, to allow the application to synchronize A/D conversion and timers.

### 3.12.1 Temperature sensor

The temperature sensor (TS) generates a voltage  $V_{SENSE}$  that varies linearly with temperature.

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.

The sensor provides good linearity but it has to be calibrated to obtain good overall accuracy of the temperature measurement. As the offset of the temperature sensor varies from chip to chip due to process variation, the uncalibrated internal temperature sensor is suitable for applications that detect temperature changes only.

To improve the accuracy of the temperature sensor measurement, each device is individually factory-calibrated by ST. The temperature sensor factory calibration data are stored by ST in the system memory area, accessible in read-only mode. See [Table 64: Temperature sensor calibration values on page 103](#).

### 3.12.2 Internal voltage reference ( $V_{REFINT}$ )

The internal voltage reference ( $V_{REFINT}$ ) provides a stable (bandgap) voltage output for the ADC and Comparators.  $V_{REFINT}$  is internally connected to the ADC\_IN17 input channel. The precise voltage of  $V_{REFINT}$  is individually measured for each part by ST during production test and stored in the system memory area. It is accessible in read-only mode.

### 3.12.3 $V_{BAT}$ battery voltage monitoring

This embedded hardware feature allows the application to measure the  $V_{BAT}$  battery voltage using the internal ADC channel ADC\_IN18. As the  $V_{BAT}$  voltage may be higher than  $V_{DDA}$ , and thus outside the ADC input range, the  $V_{BAT}$  pin is internally connected to a divider by 2. As a consequence, the converted digital value is half the  $V_{BAT}$  voltage.

### 3.13 16-bit sigma delta analog-to-digital converters (SDADC)

Up to three 16-bit sigma-delta analog-to-digital converters are embedded in the STM32F378xx. They have up to two separate supply voltages allowing the analog function voltage range to be independent from the STM32F378xx power supply. They share up to 21 input pins which may be configured in any combination of single-ended (up to 21) or differential inputs (up to 11).

The conversion speed is up to 16.6 ksps for each SDADC when converting multiple channels and up to 50 ksps per SDADC if single channel conversion is used. There are two conversion modes: single conversion mode or continuous mode, capable of automatically scanning any number of channels. The data can be automatically stored in a system RAM buffer, reducing the software overhead.

A timer triggering system can be used in order to control the start of conversion of the three SDADCs and/or the 12-bit fast ADC. This timing control is very flexible, capable of triggering simultaneous conversions or inserting a programmable delay between the ADCs.

Up to two external reference pins (VREFSD+, VREFSD-) and an internal 1.2/1.8 V reference can be used in conjunction with a programmable gain (x0.5 to x32) in order to fine-tune the input voltage range of the SDADC. VREFSD - pin is used as negative signal reference in case of single-ended input mode.

### 3.14 Digital-to-analog converter (DAC)

The devices feature up to two 12-bit buffered DACs with three output channels that can be used to convert three digital signals into three analog voltage signal outputs. The internal structure is composed of integrated resistor strings and an amplifier in inverting configuration.

This digital Interface supports the following features:

- Up to two DAC converters with three output channels:
  - DAC1 with two output channels
  - DAC2 with one output channel.
- 8-bit or 10-bit monotonic output
- Left or right data alignment in 12-bit mode
- Synchronized update capability
- Noise-wave generation (DAC1 only)
- Triangular wave generation (DAC1 only)
- Dual DAC channel independent or simultaneous conversions (DAC1 only)
- DMA capability for each channel
- External triggers for conversion

### 3.15 Fast comparators (COMP)

The STM32F378xx embeds up to 2 comparators with rail-to-rail inputs and high-speed output. The reference voltage can be internal or external (delivered by an I/O).

The threshold can be one of the following:

- DACs channel outputs
- External I/O
- Internal reference voltage ( $V_{REFINT}$ ) or submultiple ( $1/4 V_{REFINT}$ ,  $1/2 V_{REFINT}$  and  $3/4 V_{REFINT}$ )

The comparators can be combined into a window comparator.

Both comparators can wake up the device from Stop mode and generate interrupts and breaks for the timers.

### 3.16 Touch sensing controller (TSC)

The devices provide a simple solution for adding capacitive sensing functionality to any application. Capacitive sensing technology is able to detect the presence of a finger near an electrode which is protected from direct touch by a dielectric (glass, plastic, ...). The capacitive variation introduced by the finger (or any conductive object) is measured using a proven implementation based on a surface charge transfer acquisition principle. It consists of charging the electrode capacitance and then transferring a part of the accumulated charges into a sampling capacitor until the voltage across this capacitor has reached a specific threshold. To limit the CPU bandwidth usage this acquisition is directly managed by the hardware touch sensing controller and only requires few external components to operate.

The touch sensing controller is fully supported by the STMTouch touch sensing firmware library, which is free to use and allows touch sensing functionality to be implemented reliably in the end application.

Up to 24 touch sensing electrodes can be controlled by the TSC. The touch sensing I/Os are organized in 8 acquisition groups, with up to 4 I/Os in each group.

**Table 3. Capacitive sensing GPIOs available on STM32F378xx devices**

| Group | Capacitive sensing signal name | Pin name           | Group | Capacitive sensing signal name | Pin name |
|-------|--------------------------------|--------------------|-------|--------------------------------|----------|
| 1     | TSC_G1_IO1                     | PA0                | 5     | TSC_G5_IO1                     | PB3      |
|       | TSC_G1_IO2                     | PA1                |       | TSC_G5_IO2                     | PB4      |
|       | TSC_G1_IO3                     | PA2                |       | TSC_G5_IO3                     | PB6      |
|       | TSC_G1_IO4                     | PA3                |       | TSC_G5_IO4                     | PB7      |
| 2     | TSC_G2_IO1                     | PA4 <sup>(1)</sup> | 6     | TSC_G6_IO1                     | PB14     |
|       | TSC_G2_IO2                     | PA5 <sup>(1)</sup> |       | TSC_G6_IO2                     | PB15     |
|       | TSC_G2_IO3                     | PA6 <sup>(1)</sup> |       | TSC_G6_IO3                     | PD8      |
|       | TSC_G2_IO4                     | PA7                |       | TSC_G6_IO4                     | PD9      |

**Table 3. Capacitive sensing GPIOs available on STM32F378xx devices (continued)**

| Group | Capacitive sensing signal name | Pin name | Group | Capacitive sensing signal name | Pin name |
|-------|--------------------------------|----------|-------|--------------------------------|----------|
| 3     | TSC_G3_IO1                     | PC4      | 7     | TSC_G7_IO1                     | PE2      |
|       | TSC_G3_IO2                     | PC5      |       | TSC_G7_IO2                     | PE3      |
|       | TSC_G3_IO3                     | PB0      |       | TSC_G7_IO3                     | PE4      |
|       | TSC_G3_IO4                     | PB1      |       | TSC_G7_IO4                     | PE5      |
| 4     | TSC_G4_IO1                     | PA9      | 8     | TSC_G8_IO1                     | PD12     |
|       | TSC_G4_IO2                     | PA10     |       | TSC_G8_IO2                     | PD13     |
|       | TSC_G4_IO3                     | PA13     |       | TSC_G8_IO3                     | PD14     |
|       | TSC_G4_IO4                     | PA14     |       | TSC_G8_IO4                     | PD15     |

1. This GPIO offers a reduced touch sensing sensitivity. It is thus recommended to use it as sampling capacitor I/O.

**Table 4. No. of capacitive sensing channels available on STM32F378xx devices**

| Analog I/O group                      | Number of capacitive sensing channels |             |             |
|---------------------------------------|---------------------------------------|-------------|-------------|
|                                       | STM32F378Cx                           | STM32F378Rx | STM32F378Vx |
| G1                                    | 3                                     | 3           | 3           |
| G2                                    | 2                                     | 3           | 3           |
| G3                                    | 1                                     | 3           | 3           |
| G4                                    | 3                                     | 3           | 3           |
| G5                                    | 3                                     | 3           | 3           |
| G6                                    | 2                                     | 2           | 3           |
| G7                                    | 0                                     | 0           | 3           |
| G8                                    | 0                                     | 0           | 3           |
| Number of capacitive sensing channels | 14                                    | 17          | 24          |

### 3.17 Timers and watchdogs

The STM32F378xx includes two 32-bit and nine 16-bit general-purpose timers, three basic timers, two watchdog timers and a SysTick timer. The table below compares the features of the advanced control, general purpose and basic timers.

**Table 5. Timer feature comparison**

| Timer type      | Timer                   | Counter resolution | Counter type         | Prescaler factor                | DMA request generation | Capture/compare channels | Complementary outputs |
|-----------------|-------------------------|--------------------|----------------------|---------------------------------|------------------------|--------------------------|-----------------------|
| General-purpose | TIM2<br>TIM5            | 32-bit             | Up, Down,<br>Up/Down | Any integer between 1 and 65536 | Yes                    | 4                        | 0                     |
| General-purpose | TIM3,<br>TIM4,<br>TIM19 | 16-bit             | Up, Down,<br>Up/Down | Any integer between 1 and 65536 | Yes                    | 4                        | 0                     |
| General-purpose | TIM12                   | 16-bit             | Up                   | Any integer between 1 and 65536 | No                     | 2                        | 0                     |
| General-purpose | TIM15                   | 16-bit             | Up                   | Any integer between 1 and 65536 | Yes                    | 2                        | 1                     |
| General-purpose | TIM13,<br>TIM14         | 16-bit             | Up                   | Any integer between 1 and 65536 | No                     | 1                        | 0                     |
| General-purpose | TIM16,<br>TIM17         | 16-bit             | Up                   | Any integer between 1 and 65536 | Yes                    | 1                        | 1                     |
| Basic           | TIM6,<br>TIM7,<br>TIM18 | 16-bit             | Up                   | Any integer between 1 and 65536 | Yes                    | 0                        | 0                     |

### 3.17.1 General-purpose timers (TIM2 to TIM5, TIM12 to TIM17, TIM19)

There are eleven synchronizable general-purpose timers embedded in the STM32F378xx (see [Table 5](#) for differences). Each general-purpose timer can be used to generate PWM outputs, or act as a simple time base.

- TIM2, 3, 4, 5 and 19

These five timers are full-featured general-purpose timers:

- TIM2 and TIM5 have 32-bit auto-reload up/downcounters and 32-bit prescalers
- TIM3, 4, and 19 have 16-bit auto-reload up/downcounters and 16-bit prescalers

These timers all feature 4 independent channels for input capture/output compare, PWM or one-pulse mode output. They can work together, or with the other general-purpose timers via the Timer Link feature for synchronization or event chaining.

The counters can be frozen in debug mode.

All have independent DMA request generation and support quadrature encoders.

- TIM12, 13, 14, 15, 16, 17

These six timers general-purpose timers with mid-range features:

They have 16-bit auto-reload upcounters and 16-bit prescalers.

- TIM12 has 2 channels
- TIM13 and TIM14 have 1 channel
- TIM15 has 2 channels and 1 complementary channel
- TIM16 and TIM17 have 1 channel and 1 complementary channel

All channels can be used for input capture/output compare, PWM or one-pulse mode output.

The timers can work together via the Timer Link feature for synchronization or event chaining. The timers have independent DMA request generation.

The counters can be frozen in debug mode.

### 3.17.2 Basic timers (TIM6, TIM7, TIM18)

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

### 3.17.3 Independent watchdog (IWDG)

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 Stopmode. 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.

### 3.17.4 System window watchdog (WWDG)

The system 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 APB1 clock (PCLK1) derived from the main clock. It has an early warning interrupt capability and the counter can be frozen in debug mode.

### 3.17.5 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

## 3.18 Real-time clock (RTC) and backup registers

The RTC and the backup registers are supplied through a switch that takes power either from  $V_{DD}$  supply when present or through the  $V_{BAT}$  pin. The backup registers are thirty two 32-bit registers used to store 128 bytes of user application data.

They are not reset by a system or power reset.

The RTC is an independent BCD timer/counter. Its main features are the following:

- Calendar with subsecond, seconds, minutes, hours (12 or 24 format), week day, date, month, year, in BCD (binary-coded decimal) format.
- Automatic correction for 28th, 29th (leap year), 30th and 31st day of the month.
- 2 programmable alarms with wake up from Stop mode capability.
- Periodic wakeup unit with programmable resolution and period.
- On-the-fly correction from 1 to 32767 RTC clock pulses. This can be used to synchronize it with a master clock.
- Digital calibration circuit with 1 ppm resolution, to compensate for quartz crystal inaccuracy.
- 3 anti-tamper detection pins with programmable filter. The MCU can be woken up from Stop mode on tamper event detection.
- Timestamp feature which can be used to save the calendar content. This function can be triggered by an event on the timestamp pin, or by a tamper event. The MCU can be woken up from Stop mode on timestamp event detection.

- Reference clock detection: a more precise second source clock (50 or 60 Hz) can be used to enhance the calendar precision.

The RTC clock sources can be:

- A 32.768 kHz external crystal
- A resonator or oscillator
- The internal low-power RC oscillator (typical frequency of 40 kHz)
- The high-speed external clock divided by 32

### 3.19 Inter-integrated circuit interface (I<sup>2</sup>C)

Up to two I<sup>2</sup>C bus interfaces can operate in multimaster and slave modes. They can support standard (up to 100 kHz), fast (up to 400 kHz) and fast mode + (up to 1 MHz) modes with 20 mA output drive. They support 7-bit and 10-bit addressing modes, multiple 7-bit slave addresses (2 addresses, 1 with configurable mask). They also include programmable analog and digital noise filters.

**Table 6. Comparison of I<sup>2</sup>C analog and digital filters**

| -                                | Analog filter   | Digital filter  |
|----------------------------------|---|---|
| Pulse width of suppressed spikes | ≥ 50 ns   | Programmable length from 1 to 15 I <sup>2</sup> C peripheral clocks               |
| Benefits                         | Available in Stop mode                                | 1. Extra filtering capability vs. standard requirements.<br>2. Stable length      |
| Drawbacks                        | Variations depending on temperature, voltage, process | Wakeup from Stop on address match is not available when digital filter is enabled |

In addition, they provide hardware support for SMBUS 2.0 and PMBUS 1.1: ARP capability, Host notify protocol, hardware CRC (PEC) generation/verification, timeout verifications and ALERT protocol management. They also have a clock domain independent from the CPU clock, allowing the application to wake up the MCU from Stop mode on address match.

The I<sup>2</sup>C interfaces can be served by the DMA controller

Refer to [Table 7](#) for the differences between I2C1 and I2C2.

**Table 7. STM32F378xx I<sup>2</sup>C implementation**

| I <sup>2</sup> C features <sup>(1)</sup>                    | I2C1 | I2C2 |
|---|------|------|
| 7-bit addressing mode                                       | X    | X    |
| 10-bit addressing mode                                      | X    | X    |
| Standard mode (up to 100 kbit/s)                            | X    | X    |
| Fast mode (up to 400 kbit/s)                                | X    | X    |
| Fast Mode Plus with 20mA output drive I/Os (up to 1 Mbit/s) | X    | X    |
| Independent clock   | X    | X    |



Table 7. STM32F378xx I<sup>2</sup>C implementation (continued)

| I <sup>2</sup> C features <sup>(1)</sup> | I2C1 | I2C2 |
|--|------|------|
| SMBus                                    | X    | X    |
| Wakeup from STOP                         | X    | X    |

1. X = supported.

### 3.20 Universal synchronous/asynchronous receiver transmitter (USART)

The STM32F378xx embeds three universal synchronous/asynchronous receiver transmitters (USART1, USART2 and USART3).

All USARTs interfaces are able to communicate at speeds of up to 9 Mbit/s.

They provide hardware management of the CTS and RTS signals, they support IrDA SIR ENDEC, the multiprocessor communication mode, the single-wire half-duplex communication mode, Smartcard mode (ISO/IEC 7816 compliant), autobaudrate feature and have LIN Master/Slave capability. The USART interfaces can be served by the DMA controller.

Refer to [Table 8](#) for the features of USART1, USART2 and USART3.

Table 8. STM32F378xx USART implementation

| USART modes/features <sup>(1)</sup>         | USART1 | USART2 | USART3 |
|---|--------|--------|--------|
| Hardware flow control for modem             | X      | X      | X      |
| Continuous communication using DMA          | X      | X      | X      |
| Multiprocessor communication                | X      | X      | X      |
| Synchronous mode                            | X      | X      | X      |
| Smartcard mode                              | X      | X      | X      |
| Single-wire half-duplex communication       | X      | X      | X      |
| IrDA SIR ENDEC block                        | X      | X      | X      |
| LIN mode                                    | X      | X      | X      |
| Dual clock domain and wakeup from Stop mode | X      | X      | X      |
| Receiver timeout interrupt                  | X      | X      | X      |
| Modbus communication                        | X      | X      | X      |
| Auto baud rate detection                    | X      | X      | X      |
| Driver Enable                               | X      | X      | X      |

1. X = supported.

### 3.21 Serial peripheral interface (SPI)/Inter-integrated sound interfaces (I<sup>2</sup>S)

Up to three SPIs are able to communicate at up to 18 Mbits/s in slave and master modes in full-duplex and half-duplex 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.

The SPIs can be served by the DMA controller.

Three standard I<sup>2</sup>S interfaces (multiplexed with SPI1, SPI2 and SPI3) are available, that can be operated in master or slave mode. These interfaces can be configured to operate with 16/32 bit resolution, as input or output channels. Audio sampling frequencies from 8 kHz up to 192 kHz are supported. When either or both of the I<sup>2</sup>S interfaces is/are configured in master mode, the master clock can be output to the external DAC/CODEC at 256 times the sampling frequency. All I2S interfaces can operate in half-duplex mode only.

Refer to [Table 9](#) for the features between SPI1, SPI2 and SPI3.

**Table 9. STM32F378xx SPI/I2S implementation**

| SPI features <sup>(1)</sup> | SPI1 | SPI2 | SPI3 |
|-----------------------------|------|------|------|
| Hardware CRC calculation    | X    | X    | X    |
| Rx/Tx FIFO                  | X    | X    | X    |
| NSS pulse mode              | X    | X    | X    |
| I2S mode                    | X    | X    | X    |
| TI mode                     | X    | X    | X    |
| I2S full-duplex mode        | -    | -    | -    |

1. X = supported.

### 3.22 High-definition multimedia interface (HDMI) - consumer electronics control (CEC)

The device embeds a HDMI-CEC controller that provides hardware support for the Consumer Electronics Control (CEC) protocol (Supplement 1 to the HDMI standard).

This protocol provides high-level control functions between all audiovisual products in an environment. It is specified to operate at low speeds with minimum processing and memory overhead. It has a clock domain independent from the CPU clock, allowing the HDMI\_CEC controller to wakeup the MCU from Stop mode on data reception.

### 3.23 Controller area network (CAN)

The CAN is compliant with specifications 2.0A and B (active) with a bit rate up to 1 Mbit/s. It can receive and transmit standard frames with 11-bit identifiers as well as extended frames with 29-bit identifiers. It has three transmit mailboxes, two receive FIFOs with 3 stages and 14 scalable filter banks.

### 3.24 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.

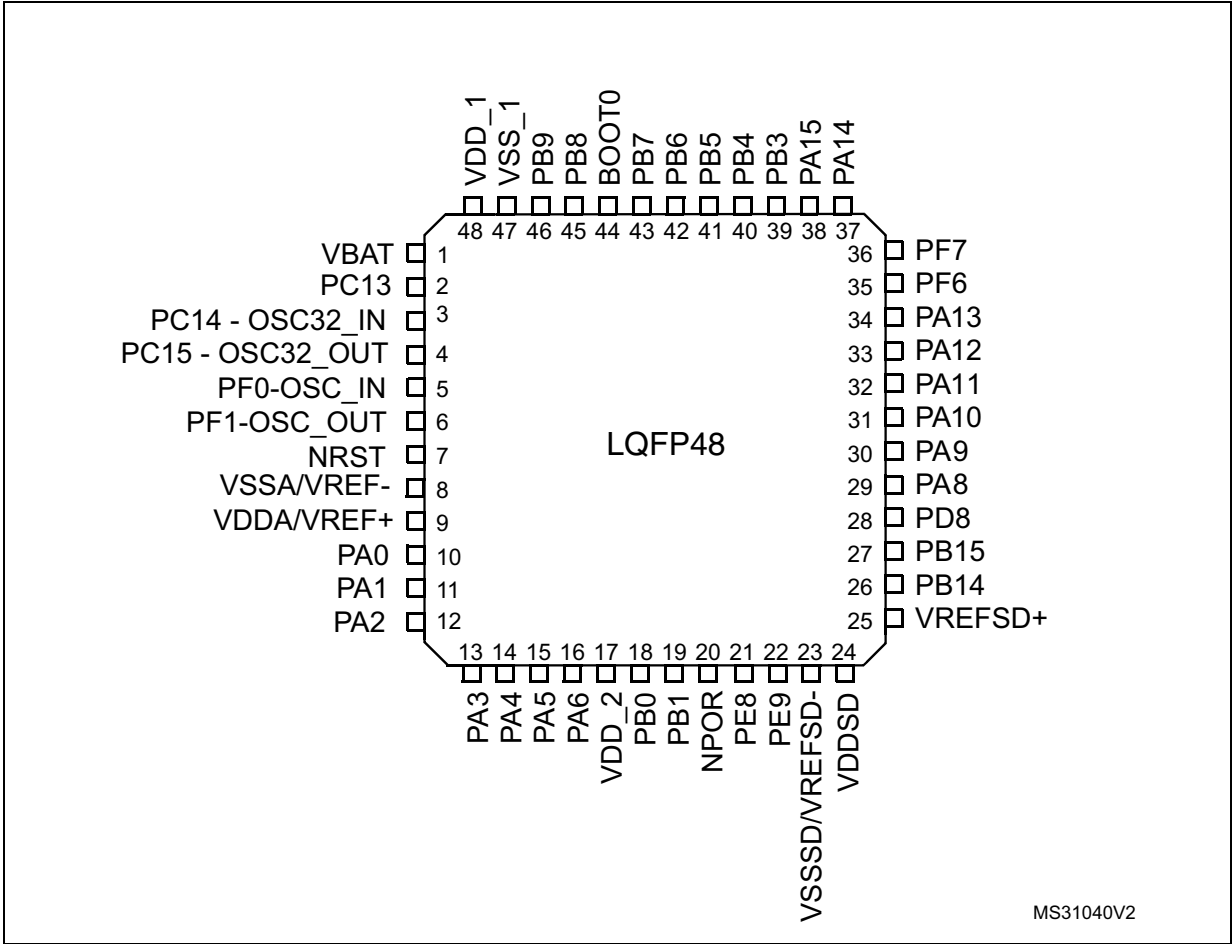
The JTAG TMS and TCK pins are shared respectively with SWDIO and SWCLK and a specific sequence on the TMS pin is used to switch between JTAG-DP and SW-DP.

### 3.25 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 STM32F378xx 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 USB, 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.

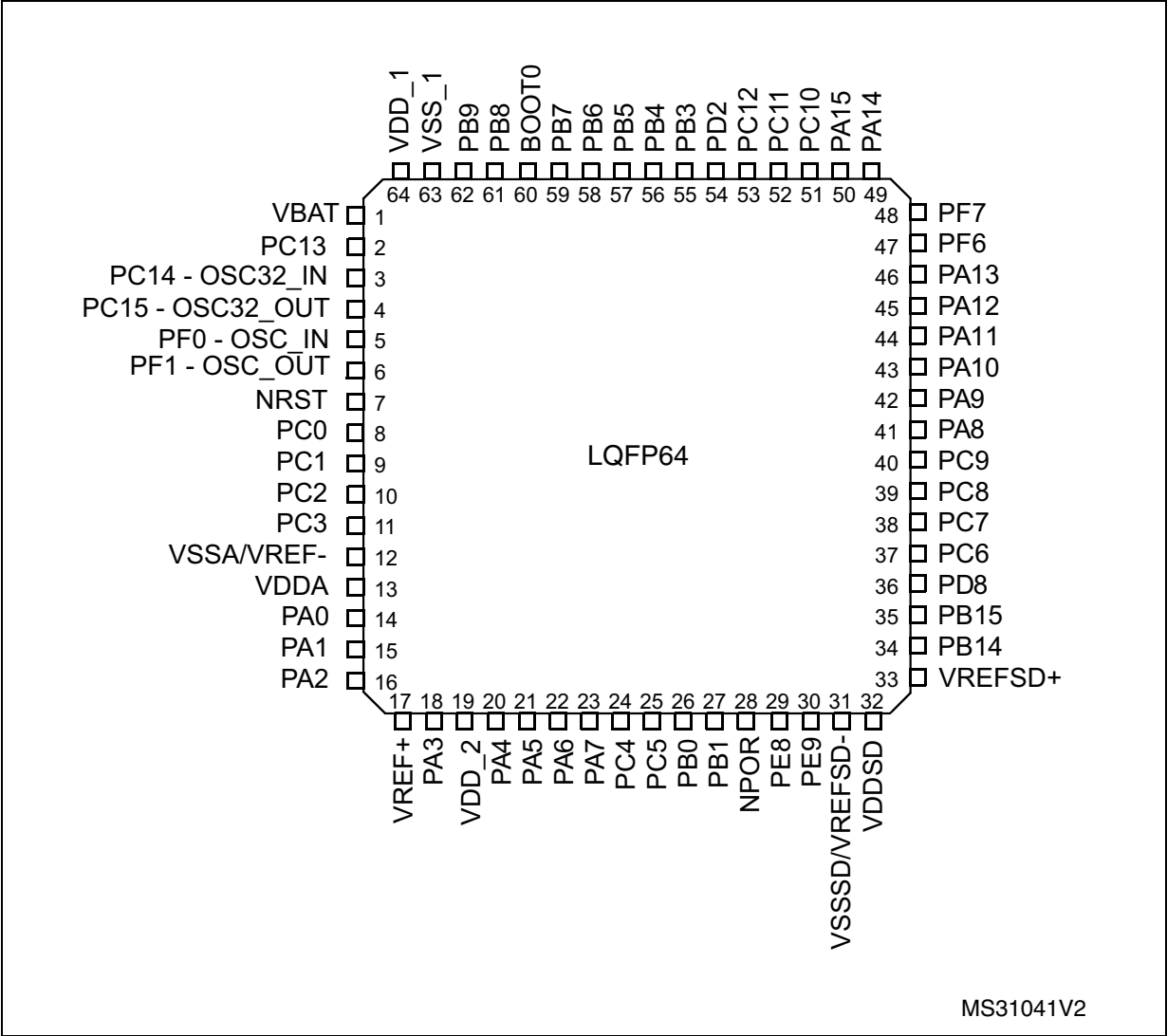
## 4 Pinouts and pin description

Figure 2. STM32F378xx LQFP48 pinout



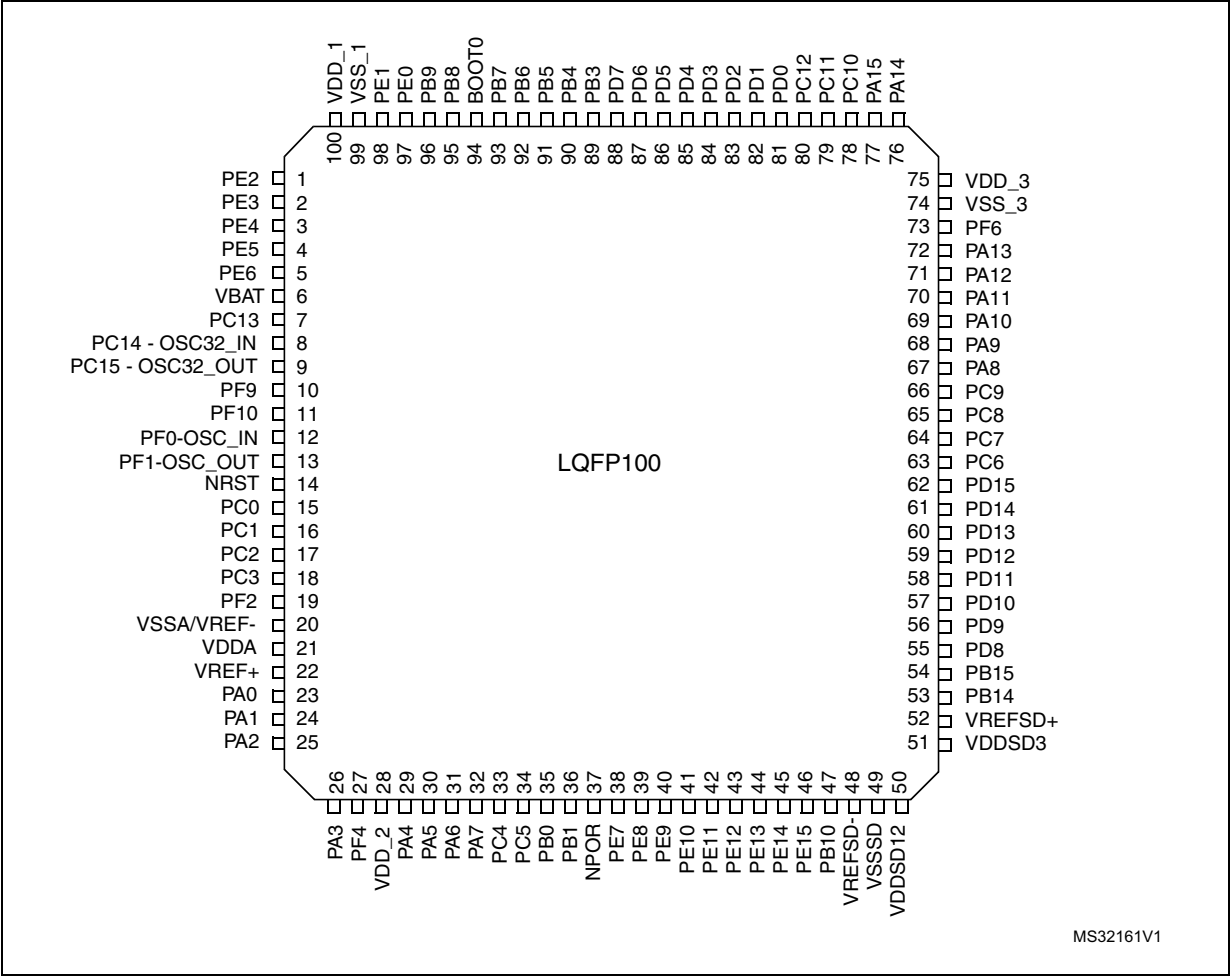
1. The above figure shows the package top view.

Figure 3. STM32F378xx LQFP64 pinout



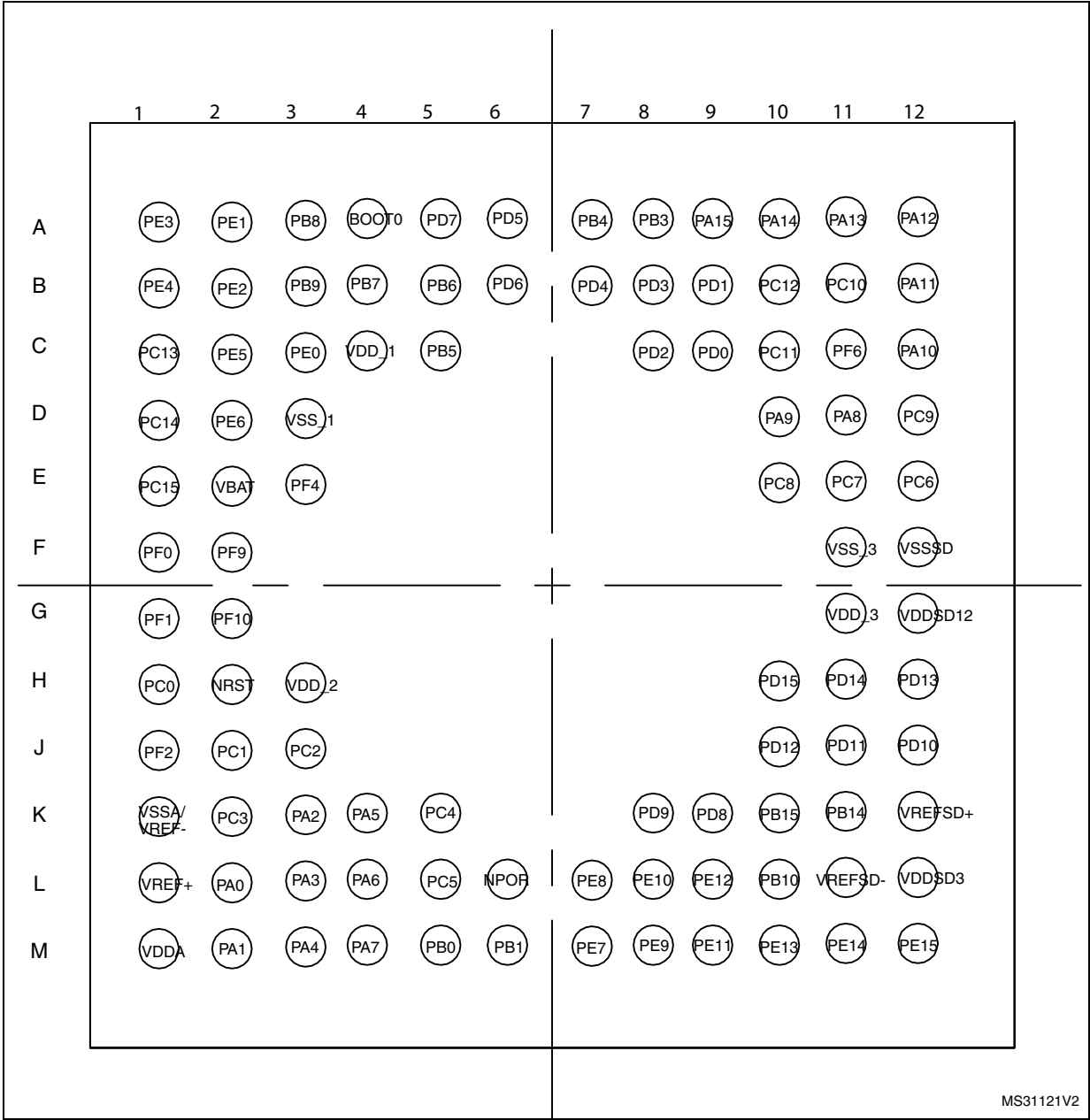
1. The above figure shows the package top view.

Figure 4. STM32F378xx LQFP100 pinout



1. The above figure shows the package top view.

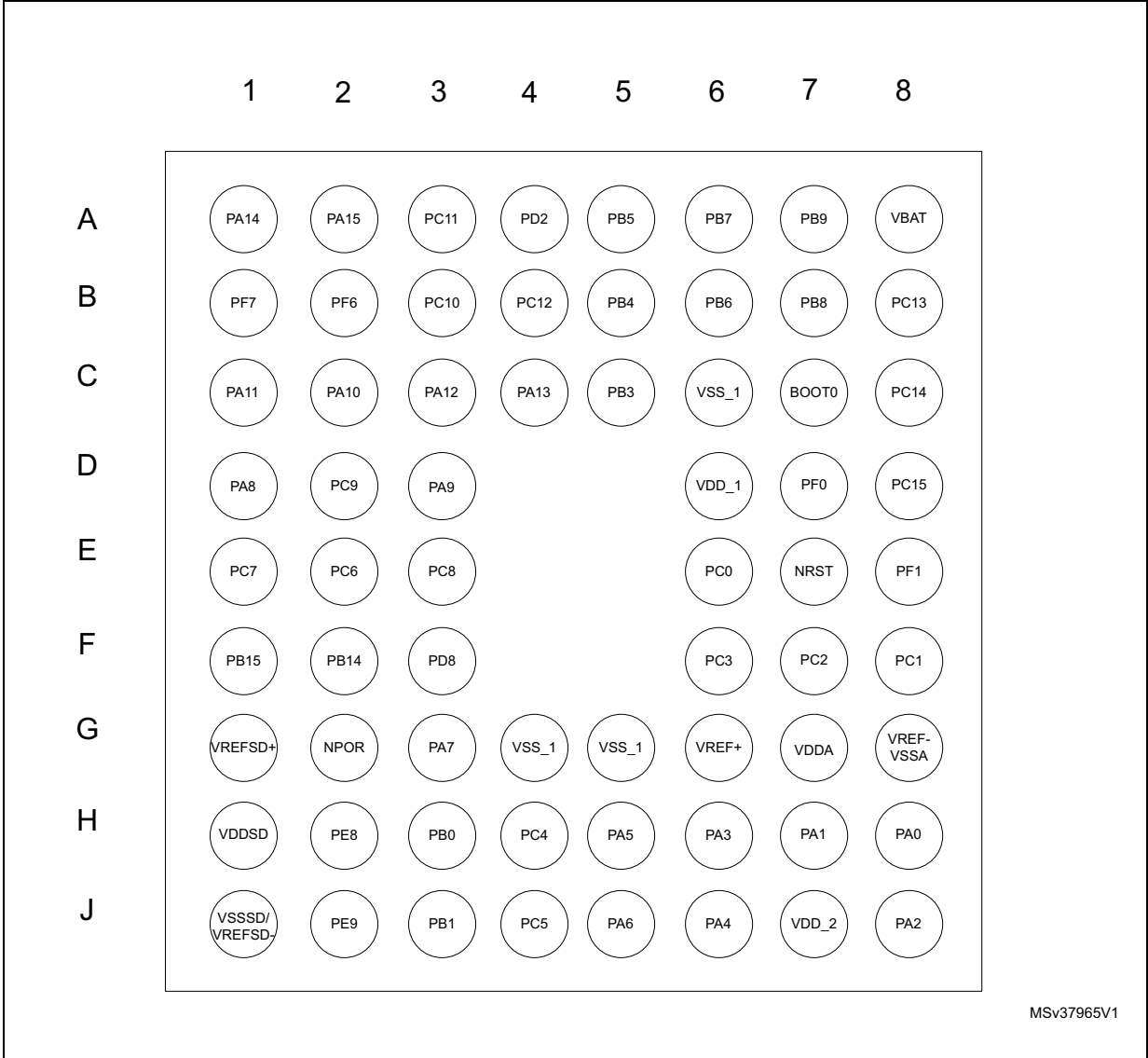
Figure 5. STM32F378xx UFBGA100 ballout



MS31121V2

1. The above figure shows the package top view.

Figure 6. STM32F378xx WLCSP66 ballout



1. The above figure shows the package top view.



Table 10. Legend/abbreviations used in the pinout table

| Name          |                      | Abbreviation  | Definition   |
|---------------|----------------------|---|--|
| Pin name      |                      | Unless otherwise specified in brackets below the pin name, the pin function during and after reset is the same as the actual pin name |  |
| Pin type      |                      | S   | Supply pin   |
|               |                      | I   | Input only pin   |
|               |                      | I/O   | Input / output pin   |
| I/O structure |                      | FT  | 5 V tolerant I/O   |
|               |                      | FTf   | 5 V tolerant I/O, FM+ capable  |
|               |                      | TTa   | 3.3 V tolerant I/O directly connected to ADC or SDADC  |
|               |                      | POR   | External power on reset pin with embedded weak pull-up resistor, powered from V <sub>DDA</sub> |
|               |                      | TC  | Standard 3.3V I/O  |
|               |                      | B   | Dedicated BOOT0 pin  |
|               |                      | RST   | Bidirectional reset pin with embedded weak pull-up resistor                                    |
| Notes         |                      | Unless otherwise specified by a note, all I/Os are set as floating inputs during and after reset                                      |  |
| Pin functions | Alternate functions  | Functions selected through GPIOx_AFR registers  |  |
|               | Additional functions | Functions directly selected/enabled through peripheral registers  |  |

Table 11. STM32F378xx pin definitions

| Pin numbers |        |        |        |         | Pin name<br>(function after<br>reset) | Pin<br>type | Notes | I/O structure | Pin functions   |   |
|-------------|--------|--------|--------|---------|---------------------------------------|-------------|-------|---------------|---|---|
| LQFP100     | BGA100 | LQFP64 | LQFP48 | WLCSP66 |                                       |             |       |               | Alternate function  | Additional functions  |
| 1           | B2     | -      | -      | -       | PE2                                   | I/O         | (1)   | FT            | TSC_G7_IO1, TRACECLK  | -   |
| 2           | A1     | -      | -      | -       | PE3                                   | I/O         | (1)   | FT            | TSC_G7_IO2, TRACED0   | -   |
| 3           | B1     | -      | -      | -       | PE4                                   | I/O         | (1)   | FT            | TSC_G7_IO3, TRACED1   | -   |
| 4           | C2     | -      | -      | -       | PE5                                   | I/O         | (1)   | FT            | TSC_G7_IO4, TRACED2   | -   |
| 5           | D2     | -      | -      | -       | PE6                                   | I/O         | (1)   | FT            | TRACED3   | WKUP3,<br>RTC_TAMPER3   |
| 6           | E2     | 1      | 1      | A8      | VBAT                                  | S           | -     | -             | Backup power supply   |   |
| 7           | C1     | 2      | 2      | B8      | PC13 <sup>(2)</sup>                   | I/O         | -     | TC            | -   | WKUP2,<br>ALARM_OUT,<br>CALIB_OUT,<br>TIMESTAMP,<br>RTC_TAMPER1 |
| 8           | D1     | 3      | 3      | C8      | PC14 -<br>OSC32_IN <sup>(2)</sup>     | I/O         | -     | TC            | -   | OSC32_IN  |
| 9           | E1     | 4      | 4      | D8      | PC15 -<br>OSC32_OUT <sup>(2)</sup>    | I/O         | -     | TC            | -   | OSC32_OUT   |
| 10          | F2     | -      | -      | -       | PF9                                   | I/O         | (1)   | FT            | TIM14_CH1   | -   |
| 11          | G2     | -      | -      | -       | PF10                                  | I/O         | (1)   | FT            | -   | -   |
| 12          | F1     | 5      | 5      | D7      | PF0 - OSC_IN                          | I/O         | -     | FTf           | I2C2_SDA  | OSC_IN  |
| 13          | G1     | 6      | 6      | E8      | PF1 -<br>OSC_OUT                      | I/O         | -     | FTf           | I2C2_SCL  | OSC_OUT   |
| 14          | H2     | 7      | 7      | E7      | NRST                                  | I/O         | -     | RST           | Device reset input / internal reset output (active low)       |   |
| 15          | H1     | 8      | -      | E6      | PC0                                   | I/O         | (1)   | TTa           | TIM5_CH1_ETR  | ADC_IN10  |
| 16          | J2     | 9      | -      | F8      | PC1                                   | I/O         | (1)   | TTa           | TIM5_CH2  | ADC_IN11  |
| 17          | J3     | 10     | -      | F7      | PC2                                   | I/O         | (1)   | TTa           | SPI2_MISO/I2S2_MCK,<br>TIM5_CH3                               | ADC_IN12  |
| 18          | K2     | 11     | -      | F6      | PC3                                   | I/O         | (1)   | TTa           | SPI2_MOSI/I2S2_SD,<br>TIM5_CH4                                | ADC_IN13  |
| 19          | J1     | -      | -      | -       | PF2                                   | I/O         | (1)   | FT            | I2C2_SMBA   | -   |
| 20          | K1     | 12     | 8      | G8      | VSSA/ VREF-                           | S           | -     | -             | Analog ground   |   |
| -           | -      | -      | 9      | -       | VDDA/ VREF+                           | S           | (1)   | -             | Analog power supply / Reference voltage for ADC,<br>COMP, DAC |   |
| 21          | M1     | 13     | -      | G7      | VDDA                                  | S           | (1)   | -             | Analog power supply   |   |
| 22          | L1     | 17     | -      | G6      | VREF+                                 | S           | (1)   | -             | Reference voltage for ADC, COMP, DAC                          |   |

Table 11. STM32F378xx pin definitions (continued)

| Pin numbers |        |        |        |         | Pin name<br>(function after<br>reset) | Pin<br>type | Notes | I/O structure | Pin functions   |  |
|-------------|--------|--------|--------|---------|---------------------------------------|-------------|-------|---------------|---|--|
| LQFP100     | BGA100 | LQFP64 | LQFP48 | WLCSP66 |                                       |             |       |               | Alternate function  | Additional functions                         |
| 23          | L2     | 14     | 10     | H8      | PA0                                   | I/O         | -     | TTa           | USART2_CTS,<br>TIM2_CH1_ETR,<br>TIM5_CH1_ETR,<br>TIM19_CH1, TSC_G1_IO1,<br>COMP1_OUT                          | RTC_TAMPER2,<br>WKUP1, ADC_IN0,<br>COMP1_INM |
| 24          | M2     | 15     | 11     | H7      | PA1                                   | I/O         | -     | TTa           | SPI3_SCK/I2S3_CK,<br>USART2_RTS, TIM2_CH2,<br>TIM15_CH1N, TIM5_CH2,<br>TIM19_CH2, TSC_G1_IO2,<br>RTC_REF_IN   | ADC_IN1,<br>COMP1_INP                        |
| 25          | K3     | 16     | 12     | J8      | PA2                                   | I/O         | -     | TTa           | COMP2_OUT,<br>TSC_G1_IO3,<br>SPI3_MISO/I2S3_MCK,<br>USART2_TX, TIM2_CH3,<br>TIM15_CH1, TIM5_CH3,<br>TIM19_CH3 | ADC_IN2,<br>COMP2_INM                        |
| 26          | L3     | 18     | 13     | H6      | PA3                                   | I/O         | -     | TTa           | SPI3_MOSI, I2S3_SD,<br>USART2_RX, TIM2_CH4,<br>TIM15_CH2, TIM5_CH4,<br>TIM19_CH4, TSC_G1_IO4                  | ADC_IN3,<br>COMP2_INP                        |
| 27          | E3     | -      | -      | -       | PF4                                   | I/O         | (1)   | FT            | -   | -  |
| 28          | H3     | 19     | 17     | J7      | VDD_2                                 | S           | -     | -             | Digital power supply  |  |
| 29          | M3     | 20     | 14     | J6      | PA4                                   | I/O         | -     | TTa           | SPI1_NSS/I2S1_WS,<br>SPI3_NSS/I2S3_WS,<br>USART2_CK, TIM3_CH2,<br>TIM12_CH1, TSC_G2_IO1                       | ADC_IN4,<br>DAC1_OUT1                        |
| 30          | K4     | 21     | 15     | H5      | PA5                                   | I/O         | -     | TTa           | SPI1_SCK/I2S1_CK, CEC,<br>TIM2_CH1_ETR,<br>TIM14_CH1, TIM12_CH2,<br>TSC_G2_IO2                                | ADC_IN5,<br>DAC1_OUT2                        |
| 31          | L4     | 22     | 16     | J5      | PA6                                   | I/O         | -     | TTa           | SPI1_MISO/I2S1_MCK,<br>TIM3_CH1, TIM13_CH1,<br>TIM16_CH1, COMP1_OUT,<br>TSC_G2_IO3                            | ADC_IN6,<br>DAC2_OUT1                        |
| 32          | M4     | 23     | -      | G3      | PA7                                   | I/O         | (1)   | TTa           | SPI1_MOSI/I2S1_SD,<br>TIM14_CH1, TIM17_CH1,<br>TIM3_CH2, COMP2_OUT,<br>TSC_G2_IO4                             | ADC_IN7                                      |
| 33          | K5     | 24     | -      | H4      | PC4                                   | I/O         | (1)   | TTa           | USART1_TX, TIM13_CH1,<br>TSC_G3_IO1   | ADC_IN14                                     |
| 34          | L5     | 25     | -      | J4      | PC5                                   | I/O         | (1)   | TTa           | USART1_RX, TSC_G3_IO2   | ADC_IN15                                     |

Table 11. STM32F378xx pin definitions (continued)

| Pin numbers |        |        |        |         | Pin name<br>(function after<br>reset) | Pin<br>type | Notes      | I/O structure | Pin functions   |   |
|-------------|--------|--------|--------|---------|---------------------------------------|-------------|------------|---------------|---|---|
| LQFP100     | BGA100 | LQFP64 | LQFP48 | WLCSP66 |                                       |             |            |               | Alternate function  | Additional functions  |
| 35          | M5     | 26     | 18     | H3      | PB0                                   | I/O         | -          | TTa           | SPI1_MOSI/I2S1_SD,<br>TIM3_CH3, TSC_G3_IO3  | ADC_IN8,<br>SDADC1_AIN6P  |
| 36          | M6     | 27     | 19     | J3      | PB1                                   | I/O         | -          | TTa           | TIM3_CH4, TSC_G3_IO4  | ADC_IN9,<br>SDADC1_AIN5P,<br>SDADC1_AIN6M                       |
| 37          | L6     | 28     | 20     | G2      | NPOR                                  | I           | (3)        | POR           | Power-on reset  |   |
| 38          | M7     | -      | -      | -       | PE7                                   | I/O         | (1)(4)     | TC            | -   | SDADC1_AIN3P,<br>SDADC1_AIN4M,<br>SDADC2_AIN5P,<br>SDADC2_AIN6M |
| 39          | L7     | 29     | 21     | H2      | PE8                                   | I/O         | (4)        | TC            | -   | SDADC1_AIN8P,<br>SDADC2_AIN8P                                   |
| 40          | M8     | 30     | 22     | J2      | PE9                                   | I/O         | (4)        | TC            | -   | SDADC1_AIN7P,<br>SDADC1_AIN8M,<br>SDADC2_AIN7P,<br>SDADC2_AIN8M |
| 41          | L8     | -      | -      | -       | PE10                                  | I/O         | (4)<br>(1) | TC            | -   | SDADC1_AIN2P  |
| 42          | M9     | -      | -      | -       | PE11                                  | I/O         | (1)(4)     | TC            | -   | SDADC1_AIN1P,<br>SDADC1_AIN2M,<br>SDADC2_AIN4P                  |
| 43          | L9     | -      | -      | -       | PE12                                  | I/O         | (1)(4)     | TC            | -   | SDADC1_AIN0P,<br>SDADC2_AIN3P,<br>SDADC2_AIN4M                  |
| 44          | M10    | -      | -      | -       | PE13                                  | I/O         | (1)(4)     | TC            | -   | SDADC1_AIN0M,<br>SDADC2_AIN2P                                   |
| 45          | M11    | -      | -      | -       | PE14                                  | I/O         | (1)(4)     | TC            | -   | SDADC2_AIN1P,<br>SDADC2_AIN2M                                   |
| 46          | M12    | -      | -      | -       | PE15                                  | I/O         | (1)(4)     | TC            | USART3_RX   | SDADC2_AIN0P  |
| 47          | L10    | -      | -      | -       | PB10                                  | I/O         | (1)(4)     | TC            | SPI2_SCK/I2S2_CK, CEC,<br>USART3_TX, TSC_SYNC   | TIM2_CH3,<br>SDADC2_AIN0M                                       |
| 48          | L11    | -      | -      | -       | VREFSD-                               | S           | (1)        | -             | External reference voltage for SDADC1, SDADC2,<br>SDADC3 (negative input), negative SDADC analog<br>input in SDADC single ended mode                                    |   |
| 49          | F12    | -      | -      | -       | VSSSD                                 | S           | (1)        | -             | SDADC1, SDADC2, SDADC3 ground   |   |
| -           | -      | 31     | 23     | J1      | VSSSD/<br>VREFSD-                     | S           | -          | -             | SDADC1, SDADC2, SDADC3 ground / External<br>reference voltage for SDADC1, SDADC2, SDADC3<br>(negative input), negative SDADC analog input in<br>SDADC single ended mode |   |

Table 11. STM32F378xx pin definitions (continued)

| Pin numbers |        |        |        |         | Pin name<br>(function after<br>reset) | Pin<br>type | Notes      | I/O structure | Pin functions   |                               |
|-------------|--------|--------|--------|---------|---------------------------------------|-------------|------------|---------------|---|-------------------------------|
| LQFP100     | BGA100 | LQFP64 | LQFP48 | WLCSP66 |                                       |             |            |               | Alternate function  | Additional functions          |
| 50          | G12    | -      | -      | -       | VDDSD12                               | S           | (1)        | -             | SDADC1 and SDADC2 power supply  |                               |
| -           | -      | 32     | 24     | H1      | VDDSD                                 | S           | -          | -             | SDADC1, SDADC2, SDADC3 power supply   |                               |
| 51          | L12    | -      | -      | -       | VDDSD3                                | S           | (1)        | -             | SDADC3 power supply   |                               |
| 52          | K12    | 33     | 25     | G1      | VREFSD+                               | S           | -          | -             | External reference voltage for SDADC1, SDADC2, SDADC3 (positive input)              |                               |
| 53          | K11    | 34     | 26     | F2      | PB14                                  | I/O         | (5)        | TC            | SPI2_MISO/I2S2_MCK,<br>USART3_RTS,<br>TIM15_CH1, TIM12_CH1,<br>TSC_G6_IO1           | SDADC3_AIN8P                  |
| 54          | K10    | 35     | 27     | F1      | PB15                                  | I/O         | (5)        | TC            | SPI2_MOSI/I2S2_SD,<br>TIM15_CH1N, TIM15_CH2,<br>TIM12_CH2, TSC_G6_IO2,<br>RTC_REFIN | SDADC3_AIN7P,<br>SDADC3_AIN8M |
| 55          | K9     | 36     | 28     | F3      | PD8                                   | I/O         | (5)        | TC            | SPI2_SCK/I2S2_CK,<br>USART3_TX, TSC_G6_IO3  | SDADC3_AIN6P                  |
| 56          | K8     | -      | -      | -       | PD9                                   | I/O         | (5)<br>(1) | TC            | USART3_RX, TSC_G6_IO4   | SDADC3_AIN5P,<br>SDADC3_AIN6M |
| 57          | J12    | -      | -      | -       | PD10                                  | I/O         | (1)(5)     | TC            | USART3_CK   | SDADC3_AIN4P                  |
| 58          | J11    | -      | -      | -       | PD11                                  | I/O         | (1)(5)     | TC            | USART3_CTS  | SDADC3_AIN3P,<br>SDADC3_AIN4M |
| 59          | J10    | -      | -      | -       | PD12                                  | I/O         | (1)(5)     | TC            | USART3_RTS, TIM4_CH1,<br>TSC_G8_IO1   | SDADC3_AIN2P                  |
| 60          | H12    | -      | -      | -       | PD13                                  | I/O         | (1)(5)     | TC            | TIM4_CH2, TSC_G8_IO2  | SDADC3_AIN1P,<br>SDADC3_AIN2M |
| 61          | H11    | -      | -      | -       | PD14                                  | I/O         | (1)(5)     | TC            | TIM4_CH3, TSC_G8_IO3  | SDADC3_AIN0P                  |
| 62          | H10    | -      | -      | -       | PD15                                  | I/O         | (1)(5)     | TC            | TIM4_CH4, TSC_G8_IO4  | SDADC3_AIN0M                  |
| 63          | E12    | 37     | -      | E2      | PC6                                   | I/O         | (1)        | FT            | SPI1_NSS/I2S1_WS,<br>TIM3_CH1   | -                             |
| 64          | E11    | 38     | -      | E1      | PC7                                   | I/O         | (1)        | FT            | SPI1_SCK/I2S1_CK,<br>TIM3_CH2   | -                             |
| 65          | E10    | 39     | -      | E3      | PC8                                   | I/O         | (1)        | FT            | SPI1_MISO/I2S1_MCK,<br>TIM3_CH3   | -                             |
| 66          | D12    | 40     | -      | D2      | PC9                                   | I/O         | (1)        | FT            | SPI1_MOSI/I2S1_SD,<br>TIM3_CH4  | -                             |

Table 11. STM32F378xx pin definitions (continued)

| Pin numbers |        |        |        |         | Pin name<br>(function after<br>reset) | Pin<br>type | Notes | I/O structure | Pin functions  |                      |
|-------------|--------|--------|--------|---------|---------------------------------------|-------------|-------|---------------|--|----------------------|
| LQFP100     | BGA100 | LQFP64 | LQFP48 | WLCSP66 |                                       |             |       |               | Alternate function   | Additional functions |
| 67          | D11    | 41     | 29     | D1      | PA8                                   | I/O         | -     | FT            | SPI2_SCK/I2S2_CK,<br>I2C2_SMBA, USART1_CK,<br>TIM4_ETR,<br>TIM5_CH1_ETR,<br>CLK_CLKOUT                 | -                    |
| 68          | D10    | 42     | 30     | D3      | PA9                                   | I/O         | -     | FTf           | SPI2_MISO/I2S2_MCK,<br>I2C2_SCL, USART1_TX,<br>TIM2_CH3, TIM15_BKIN,<br>TIM13_CH1, TSC_G4_IO1          | -                    |
| 69          | C12    | 43     | 31     | C2      | PA10                                  | I/O         | -     | FTf           | SPI2_MOSI/I2S2_SD,<br>I2C2_SDA, USART1_RX,<br>TIM2_CH4, TIM17_BKIN,<br>TIM14_CH1, TSC_G4_IO2           | -                    |
| 70          | B12    | 44     | 32     | C1      | PA11                                  | I/O         | -     | FT            | SPI2_NSS/I2S2_WS,<br>SPI1_NSS/I2S1_WS,<br>USART1_CTS, CAN_RX,<br>TIM4_CH1, TIM5_CH2,<br>COMP1_OUT      | -                    |
| 71          | A12    | 45     | 33     | C3      | PA12                                  | I/O         | -     | FT            | SPI1_SCK/I2S1_CK,<br>USART1_RTS, CAN_TX,<br>TIM16_CH1, TIM4_CH2,<br>TIM5_CH3, COMP2_OUT                | -                    |
| 72          | A11    | 46     | 34     | C4      | PA13                                  | I/O         | -     | FT            | SPI1_MISO/I2S1_MCK,<br>USART3_CTS, IR_OUT,<br>TIM16_CH1N, TIM4_CH3,<br>TIM5_CH4, G4_IO3,<br>SWDIO-JTMS | -                    |
| 73          | C11    | 47     | 35     | B2      | PF6                                   | I/O         | -     | FTf           | SPI1_MOSI, I2S1_SD,<br>USART3_RTS, TIM4_CH4,<br>I2C2_SCL   | -                    |
| 74          | F11    | -      | -      | -       | VSS_3                                 | S           | (1)   | -             | Ground   |                      |
| 75          | G11    | -      | -      | -       | VDD_3                                 | S           | (1)   | -             | Digital power supply   |                      |
| -           | -      | 48     | 36     | B1      | PF7                                   | I/O         | -     | FTf           | I2C2_SDA, USART2_CK  | -                    |
| 76          | A10    | 49     | 37     | A1      | PA14                                  | I/O         | -     | FTf           | I2C1_SDA, TIM12_CH1,<br>TSC_G4_IO4, SWCLK-<br>JTCK   | -                    |
| 77          | A9     | 50     | 38     | A2      | PA15                                  | I/O         | -     | FTf           | SPI1_NSS/I2S1_WS,<br>SPI3_NSS/I2S3_WS,<br>I2C1_SCL,<br>TIM2_CH1_ETR,<br>TIM12_CH2, TSC_SYNC,<br>JTDI   | -                    |

Table 11. STM32F378xx pin definitions (continued)

| Pin numbers |        |        |        |         | Pin name<br>(function after<br>reset) | Pin<br>type | Notes | I/O structure | Pin functions   |                      |
|-------------|--------|--------|--------|---------|---------------------------------------|-------------|-------|---------------|---|----------------------|
| LQFP100     | BGA100 | LQFP64 | LQFP48 | WLCSP66 |                                       |             |       |               | Alternate function  | Additional functions |
| 78          | B11    | 51     | -      | B3      | PC10                                  | I/O         | (1)   | FT            | SPI3_SCK/I2S3_CK,<br>USART3_TX, TIM19_CH1   | -                    |
| 79          | C10    | 52     | -      | A3      | PC11                                  | I/O         | (1)   | FT            | SPI3_MISO/I2S3_MCK,<br>USART3_RX, TIM19_CH2   | -                    |
| 80          | B10    | 53     | -      | B4      | PC12                                  | I/O         | (1)   | FT            | SPI3_MOSI/I2S3_SD,<br>USART3_CK, TIM19_CH3  | -                    |
| 81          | C9     | -      | -      | -       | PD0                                   | I/O         | (1)   | FT            | CAN_RX, TIM19_CH4   | -                    |
| 82          | B9     | -      | -      | -       | PD1                                   | I/O         | (1)   | FT            | CAN_TX, TIM19_ETR   | -                    |
| 83          | C8     | 54     | -      | A4      | PD2                                   | I/O         | (1)   | FT            | TIM3_ETR  | -                    |
| 84          | B8     | -      | -      | -       | PD3                                   | I/O         | (1)   | FT            | SPI2_MISO/I2S2_MCK,<br>USART2_CTS   | -                    |
| 85          | B7     | -      | -      | -       | PD4                                   | I/O         | (1)   | FT            | SPI2_MOSI/I2S2_SD,<br>USART2_RTS  | -                    |
| 86          | A6     | -      | -      | -       | PD5                                   | I/O         | (1)   | FT            | USART2_TX   | -                    |
| 87          | B6     | -      | -      | -       | PD6                                   | I/O         | (1)   | FT            | SPI2_NSS/I2S2_WS,<br>USART2_RX  | -                    |
| 88          | A5     | -      | -      | -       | PD7                                   | I/O         | (1)   | FT            | SPI2_SCK/I2S2_CK,<br>USART2_CK  | -                    |
| 89          | A8     | 55     | 39     | C5      | PB3                                   | I/O         | -     | FT            | SPI1_SCK/I2S1_CK,<br>SPI3_SCK/I2S3_CK,<br>USART2_TX, TIM2_CH2,<br>TIM3_ETR, TIM4_ETR,<br>TIM13_CH1, TSC_G5_IO1,<br>JTDO-TRACESWO      | -                    |
| 90          | A7     | 56     | 40     | B5      | PB4                                   | I/O         | -     | FT            | SPI1_MISO/I2S1_MCK,<br>SPI3_MISO/I2S3_MCK,<br>USART2_RX,<br>TIM162_CH1, TIM3_CH1,<br>TIM17_BKIN,<br>TIM15_CH1N,<br>TSC_G5_IO2, NJTRST | -                    |
| 91          | C5     | 57     | 41     | A5      | PB5                                   | I/O         | -     | FT            | SPI1_MOSI/I2S1_SD,<br>SPI3_MOSI/I2S3_SD,<br>I2C1_SMB, USART2_CK,<br>TIM16_BKIN, TIM3_CH2,<br>TIM17_CH1, TIM19_ETR                     | -                    |
| 92          | B5     | 58     | 42     | B6      | PB6                                   | I/O         | -     | FTf           | I2C1_SCL, USART1_TX,<br>TIM16_CH1N, TIM3_CH3,<br>TIM4_CH1, TIM19_CH1,<br>TIM15_CH1, TSC_G5_IO3  | -                    |

Table 11. STM32F378xx pin definitions (continued)

| Pin numbers |        |        |        |         | Pin name<br>(function after<br>reset) | Pin<br>type | Notes | I/O structure | Pin functions  |                      |
|-------------|--------|--------|--------|---------|---------------------------------------|-------------|-------|---------------|--|----------------------|
| LQFP100     | BGA100 | LQFP64 | LQFP48 | WLCSP66 |                                       |             |       |               | Alternate function   | Additional functions |
| 93          | B4     | 59     | 43     | A6      | PB7                                   | I/O         | -     | FTf           | I2C1_SDA, USART1_RX,<br>TIM17_CH1N, TIM3_CH4,<br>TIM4_CH2, TIM19_CH2,<br>TIM15_CH2, TSC_G5_IO4                         | -                    |
| 94          | A4     | 60     | 44     | C7      | BOOT0                                 | I           | -     | B             | Boot memory selection  |                      |
| 95          | A3     | 61     | 45     | B7      | PB8                                   | I/O         | -     | FTf           | SPI2_SCK/I2S2_CK,<br>I2C1_SCL, USART3_TX,<br>CAN_RX, CEC,<br>TIM16_CH1, TIM4_CH3,<br>TIM19_CH3, COMP1_OUT,<br>TSC_SYNC | -                    |
| 96          | B3     | 62     | 46     | A7      | PB9                                   | I/O         | -     | FTf           | SPI2_NSS/I2S2_WS,<br>I2C1_SDA, USART3_RX,<br>CAN_TX, IR_OUT,<br>TIM17_CH1, TIM4_CH4,<br>TIM19_CH4, COMP2_OUT           | -                    |
| 97          | C3     | -      | -      | -       | PE0                                   | I/O         | (1)   | FT            | USART1_TX, TIM4_ETR  | -                    |
| 98          | A2     | -      | -      | -       | PE1                                   | I/O         | (1)   | FT            | USART1_RX  | -                    |
| 99          | D3     | 63     | 47     | C6      | VSS_1                                 | S           | -     | -             | Ground   |                      |
| -           | -      | -      | -      | G5      | VSS_1                                 | S           | (1)   | -             | Ground   |                      |
| -           | -      | -      | -      | G4      | VSS_1                                 | S           | (1)   | -             | Ground   |                      |
| 100         | C4     | 64     | 48     | D6      | VDD_1                                 | S           | -     | -             | Digital power supply   |                      |

- When using the small packages (48 and 64 pin packages), the GPIO pins which are not present on these packages, must not be configured in analog mode.
- PC13, PC14 and PC15 are supplied through the power switch. Since the switch sinks only a limited amount of current (3 mA), the use of GPIO PC13 to PC15 in output mode is limited:
  - The speed should not exceed 2 MHz with a maximum load of 30 pF
  - These GPIOs must not be used as current sources (e.g. to drive an LED)
 After the first backup domain power-up, PC13, PC14 and PC15 operate as GPIOs. Their function then depends on the content of the Backup registers which is not reset by the main reset. For details on how to manage these GPIOs, refer to the Battery backup domain and BKP register description sections in the RM0313 reference manual.
- These pins are powered by  $V_{DDA}$ .
- These pins are powered by VDDSD12.
- These pins are powered by VDDSD3.





Table 12. Alternate functions for port PA

| Pin Name | AF0       | AF1          | AF2          | AF3        | AF4       | AF5                | AF6                | AF7        | AF8       | AF9        | AF10      | AF11      | AF14 | AF15      |
|----------|-----------|--------------|--------------|------------|-----------|--------------------|--------------------|------------|-----------|------------|-----------|-----------|------|-----------|
| PA0      | -         | TIM2_CH1_ETR | TIM5_CH1_ETR | TSC_G1_IO1 | -         | -                  | -                  | USART2_CTS | COMP1_OUT | -          | -         | TIM19_CH1 | -    | EVENT OUT |
| PA1      | RTC_REFIN | TIM2_CH2     | TIM5_CH2     | TSC_G1_IO2 | -         | -                  | SPI3_SCK/I2S3_CK   | USART2_RTS | -         | TIM15_CH1N | -         | TIM19_CH2 | -    | EVENT OUT |
| PA2      | -         | TIM2_CH3     | TIM5_CH3     | TSC_G1_IO3 | -         | -                  | SPI3_MISO/I2S3_MCK | USART2_TX  | COMP2_OUT | TIM15_CH1  | -         | TIM19_CH3 | -    | EVENT OUT |
| PA3      | -         | TIM2_CH4     | TIM5_CH4     | TSC_G1_IO4 | -         | -                  | SPI3_MOSI/I2S3_SD  | USART2_RX  | -         | TIM15_CH2  | -         | TIM19_CH4 | -    | EVENT OUT |
| PA4      | -         | -            | TIM3_CH2     | TSC_G2_IO1 | -         | SPI1_NSS/I2S1_WS   | SPI3_NSS/I2S3_WS   | USART2_CK  | -         | -          | TIM12_CH1 | -         | -    | EVENT OUT |
| PA5      | -         | TIM2_CH1_ETR | -            | TSC_G2_IO2 | -         | SPI1_SCK/I2S1_CK   | -                  | CEC        | -         | TIM14_CH1  | TIM12_CH2 | -         | -    | EVENT OUT |
| PA6      | -         | TIM16_CH1    | TIM3_CH1     | TSC_G2_IO3 | -         | SPI1_MISO/I2S1_MCK | -                  | -          | COMP1_OUT | TIM13_CH1  | -         | -         | -    | EVENT OUT |
| PA7      | -         | TIM17_CH1    | TIM3_CH2     | TSC_G2_IO4 | -         | SPI1_MOSI/I2S1_SD  | -                  | -          | COMP2_OUT | TIM14_CH1  | -         | -         | -    | EVENT OUT |
| PA8      | MCO       | -            | TIM5_CH1_ETR | -          | I2C2_SMBA | SPI2_SCK/I2S2_CK   | -                  | USART1_CK  | -         | -          | TIM4_ETR  | -         | -    | EVENT OUT |
| PA9      | -         | -            | TIM13_CH1    | TSC_G4_IO1 | I2C2_SCL  | SPI2_MISO/I2S2_MCK | -                  | USART1_TX  | -         | TIM15_BKIN | TIM2_CH3  | -         | -    | EVENT OUT |
| PA10     | -         | TIM17_BKIN   | -            | TSC_G4_IO2 | I2C2_SDA  | SPI2_MOSI/I2S2_SD  | -                  | USART1_RX  | -         | TIM14_CH1  | TIM2_CH4  | -         | -    | EVENT OUT |
| PA11     | -         | -            | TIM5_CH2     | -          | -         | SPI2_NSS/I2S2_WS   | SPI1_NSS/I2S1_WS   | USART1_CTS | COMP1_OUT | CAN_RX     | TIM4_CH1  | -         | -    | EVENT OUT |
| PA12     | -         | TIM16_CH1    | TIM5_CH3     | -          | -         | -                  | SPI1_SCK/I2S1_CK   | USART1_RTS | COMP2_OUT | CAN_TX     | TIM4_CH2  | -         | -    | EVENT OUT |



Table 12. Alternate functions for port PA (continued)

| Pin Name | AF0            | AF1              | AF2          | AF3            | AF4          | AF5                  | AF6                    | AF7        | AF8 | AF9 | AF10          | AF11 | AF14 | AF15         |
|----------|----------------|------------------|--------------|----------------|--------------|----------------------|------------------------|------------|-----|-----|---------------|------|------|--------------|
| PA13     | SWDIO<br>-JTMS | TIM16_<br>CH1N   | TIM5_<br>CH4 | TSC_<br>G4_IO3 | -            | IR-OUT               | SPI1_MISO<br>/I2S1_MCK | USART3_CTS | -   | -   | TIM4_<br>CH3  | -    | -    | EVENT<br>OUT |
| PA14     | SWCLK<br>-JTCK | -                | -            | TSC_<br>G4_IO4 | I2C1_<br>SDA | -                    | -                      | -          | -   | -   | TIM12_<br>CH1 | -    | -    | EVENT<br>OUT |
| PA15     | JTDI           | TIM2_<br>CH1_ETR | -            | TSC_<br>SYNC   | I2C1_<br>SCL | SPI1_NSS/<br>I2S1_WS | SPI3_NSS/<br>I2S3_WS   | -          | -   | -   | TIM12_<br>CH2 | -    | -    | EVENT<br>OUT |



Table 13. Alternate functions for port PB

| Pin Name | AF0               | AF1        | AF2        | AF3        | AF4       | AF5                    | AF6                    | AF7        | AF8       | AF9        | AF10       | AF11      | AF15     |
|----------|-------------------|------------|------------|------------|-----------|------------------------|------------------------|------------|-----------|------------|------------|-----------|----------|
| PB0      | -                 | -          | TIM3_CH3   | TSC_G3_IO3 | -         | SPI_MOSI/<br>I2S1_SD   | -                      | -          | -         | -          | TIM3_CH2   | -         | EVENTOUT |
| PB1      | -                 | -          | TIM3_CH4   | TSC_G3_IO4 | -         | -                      | -                      | -          | -         | -          | -          | -         | EVENTOUT |
| PB3      | JTDO-<br>TRACESWO | TIM2_CH2   | TIM4_ETR   | TSC_G5_IO1 | -         | SPI1_SCK/<br>I2S1_CK   | SPI3_SCK/<br>I2S3_CK   | USART2_TX  | -         | TIM13_CH1  | TIM3_ETR   | -         | EVENTOUT |
| PB4      | NJTRST            | TIM16_CH1  | TIM3_CH1   | TSC_G5_IO2 | -         | SPI1_MISO/<br>I2S1_MCK | SPI3_MISO/<br>I2S3_MCK | USART2_RX  | -         | TIM15_CH1N | TIM17_BKIN | -         | EVENTOUT |
| PB5      | -                 | TIM16_BKIN | TIM3_CH2   | -          | I2C1_SMBA | SPI1_MOSI/<br>I2S1_SD  | SPI3_MOSI/<br>I2S3_SD  | USART2_CK  | -         | -          | TIM17_CH1  | TIM19_ETR | EVENTOUT |
| PB6      | -                 | TIM16_CH1N | TIM4_CH1   | TSC_G5_IO3 | I2C1_SCL  | -                      | -                      | USART1_TX  | -         | TIM15_CH1  | TIM3_CH3   | TIM19_CH1 | EVENTOUT |
| PB7      | -                 | TIM17_CH1N | TIM4_CH2   | TSC_G5_IO4 | I2C1_SDA  | -                      | -                      | USART1_RX  | -         | TIM15_CH2  | TIM3_CH4   | TIM19_CH2 | EVENTOUT |
| PB8      | -                 | TIM16_CH1  | TIM4_CH3   | TSC_SYNC   | I2C1_SCL  | SPI2_SCK/<br>I2S2_CK   | CEC                    | USART3_TX  | COMP1_OUT | CAN_RX     | -          | TIM19_CH3 | EVENTOUT |
| PB9      | -                 | TIM17_CH1  | TIM4_CH4   | -          | I2C1_SDA  | SPI2_NSS/<br>I2S2_WS   | IR-OUT                 | USART3_RX  | COMP2_OUT | CAN_TX     | -          | TIM19_CH4 | EVENTOUT |
| PB10     | -                 | TIM2_CH3   | -          | TSC_SYNCH  | -         | SPI2_SCK/<br>I2S2_CK   | CEC                    | USART3_TX  | -         | -          | -          | -         | EVENTOUT |
| PB14     | -                 | TIM15_CH1  | -          | TSC_G6_IO1 | -         | SPI2_MISO/<br>I2S2_MCK | -                      | USART3_RTS | -         | TIM12_CH1  | -          | -         | EVENTOUT |
| PB15     | RTC_REFIN         | TIM15_CH2  | TIM15_CH1N | TSC_G6_IO2 | -         | SPI2_MOSI/<br>I2S2_SD  | -                      | -          | -         | TIM12_CH2  | -          | -         | EVENTOUT |



Table 14. Alternate functions for port PC

| Pin Name | AF0 | AF1      | AF2          | AF3        | AF4 | AF5                | AF6                | AF7       |
|----------|-----|----------|--------------|------------|-----|--------------------|--------------------|-----------|
| PC0      | -   | EVENTOUT | TIM5_CH1_ETR | -          | -   | -                  | -                  | -         |
| PC1      | -   | EVENTOUT | TIM5_CH2     | -          | -   | -                  | -                  | -         |
| PC2      | -   | EVENTOUT | TIM5_CH3     | -          | -   | SPI2_MISO/I2S2_MCK | -                  | -         |
| PC3      | -   | EVENTOUT | TIM5_CH4     | -          | -   | SPI2_MOSI/I2S2_SD  | -                  | -         |
| PC4      | -   | EVENTOUT | TIM13_CH1    | TSC_G3_IO1 | -   | -                  | -                  | USART1_TX |
| PC5      | -   | EVENTOUT | -            | TSC_G3_IO2 | -   | -                  | -                  | USART1_RX |
| PC6      | -   | EVENTOUT | TIM3_CH1     | -          | -   | SPI1_NSS/I2S1_WS   | -                  | -         |
| PC7      | -   | EVENTOUT | TIM3_CH2     | -          | -   | SPI1_SCK/I2S1_CK   | -                  | -         |
| PC8      | -   | EVENTOUT | TIM3_CH3     | -          | -   | SPI1_MISO/I2S1_MCK | -                  | -         |
| PC9      | -   | EVENTOUT | TIM3_CH4     | -          | -   | SPI1_MOSI/I2S1_SD  | -                  | -         |
| PC10     | -   | EVENTOUT | TIM19_CH1    | -          | -   | -                  | SPI3_SCK/I2S3_CK   | USART3_TX |
| PC11     | -   | EVENTOUT | TIM19_CH2    | -          | -   | -                  | SPI3_MISO/I2S3_MCK | USART3_RX |
| PC12     | -   | EVENTOUT | TIM19_CH3    | -          | -   | -                  | SPI3_MOSI/I2S3_SD  | USART3_CK |
| PC13     | -   | -        | -            | -          | -   | -                  | -                  | -         |
| PC14     | -   | -        | -            | -          | -   | -                  | -                  | -         |
| PC15     | -   | -        | -            | -          | -   | -                  | -                  | -         |



Table 15. Alternate functions for port PD

| Pin Name | AF0 | AF1      | AF2       | AF3        | AF4 | AF5                | AF6 | AF7        |
|----------|-----|----------|-----------|------------|-----|--------------------|-----|------------|
| PD0      | -   | EVENTOUT | TIM19_CH4 | -          | -   | -                  | -   | CAN_RX     |
| PD1      | -   | EVENTOUT | TIM19_ETR | -          | -   | -                  | -   | CAN_TX     |
| PD2      | -   | EVENTOUT | TIM3_ETR  | -          | -   | -                  | -   | -          |
| PD3      | -   | EVENTOUT | -         | -          | -   | SPI2_MISO/I2S2_MCK | -   | USART2_CTS |
| PD4      | -   | EVENTOUT | -         | -          | -   | SPI2_MOSI/I2S2_SD  | -   | USART2_RTS |
| PD5      | -   | EVENTOUT | -         | -          | -   | -                  | -   | USART2_TX  |
| PD6      | -   | EVENTOUT | -         | -          | -   | SPI2_NSS/I2S2_WS   | -   | USART2_RX  |
| PD7      | -   | EVENTOUT | -         | -          | -   | SPI2_SCK/I2S2_CK   | -   | USART2_CK  |
| PD8      | -   | EVENTOUT | -         | TSC_G6_IO3 | -   | SPI2_SCK/I2S2_CK   | -   | USART3_TX  |
| PD9      | -   | EVENTOUT | -         | TSC_G6_IO4 | -   | -                  | -   | USART3_RX  |
| PD10     | -   | EVENTOUT | -         | -          | -   | -                  | -   | USART3_CK  |
| PD11     | -   | EVENTOUT | -         | -          | -   | -                  | -   | USART3_CTS |
| PD12     | -   | EVENTOUT | TIM4_CH1  | TSC_G8_IO1 | -   | -                  | -   | USART3_RTS |
| PD13     | -   | EVENTOUT | TIM4_CH2  | TSC_G8_IO2 | -   | -                  | -   | -          |
| PD14     | -   | EVENTOUT | TIM4_CH3  | TSC_G8_IO3 | -   | -                  | -   | -          |
| PD15     | -   | EVENTOUT | TIM4_CH4  | TSC_G8_IO4 | -   | -                  | -   | -          |



Table 16. Alternate functions for port PE

| Pin Name | AF0      | AF1      | AF2      | AF3        | AF4 | AF5 | AF6 | AF7       |
|----------|----------|----------|----------|------------|-----|-----|-----|-----------|
| PE0      | -        | EVENTOUT | TIM4_ETR | -          | -   | -   | -   | USART1_TX |
| PE1      | -        | EVENTOUT | -        | -          | -   | -   | -   | USART1_RX |
| PE2      | TRACECLK | EVENTOUT | -        | TSC_G7_IO1 | -   | -   | -   | -         |
| PE3      | TRACED0  | EVENTOUT | -        | TSC_G7_IO2 | -   | -   | -   | -         |
| PE4      | TRACED1  | EVENTOUT | -        | TSC_G7_IO3 | -   | -   | -   | -         |
| PE5      | TRACED2  | EVENTOUT | -        | TSC_G7_IO4 | -   | -   | -   | -         |
| PE6      | TRACED3  | EVENTOUT | -        | -          | -   | -   | -   | -         |
| PE7      | -        | EVENTOUT | -        | -          | -   | -   | -   | -         |
| PE8      | -        | EVENTOUT | -        | -          | -   | -   | -   | -         |
| PE9      | -        | EVENTOUT | -        | -          | -   | -   | -   | -         |
| PE10     | -        | EVENTOUT | -        | -          | -   | -   | -   | -         |
| PE11     | -        | EVENTOUT | -        | -          | -   | -   | -   | -         |
| PE12     | -        | EVENTOUT | -        | -          | -   | -   | -   | -         |
| PE13     | -        | EVENTOUT | -        | -          | -   | -   | -   | -         |
| PE14     | -        | EVENTOUT | -        | -          | -   | -   | -   | -         |
| PE15     | -        | EVENTOUT | -        | -          | -   | -   | -   | USART3_RX |

Table 17. Alternate functions for port PF

| Pin Name | AF0 | AF1      | AF2       | AF3 | AF4       | AF5               | AF6 | AF7        |
|----------|-----|----------|-----------|-----|-----------|-------------------|-----|------------|
| PF0      | -   | -        | -         | -   | I2C2_SDA  | -                 | -   | -          |
| PF1      | -   | -        | -         | -   | I2C2_SCL  | -                 | -   | -          |
| PF2      | -   | EVENTOUT | -         | -   | I2C2_SMBA | -                 | -   | -          |
| PF4      | -   | EVENTOUT | -         | -   | -         | -                 | -   | -          |
| PF6      | -   | EVENTOUT | TIM4_CH4  | -   | I2C2_SCL  | SPI1_MOSI/I2S1_SD | -   | USART3_RTS |
| PF7      | -   | EVENTOUT | -         | -   | I2C2_SDA  | -                 | -   | USART2_CK  |
| PF9      | -   | EVENTOUT | TIM14_CH1 | -   | -         | -                 | -   | -          |
| PF10     | -   | EVENTOUT | -         | -   | -         | -                 | -   | -          |

5 Memory mapping

Figure 7. STM32F378xx memory map

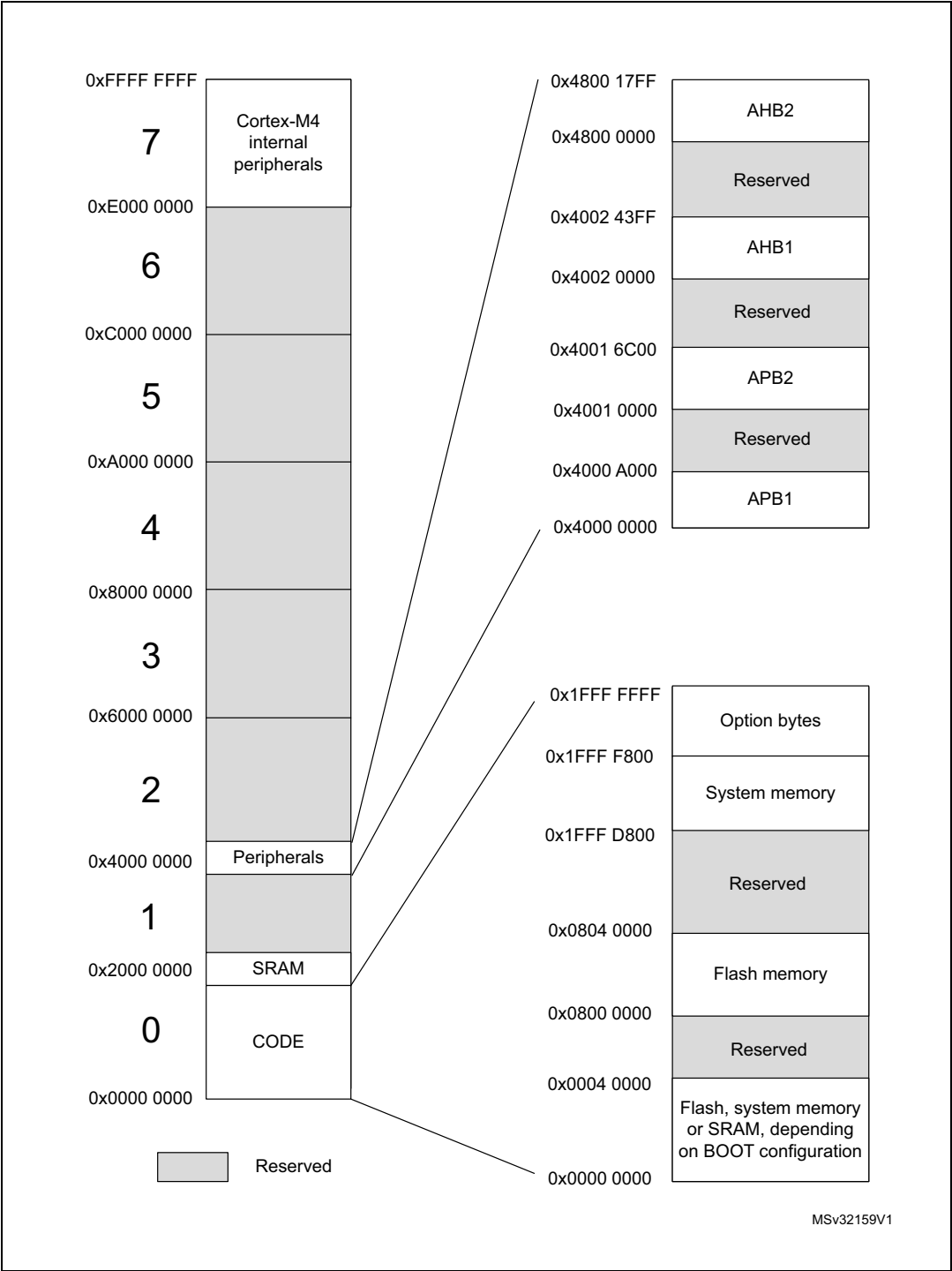




Table 18. STM32F378xx peripheral register boundary addresses<sup>(1)</sup>

| Bus  | Boundary address          | Size    | Peripheral             |
|------|---------------------------|---------|------------------------|
| AHB2 | 0x4800 1400 - 0x4800 17FF | 1KB     | GPIOF                  |
|      | 0x4800 1000 - 0x4800 13FF | 1KB     | GPIOE                  |
|      | 0x4800 0C00 - 0x4800 0FFF | 1KB     | GPIOD                  |
|      | 0x4800 0800 - 0x4800 0BFF | 1KB     | GPIOC                  |
|      | 0x4800 0400 - 0x4800 07FF | 1KB     | GPIOB                  |
|      | 0x4800 0000 - 0x4800 03FF | 1KB     | GPIOA                  |
| -    | 0x4002 4400 - 0x47FF FFFF | ~128 MB | Reserved               |
| AHB1 | 0x4002 4000 - 0x4002 43FF | 1 KB    | TSC                    |
|      | 0x4002 3400 - 0x4002 3FFF | 3 KB    | Reserved               |
|      | 0x4002 3000 - 0x4002 33FF | 1 KB    | CRC                    |
|      | 0x4002 2400 - 0x4002 2FFF | 3 KB    | Reserved               |
|      | 0x4002 2000 - 0x4002 23FF | 1 KB    | FLASH memory interface |
|      | 0x4002 1400 - 0x4002 1FFF | 3 KB    | Reserved               |
|      | 0x4002 1000 - 0x4002 13FF | 1 KB    | RCC                    |
|      | 0x4002 0800 - 0x4002 0FFF | 2 KB    | Reserved               |
|      | 0x4002 0400 - 0x4002 07FF | 1 KB    | DMA2                   |
|      | 0x4002 0000 - 0x4002 03FF | 1 KB    | DMA1                   |
| -    | 0x4001 6C00 - 0x4001 FFFF | 37 KB   | Reserved               |

Table 18. STM32F378xx peripheral register boundary addresses<sup>(1)</sup> (continued)

| Bus  | Boundary address          | Size  | Peripheral    |
|------|---------------------------|-------|---------------|
| APB2 | 0x4001 6800 - 0x4001 6BFF | 1 KB  | SDADC3        |
|      | 0x4001 6400 - 0x4001 67FF | 1 KB  | SDADC2        |
|      | 0x4001 6000 - 0x4001 63FF | 1 KB  | SDADC1        |
|      | 0x4001 5C00 - 0x4001 5FFF | 1 KB  | TIM19         |
|      | 0x4001 4C00 - 0x4001 5BFF | 4 KB  | Reserved      |
|      | 0x4001 4800 - 0x4001 4BFF | 1 KB  | TIM17         |
|      | 0x4001 4400 - 0x4001 47FF | 1 KB  | TIM16         |
|      | 0x4001 4000 - 0x4001 43FF | 1 KB  | TIM15         |
|      | 0x4001 3C00 - 0x4001 3FFF | 1 KB  | Reserved      |
|      | 0x4001 3800 - 0x4001 3BFF | 1 KB  | USART1        |
|      | 0x4001 3400 - 0x4001 37FF | 1 KB  | Reserved      |
|      | 0x4001 3000 - 0x4001 33FF | 1 KB  | SPI1/I2S1     |
|      | 0x4001 2800 - 0x4001 2FFF | 1 KB  | Reserved      |
|      | 0x4001 2400 - 0x4001 27FF | 1 KB  | ADC           |
|      | 0x4001 0800 - 0x4001 23FF | 7 KB  | Reserved      |
|      | 0x4001 0400 - 0x4001 07FF | 1 KB  | EXTI          |
|      | 0x4001 0000 - 0x4001 03FF | 1 KB  | SYSCFG + COMP |
| -    | 0x4000 4000 - 0x4000 FFFF | 24 KB | Reserved      |
| APB1 | 0x4000 9C00 - 0x4000 9FFF | 1 KB  | TIM18         |
|      | 0x4000 9800 - 0x4000 9BFF | 1 KB  | DAC2          |
|      | 0x4000 7C00 - 0x4000 97FF | 8 KB  | Reserved      |
|      | 0x4000 7800 - 0x4000 7BFF | 1 KB  | CEC           |
|      | 0x4000 7400 - 0x4000 77FF | 1 KB  | DAC1          |
|      | 0x4000 7000 - 0x4000 73FF | 1 KB  | PWR           |
|      | 0x4000 6800 - 0x4000 6FFF | 2 KB  | Reserved      |
|      | 0x4000 6400 - 0x4000 67FF | 1 KB  | CAN           |
|      | 0x4000 5C00 - 0x4000 63FF | 2 KB  | Reserved      |

Table 18. STM32F378xx peripheral register boundary addresses<sup>(1)</sup> (continued)

| Bus  | Boundary address          | Size | Peripheral |
|------|---------------------------|------|------------|
| APB1 | 0x4000 5800 - 0x4000 5BFF | 1 KB | I2C2       |
|      | 0x4000 5400 - 0x4000 57FF | 1 KB | I2C1       |
|      | 0x4000 4C00 - 0x4000 53FF | 2 KB | Reserved   |
|      | 0x4000 4800 - 0x4000 4BFF | 1 KB | USART3     |
|      | 0x4000 4400 - 0x4000 47FF | 1 KB | USART2     |
|      | 0x4000 4000 - 0x4000 43FF | 1 KB | Reserved   |
|      | 0x4000 3C00 - 0x4000 3FFF | 1 KB | SPI3/I2S3  |
|      | 0x4000 3800 - 0x4000 3BFF | 1 KB | SPI2/I2S2  |
|      | 0x4000 3400 - 0x4000 37FF | 1 KB | Reserved   |
|      | 0x4000 3000 - 0x4000 33FF | 1 KB | IWDG       |
|      | 0x4000 2C00 - 0x4000 2FFF | 1 KB | WWDG       |
|      | 0x4000 2800 - 0x4000 2BFF | 1 KB | RTC        |
|      | 0x4000 2400 - 0x4000 27FF | 1 KB | Reserved   |
|      | 0x4000 2000 - 0x4000 23FF | 1 KB | TIM14      |
|      | 0x4000 1C00 - 0x4000 1FFF | 1 KB | TIM13      |
|      | 0x4000 1800 - 0x4000 1BFF | 1 KB | TIM12      |
|      | 0x4000 1400 - 0x4000 17FF | 1 KB | TIM7       |
|      | 0x4000 1000 - 0x4000 13FF | 1 KB | TIM6       |
|      | 0x4000 0C00 - 0x4000 0FFF | 1 KB | TIM5       |
|      | 0x4000 0800 - 0x4000 0BFF | 1 KB | TIM4       |
|      | 0x4000 0400 - 0x4000 07FF | 1 KB | TIM3       |
|      | 0x4000 0000 - 0x4000 03FF | 1 KB | TIM2       |

1. Cells in gray indicate Reserved memory locations.

## 6 Electrical characteristics

### 6.1 Parameter conditions

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

#### 6.1.1 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 ( $\text{mean} \pm 3\sigma$ ).

#### 6.1.2 Typical values

Unless otherwise specified, typical data are based on  $T_A = 25\text{ }^{\circ}\text{C}$ ,  $V_{DD} = 1.8\text{ V}$ ,  $V_{DDA} = V_{DDSDx} = 3.3\text{ V}$ . They are given only as design guidelines and are not tested.

Typical ADC and SDADC 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 ( $\text{mean} \pm 2\sigma$ ).

#### 6.1.3 Typical curves

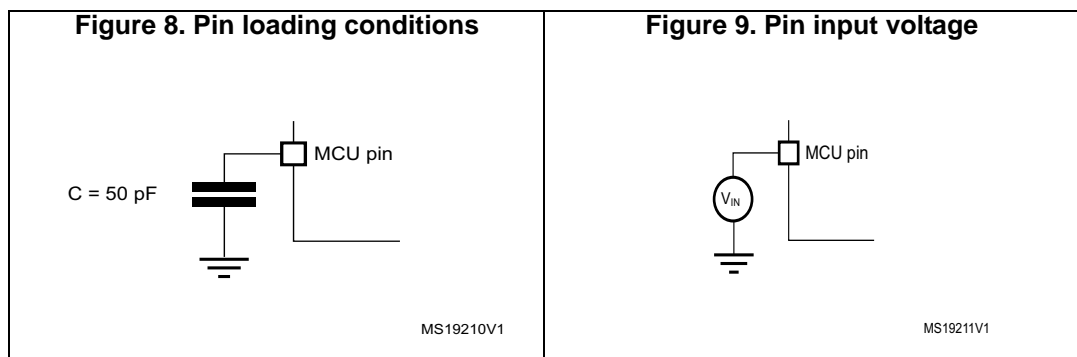
Unless otherwise specified, all typical curves are given only as design guidelines and are not tested.

#### 6.1.4 Loading capacitor

The loading conditions used for pin parameter measurement are shown in [Figure 8](#).

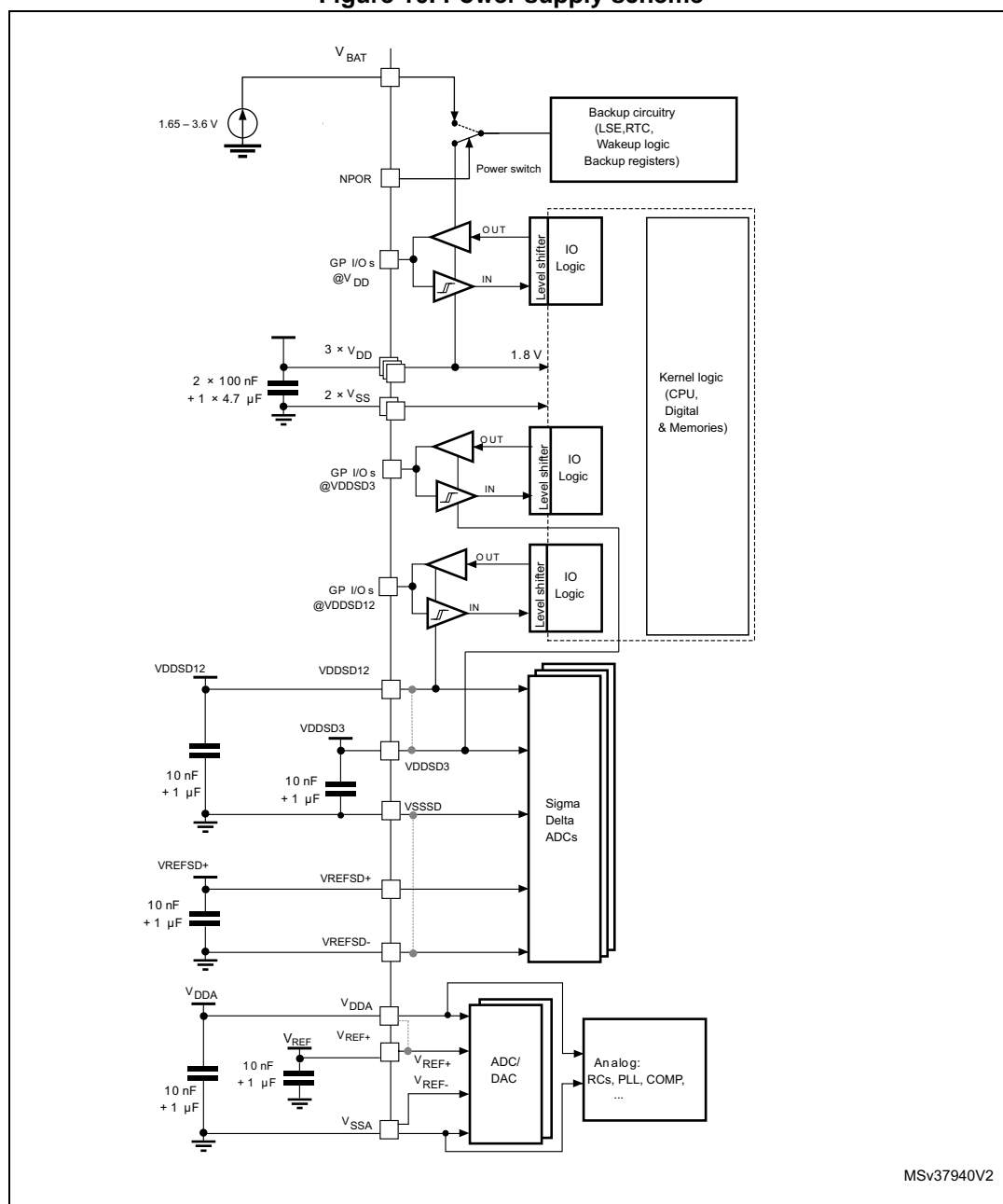
#### 6.1.5 Pin input voltage

The input voltage measurement on a pin of the device is described in [Figure 9](#).



## 6.1.6 Power supply scheme

Figure 10. Power supply scheme

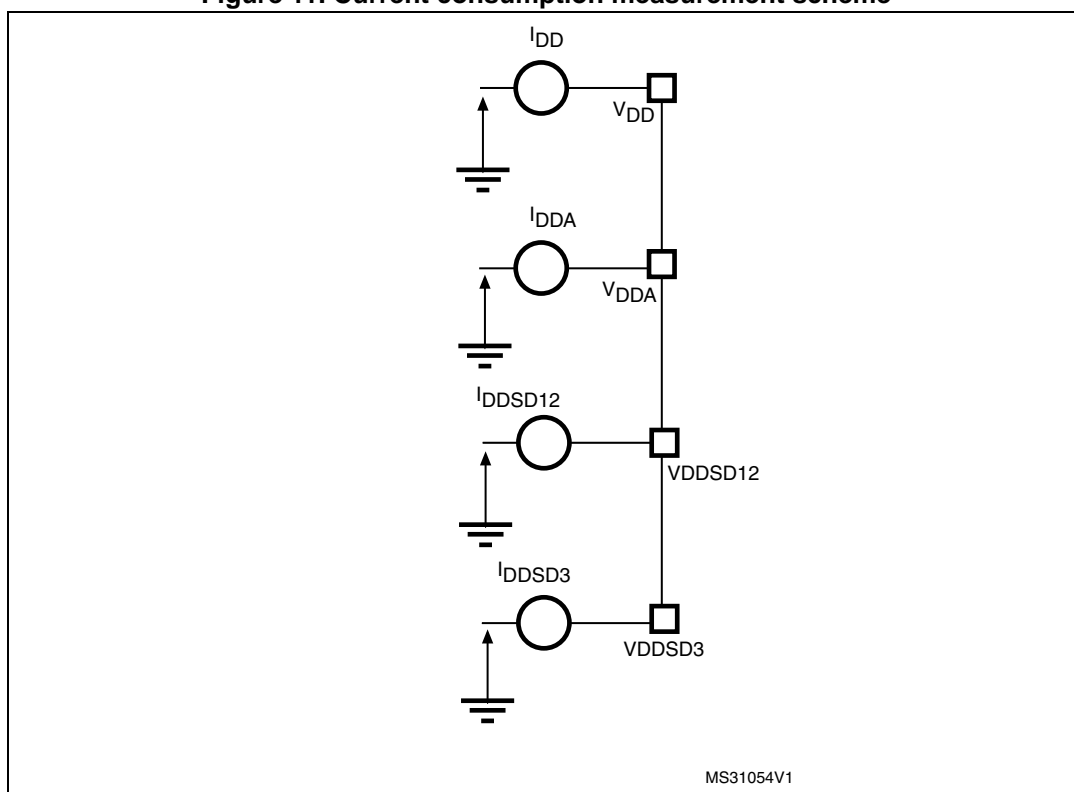


1. Dotted lines represent the internal connections on low pin count packages, joining the dedicated supply pins.

**Caution:** Each power supply pair ( $V_{DD}/V_{SS}$ ,  $V_{DDA}/V_{SSA}$  etc..) must be decoupled with filtering ceramic capacitors as shown above. These capacitors must be placed as close as possible to, or below, the appropriate pins on the underside of the PCB to ensure the good functionality of the device.

### 6.1.7 Current consumption measurement

Figure 11. Current consumption measurement scheme



## 6.2 Absolute maximum ratings

Stresses above the absolute maximum ratings listed in [Table 19: Voltage characteristics](#), [Table 20: Current characteristics](#), and [Table 21: 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 19. Voltage characteristics<sup>(1)</sup>**

| Symbol                   | Ratings   | Min  | Max             | Unit |
|--------------------------|---|--|-----------------|------|
| $V_{DDA}-V_{SS}$         | External main supply voltage (including $V_{DDA}$ , $V_{DDSDx}$ , $V_{BAT}$ ) | -0.3   | 4.0             | V    |
| $V_{DD}-V_{SS}$          | External supply voltage $V_{DD}$  | -0.3   | 1.95            |      |
| $V_{DD}-V_{DDA}$         | Allowed voltage difference for $V_{DD} > V_{DDA}$                             | -  | 0.4             |      |
| $V_{DDSDx} - V_{DDA}$    | Allowed voltage difference for $V_{DDSDx} > V_{DDA}$                          | -  | 0.4             |      |
| $V_{REFSD+} - V_{DDSD3}$ | Allowed voltage difference for $V_{REFSD+} > V_{DDSD3}$                       | -  | 0.4             |      |
| $V_{REF+} - V_{DDA}$     | Allowed voltage difference for $V_{REF+} > V_{DDA}$                           | -  | 0.4             |      |
| $V_{IN}^{(2)}$           | Input voltage on FT and FTf pins  | $V_{SS} - 0.3$   | $V_{DD} + 4.0$  |      |
|                          | Input voltage on POR pins   | $V_{SS} - 0.3$   | $V_{DDA} + 4.0$ |      |
|                          | Input voltage on TTa pins   | $V_{SS} - 0.3$   | 4.0             |      |
|                          | Input voltage on TC pins on SDADCx channels inputs <sup>(3)</sup>             | $V_{SS} - 0.3$   | 4.0             |      |
|                          | Input voltage on any other pin  | $V_{SS} - 0.3$   | 4.0             |      |
| $ V_{SSx} - V_{SS} $     | Variations between all the different ground pins                              | -  | 50              | mV   |
| $ V_{REFSD-} - V_{SSx} $ |   | -  | 50              | mV   |
| $V_{ESD(HBM)}$           | Electrostatic discharge voltage (human body model)                            | see <a href="#">Section 6.3.11: Electrical sensitivity characteristics</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 20: Current characteristics](#) for the maximum allowed injected current values.
3.  $V_{DDSD12}$  is the external power supply for the PB10, and PE7 to PE15 I/O pins (the I/O pin ground is internally connected to  $V_{SS}$ ).  $V_{DDSD3}$  is the external power supply for PB14 to PB15 and PD8 to PD15 I/O pins (the I/O pin ground is internally connected to  $V_{SS}$ ).

All main power ( $V_{DD}$ ,  $V_{DDSD12}$ ,  $V_{DDSD3}$  and  $V_{DDA}$ ) and ground ( $V_{SS}$ ,  $V_{SSSD}$ , and  $V_{SSA}$ ) pins must always be connected to the external power supply, in the permitted range.

The following relationship must be respected between  $V_{DDA}$  and  $V_{DD}$ :  $V_{DDA}$  must power on before or at the same time as  $V_{DD}$  in the power up sequence.  $V_{DDA}$  must be greater than or equal to  $V_{DD}$ .

The following relationship must be respected between  $V_{DDA}$  and  $V_{DDSD12}$ :  $V_{DDA}$  must power on before or at the same time as  $V_{DDSD12}$  or  $V_{DDSD3}$  in the power up sequence.  $V_{DDA}$  must be greater than or equal to  $V_{DDSD12}$  or  $V_{DDSD3}$ .

The following relationship must be respected between  $V_{DDSD12}$  and  $V_{DDSD3}$ :  $V_{DDSD3}$  must power on before or at the same time as  $V_{DDSD12}$  in the power up sequence.

After power up ( $V_{DDSD12} > V_{REFINT} = 1.2\text{ V}$ )  $V_{DDSD3}$  can be higher or lower than  $V_{DDSD12}$ .

The following relationship must be respected between  $V_{REFSD+}$  and  $V_{DDSD12}$ ,  $V_{DDSD3}$ :  $V_{REFSD+}$  must be lower than  $V_{DDSD3}$ .

Depending on the SDADCx operation mode, there can be more constraints between  $V_{REFSD+}$ ,  $V_{DDSD12}$  and  $V_{DDSD3}$  which are described in reference manual RM0313.

Table 20. Current characteristics

| Symbol                | Ratings  | Max.     | Unit |
|-----------------------|--|----------|------|
| $\Sigma I_{VDD}$      | Total current into sum of all VDD_x and VDDSDx power lines (source) <sup>(1)</sup> | 160      | mA   |
| $\Sigma I_{VSS}$      | Total current out of sum of all VSS_x and VSSSD ground lines (sink) <sup>(1)</sup> | -160     |      |
| $I_{VDD(PIN)}$        | Maximum current into each VDD_x or VDDSDx power pin (source) <sup>(1)</sup>        | 100      |      |
| $I_{VSS(PIN)}$        | Maximum current out of each VSS_x or VSSSD ground pin (sink) <sup>(1)</sup>        | -100     |      |
| $I_{IO(PIN)}$         | Output current sunk by any I/O and control pin                                     | 25       |      |
|                       | Output current source by any I/O and control pin                                   | -25      |      |
| $\Sigma I_{IO(PIN)}$  | Total output current sunk by sum of all IOs and control pins <sup>(2)</sup>        | 80       |      |
|                       | Total output current sourced by sum of all IOs and control pins <sup>(2)</sup>     | -80      |      |
| $I_{INJ(PIN)}$        | Injected current on FT, FTf, POR and B pins <sup>(3)</sup>                         | -5/+0    |      |
|                       | Injected current on TC and RST pin <sup>(4)</sup>                                  | $\pm 5$  |      |
|                       | Injected current on TTa pins <sup>(5)</sup>  | $\pm 5$  |      |
| $\Sigma I_{INJ(PIN)}$ | Total injected current (sum of all I/O and control pins) <sup>(6)</sup>            | $\pm 25$ |      |

1. VDDSD12 is the external power supply for the PB10, and PE7 to PE15 I/O pins (the I/O pin ground is internally connected to  $V_{SS}$ ). VDDSD3 is the external power supply for PB14 to PB15 and PD8 to PD15 I/O pins (the I/O pin ground is internally connected to  $V_{SS}$ ).  $V_{DD}$  (VDD\_x) is the external power supply for all remaining I/O pins (the I/O pin ground is internally connected to  $V_{SS}$ ).
2. This current consumption must be correctly distributed over all I/Os and control pins. The total output current must not be sunk/sourced between two consecutive power supply pins referring to high pin count LQFP packages.
3. Positive injection is not possible on these I/Os and does not occur for input voltages lower than the specified maximum value.
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 19: Voltage characteristics](#) for the maximum allowed input voltage values.
5. A positive injection is induced by  $V_{IN} > V_{DDA}$  while a negative injection is induced by  $V_{IN} < V_{SS}$ .  $I_{INJ(PIN)}$  must never be exceeded. Refer also to [Table 19: Voltage characteristics](#) for the maximum allowed input voltage values. Negative injection disturbs the analog performance of the device. See note <sup>(2)</sup> below [Table 61](#).
6. 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 21. Thermal characteristics

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



## 6.3 Operating conditions

### 6.3.1 General operating conditions

Table 22. General operating conditions

| Symbol          | Parameter   | Conditions   | Min   | Max               | Unit |
|-----------------|---|--|-------|-------------------|------|
| $f_{HCLK}$      | Internal AHB clock frequency                                      | -  | 0     | 72                | MHz  |
| $f_{PCLK1}$     | Internal APB1 clock frequency                                     | -  | 0     | 36                |      |
| $f_{PCLK2}$     | Internal APB2 clock frequency                                     | -  | 0     | 72                |      |
| $V_{DD}$        | Standard operating voltage  | Must have a potential equal to or lower than $V_{DDA}$       | 1.65  | 1.95              | V    |
| $V_{DDA}^{(1)}$ | Analog operating voltage (ADC and DAC used)                       | Must have a potential equal to or higher than $V_{DD}$       | 2.4   | 3.6               | V    |
|                 | Analog operating voltage (ADC and DAC not used)                   |  | 1.65  | 3.6               |      |
| $V_{DDSD12}$    | VDDSD12 operating voltage (SDADC used)                            | Must have a potential equal to or lower than $V_{DDA}$       | 2.2   | 3.6               | V    |
|                 | VDDSD12 operating voltage (SDADC not used)                        |  | 1.65  | 3.6               |      |
| $V_{DDSD3}$     | VDDSD3 operating voltage (SDADC used)                             | Must have a potential equal to or lower than $V_{DDA}$       | 2.2   | 3.6               | V    |
|                 | VDDSD3 operating voltage (SDADC not used)                         |  | 1.65  | 3.6               |      |
| $V_{REF+}$      | Positive reference voltage (ADC and DAC used)                     | Must have a potential equal to or lower than $V_{DDA}$       | 2.4   | 3.6               | V    |
|                 | Positive reference voltage (ADC and DAC not used)                 |  | 1.65  | 3.6               |      |
| $V_{REFSD+}$    | SDADCx positive reference voltage                                 | Must have a potential equal to or lower than any $V_{DDSDx}$ | 1.1   | 3.6               | V    |
| $V_{BAT}$       | Backup operating voltage  | -  | 1.65  | 3.6               | V    |
| $V_{IN}$        | Input voltage on FT, FTf and POR pins <sup>(2)</sup>              | -  | - 0.3 | 5.2               | V    |
|                 | Input voltage on TTa pins   |  | - 0.3 | $V_{DDA} + 0.3$   |      |
|                 | Input voltage on TC pins on SDADCx channels inputs <sup>(3)</sup> |  | - 0.3 | $V_{DDSDx} + 0.3$ |      |
|                 | Input voltage on BOOT0 pin  |  | 0     | 5.5               |      |
|                 | Input voltage on any other pin                                    |  | - 0.3 | $V_{DD} + 0.3$    |      |

Table 22. General operating conditions (continued)

| Symbol | Parameter   | Conditions                           | Min | Max | Unit |
|--------|---|--------------------------------------|-----|-----|------|
| $P_D$  | Power dissipation at $T_A = 85\text{ °C}$ for suffix 6 or $T_A = 105\text{ °C}$ for suffix 7 <sup>(4)</sup> | WLCSP66                              | -   | 376 | mW   |
|        |   | LQFP100                              | -   | 434 |      |
|        |   | LQFP64                               | -   | 444 |      |
|        |   | LQFP48                               | -   | 364 |      |
|        |   | BGA100                               | -   | 338 |      |
| $T_A$  | Ambient temperature for 6 suffix version  | Maximum power dissipation            | -40 | 85  | °C   |
|        |   | Low power dissipation <sup>(5)</sup> | -40 | 105 |      |
|        | Ambient temperature for 7 suffix version  | Maximum power dissipation            | -40 | 105 | °C   |
|        |   | Low power dissipation <sup>(5)</sup> | -40 | 125 |      |
| $T_J$  | Junction temperature range  | 6 suffix version                     | -40 | 105 | °C   |
|        |   | 7 suffix version                     | -40 | 125 |      |

- When the ADC is used, refer to [Table 59: ADC characteristics](#).
- To sustain a voltage higher than  $V_{DD}+0.3\text{ V}$ , the internal pull-up/pull-down resistors must be disabled.
- VDDSD12 is the external power supply for the PB10, and PE7 to PE15 I/O pins (the I/O pin ground is internally connected to VSS). VDDSD3 is the external power supply for PB14 to PB15 and PD8 to PD15 I/O pins (the I/O pin ground is internally connected to VSS).
- If  $T_A$  is lower, higher  $P_D$  values are allowed as long as  $T_J$  does not exceed  $T_{Jmax}$ .
- In low power dissipation state,  $T_A$  can be extended to this range as long as  $T_J$  does not exceed  $T_{Jmax}$ .

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

The parameters given in [Table 23](#) are derived from tests performed under the ambient temperature condition summarized in [Table 22](#).

Table 23. 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  | $\infty$ |                 |
| $t_{VDDA}$ | $V_{DDA}$ rise time rate | -          | 0   | $\infty$ |                 |
|            | $V_{DDA}$ fall time rate |            | 20  | $\infty$ |                 |

### 6.3.3 Embedded reference voltage

The parameters given in [Table 25](#) are derived from tests performed under ambient temperature and  $V_{DD}$  supply voltage conditions summarized in [Table 22](#).

**Table 24. Embedded internal reference voltage calibration values**

| Calibration value name | Description  | Memory address            |
|------------------------|--|---------------------------|
| VREFINT_CAL            | Raw data acquired at temperature of 30 °C<br>$V_{DDA} = 3.3$ V | 0x1FFF F7BA - 0x1FFF F7BB |

**Table 25. Embedded internal reference voltage**

| Symbol                     | Parameter   | Conditions                             | Min   | Typ  | Max  | Unit   |
|----------------------------|---|--|-------|------|------|--------|
| $V_{REFINT}$               | Internal reference voltage                                    | $-40\text{ °C} < T_A < +105\text{ °C}$ | 1.20  | 1.23 | 1.25 | V      |
| $T_{S\_vrefint}^{(1)}$     | ADC sampling time when reading the internal reference voltage | -                                      | 17.10 | -    | -    | µs     |
| $V_{REFINT\_S}^{(2)}$      | 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/°C |
| $t_{START}^{(2)}$          | Startup time  | -                                      | -     | -    | 10   | µs     |
| $t_{VREFINT\_RD\_Y}^{(3)}$ | Internal reference voltage temporization                      | -                                      | 1.50  | 2.50 | 4.50 | ms     |

1. Shortest sampling time can be determined in the application by multiple iterations.
2. Guaranteed by design.
3. Guaranteed by design. Latency between the time when the NPOR pin is set to 1 by the application and the time when the VREFINTRDYF bit is set to 1 by the hardware.

### 6.3.4 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 11: 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 CoreMark code.

#### Typical and 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 when explicitly mentioned
- The Flash memory access time is adjusted to the  $f_{HCLK}$  frequency (0 wait state from 0 to 24 MHz, 1 wait state from 24 to 48 MHz and 2 wait states from 48 MHz to 72 MHz)
- Prefetch in ON (reminder: this bit must be set before clock setting and bus prescaling)
- When the peripherals are enabled  $f_{APB1} = f_{AHB}/2$ ,  $f_{APB2} = f_{AHB}$
- When  $f_{HCLK} > 8$  MHz PLL is ON and PLL inputs is equal to  $HSI/2 = 4$  MHz (if internal clock is used) or HSE = 8 MHz (if HSE bypass mode is used)

The parameters given in [Table 26](#) to [Table 32](#) are derived from tests performed under ambient temperature and supply voltage conditions summarized in [Table 22](#).

**Table 26. Typical and maximum current consumption from  $V_{DD}$  supply at  $V_{DD} = 1.8V^{(1)}$**

| Symbol          | Parameter   | Conditions          | f <sub>HCLK</sub> | All peripherals enabled |                                     |       |        | All peripherals disabled |                                     |       |        | Unit |
|-----------------|---|---------------------|-------------------|-------------------------|-------------------------------------|-------|--------|--------------------------|-------------------------------------|-------|--------|------|
|                 |   |                     |                   | Typ                     | Max @ T <sub>A</sub> <sup>(2)</sup> |       |        | Typ                      | Max @ T <sub>A</sub> <sup>(2)</sup> |       |        |      |
|                 |   |                     |                   |                         | 25 °C                               | 85 °C | 105 °C |                          | 25 °C                               | 85 °C | 105 °C |      |
| I <sub>DD</sub> | Supply current in Run mode, code executing from Flash | HSE bypass, PLL on  | 72 MHz            | 64.9                    | 75.3                                | 77.1  | 84.0   | 31.0                     | 34.0                                | 35.0  | 36.7   | mA   |
|                 |   |                     | 64 MHz            | 58.3                    | 67.0                                | 68.7  | 74.4   | 27.8                     | 30.4                                | 31.2  | 32.7   |      |
|                 |   |                     | 48 MHz            | 44.8                    | 50.5                                | 52.0  | 55.5   | 21.3                     | 23.1                                | 23.9  | 24.8   |      |
|                 |   |                     | 32 MHz            | 30.7                    | 33.9                                | 35.1  | 36.7   | 14.6                     | 15.8                                | 16.4  | 17.1   |      |
|                 |   |                     | 24 MHz            | 23.4                    | 25.6                                | 26.6  | 27.5   | 11.3                     | 12.1                                | 12.7  | 13.3   |      |
|                 |   | HSE bypass, PLL off | 8 MHz             | 8.1                     | 8.9                                 | 9.3   | 9.9    | 4.0                      | 4.4                                 | 4.8   | 5.3    |      |
|                 |   |                     | 1 MHz             | 1.3                     | 1.7                                 | 2.0   | 2.5    | 0.9                      | 1.2                                 | 1.6   | 2.0    |      |
|                 |   | HSI clock, PLL on   | 64 MHz            | 54.0                    | 61.6                                | 63.2  | 68.2   | 27.5                     | 30.1                                | 30.9  | 32.3   |      |
|                 |   |                     | 48 MHz            | 41.5                    | 46.6                                | 47.9  | 51.0   | 21.1                     | 22.9                                | 23.6  | 24.5   |      |
|                 |   |                     | 32 MHz            | 28.4                    | 31.3                                | 32.5  | 33.9   | 14.5                     | 15.6                                | 16.2  | 16.9   |      |
|                 |   |                     | 24 MHz            | 21.8                    | 23.8                                | 24.8  | 25.6   | 7.6                      | 8.2                                 | 8.8   | 9.3    |      |
|                 |   | HSI clock, PLL off  | 8 MHz             | 7.7                     | 8.4                                 | 8.9   | 9.5    | 4.0                      | 4.4                                 | 4.8   | 5.3    |      |

Table 26. Typical and maximum current consumption from V<sub>DD</sub> supply at V<sub>DD</sub> = 1.8V<sup>(1)</sup> (continued)

| Symbol          | Parameter  | Conditions          | f <sub>HCLK</sub> | All peripherals enabled |                                     |       |        | All peripherals disabled |                                     |       |        | Unit |
|-----------------|--|---------------------|-------------------|-------------------------|-------------------------------------|-------|--------|--------------------------|-------------------------------------|-------|--------|------|
|                 |  |                     |                   | Typ                     | Max @ T <sub>A</sub> <sup>(2)</sup> |       |        | Typ                      | Max @ T <sub>A</sub> <sup>(2)</sup> |       |        |      |
|                 |  |                     |                   |                         | 25 °C                               | 85 °C | 105 °C |                          | 25 °C                               | 85 °C | 105 °C |      |
| I <sub>DD</sub> | Supply current in Run mode, code executing from RAM            | HSE bypass, PLL on  | 72 MHz            | 65.5                    | 77.8                                | 78.1  | 86.6   | 31.6                     | 35.1                                | 35.6  | 38.0   | mA   |
|                 |  |                     | 64 MHz            | 58.7                    | 69.0                                | 69.5  | 76.5   | 28.2                     | 31.2                                | 31.7  | 33.7   |      |
|                 |  |                     | 48 MHz            | 44.8                    | 51.6                                | 52.2  | 56.6   | 21.4                     | 23.3                                | 23.9  | 25.1   |      |
|                 |  |                     | 32 MHz            | 30.4                    | 34.2                                | 34.9  | 37.1   | 14.4                     | 15.6                                | 16.1  | 16.8   |      |
|                 |  |                     | 24 MHz            | 23.1                    | 25.7                                | 26.2  | 27.6   | 10.9                     | 11.8                                | 12.2  | 12.8   |      |
|                 |  | HSE bypass, PLL off | 8 MHz             | 7.7                     | 8.4                                 | 8.9   | 9.5    | 3.6                      | 4.0                                 | 4.4   | 5.0    |      |
|                 |  |                     | 1 MHz             | 1.0                     | 1.3                                 | 1.7   | 2.2    | 0.5                      | 0.7                                 | 1.1   | 1.7    |      |
|                 |  | HSI clock, PLL on   | 64 MHz            | 54.3                    | 63.3                                | 63.9  | 70.1   | 27.9                     | 30.8                                | 31.2  | 33.2   |      |
|                 |  |                     | 48 MHz            | 41.5                    | 47.3                                | 48.0  | 51.9   | 21.1                     | 23.0                                | 23.5  | 24.7   |      |
|                 |  |                     | 32 MHz            | 28.2                    | 31.5                                | 32.2  | 34.1   | 14.2                     | 15.3                                | 15.9  | 16.5   |      |
|                 |  |                     | 24 MHz            | 21.4                    | 23.6                                | 24.3  | 25.5   | 7.2                      | 7.8                                 | 8.2   | 8.8    |      |
|                 |  | HSI clock, PLL off  | 8 MHz             | 7.3                     | 7.9                                 | 8.4   | 9.1    | 3.6                      | 4.0                                 | 4.4   | 4.9    |      |
|                 | Supply current in Sleep mode, code executing from Flash or RAM | HSE bypass, PLL on  | 72 MHz            | 46.4                    | 54.0                                | 54.8  | 59.5   | 7.2                      | 7.9                                 | 8.4   | 9.0    |      |
|                 |  |                     | 64 MHz            | 41.5                    | 48.0                                | 48.8  | 52.6   | 6.5                      | 7.1                                 | 7.5   | 8.1    |      |
|                 |  |                     | 48 MHz            | 31.6                    | 35.9                                | 36.7  | 39.0   | 4.9                      | 5.3                                 | 5.8   | 6.4    |      |
|                 |  |                     | 32 MHz            | 21.4                    | 23.8                                | 24.7  | 25.7   | 3.3                      | 3.7                                 | 4.2   | 4.7    |      |
|                 |  |                     | 24 MHz            | 16.2                    | 17.9                                | 18.6  | 19.4   | 2.5                      | 2.8                                 | 3.3   | 3.8    |      |
|                 |  | HSE bypass, PLL off | 8 MHz             | 5.4                     | 5.9                                 | 6.5   | 7.0    | 0.8                      | 1.1                                 | 1.6   | 2.1    |      |
|                 |  |                     | 1 MHz             | 0.7                     | 1.0                                 | 1.4   | 1.9    | 0.1                      | 0.3                                 | 0.7   | 1.3    |      |
|                 |  | HSI clock, PLL on   | 64 MHz            | 37.0                    | 42.4                                | 43.3  | 46.4   | 6.1                      | 6.7                                 | 7.2   | 7.7    |      |
|                 |  |                     | 48 MHz            | 28.2                    | 31.8                                | 32.7  | 34.5   | 4.6                      | 5.0                                 | 5.5   | 6.1    |      |
|                 |  |                     | 32 MHz            | 19.1                    | 21.2                                | 22.0  | 22.9   | 3.1                      | 3.5                                 | 4.0   | 4.5    |      |
|                 |  |                     | 24 MHz            | 14.5                    | 16.0                                | 16.7  | 17.4   | 1.7                      | 2.0                                 | 2.4   | 2.9    |      |
|                 |  | HSI clock, PLL off  | 8 MHz             | 5.0                     | 5.5                                 | 6.0   | 6.6    | 0.8                      | 1.1                                 | 1.5   | 2.0    |      |

1. To calculate complete device consumption there must be added consumption from VDDA (Table 27).

2. Guaranteed by characterization results.

Table 27. Typical and maximum current consumption from V<sub>DDA</sub> supply

| Symbol           | Parameter   | Conditions<br>(1)   | f <sub>HCLK</sub> | V <sub>DDA</sub> = 2.4 V |                                     |       |        | V <sub>DDA</sub> = 3.6 V |                                     |       |        | Unit |
|------------------|---|---------------------|-------------------|--------------------------|-------------------------------------|-------|--------|--------------------------|-------------------------------------|-------|--------|------|
|                  |   |                     |                   | Typ                      | Max @ T <sub>A</sub> <sup>(2)</sup> |       |        | Typ                      | Max @ T <sub>A</sub> <sup>(2)</sup> |       |        |      |
|                  |   |                     |                   |                          | 25 °C                               | 85 °C | 105 °C |                          | 25 °C                               | 85 °C | 105 °C |      |
| I <sub>DDA</sub> | Supply current in Run or Sleep mode, code executing from Flash or RAM | HSE bypass, PLL on  | 72 MHz            | 226                      | 250                                 | 272   | 279    | 247                      | 268                                 | 302   | 308    | μA   |
|                  |   |                     | 64 MHz            | 200                      | 223                                 | 245   | 250    | 218                      | 240                                 | 267   | 273    |      |
|                  |   |                     | 48 MHz            | 150                      | 172                                 | 189   | 194    | 163                      | 182                                 | 207   | 210    |      |
|                  |   |                     | 32 MHz            | 103                      | 122                                 | 137   | 139    | 111                      | 130                                 | 147   | 148    |      |
|                  |   |                     | 24 MHz            | 80                       | 99                                  | 109   | 111    | 86                       | 102                                 | 117   | 117    |      |
|                  |   | HSE bypass, PLL off | 8 MHz             | 1                        | 3                                   | 3     | 3      | 1                        | 3                                   | 3     | 4      |      |
|                  |   |                     | 1 MHz             | 1                        | 3                                   | 3     | 4      | 1                        | 3                                   | 4     | 4      |      |
|                  |   | HSI clock, PLL on   | 64 MHz            | 268                      | 293                                 | 319   | 325    | 296                      | 321                                 | 351   | 358    |      |
|                  |   |                     | 48 MHz            | 219                      | 242                                 | 263   | 267    | 241                      | 263                                 | 290   | 296    |      |
|                  |   |                     | 32 MHz            | 171                      | 193                                 | 210   | 213    | 189                      | 209                                 | 230   | 234    |      |
|                  |   |                     | 24 MHz            | 148                      | 169                                 | 181   | 184    | 165                      | 182                                 | 200   | 203    |      |
|                  |   | HSI clock, PLL off  | 8 MHz             | 68                       | 84                                  | 86    | 87     | 80                       | 93                                  | 95    | 97     |      |

1. Current consumption from the V<sub>DDA</sub> supply is independent of whether the peripherals are on or off. Furthermore when the PLL is off, I<sub>DDA</sub> is independent from the frequency.

2. Guaranteed by characterization results.

Table 28. Typical and maximum V<sub>DD</sub> consumption in Stop mode

| Symbol          | Parameter                   | Conditions          | Typ@V <sub>DD</sub><br>(V <sub>DD</sub> =1.8 V, V <sub>DDA</sub> =3.3 V) | Max                       |                           |                            | Unit |
|-----------------|-----------------------------|---------------------|--|---------------------------|---------------------------|----------------------------|------|
|                 |                             |                     |  | T <sub>A</sub> =<br>25 °C | T <sub>A</sub> =<br>85 °C | T <sub>A</sub> =<br>105 °C |      |
| I <sub>DD</sub> | Supply current in Stop mode | All oscillators OFF | 5.19   | 29.2                      | 485.7                     | 1052.2                     | μA   |

Note: To calculate complete device consumption there must be added consumption from V<sub>DDA</sub> (Table 29).

Table 29. Typical and maximum V<sub>DDA</sub> consumption in Stop mode

| Symbol           | Parameter                   | Conditions          | Typ@V <sub>DDA</sub> (V <sub>DD</sub> = 1.8 V) |       |       |       |       |       |       | Max <sup>(1)</sup>        |                           |                            | Unit |
|------------------|-----------------------------|---------------------|--|-------|-------|-------|-------|-------|-------|---------------------------|---------------------------|----------------------------|------|
|                  |                             |                     | 1.8 V  | 2.0 V | 2.4 V | 2.7 V | 3.0 V | 3.3 V | 3.6 V | T <sub>A</sub> =<br>25 °C | T <sub>A</sub> =<br>85 °C | T <sub>A</sub> =<br>105 °C |      |
| I <sub>DDA</sub> | Supply current in Stop mode | All oscillators OFF | 0.74   | 0.76  | 0.78  | 0.81  | 0.86  | 0.92  | 1     | 8.8                       | 10.1                      | 11.6                       | μA   |

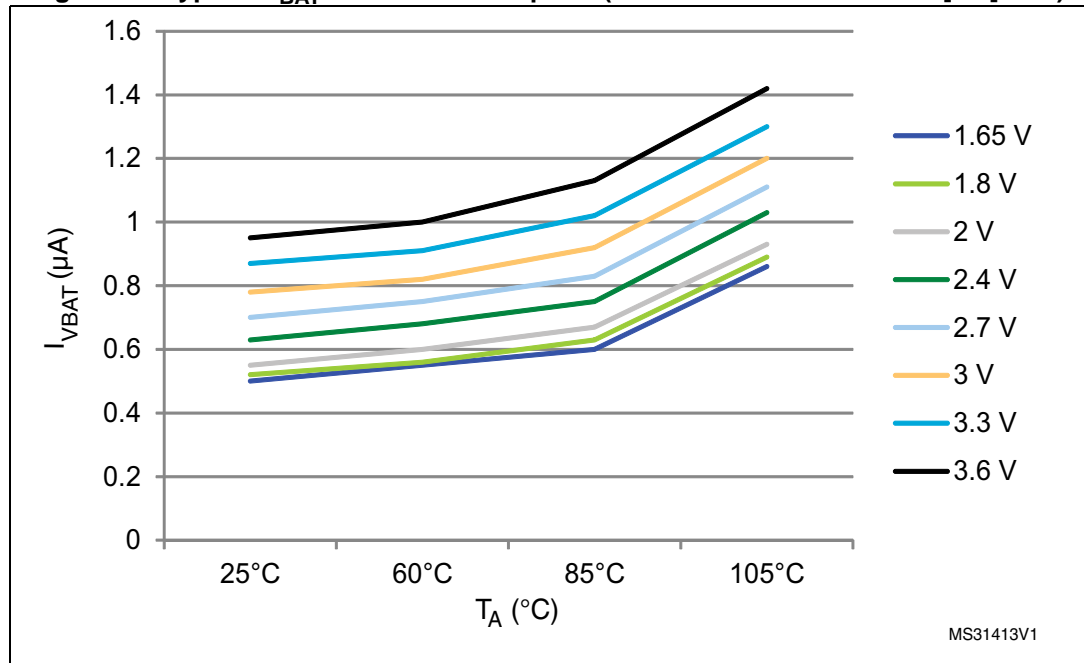
1. Data based on characterization results and tested in production.

Table 30. Typical and maximum current consumption from  $V_{BAT}$  supply<sup>(1)</sup>

| Symbol         | Parameter                    | Conditions  | Typ @ $V_{BAT}$ |         |         |         |         |         |         | Max <sup>(2)</sup>               |                                  |                                   | Unit          |
|----------------|------------------------------|---|-----------------|---------|---------|---------|---------|---------|---------|----------------------------------|----------------------------------|-----------------------------------|---------------|
|                |                              |   | = 1.65 V        | = 1.8 V | = 2.0 V | = 2.4 V | = 2.7 V | = 3.3 V | = 3.6 V | $T_A = 25\text{ }^\circ\text{C}$ | $T_A = 85\text{ }^\circ\text{C}$ | $T_A = 105\text{ }^\circ\text{C}$ |               |
| $I_{DD\_VBAT}$ | Backup domain supply current | LSE & RTC ON; "Xtal mode" lower driving capability; LSEDRV[1:0] = '00'  | 0.50            | 0.52    | 0.55    | 0.63    | 0.70    | 0.87    | 0.95    | 1.1                              | 1.6                              | 2.2                               | $\mu\text{A}$ |
|                |                              | LSE & RTC ON; "Xtal mode" higher driving capability; LSEDRV[1:0] = '11' | 0.85            | 0.90    | 0.93    | 1.02    | 1.10    | 1.27    | 1.38    | 1.6                              | 2.4                              | 3.0                               |               |

1. Crystal used: Abracon ABS07-120-32.768kHz-T with 6 pF of CL for typical values.

2. Guaranteed by characterization results.

Figure 12. Typical  $V_{BAT}$  current consumption (LSE and RTC ON/LSEDRV[1:0]='00')

### Typical current consumption

The MCU is placed under the following conditions:

- $V_{DD} = 1.8\text{ V}$ ,  $V_{DDA} = V_{DDSD12} = V_{DDSD3} = 3.3\text{ V}$
- All I/O pins are in analog input configuration
- The Flash access time is adjusted to  $f_{HCLK}$  frequency (0 wait states from 0 to 24 MHz, 1 wait state from 24 to 48 MHz and 2 wait states from 48 MHz to 72 MHz)
- Prefetch is ON
- When the peripherals are enabled,  $f_{APB1} = f_{AHB}/2$ ,  $f_{APB2} = f_{AHB}$
- PLL is used for frequencies greater than 8 MHz
- AHB prescaler of 2, 4, 8, 16 and 64 is used for the frequencies 4 MHz, 2 MHz, 1 MHz, 500 kHz and 125 kHz respectively

**Table 31. Typical current consumption in Run mode, code with data processing running from Flash**

| Symbol   | Parameter                                       | Conditions   | $f_{HCLK}$ | Typ                 |                      | Unit |
|----------|---|--|------------|---------------------|----------------------|------|
|          |   |  |            | Peripherals enabled | Peripherals disabled |      |
| $I_{DD}$ | Supply current in Run mode from $V_{DD}$ supply | Running from HSE crystal clock 8 MHz, code executing from Flash, PLL on  | 72 MHz     | 61.0                | 28.6                 | mA   |
|          |   |  | 64 MHz     | 54.7                | 25.7                 |      |
|          |   |  | 48 MHz     | 42.0                | 20.0                 |      |
|          |   |  | 32 MHz     | 28.5                | 13.7                 |      |
|          |   |  | 24 MHz     | 21.8                | 10.5                 |      |
|          |   |  | 16 MHz     | 14.6                | 7.3                  |      |
|          |   | Running from HSE crystal clock 8 MHz, code executing from Flash, PLL off | 8 MHz      | 7.5                 | 3.8                  |      |
|          |   |  | 4 MHz      | 4.3                 | 2.2                  |      |
|          |   |  | 2 MHz      | 2.5                 | 1.4                  |      |
|          |   |  | 1 MHz      | 1.6                 | 1.0                  |      |
|          |   |  | 500 kHz    | 1.2                 | 0.8                  |      |
|          |   |  | 125 kHz    | 0.9                 | 0.6                  |      |



**Table 31. Typical current consumption in Run mode, code with data processing running from Flash (continued)**

| Symbol                                     | Parameter  | Conditions   | f <sub>HCLK</sub> | Typ                 |                      | Unit |
|--|--|--|-------------------|---------------------|----------------------|------|
|  |  |  |                   | Peripherals enabled | Peripherals disabled |      |
| I <sub>DDA</sub> <sup>(1)(2)</sup>         | Supply current in Run mode from V <sub>DDA</sub> supply                                      | Running from HSE crystal clock 8 MHz, code executing from Flash, PLL on  | 72 MHz            | 243.1               | 243.1                | μA   |
|  |  |  | 64 MHz            | 214.1               | 214.1                |      |
|  |  |  | 48 MHz            | 159.4               | 159.4                |      |
|  |  |  | 32 MHz            | 109.1               | 109.1                |      |
|  |  |  | 24 MHz            | 84.7                | 84.7                 |      |
|  |  |  | 16 MHz            | 60.6                | 60.6                 |      |
|  |  | Running from HSE crystal clock 8 MHz, code executing from Flash, PLL off | 8 MHz             | 1.0                 | 1.0                  |      |
|  |  |  | 4 MHz             | 1.0                 | 1.0                  |      |
|  |  |  | 2 MHz             | 1.0                 | 1.0                  |      |
|  |  |  | 1 MHz             | 1.0                 | 1.0                  |      |
|  |  |  | 500 kHz           | 1.0                 | 1.0                  |      |
|  |  |  | 125 kHz           | 1.0                 | 1.0                  |      |
| I <sub>SDADC12</sub> + I <sub>SDADC3</sub> | Supply currents in Run mode from V <sub>DDSD12</sub> and V <sub>DDSD3</sub> (SDADCs are off) | -  | -                 | 2.5                 | 1                    | μA   |

1. V<sub>DDA</sub> monitoring is off, V<sub>DDSD12</sub> monitoring is off.
2. When peripherals are enabled, power consumption of the analog part of peripherals such as ADC, DACs, Comparators, etc. is not included. Refer to those peripherals characteristics in the subsequent sections.

Table 32. Typical current consumption in Sleep mode, code running from Flash or RAM

| Symbol                          | Parameter   | Conditions  | f <sub>HCLK</sub> | Typ                 |                      | Unit |
|---------------------------------|---|---|-------------------|---------------------|----------------------|------|
|                                 |   |   |                   | Peripherals enabled | Peripherals disabled |      |
| I <sub>DD</sub>                 | Supply current in Sleep mode from V <sub>DD</sub> supply  | Running from HSE crystal clock 8 MHz, code executing from Flash or RAM, PLL on  | 72 MHz            | 42.6                | 6.7                  | mA   |
|                                 |   |   | 64 MHz            | 38.0                | 6.0                  |      |
|                                 |   |   | 48 MHz            | 28.7                | 4.5                  |      |
|                                 |   |   | 32 MHz            | 19.3                | 3.1                  |      |
|                                 |   |   | 24 MHz            | 14.6                | 2.4                  |      |
|                                 |   |   | 16 MHz            | 9.8                 | 1.7                  |      |
|                                 |   | Running from HSE crystal clock 8 MHz, code executing from Flash or RAM, PLL off | 8 MHz             | 4.8                 | 0.8                  |      |
|                                 |   |   | 4 MHz             | 3.0                 | 0.7                  |      |
|                                 |   |   | 2 MHz             | 1.9                 | 0.6                  |      |
|                                 |   |   | 1 MHz             | 1.3                 | 0.6                  |      |
|                                 |   |   | 500 kHz           | 1.0                 | 0.6                  |      |
|                                 |   |   | 125 kHz           | 0.8                 | 0.5                  |      |
| I <sub>DDA</sub> <sup>(1)</sup> | Supply current in Sleep mode from V <sub>DDA</sub> supply | Running from HSE crystal clock 8 MHz, code executing from Flash or RAM, PLL on  | 72 MHz            | 243.1               | 243.1                | μA   |
|                                 |   |   | 64 MHz            | 214.1               | 214.1                |      |
|                                 |   |   | 48 MHz            | 159.4               | 159.4                |      |
|                                 |   |   | 32 MHz            | 109.1               | 109.1                |      |
|                                 |   |   | 24 MHz            | 84.7                | 84.7                 |      |
|                                 |   |   | 16 MHz            | 60.6                | 60.6                 |      |
|                                 |   | Running from HSE crystal clock 8 MHz, code executing from Flash or RAM, PLL off | 8 MHz             | 1.0                 | 1.0                  |      |
|                                 |   |   | 4 MHz             | 1.0                 | 1.0                  |      |
|                                 |   |   | 2 MHz             | 1.0                 | 1.0                  |      |
|                                 |   |   | 1 MHz             | 1.0                 | 1.0                  |      |
|                                 |   |   | 500 kHz           | 1.0                 | 1.0                  |      |
|                                 |   |   | 125 kHz           | 1.0                 | 1.0                  |      |

1. V<sub>DDA</sub> monitoring is off, V<sub>DDSD12</sub> monitoring is off.

## I/O system current consumption

The current consumption of the I/O system has two components: static and dynamic.

### I/O static current consumption

All the I/Os used as inputs with pull-up generate current consumption when the pin is externally held low. The value of this current consumption can be simply computed by using the pull-up/pull-down resistors values given in [Table 50: I/O static characteristics](#).

For the output pins, any external pull-down or external load must also be considered to estimate the current consumption.

Additional I/O current consumption is due to I/Os configured as inputs if an intermediate voltage level is externally applied. This current consumption is caused by the input Schmitt trigger circuits used to discriminate the input value. Unless this specific configuration is required by the application, this supply current consumption can be avoided by configuring these I/Os in analog mode. This is notably the case of ADC and SDADC input pins which should be configured as analog inputs.

**Caution:** Any floating input pin can also settle to an intermediate voltage level or switch inadvertently, as a result of external electromagnetic noise. To avoid current consumption related to floating pins, they must either be configured in analog mode, or forced internally to a definite digital value. This can be done either by using pull-up/down resistors or by configuring the pins in output mode. Under reset conditions all I/Os are configured in input floating mode - so if some inputs do not have a defined voltage level then they can generate additional consumption. This consumption is visible on  $V_{DD}$  supply and also on  $V_{DDSDx}$  supply because some I/Os are powered from SDADCx supply (all I/Os which have SDADC analog input functionality).

### I/O dynamic current consumption

In addition to the internal peripheral current consumption (see [Table 34: Peripheral current consumption](#)), the I/Os used by an application also contribute to the current consumption. When an I/O pin switches, it uses the current from the MCU supply voltage to supply the I/O pin circuitry and to charge/discharge the capacitive load (internal or external) connected to the pin:

$$I_{SW} = V_{DD} \times f_{SW} \times C$$

where

$I_{SW}$  is the current sunk by a switching I/O to charge/discharge the capacitive load

$V_{DD}$  is the MCU supply voltage

$f_{SW}$  is the I/O switching frequency

$C$  is the total capacitance seen by the I/O pin:  $C = C_{INT} + C_{EXT} + C_S$

$C_S$  is the PCB board capacitance including the pad pin.

The test pin is configured in push-pull output mode and is toggled by software at a fixed frequency.

Table 33. Switching output I/O current consumption

| Symbol          | Parameter               | Conditions <sup>(1)</sup>   | I/O toggling frequency (f <sub>SW</sub> ) | Typ  | Unit |
|-----------------|-------------------------|---|---|------|------|
| I <sub>SW</sub> | I/O current consumption | V <sub>DD</sub> = 1.8 V<br>C <sub>ext</sub> = 0 pF<br>C = C <sub>INT</sub> + C <sub>EXT</sub> + C <sub>S</sub>  | 2 MHz                                     | 0.09 | mA   |
|                 |                         |   | 4 MHz                                     | 0.17 |      |
|                 |                         |   | 8 MHz                                     | 0.34 |      |
|                 |                         |   | 18 MHz                                    | 0.79 |      |
|                 |                         |   | 36 MHz                                    | 1.50 |      |
|                 |                         |   | 48 MHz                                    | 2.06 |      |
|                 |                         | V <sub>DD</sub> = 1.8 V<br>C <sub>ext</sub> = 10 pF<br>C = C <sub>INT</sub> + C <sub>EXT</sub> + C <sub>S</sub> | 2 MHz                                     | 0.13 |      |
|                 |                         |   | 4 MHz                                     | 0.26 |      |
|                 |                         |   | 8 MHz                                     | 0.50 |      |
|                 |                         |   | 18 MHz                                    | 1.18 |      |
|                 |                         |   | 36 MHz                                    | 2.27 |      |
|                 |                         |   | 48 MHz                                    | 3.03 |      |
|                 |                         | V <sub>DD</sub> = 1.8 V<br>C <sub>ext</sub> = 22 pF<br>C = C <sub>INT</sub> + C <sub>EXT</sub> + C <sub>S</sub> | 2 MHz                                     | 0.18 | mA   |
|                 |                         |   | 4 MHz                                     | 0.36 |      |
|                 |                         |   | 8 MHz                                     | 0.69 |      |
|                 |                         |   | 18 MHz                                    | 1.60 |      |
|                 |                         |   | 36 MHz                                    | 3.27 |      |
|                 |                         |   | 48 MHz                                    | 4.35 |      |
|                 |                         | V <sub>DD</sub> = 1.8 V<br>C <sub>ext</sub> = 33 pF<br>C = C <sub>INT</sub> + C <sub>EXT</sub> + C <sub>S</sub> | 2 MHz                                     | 0.23 |      |
|                 |                         |   | 4 MHz                                     | 0.45 |      |
|                 |                         |   | 8 MHz                                     | 0.87 |      |
|                 |                         |   | 18 MHz                                    | 2.0  |      |
|                 |                         |   | 36 MHz                                    | 3.7  |      |
|                 |                         |   | 48 MHz                                    | 4.9  |      |
|                 |                         | V <sub>DD</sub> = 1.8 V<br>C <sub>ext</sub> = 47 pF<br>C = C <sub>INT</sub> + C <sub>EXT</sub> + C <sub>S</sub> | 2 MHz                                     | 0.29 | mA   |
|                 |                         |   | 4 MHz                                     | 0.55 |      |
|                 |                         |   | 8 MHz                                     | 1.09 |      |
|                 |                         |   | 18 MHz                                    | 2.43 |      |

1. C<sub>S</sub> = 5 pF (estimated value).

### On-chip peripheral current consumption

The MCU is placed under the following conditions:

- All I/O pins are in analog input configuration.
- 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 at 25°C and  $V_{DD} = 1.8\text{ V}$ ,  $V_{DDA} = V_{DDSD12} = V_{DDSD3} = 3.3\text{ V}$ .

**Table 34. Peripheral current consumption**

| Peripheral                 | Typical consumption <sup>(1)</sup> | Unit   |
|----------------------------|------------------------------------|--------|
| AHB peripherals            |                                    | -      |
| BusMatrix <sup>(2)</sup>   | 6.9                                | μA/MHz |
| DMA1                       | 18.3                               |        |
| DMA2                       | 4.8                                |        |
| CRC                        | 2.6                                |        |
| GPIOA                      | 12.2                               |        |
| GPIOB                      | 11.9                               |        |
| GPIOC                      | 4.3                                |        |
| GIOD                       | 12.0                               |        |
| GPIOE                      | 4.4                                |        |
| GPIOF                      | 3.7                                |        |
| TSC                        | 5.7                                |        |
| APB2 peripherals           |                                    |        |
| APB2-Bridge <sup>(3)</sup> | 4.2                                |        |
| SYSCFG & COMP              | 2.8                                |        |
| ADC1                       | 17.7                               |        |
| SPI1                       | 12.3                               |        |
| USART1                     | 22.9                               |        |
| TIM15                      | 15.7                               |        |
| TIM16                      | 12.2                               |        |
| TIM17                      | 12.1                               |        |
| TIM19                      | 18.5                               |        |
| SDAC1                      | 10.8                               |        |
| SDAC2                      | 10.5                               |        |
| SDAC3                      | 10.3                               |        |

Table 34. Peripheral current consumption (continued)

| Peripheral                 | Typical consumption <sup>(1)</sup> | Unit   |
|----------------------------|------------------------------------|--------|
| APB1 peripherals           |                                    |        |
| APB1-Bridge <sup>(3)</sup> | 6.9                                | μA/MHz |
| TIM2                       | 47.9                               |        |
| TIM3                       | 36.8                               |        |
| TIM4                       | 36.9                               |        |
| TIM5                       | 45.5                               |        |
| TIM6                       | 8.4                                |        |
| TIM7                       | 8.2                                |        |
| TIM12                      | 21.3                               |        |
| TIM13                      | 14.2                               |        |
| TIM14                      | 14.4                               |        |
| TIM18                      | 10.1                               |        |
| WWDG                       | 4.7                                |        |
| SPI2                       | 24.3                               |        |
| SPI3                       | 25.3                               |        |
| USART2                     | 45.3                               |        |
| USART3                     | 43.1                               |        |
| I2C1                       | 14.0                               |        |
| I2C2                       | 13.9                               |        |
| CAN                        | 38.1                               |        |
| DAC2                       | 7.7                                |        |
| PWR                        | 5.4                                |        |
| DAC1                       | 14.8                               |        |
| CEC                        | 5.4                                |        |

1. When peripherals are enabled, power consumption of the analog part of peripherals such as ADC, DACs, Comparators, etc. is not included. Refer to those peripherals characteristics in the subsequent sections.

2. The BusMatrix is automatically active when at least one master is ON (CPU, DMA1 or DMA2).

3. The APBx Bridge is automatically active when at least one peripheral is ON on the same Bus.

### 6.3.5 Wakeup time from low-power mode

The wakeup times given in [Table 44](#) are measured from the wakeup event trigger to the first instruction executed by the CPU. The clock source used to wake up the device depends from the current operating mode:

- Stop or sleep mode: the wakeup event is WFE.
- The WKUP1 (PA0) pin is used to wakeup from stop and sleep modes.

All timings are derived from tests performed under ambient temperature and  $V_{DD}$  supply voltage conditions summarized in [Table 22](#).

Table 35. Low-power mode wakeup timings

| Symbol               | Parameter                   | Conditions                     | Typ @V <sub>DD</sub> = 1.8 V,<br>V <sub>DPA</sub> = 3.3 V | Max  | Unit             |
|----------------------|-----------------------------|--------------------------------|---|------|------------------|
| t <sub>WUSTOP</sub>  | Wakeup from Stop mode       | -                              | 3.6   | 5.21 | μs               |
| t <sub>WUSLEEP</sub> | Wakeup from Sleep mode      | After WFE instruction          | 6   |      | CPU clock cycles |
| t <sub>WUPOR</sub>   | Wakeup from Power off state | Startup after NPOR pin release | 62.6  | 100  | μs               |

### 6.3.6 External clock source characteristics

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

In bypass mode the HSE oscillator is switched off and the input pin is a standard GPIO.

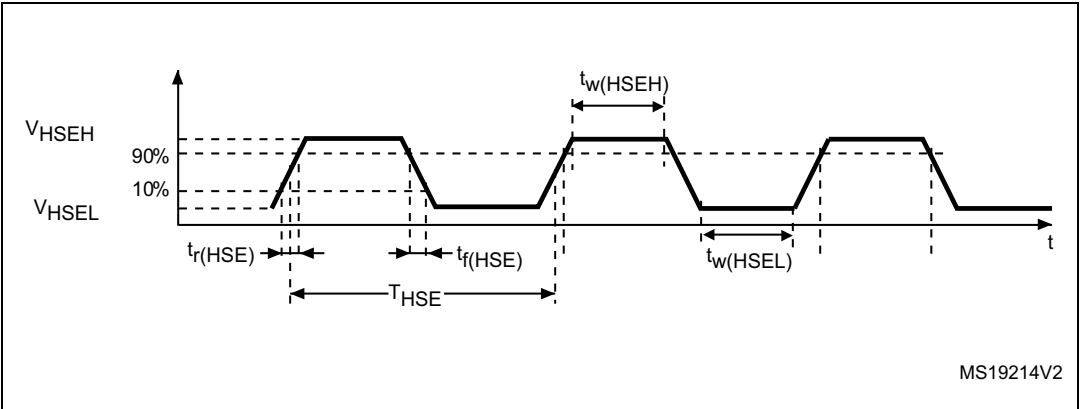
The external clock signal has to respect the I/O characteristics in [Section 6.3.13](#). However, the recommended clock input waveform is shown in [Figure 13](#).

Table 36. High-speed external user clock characteristics

| Symbol                                       | Parameter <sup>(1)</sup>             | Conditions               | Min                 | Typ | Max                 | Unit |
|--|--------------------------------------|--------------------------|---------------------|-----|---------------------|------|
| f <sub>HSE_ext</sub>                         | User external clock source frequency | CSS is on or PLL is used | 1                   | 8   | 32                  | MHz  |
|  |                                      | CSS is off, PLL not used | 0                   |     |                     |      |
| V <sub>HSEH</sub>                            | OSC_IN input pin high level voltage  | -                        | 0.7 V <sub>DD</sub> | -   | V <sub>DD</sub>     | V    |
| V <sub>HSEL</sub>                            | OSC_IN input pin low level voltage   | -                        | V <sub>SS</sub>     | -   | 0.3 V <sub>DD</sub> |      |
| t <sub>w(HSEH)</sub><br>t <sub>w(HSEL)</sub> | OSC_IN high or low time              | -                        | 15                  | -   | -                   | ns   |
| t <sub>r(HSE)</sub><br>t <sub>f(HSE)</sub>   | OSC_IN rise or fall time             | -                        | -                   | -   | 20                  |      |

1. Guaranteed by design.

Figure 13. High-speed external clock source AC timing diagram



MS19214V2

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

In bypass mode the LSE oscillator is switched off and the input pin is a standard GPIO.

The external clock signal has to respect the I/O characteristics in [Section 6.3.13](#). However, the recommended clock input waveform is shown in [Figure 14](#).

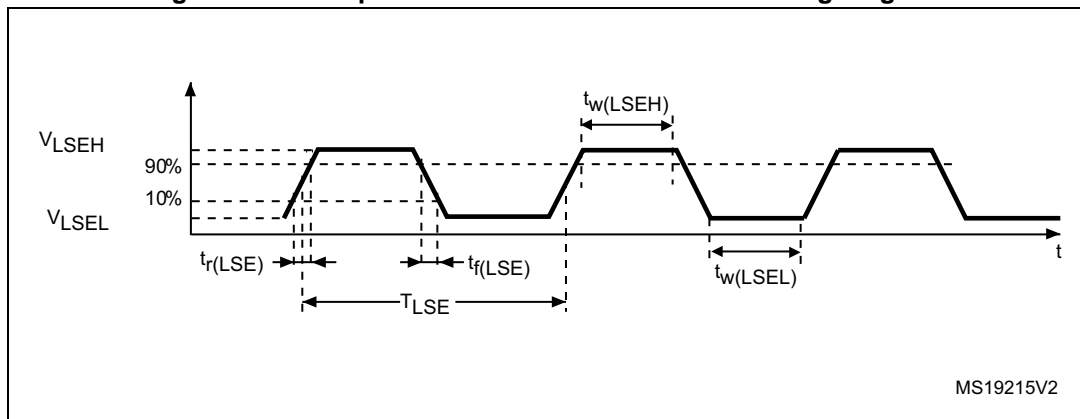
Table 37. Low-speed external user clock characteristics

| Symbol                         | Parameter <sup>(1)</sup>              | Conditions | Min         | Typ    | Max         | Unit |
|--------------------------------|---------------------------------------|------------|-------------|--------|-------------|------|
| $f_{LSE\_ext}$                 | User External clock source frequency  | -          | -           | 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  | -          | $V_{SS}$    | -      | $0.3V_{DD}$ |      |
| $t_{w(LSEH)}$<br>$t_{w(LSEL)}$ | OSC32_IN high or low time             | -          | 450         | -      | -           | ns   |
| $t_{r(LSE)}$<br>$t_{f(LSE)}$   | OSC32_IN rise or fall time            | -          | -           | -      | 50          |      |

1. Guaranteed by design.



Figure 14. Low-speed external clock source AC timing diagram



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

The high-speed external (HSE) clock can be supplied with a 4 to 32 MHz crystal/ceramic resonator oscillator. All the information given in this paragraph are based on design simulation results obtained with typical external components specified in [Table 38](#). 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 38. HSE oscillator characteristics

| Symbol              | Parameter                   | Conditions <sup>(1)</sup>   | Min <sup>(2)</sup> | Typ | Max <sup>(2)</sup> | Unit       |
|---------------------|-----------------------------|---|--------------------|-----|--------------------|------------|
| $f_{OSC\_IN}$       | Oscillator frequency        | -   | 4                  | 8   | 32                 | MHz        |
| $R_F$               | Feedback resistor           | -   | -                  | 200 | -                  | k $\Omega$ |
| $I_{DD}$            | HSE current consumption     | During startup <sup>(3)</sup>   | -                  | -   | 8.5                | mA         |
|                     |                             | $V_{DD} = 1.8\text{ V}$ , $R_m = 30\ \Omega$ ,<br>$CL = 10\text{ pF}@8\text{ MHz}$  | -                  | 0.4 | -                  |            |
|                     |                             | $V_{DD} = 1.8\text{ V}$ , $R_m = 45\ \Omega$ ,<br>$CL = 10\text{ pF}@8\text{ MHz}$  | -                  | 0.5 | -                  |            |
|                     |                             | $V_{DD} = 1.8\text{ V}$ , $R_m = 30\ \Omega$ ,<br>$CL = 5\text{ pF}@32\text{ MHz}$  | -                  | 0.8 | -                  |            |
|                     |                             | $V_{DD} = 1.8\text{ V}$ , $R_m = 30\ \Omega$ ,<br>$CL = 10\text{ pF}@32\text{ MHz}$ | -                  | 1   | -                  |            |
|                     |                             | $V_{DD} = 1.8\text{ V}$ , $R_m = 30\ \Omega$ ,<br>$CL = 20\text{ pF}@32\text{ MHz}$ | -                  | 1.5 | -                  |            |
| $g_m$               | Oscillator transconductance | Startup   | 10                 | -   | -                  | mA/V       |
| $t_{SU(HSE)}^{(4)}$ | Startup time                | $V_{DD}$ is stabilized  | -                  | 2   | -                  | ms         |

1. Resonator characteristics given by the crystal/ceramic resonator manufacturer.

2. Guaranteed by design.

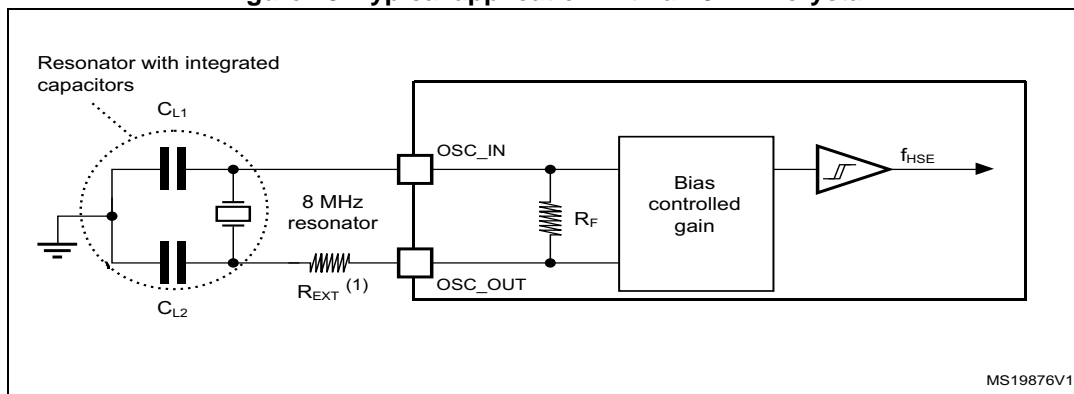
3. This consumption level occurs during the first 2/3 of the  $t_{SU(HSE)}$  startup time

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 20 pF range (typ.), designed for high-frequency applications, and selected to match the requirements of the crystal or resonator (see [Figure 15](#)).  $C_{L1}$  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  $C_{L2}$ .

*Note:* For information on electing the crystal, 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 15. Typical application with an 8 MHz crystal**



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

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

The low-speed external (LSE) clock can be supplied with a 32.768 kHz crystal resonator oscillator. All the information given in this paragraph are based on design simulation results obtained with typical external components specified in [Table 39](#). 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).

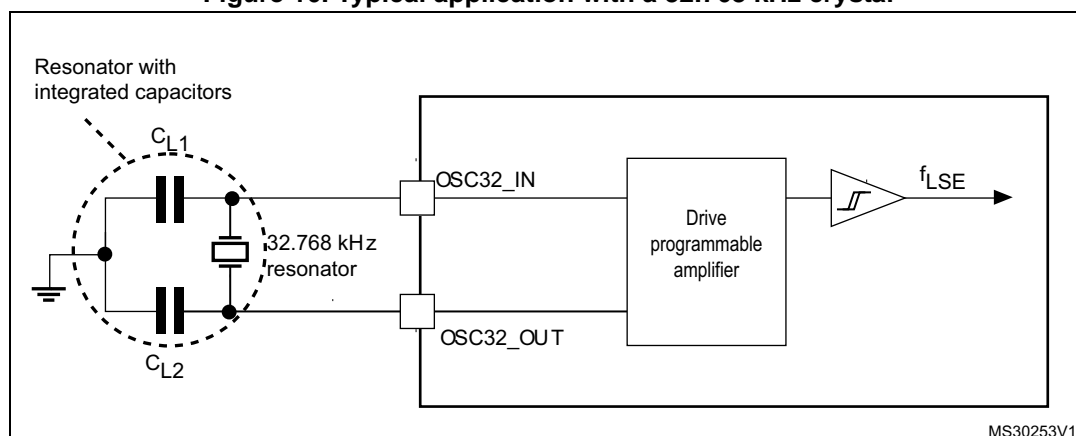
**Table 39. LSE oscillator characteristics ( $f_{LSE} = 32.768$  kHz)**

| Symbol              | Parameter                   | Conditions <sup>(1)</sup>                          | Min <sup>(2)</sup> | Typ | Max <sup>(2)</sup> | Unit      |
|---------------------|-----------------------------|--|--------------------|-----|--------------------|-----------|
| $I_{DD}$            | LSE current consumption     | LSEDRV[1:0]=00<br>lower driving capability         | -                  | 0.5 | 0.9                | $\mu A$   |
|                     |                             | LSEDRV[1:0]= 10<br>medium low driving capability   | -                  | -   | 1                  |           |
|                     |                             | LSEDRV[1:0] = 01<br>medium high driving capability | -                  | -   | 1.3                |           |
|                     |                             | LSEDRV[1:0]=11<br>higher driving capability        | -                  | -   | 1.6                |           |
| $g_m$               | Oscillator transconductance | LSEDRV[1:0]=00<br>lower driving capability         | 5                  | -   | -                  | $\mu A/V$ |
|                     |                             | LSEDRV[1:0]= 10<br>medium low driving capability   | 8                  | -   | -                  |           |
|                     |                             | LSEDRV[1:0] = 01<br>medium high driving capability | 15                 | -   | -                  |           |
|                     |                             | LSEDRV[1:0]=11<br>higher driving capability        | 25                 | -   | -                  |           |
| $t_{SU(LSE)}^{(3)}$ | Startup time                | $V_{DD}$ is stabilized                             | -                  | 2   | -                  | s         |

1. Refer to the note and caution paragraphs below the table, and to the application note AN2867 "Oscillator design guide for ST microcontrollers".
2. Guaranteed by design.
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 information on selecting the crystal, 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 16. Typical application with a 32.768 kHz crystal



**Note:** An external resistor is not required between OSC32\_IN and OSC32\_OUT and it is forbidden to add one.

### 6.3.7 Internal clock source characteristics

The parameters given in [Table 40](#) are derived from tests performed under ambient temperature and supply voltage conditions summarized in [Table 22](#).

The provided curves are characterization results, not tested in production.

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

Table 40. HSI oscillator characteristics<sup>(1)</sup>

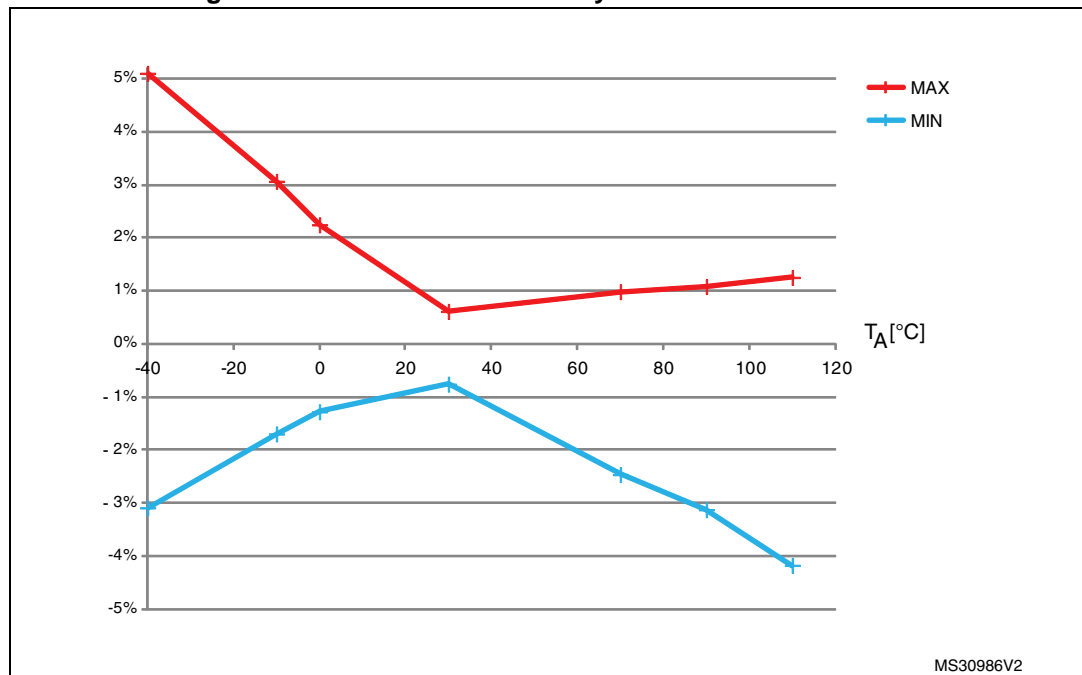
| Symbol                | Parameter   | Conditions              | Min                 | Typ | Max                 | Unit |
|-----------------------|---|-------------------------|---------------------|-----|---------------------|------|
| $f_{\text{HSI}}$      | Frequency   | -                       | -                   | 8   | -                   | MHz  |
| TRIM                  | HSI user trimming step                              | -                       | -                   | -   | 1 <sup>(2)</sup>    | %    |
| DuCy <sub>(HSI)</sub> | Duty cycle  | -                       | 45 <sup>(2)</sup>   | -   | 55 <sup>(2)</sup>   | %    |
| ACC <sub>HSI</sub>    | Accuracy of the HSI oscillator (factory calibrated) | $T_A = -40$ to $105$ °C | -3.8 <sup>(3)</sup> | -   | 4.6 <sup>(3)</sup>  | %    |
|                       |   | $T_A = -10$ to $85$ °C  | -2.9 <sup>(3)</sup> | -   | 2.9 <sup>(3)</sup>  | %    |
|                       |   | $T_A = 0$ to $70$ °C    | -2.3 <sup>(3)</sup> | -   | -2.2 <sup>(3)</sup> | %    |
|                       |   | $T_A = 25$ °C           | -1                  | -   | 1                   | %    |
| $t_{\text{su(HSI)}}$  | HSI oscillator startup time                         | -                       | 1 <sup>(3)</sup>    | -   | 2 <sup>(3)</sup>    | μs   |
| $I_{\text{DD(HSI)}}$  | HSI oscillator power consumption                    | -                       | -                   | 80  | 100 <sup>(3)</sup>  | μA   |

1.  $V_{\text{DDA}} = 3.3$  V,  $T_A = -40$  to  $105$  °C unless otherwise specified.

2. Guaranteed by design.

3. Guaranteed by characterization results.

Figure 17. HSI oscillator accuracy characterization results



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

Table 41. LSI oscillator characteristics<sup>(1)</sup>

| Symbol                              | Parameter                        | Min | Typ  | Max | Unit |
|-------------------------------------|----------------------------------|-----|------|-----|------|
| f <sub>LSI</sub>                    | Frequency                        | 30  | 40   | 60  | kHz  |
| t <sub>su(LSI)</sub> <sup>(2)</sup> | LSI oscillator startup time      | -   | -    | 85  | μs   |
| I <sub>DD(LSI)</sub> <sup>(2)</sup> | LSI oscillator power consumption | -   | 0.75 | 1.2 | μA   |

1. V<sub>DDA</sub> = 3.3 V, T<sub>A</sub> = -40 to 105 °C unless otherwise specified.

2. Guaranteed by design.

### 6.3.8 PLL characteristics

The parameters given in [Table 42](#) are derived from tests performed under ambient temperature and supply voltage conditions summarized in [Table 22](#).

Table 42. PLL characteristics

| Symbol               | Parameter                      | Value             |     |                    | Unit |
|----------------------|--------------------------------|-------------------|-----|--------------------|------|
|                      |                                | Min               | Typ | Max                |      |
| f <sub>PLL_IN</sub>  | PLL input clock <sup>(1)</sup> | 1 <sup>(2)</sup>  | -   | 24 <sup>(2)</sup>  | MHz  |
|                      | PLL input clock duty cycle     | 40 <sup>(2)</sup> | -   | 60 <sup>(2)</sup>  | %    |
| f <sub>PLL_OUT</sub> | PLL multiplier output clock    | 16 <sup>(2)</sup> | -   | 72                 | MHz  |
| t <sub>LOCK</sub>    | PLL lock time                  | -                 | -   | 200 <sup>(2)</sup> | μs   |
| Jitter               | Cycle-to-cycle jitter          | -                 | -   | 300 <sup>(2)</sup> | ps   |

1. Take care of using the appropriate multiplier factors so as to have PLL input clock values compatible with the range defined by f<sub>PLL\_OUT</sub>.

2. Guaranteed by design.

### 6.3.9 Memory characteristics

#### Flash memory

The characteristics are given at  $T_A = -40$  to  $+105$  °C unless otherwise specified.

**Table 43. Flash memory characteristics**

| Symbol             | Parameter               | Conditions               | Min | Typ  | Max <sup>(1)</sup> | Unit |
|--------------------|-------------------------|--------------------------|-----|------|--------------------|------|
| $t_{\text{prog}}$  | 16-bit programming time | $T_A = -40$ to $+105$ °C | 40  | 53.5 | 60                 | μs   |
| $t_{\text{ERASE}}$ | Page (2 kB) erase time  | $T_A = -40$ to $+105$ °C | 20  | -    | 40                 | ms   |
| $t_{\text{ME}}$    | Mass erase time         | $T_A = -40$ to $+105$ °C | 20  | -    | 40                 | ms   |
| $I_{\text{DD}}$    | Supply current          | Write mode               | -   | -    | 10                 | mA   |
|                    |                         | Erase mode               | -   | -    | 12                 | mA   |

1. Guaranteed by design.

**Table 44. Flash memory endurance and data retention**

| Symbol           | Parameter      | Conditions  | Value              | Unit    |
|------------------|----------------|---|--------------------|---------|
|                  |                |   | Min <sup>(1)</sup> |         |
| $N_{\text{END}}$ | Endurance      | $T_A = -40$ to $+85$ °C (6 suffix versions)<br>$T_A = -40$ to $+105$ °C (7 suffix versions) | 10                 | kcycles |
| $t_{\text{RET}}$ | Data retention | 1 kcycle <sup>(2)</sup> at $T_A = 85$ °C  | 30                 | Years   |
|                  |                | 1 kcycle <sup>(2)</sup> at $T_A = 105$ °C   | 10                 |         |
|                  |                | 10 kcycles <sup>(2)</sup> at $T_A = 55$ °C  | 20                 |         |

1. Guaranteed by characterization results.

2. Cycling performed over the whole temperature range.

### 6.3.10 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 45](#). They are based on the EMS levels and classes defined in application note AN1709.

**Table 45. EMS characteristics**

| Symbol     | Parameter   | Conditions  | Level/Class |
|------------|---|---|-------------|
| $V_{FESD}$ | Voltage limits to be applied on any I/O pin to induce a functional disturbance  | $V_{DD} = 1.8\text{ V}$ , LQFP100, $T_A = +25\text{ °C}$ ,<br>$f_{HCLK} = 72\text{ MHz}$<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 | $V_{DD} = 1.8\text{ V}$ , LQFP100, $T_A = +25\text{ °C}$ ,<br>$f_{HCLK} = 72\text{ MHz}$<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 prequalification 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 are 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 46. EMI characteristics**

| Symbol           | Parameter  | Conditions  | Monitored frequency band | Max vs. [f <sub>HSE</sub> /f <sub>HCLK</sub> ] | Unit |
|------------------|------------|---|--------------------------|--|------|
|                  |            |   |                          | 8/72 MHz                                       |      |
| S <sub>EMI</sub> | Peak level | V <sub>DD</sub> - 1.8 V, T <sub>A</sub> - 25 °C, LQFP100 package compliant with IEC 61967-2 | 0.1 to 30 MHz            | 16   | dBμV |
|                  |            |   | 30 to 130 MHz            | 20   |      |
|                  |            |   | 130 MHz to 1 GHz         | 26   |      |
|                  |            |   | SAE EMI Level            | 4  | -    |

### 6.3.11 Electrical sensitivity characteristics

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/C101 standard.

**Table 47. ESD absolute maximum ratings**

| Symbol                | Ratings   | Conditions  | Class | Maximum value <sup>(1)</sup> | Unit |
|-----------------------|---|---|-------|------------------------------|------|
| V <sub>ESD(HBM)</sub> | Electrostatic discharge voltage (human body model)    | T <sub>A</sub> = +25 °C, conforming to JESD22-A114  | 2     | 2000                         | V    |
| V <sub>ESD(CDM)</sub> | Electrostatic discharge voltage (charge device model) | T <sub>A</sub> = +25 °C, conforming to ANSI/ESD STM5.3.1, LQFP100, LQFP64, LQFP48 and BGA100 packages | II    | 500                          |      |
|                       |   | T <sub>A</sub> = +25 °C, conforming to JESD22-C101, WLCSP66 package                                   | II    | 250                          |      |

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 78A IC latch-up standard.

**Table 48. Electrical sensitivities**

| Symbol | Parameter             | Conditions   | Class      |
|--------|-----------------------|--|------------|
| LU     | Static latch-up class | $T_A = +105\text{ }^{\circ}\text{C}$ conforming to JESD78A | II level A |

### 6.3.12 I/O current injection characteristics

As a general rule, current injection to the I/O pins, due to external voltage below  $V_{SS}$  or above  $V_{DD}$  (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 (higher than 5 LSB TUE), out of conventional limits of induced leakage current on adjacent pins (out of  $-5\text{ }\mu\text{A}/+0\text{ }\mu\text{A}$  range), or other functional failure (for example reset occurrence or oscillator frequency deviation).

The test results are given in [Table 49](#).

Table 49. I/O current injection susceptibility

| Symbol           | Description   | Functional susceptibility |                    | Unit |
|------------------|---|---------------------------|--------------------|------|
|                  |   | Negative injection        | Positive injection |      |
| I <sub>INJ</sub> | Injected current on BOOT0 pin   | -0                        | NA                 | mA   |
|                  | Injected current on PC0 pin   | -0                        | +5                 |      |
|                  | Injected current on TC type I/O pins on VDDSD12 power domain: PE7, PE8, PE9, PE10, PE11, PE12, PE13, PE14, PE15, PB10 with induced leakage current on other pins from this group less than -50 µA | -5                        | +5                 |      |
|                  | Injected current on TC type I/O pins on VDDSD3 power domain: PB14, PB15, PD8, PD9, PD10, PD12, PD13, PD14, PD15 with induced leakage current on other pins from this group less than -50 µA       | -5                        | +5                 |      |
|                  | Injected current on TTa type pins: PA4, PA5, PA6 with induced leakage current on adjacent pins less than -10 µA   | -5                        | +5                 |      |
|                  | Injected current NPOR pin and on any other FT and FTf pins  | -5                        | NA                 |      |
|                  | Injected current on any other pins  | -5                        | +5                 |      |

**Note:** *It is recommended to add a Schottky diode (pin to ground) to analog pins which may potentially inject negative currents.*

### 6.3.13 I/O port characteristics

#### General input/output characteristics

Unless otherwise specified, the parameters given in [Table 50](#) are derived from tests performed under the conditions summarized in [Table 22](#). All I/Os are CMOS and TTL compliant.

**Table 50. I/O static characteristics <sup>(1)</sup>**

| Symbol    | Parameter   | Conditions   | Min                       | Typ         | Max                     | Unit       |
|-----------|---|--|---------------------------|-------------|-------------------------|------------|
| $V_{IL}$  | Low level input voltage                           | TC and TTa I/O   | -                         | -           | $0.3V_{DD}+0.07^{(2)}$  | V          |
|           |   | FT and FTf I/O   | -                         | -           | $0.475V_{DD}-0.2^{(2)}$ |            |
|           |   | BOOT0  | -                         | -           | $0.3V_{DD}-0.3^{(2)}$   |            |
|           |   | All I/Os except BOOT0 pin  | -                         | -           | $0.3V_{DD}$             |            |
| $V_{IH}$  | High level input voltage                          | TC and TTa I/O   | $0.445V_{DD}+0.398^{(2)}$ | -           | -                       | V          |
|           |   | FT and FTf I/O   | $0.5V_{DD}+0.2^{(2)}$     | -           | -                       |            |
|           |   | BOOT0  | $0.2V_{DD}+0.95^{(2)}$    | -           | -                       |            |
|           |   | All I/Os except BOOT0 pin  | $0.7V_{DD}$               | -           | -                       |            |
| $V_{hys}$ | Schmitt trigger hysteresis                        | TC and TTa I/O   | -                         | $200^{(2)}$ | -                       | mV         |
|           |   | FT and FTf I/O   | -                         | $100^{(2)}$ | -                       |            |
|           |   | BOOT0  | -                         | $300^{(2)}$ | -                       |            |
| $I_{Ikg}$ | Input leakage current <sup>(3)</sup>              | TC, FT, FTf and POR I/O<br>TTa in digital mode<br>$V_{SS} \leq V_{IN} \leq V_{DD}$ | -                         | -           | $\pm 0.1$               | $\mu A$    |
|           |   | TTa in digital mode<br>$V_{DD} \leq V_{IN} \leq V_{DDA}$                           | -                         | -           | 1                       |            |
|           |   | TTa in analog mode<br>$V_{SS} \leq V_{IN} \leq V_{DDA}$                            | -                         | -           | $\pm 0.2$               |            |
|           |   | FT and FTf I/O <sup>(3)</sup><br>$V_{DD} \leq V_{IN} \leq 5 V$                     | -                         | -           | 10                      |            |
|           |   | POR<br>$V_{DDA} \leq V_{IN} \leq 5 V$  | -                         | -           | 10                      |            |
| $R_{PU}$  | Weak pull-up equivalent resistor <sup>(4)</sup>   | $V_{IN} = V_{SS}$  | 25                        | 40          | 55                      | k $\Omega$ |
| $R_{PD}$  | Weak pull-down equivalent resistor <sup>(4)</sup> | $V_{IN} = V_{DD}$  | 25                        | 40          | 55                      |            |
| $C_{IO}$  | I/O pin capacitance                               | -  | -                         | 5           | -                       | pF         |

1. VDDSD12 is the external power supply for the PB10, and PE7 to PE15 I/O pins (the I/O pin ground is internally connected to VSS). VDDSD3 is the external power supply for PB14 to PB15 and PD8 to PD15 I/O pins (the I/O pin ground is internally connected to VSS). For those pins all  $V_{DD}$  supply references in this table are related to their given VDDSDx power supply.

2. Guaranteed by design.

3. Leakage could be higher than maximum value, if negative current is injected on adjacent pins.

4. 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 minimal (~10% order).

Note: I/O pins are powered from  $V_{DD}$  voltage except pins which can be used as SDADC inputs:

- The PB10 and PE7 to PE15 I/O pins are powered from  $V_{DDSD12}$ .
- PB14 to PB15 and PD8 to PD15 I/O pins are powered from  $V_{DDSD3}$ . All I/O pin ground is internally connected to  $V_{SS}$ .

$V_{DD}$  mentioned in the Table 50 represents power voltage for a given I/O pin ( $V_{DD}$  or  $V_{DDSD12}$  or  $V_{DDSD3}$ ).

All I/Os are CMOS and TTL compliant (no software configuration required). Their characteristics cover more than the strict CMOS-technology parameters. The coverage of these requirements is shown in Figure 18 for standard I/Os, and in Figure 19 for 5 V tolerant I/Os. The following curves are design simulation results, not tested in production.

Figure 18. TC and TTa I/O input characteristics

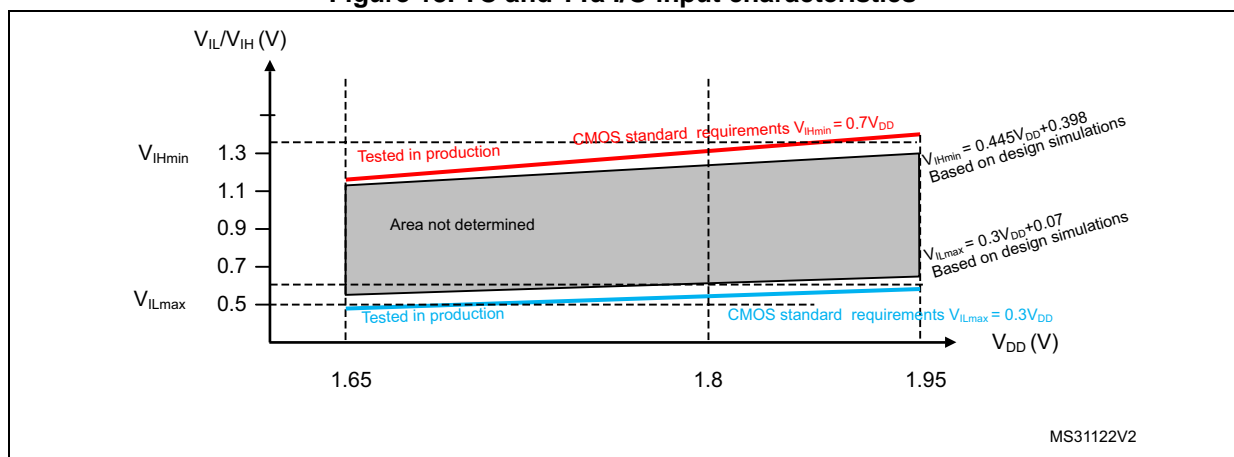
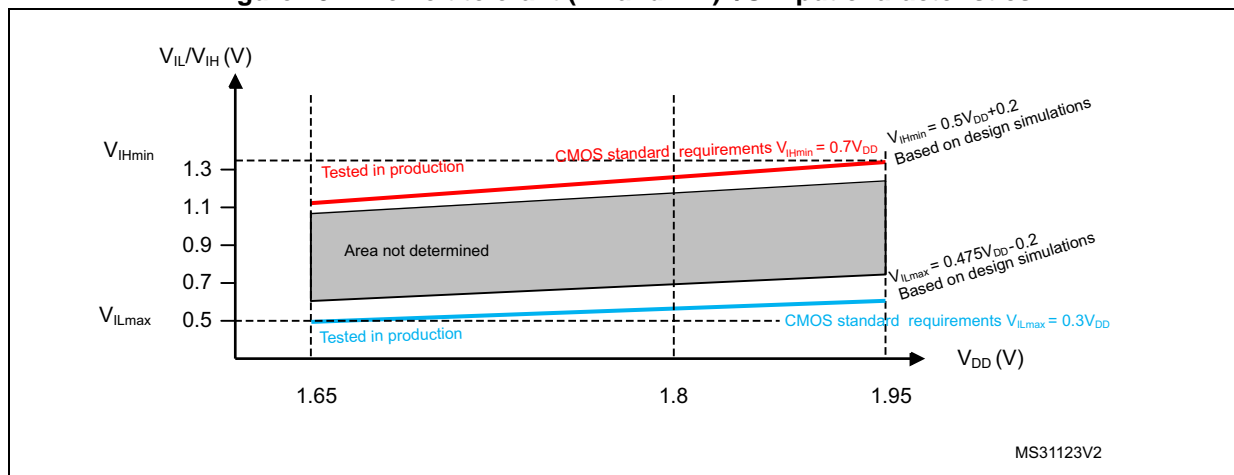


Figure 19. Five volt tolerant (FT and FTf) I/O input characteristics



### 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  $V_{OL}/V_{OH}$ ).

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 6.2](#):

- The sum of the currents sourced by all the I/Os on all VDD\_x and VDDSDx, plus the maximum Run consumption of the MCU sourced on V<sub>DD</sub> cannot exceed the absolute maximum rating SI<sub>VDD</sub> (see [Table 20](#)).
- The sum of the currents sunk by all the I/Os on all VSS\_x and VSSSD, plus the maximum Run consumption of the MCU sunk on V<sub>SS</sub> cannot exceed the absolute maximum rating SI<sub>VSS</sub> (see [Table 20](#)).

### Output voltage levels

Unless otherwise specified, the parameters given in [Table 51](#) are derived from tests performed under ambient temperature and V<sub>DD</sub> supply voltage conditions summarized in [Table 22](#). All I/Os are CMOS and TTL compliant (FT, TTa or TC unless otherwise specified).

**Table 51. Output voltage characteristics <sup>(1)</sup>**

| Symbol                            | Parameter   | Conditions  | Min                  | Max | Unit |
|-----------------------------------|---|---|----------------------|-----|------|
| V <sub>OL</sub> <sup>(2)</sup>    | Output low level voltage for an I/O pin                                   | I <sub>IO</sub> = +4 mA<br>1.65 V < V <sub>DD</sub> < 1.95 V  | -                    | 0.4 | V    |
| V <sub>OH</sub> <sup>(3)</sup>    | Output high level voltage for an I/O pin                                  | I <sub>IO</sub> = +4 mA<br>1.65 V < V <sub>DD</sub> < 1.95 V  | V <sub>DD</sub> -0.4 | -   |      |
| V <sub>OL</sub> <sup>(2)(4)</sup> | Output low level voltage for an I/O pin powered by VDDSDx <sup>(1)</sup>  | I <sub>IO</sub> = +8 mA<br>2.7 V < VDDSDx < 3.6 V             | -                    | 0.4 |      |
| V <sub>OH</sub> <sup>(3)(4)</sup> | Output high level voltage for an I/O pin powered by VDDSDx <sup>(1)</sup> |   | VDDSDx-0.4           | -   |      |
| V <sub>OL</sub> <sup>(2)(4)</sup> | Output low level voltage for an I/O pin powered by VDDSDx <sup>(1)</sup>  | I <sub>IO</sub> = +20 mA<br>2.7 V < VDDSDx < 3.6 V            | -                    | 1.3 |      |
| V <sub>OH</sub> <sup>(3)(4)</sup> | Output high level voltage for an I/O pin powered by VDDSDx <sup>(1)</sup> |   | VDDSDx-1.3           | -   |      |
| V <sub>OLFM+</sub> <sup>(2)</sup> | Output low level voltage for a FTf I/O pins in FM+ mode                   | I <sub>IO</sub> = +10 mA<br>1.65 V < V <sub>DD</sub> < 1.95 V | -                    | 0.4 |      |

1. VDDSD12 is the external power supply for the PB10, and PE7 to PE15 I/O pins (the I/O pin ground is internally connected to VSS). VDDSD3 is the external power supply for PB14 to PB15 and PD8 to PD15 I/O pins (the I/O pin ground is internally connected to VSS). For those pins all V<sub>DD</sub> supply references in this table are related to their given VDDSDx power supply.
2. The I<sub>IO</sub> current sunk by the device must always respect the absolute maximum rating specified in [Table 20](#) and the sum of I<sub>IO</sub> (I/O ports and control pins) must not exceed I<sub>VSS(Σ)</sub>.
3. The I<sub>IO</sub> current sourced by the device must always respect the absolute maximum rating specified in [Table 20](#) and the sum of I<sub>IO</sub> (I/O ports and control pins) must not exceed I<sub>VDD(Σ)</sub>.
4. Guaranteed by design.

**Note:** I/O pins are powered from V<sub>DD</sub> voltage except pins which can be used as SDADC inputs:

- The PB10 and PE7 to PE15 I/O pins are powered from V<sub>DDSD12</sub>.
- PB14 to PB15 and PD8 to PD15 I/O pins are powered from V<sub>DDSD3</sub>. All I/O pin ground is internally connected to V<sub>SS</sub>.

V<sub>DD</sub> mentioned in the [Table 51](#) represents power voltage for a given I/O pin (V<sub>DD</sub> or V<sub>DDSD12</sub> or V<sub>DDSD3</sub>).

### Input/output AC characteristics

The definition and values of input/output AC characteristics are given in [Figure 20](#) and [Table 52](#), respectively.

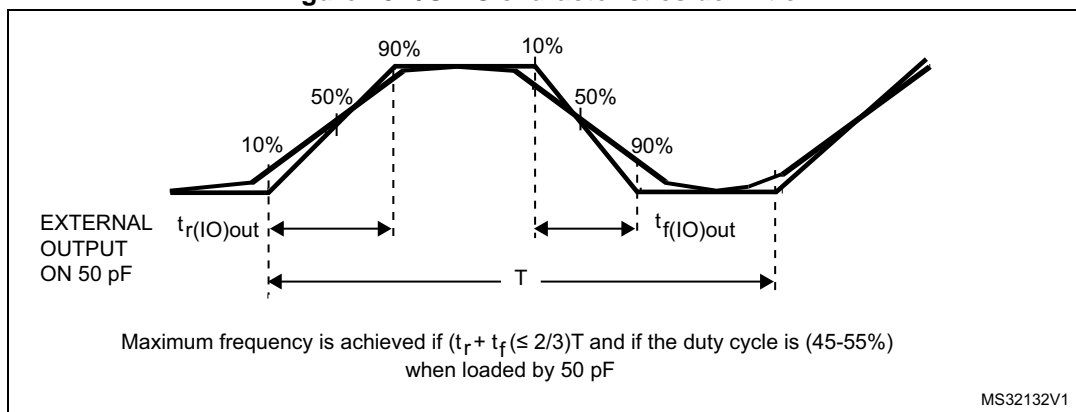
Unless otherwise specified, the parameters given are derived from tests performed under ambient temperature and  $V_{DD}$  supply voltage conditions summarized in [Table 22](#).

**Table 52. I/O AC characteristics<sup>(1)</sup>**

| OSPEEDRy<br>[1:0] value <sup>(1)</sup> | Symbol                          | Parameter   | Conditions   | Min | Max                | Unit |
|--|---------------------------------|---|--|-----|--------------------|------|
| x0                                     | $f_{\max(\text{IO})\text{out}}$ | Maximum frequency <sup>(2)</sup>                                | $C_L = 50 \text{ pF}$ , $V_{DD} = 1.65 \text{ V to } 1.95 \text{ V}$ | -   | 1                  | MHz  |
|  | $t_{f(\text{IO})\text{out}}$    | Output high to low level fall time                              | $C_L = 50 \text{ pF}$ , $V_{DD} = 1.65 \text{ V to } 1.95 \text{ V}$ | -   | 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>                                | $C_L = 50 \text{ pF}$ , $V_{DD} = 1.65 \text{ V to } 1.95 \text{ V}$ | -   | 4                  | MHz  |
|  | $t_{f(\text{IO})\text{out}}$    | Output high to low level fall time                              | $C_L = 50 \text{ pF}$ , $V_{DD} = 1.65 \text{ V to } 1.95 \text{ V}$ | -   | 62.5               | ns   |
|  | $t_{r(\text{IO})\text{out}}$    | Output low to high level rise time                              |  | -   | 62.5               |      |
| 11                                     | $f_{\max(\text{IO})\text{out}}$ | Maximum frequency <sup>(2)(3)</sup>                             | $C_L = 50 \text{ pF}$ , $V_{DD} = 1.65 \text{ V to } 1.95 \text{ V}$ | -   | 10                 | MHz  |
|  | $t_{f(\text{IO})\text{out}}$    | Output high to low level fall time                              | $C_L = 50 \text{ pF}$ , $V_{DD} = 1.65 \text{ V to } 1.95 \text{ V}$ | -   | 25                 | ns   |
|  | $t_{r(\text{IO})\text{out}}$    | Output low to high level rise time                              | $C_L = 50 \text{ pF}$ , $V_{DD} = 1.65 \text{ V to } 1.95 \text{ V}$ | -   | 25                 |      |
| FM+<br>configuration<br>(4)            | $f_{\max(\text{IO})\text{out}}$ | Maximum frequency <sup>(2)</sup>                                | $C_L = 50 \text{ pF}$ , $V_{DD} = 1.65 \text{ V to } 1.95 \text{ V}$ | -   | 0.5                | MHz  |
|  | $t_{f(\text{IO})\text{out}}$    | Output high to low level fall time                              |  | -   | 16                 | ns   |
|  | $t_{r(\text{IO})\text{out}}$    | Output low to high level rise time                              |  | -   | 44                 |      |
| -                                      | $t_{\text{EXTI}pw}$             | Pulse width of external signals detected by the EXTI controller | -  | 10  | -                  | ns   |

1. The I/O speed is configured using the OSPEEDRx[1:0] bits. Refer to the RM0313 reference manual for a description of GPIO Port configuration register.
2. The maximum frequency is defined in [Figure 20](#).
3. Guaranteed by design.
4. The I/O speed configuration is bypassed in FM+ I/O mode. Refer to the STM32F37xx reference manual RM0313 for a description of FM+ I/O mode configuration

Figure 20. I/O AC characteristics definition



### 6.3.14 NRST and NPOR pins characteristics

#### NRST pin characteristics

The NRST pin input driver uses CMOS technology. It is connected to a permanent pull-up resistor,  $R_{PU}$  (see [Table 50](#)).

Unless otherwise specified, the parameters given in [Table 53](#) are derived from tests performed under ambient temperature and  $V_{DD}$  supply voltage conditions summarized in [Table 22](#).

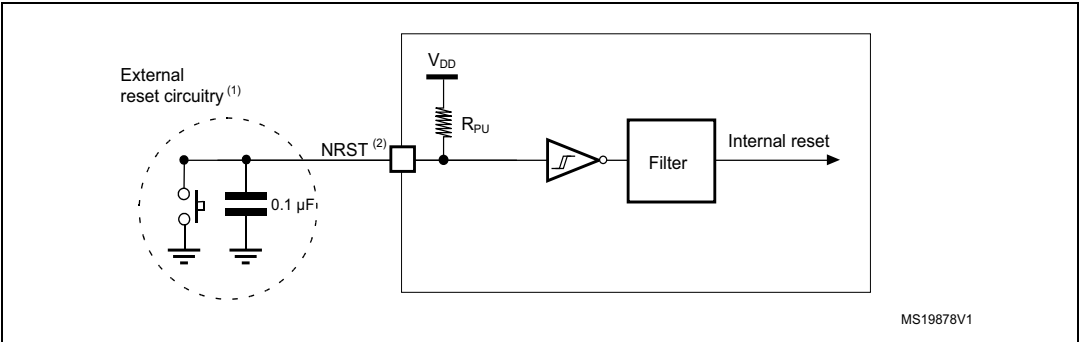
Table 53. NRST pin characteristics

| Symbol                | Parameter                                       | Conditions        | Min                         | Typ | Max                      | Unit       |
|-----------------------|---|-------------------|-----------------------------|-----|--------------------------|------------|
| $V_{IL(NRST)}^{(1)}$  | NRST Input low level voltage                    | -                 | -                           | -   | $0.3V_{DD} + 0.07^{(1)}$ | V          |
| $V_{IH(NRST)}^{(1)}$  | NRST Input high level voltage                   | -                 | $0.445V_{DD} + 0.398^{(1)}$ | -   | -                        |            |
| $V_{hys(NRST)}^{(1)}$ | NRST Schmitt trigger voltage hysteresis         | -                 | -                           | 200 | -                        | mV         |
| $R_{PU}$              | Weak pull-up equivalent resistor <sup>(2)</sup> | $V_{IN} = V_{SS}$ | 25                          | 40  | 55                       | k $\Omega$ |
| $V_{F(NRST)}^{(1)}$   | NRST Input filtered pulse                       | -                 | -                           | -   | 100                      | ns         |
| $V_{NF(NRST)}^{(1)}$  | NRST Input not filtered pulse                   | -                 | 700                         | -   | -                        | 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 is minimal (~10% order).

Figure 21. 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 53](#). Otherwise the reset will not be taken into account by the device.

### NPOR pin characteristics

The NPOR pin input driver uses CMOS technology. It is connected to a permanent pull-up resistor to the  $V_{DDA}$ ,  $R_{PU}$  (see [Table 50](#)).

Unless otherwise specified, the parameters given in [Table 54](#) are derived from tests performed under ambient temperature and  $V_{DDA}$  supply voltage conditions summarized in [Table 22](#).

Table 54. NPOR pin characteristics

| Symbol                | Parameter                                       | Conditions        | Min                | Typ | Max                  | Unit |
|-----------------------|---|-------------------|--------------------|-----|----------------------|------|
| $V_{IL(NPOR)}^{(1)}$  | NPOR Input low level voltage                    | -                 | -                  | -   | $0.475V_{DDA} - 0.2$ | V    |
| $V_{IH(NPOR)}^{(1)}$  | NPOR Input high level voltage                   | -                 | $0.5V_{DDA} + 0.2$ | -   | -                    |      |
| $V_{hys(NPOR)}^{(1)}$ | NPOR Schmitt trigger voltage hysteresis         | -                 | -                  | 100 | -                    | mV   |
| $R_{PU}$              | Weak pull-up equivalent resistor <sup>(2)</sup> | $V_{IN} = V_{SS}$ | 25                 | 40  | 55                   | kΩ   |

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 is minimal (~10% order).



### 6.3.15 Communications interfaces

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

The 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 55](#). Refer also to [Section 6.3.13: I/O port characteristics](#) for more details on the input/output alternate function characteristics (SDA and SCL).

**Table 55. I<sup>2</sup>C characteristics<sup>(1)</sup>**

| Symbol              | Parameter  | Standard |                     | Fast mode |                    | Fast mode + |                     | Unit |
|---------------------|--|----------|---------------------|-----------|--------------------|-------------|---------------------|------|
|                     |  | Min      | Max                 | Min       | Max                | Min         | Max                 |      |
| f <sub>SCL</sub>    | SCL clock frequency                              | 0        | 100                 | 0         | 400                | 0           | 1000                | KHz  |
| t <sub>LOW</sub>    | Low period of the SCL clock                      | 4.7      | -                   | 1.3       | -                  | 0.5         | -                   | μs   |
| t <sub>HIGH</sub>   | High Period of the SCL clock                     | 4        | -                   | 0.6       | -                  | 0.26        | -                   | μs   |
| t <sub>r</sub>      | Rise time of both SDA and SCL signals            | -        | 1000                | -         | 300                | -           | 120                 | ns   |
| t <sub>f</sub>      | Fall time of both SDA and SCL signals            | -        | 300                 | -         | 300                | -           | 120                 | ns   |
| t <sub>HD;DAT</sub> | Data hold time                                   | 0        | -                   | 0         | -                  | 0           | -                   | μs   |
| t <sub>VD;DAT</sub> | Data valid time                                  | -        | 3.45 <sup>(2)</sup> | -         | 0.9 <sup>(2)</sup> | -           | 0.45 <sup>(2)</sup> | μs   |
| t <sub>VD;ACK</sub> | Data valid acknowledge time                      | -        | 3.45 <sup>(2)</sup> | -         | 0.9 <sup>(2)</sup> | -           | 0.45 <sup>(2)</sup> | μs   |
| t <sub>SU;DAT</sub> | Data setup time                                  | 250      | -                   | 100       | -                  | 50          | -                   | ns   |
| t <sub>HD;STA</sub> | Hold time (repeated) START condition             | 4.0      | -                   | 0.6       | -                  | 0.26        | -                   | μs   |
| t <sub>SU;STA</sub> | Set-up time for a repeated START condition       | 4.7      | -                   | 0.6       | -                  | 0.26        | -                   | μs   |
| t <sub>SU;STO</sub> | Set-up time for STOP condition                   | 4.0      | -                   | 0.6       | -                  | 0.26        | -                   | μs   |
| t <sub>BUF</sub>    | Bus free time between a STOP and START condition | 4.7      | -                   | 1.3       | -                  | 0.5         | -                   | μs   |
| C <sub>b</sub>      | Capacitive load for each bus line                | -        | 400                 | -         | 400                | -           | 550                 | pF   |

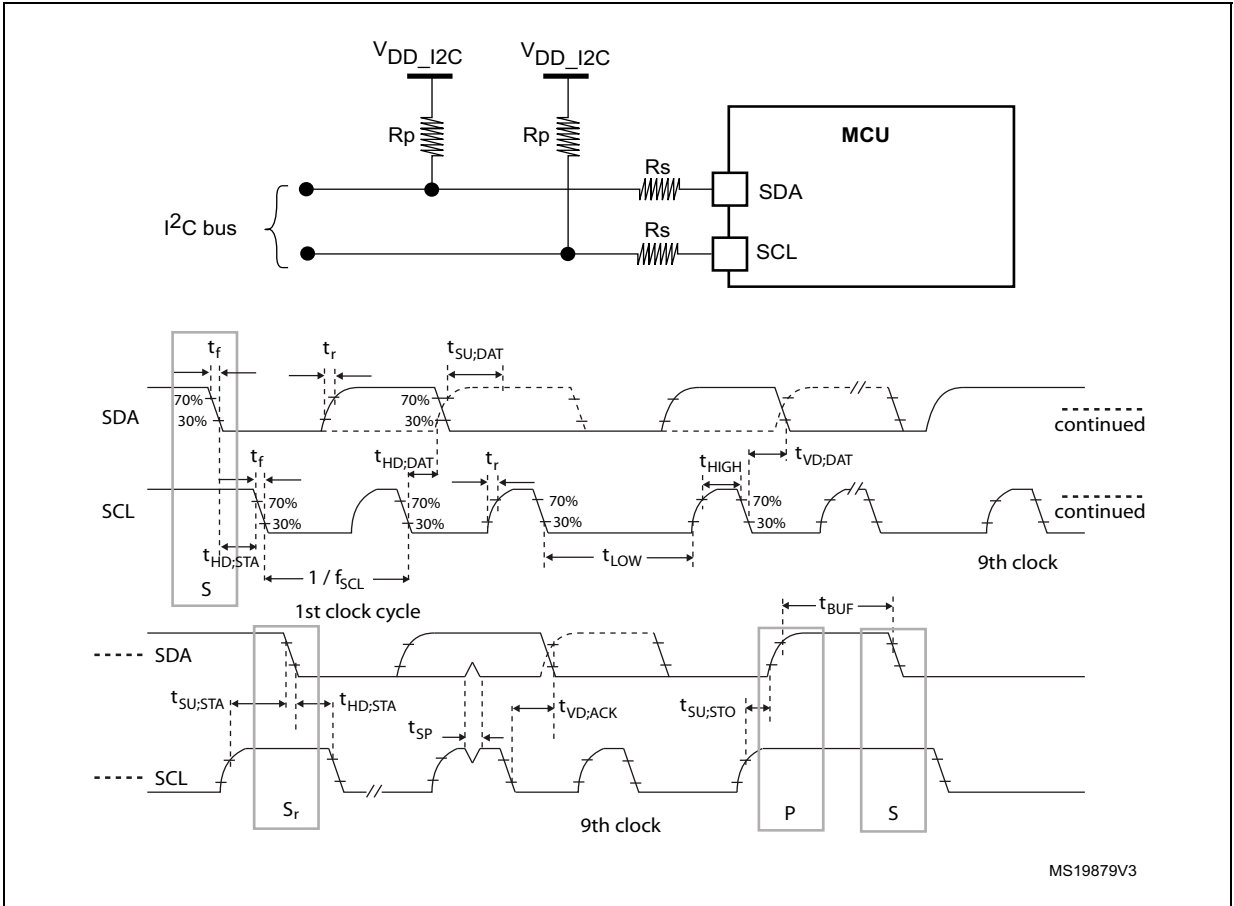
1. The I<sup>2</sup>C characteristics are the requirements from the I<sup>2</sup>C bus specification rev03. They are guaranteed by design when the I2Cx\_TIMING register is correctly programmed (refer to reference manual). These characteristics are not tested in production.
2. The maximum t<sub>HD;DAT</sub> could be 3.45 μs, 0.9 μs and 0.45 μs for standard mode, fast mode and fast mode plus, but must be less than the maximum of t<sub>VD;DAT</sub> or t<sub>VD;ACK</sub> by a transition time.

Table 56. I<sup>2</sup>C analog filter characteristics<sup>(1)</sup>

| Symbol   | Parameter  | Min               | Max                | Unit |
|----------|--|-------------------|--------------------|------|
| $t_{AF}$ | Maximum pulse width of spikes that are suppressed by the analog filter | 50 <sup>(2)</sup> | 260 <sup>(3)</sup> | ns   |

1. Guaranteed by design.
2. Spikes width below  $t_{AF}(\min)$  are filtered.
3. Spikes width above  $t_{AF}(\max)$  are not filtered.

Figure 22. I<sup>2</sup>C bus AC waveforms and measurement circuit



1. Legend: Rs: Series protection resistors. Rp: Pull-up resistors.  $V_{DD\_I2C}$ : I2C bus supply.

## SPI/I<sup>2</sup>S characteristics

Unless otherwise specified, the parameters given in [Table 57](#) for SPI or in [Table 58](#) for I<sup>2</sup>S are derived from tests performed under ambient temperature,  $f_{\text{PCLKx}}$  frequency and  $V_{\text{DD}}$  supply voltage conditions summarized in [Table 22](#).

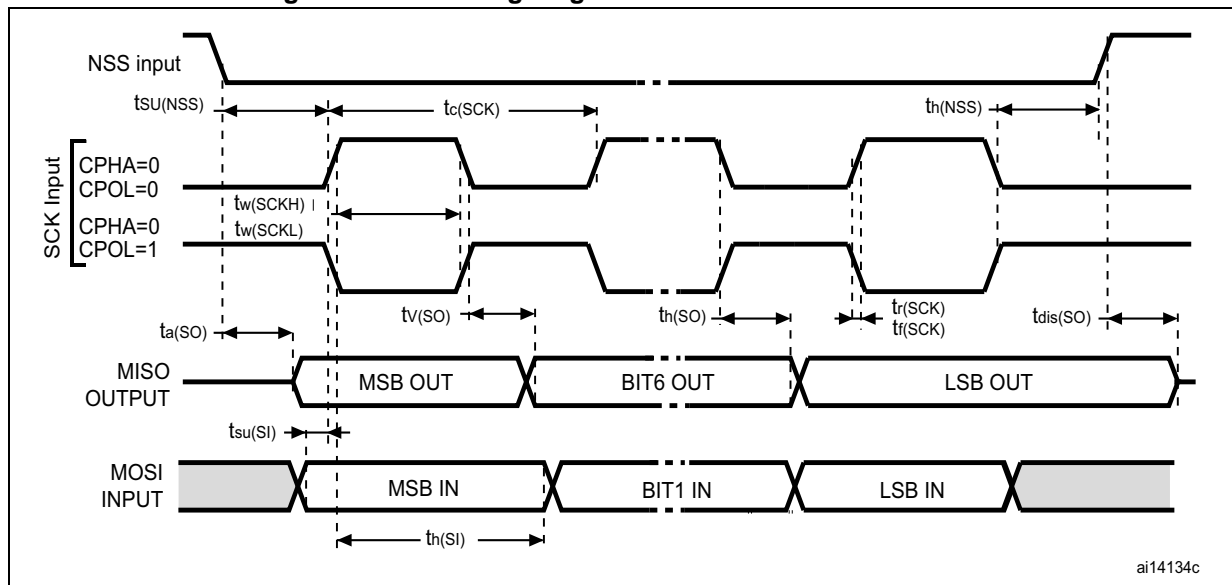
Refer to [Section 6.3.13: I/O port characteristics](#) for more details on the input/output alternate function characteristics (NSS, SCK, MOSI, MISO for SPI and WS, CK, SD for I<sup>2</sup>S).

**Table 57. SPI characteristics**

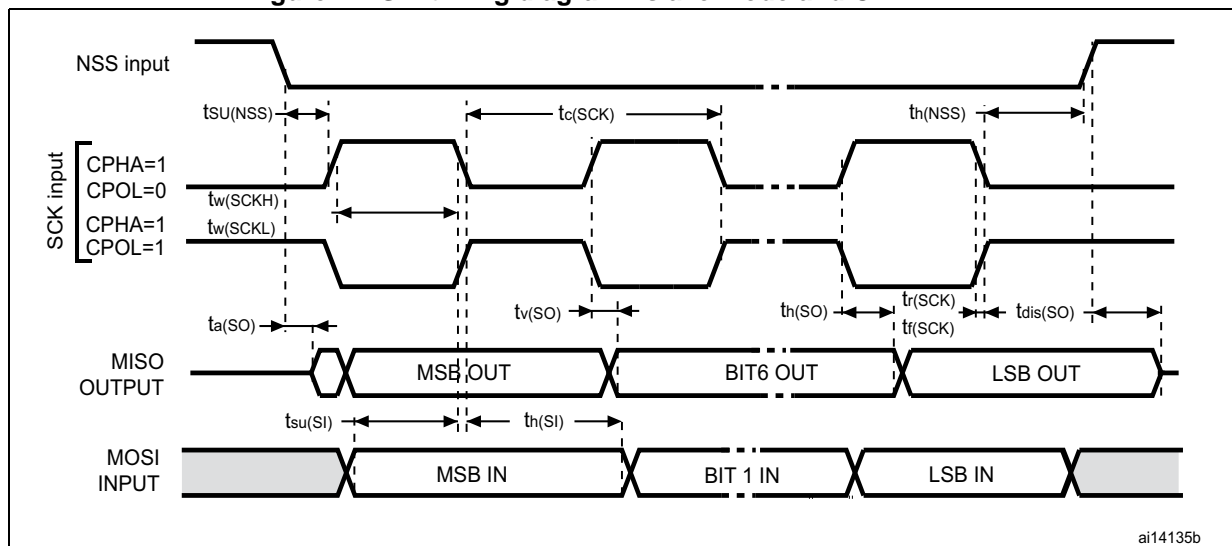
| Symbol   | Parameter                        | Conditions   | Min                         | Max                         | Unit |
|--|----------------------------------|--|-----------------------------|-----------------------------|------|
| $f_{\text{SCK}}$<br>$1/t_{\text{c(SCK)}}^{(1)}$          | SPI clock frequency              | Master mode (C = 30 pF)  | -                           | 18                          | MHz  |
|  |                                  | Slave mode   | -                           | 18                          |      |
| $t_{\text{r(SCK)}}^{(1)}$<br>$t_{\text{f(SCK)}}^{(1)}$   | SPI clock rise and fall time     | Capacitive load: C = 30 pF                                     | -                           | 8                           | ns   |
| $\text{DuCy(SCK)}^{(1)}$                                 | SPI slave input clock duty cycle | Slave mode   | 30                          | 70                          | %    |
| $t_{\text{su(NSS)}}^{(1)}$                               | NSS setup time                   | Slave mode   | 2T <sub>pclk</sub>          | -                           | ns   |
| $t_{\text{h(NSS)}}^{(1)}$                                | NSS hold time                    | Slave mode   | 4T <sub>pclk</sub>          | -                           |      |
| $t_{\text{w(SCKH)}}^{(1)}$<br>$t_{\text{w(SCKL)}}^{(1)}$ | SCK high and low time            | Master mode, $f_{\text{PCLK}} = 36 \text{ MHz}$ ,<br>presc = 4 | T <sub>pclk</sub> /2<br>- 3 | T <sub>pclk</sub> /2<br>+ 3 |      |
| $t_{\text{su(MI)}}^{(1)}$<br>$t_{\text{su(SI)}}^{(1)}$   | Data input setup time            | Master mode  | 5.5                         | -                           |      |
|  |                                  | Slave mode   | 6.5                         | -                           |      |
| $t_{\text{h(MI)}}^{(1)}$<br>$t_{\text{h(SI)}}^{(1)}$     | Data input hold time             | Master mode  | 5                           | -                           |      |
|  |                                  | Slave mode   | 5                           | -                           |      |
| $t_{\text{a(SO)}}^{(1)(2)}$                              | Data output access time          | Slave mode, $f_{\text{PCLK}} = 24 \text{ MHz}$                 | 0                           | 4T <sub>pclk</sub>          |      |
| $t_{\text{dis(SO)}}^{(1)(3)}$                            | Data output disable time         | Slave mode   | 0                           | 24                          |      |
| $t_{\text{v(SO)}}^{(1)}$                                 | Data output valid time           | Slave mode (after enable edge)                                 | -                           | 39                          |      |
| $t_{\text{v(MO)}}^{(1)}$                                 | Data output valid time           | Master mode (after enable edge)                                | -                           | 3                           |      |
| $t_{\text{h(SO)}}^{(1)}$<br>$t_{\text{h(MO)}}^{(1)}$     | Data output hold time            | Slave mode (after enable edge)                                 | 15                          | -                           |      |
|  |                                  | Master mode (after enable edge)                                | 4                           | -                           |      |

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 23. SPI timing diagram - slave mode and CPHA = 0

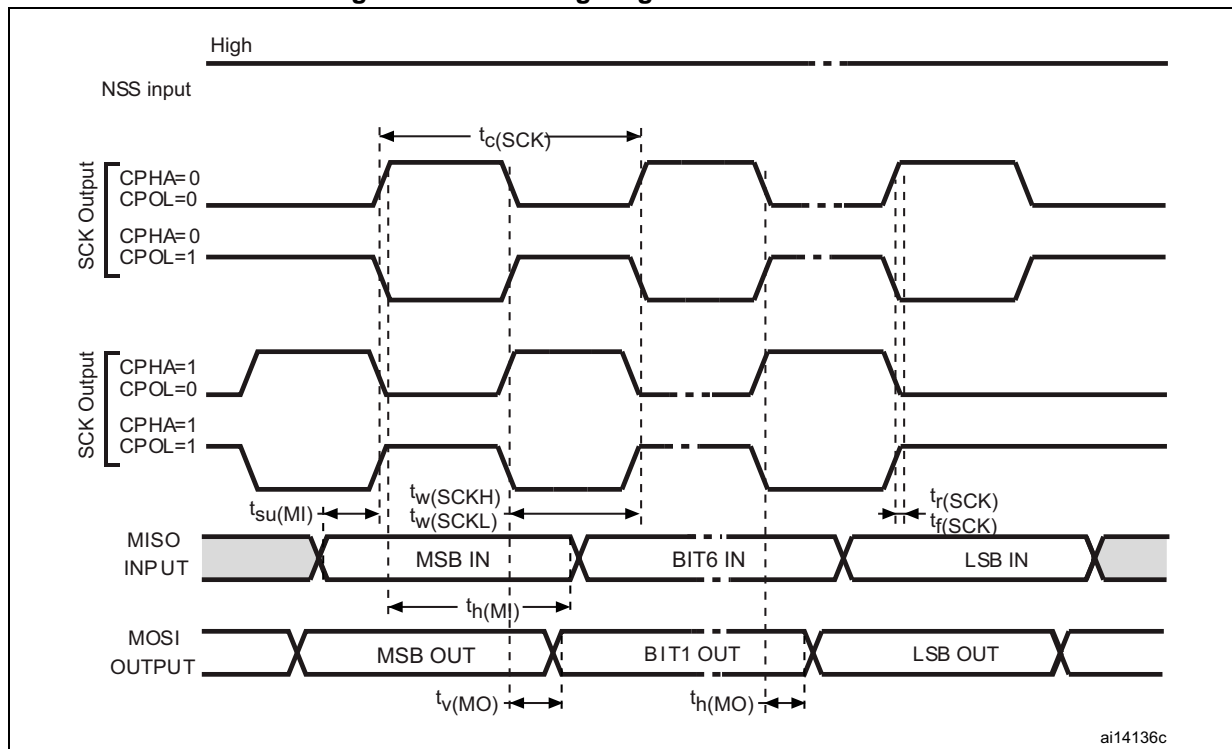


ai14134c

Figure 24. SPI timing diagram - slave mode and CPHA = 1<sup>(1)</sup>

ai14135b

1. Measurement points are done at  $0.5V_{DD}$  level and with external  $C_L = 30$  pF.

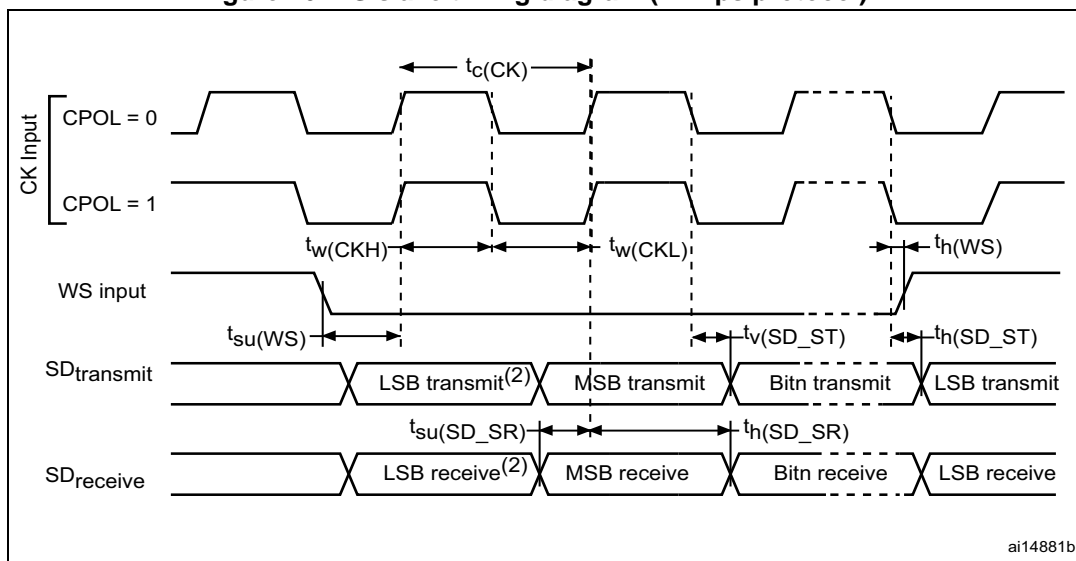
Figure 25. SPI timing diagram - master mode<sup>(1)</sup>

1. Measurement points are done at  $0.5V_{DD}$  level and with external  $C_L = 30 \text{ pF}$ .

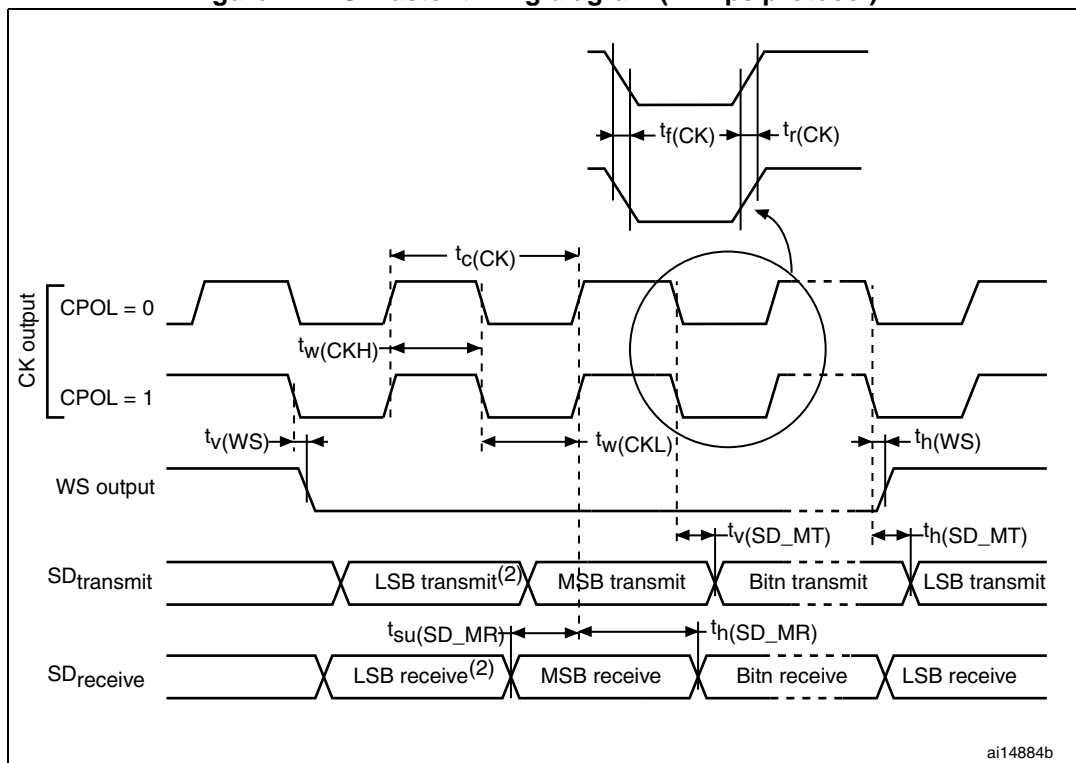
Table 58. I<sup>2</sup>S characteristics

| Symbol                           | Parameter                                 | Conditions  | Min   | Max    | Unit |
|----------------------------------|---|---|-------|--------|------|
| DuCy(SCK) <sup>(1)</sup>         | I2S slave input clock duty cycle          | Slave mode  | 30    | 70     | %    |
| $f_{CK}^{(1)}$<br>$1/t_{c(CK)}$  | I <sup>2</sup> S clock frequency          | Master mode (data: 16 bits, Audio frequency = 48 kHz) | 1.528 | 1.539  | MHz  |
|                                  |   | Slave mode  | 0     | 12.288 |      |
| $t_{r(CK)}^{(1)}$<br>$t_{f(CK)}$ | I <sup>2</sup> S clock rise and fall time | Capacitive load $C_L = 30$ pF                         | -     | 8      | ns   |
| $t_{v(WS)}^{(1)}$                | WS valid time                             | Master mode   | 4     | -      |      |
| $t_{h(WS)}^{(1)}$                | WS hold time                              | Master mode   | 4     | -      |      |
| $t_{su(WS)}^{(1)}$               | WS setup time                             | Slave mode  | 2     | -      |      |
| $t_{h(WS)}^{(1)}$                | WS hold time                              | Slave mode  | -     | -      |      |
| $t_{w(CKH)}^{(1)}$               | I2S clock high time                       | Master $f_{PCLK} = 16$ MHz, audio frequency = 48 kHz  | 306   | -      |      |
| $t_{w(CKL)}^{(1)}$               | I2S clock low time                        |   | 312   | -      |      |
| $t_{su(SD\_MR)}^{(1)}$           | Data input setup time                     | Master receiver                                       | 6     | -      |      |
| $t_{su(SD\_SR)}^{(1)}$           |   | Slave receiver  | 3     | -      |      |
| $t_{h(SD\_MR)}^{(1)}$            | Data input hold time                      | Master receiver                                       | 1.5   | -      |      |
| $t_{h(SD\_SR)}^{(1)}$            |   | Slave receiver  | 1.5   | -      |      |
| $t_{v(SD\_ST)}^{(1)}$            | Data output valid time                    | Slave transmitter (after enable edge)                 | -     | 16     |      |
| $t_{h(SD\_ST)}^{(1)}$            | Data output hold time                     | Slave transmitter (after enable edge)                 | 16    | -      |      |
| $t_{v(SD\_MT)}^{(1)}$            | Data output valid time                    | Master transmitter (after enable edge)                | -     | 2      |      |
| $t_{h(SD\_MT)}^{(1)}$            | Data output hold time                     | Master transmitter (after enable edge)                | 0     | -      |      |

1. Guaranteed by characterization results.

Figure 26. I<sup>2</sup>S slave timing diagram (Philips protocol)<sup>(1)</sup>

1. Measurement points are done at 0.5  $V_{DD}$  level and with external  $C_L = 30$  pF.
2. LSB transmit/receive of the previously transmitted byte. No LSB transmit/receive is sent before the first byte.

Figure 27. I<sup>2</sup>S master timing diagram (Philips protocol)<sup>(1)</sup>

1. Measurement points are done at 0.5  $V_{DD}$  level and with external  $C_L = 30$  pF.
2. LSB transmit/receive of the previously transmitted byte. No LSB transmit/receive is sent before the first byte.

### 6.3.16 12-bit ADC characteristics

Unless otherwise specified, the parameters given in [Table 59](#) are preliminary values derived from tests performed under ambient temperature,  $f_{PCLK2}$  frequency and  $V_{DDA}$  supply voltage conditions summarized in [Table 22](#).

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

**Table 59. ADC characteristics**

| Symbol               | Parameter                                       | Conditions  | Min  | Typ                | Max                | Unit         |
|----------------------|---|---|--|--------------------|--------------------|--------------|
| $V_{DDA}$            | Power supply                                    | -   | 2.4  | -                  | 3.6                | V            |
| $V_{REF+}$           | Positive reference voltage                      | -   | 2.4  | -                  | $V_{DDA}$          | V            |
| $V_{REF-}$           | Negative reference voltage                      | -   | 0  | -                  | -                  | V            |
| $I_{DDA(ADC)}^{(1)}$ | Current consumption from $V_{DDA}$              | $V_{DDA} = 3.3$ V   | -  | 0.9                | -                  | mA           |
| $I_{VREF}$           | Current on the $V_{REF}$ input pin              | -   | -  | 160 <sup>(2)</sup> | 220 <sup>(2)</sup> | μA           |
| $f_{ADC}$            | ADC clock frequency                             | -   | 0.6  | -                  | 14                 | MHz          |
| $f_S^{(3)}$          | Sampling rate                                   | -   | 0.05   | -                  | 1                  | MHz          |
| $f_{TRIG}^{(3)}$     | External trigger frequency                      | $f_{ADC} = 14$ MHz  | -  | -                  | 823                | kHz          |
|                      |   | -   | -  | -                  | 17                 | 1/ $f_{ADC}$ |
| $V_{AIN}$            | Conversion voltage range                        | -   | 0 ( $V_{SSA}$ or $V_{REF-}$ tied to ground)                        | -                  | $V_{REF+}$         | V            |
| $R_{SRC}^{(3)}$      | Signal source impedance                         | See <a href="#">Equation 1</a> and <a href="#">Table 60</a> for details | -  | -                  | 50                 | kΩ           |
| $R_{ADC}^{(3)}$      | Sampling switch resistance                      | -   | -  | -                  | 1                  | kΩ           |
| $C_{ADC}^{(3)}$      | Internal sample and hold capacitor              | -   | -  | -                  | 8                  | pF           |
| $t_{CAL}^{(3)}$      | Calibration time                                | $f_{ADC} = 14$ MHz  | 5.9  |                    |                    | μs           |
|                      |   | -   | 83   |                    |                    | 1/ $f_{ADC}$ |
| $t_{lat}^{(3)}$      | Injection trigger conversion latency            | $f_{ADC} = 14$ MHz  | -  | -                  | 0.214              | μs           |
|                      |   | -   | -  | -                  | 2 <sup>(4)</sup>   | 1/ $f_{ADC}$ |
| $t_{latr}^{(3)}$     | Regular trigger conversion latency              | $f_{ADC} = 14$ MHz  | -  | -                  | 0.143              | μs           |
|                      |   | -   | -  | -                  | 2 <sup>(4)</sup>   | 1/ $f_{ADC}$ |
| $t_S^{(3)}$          | Sampling time                                   | $f_{ADC} = 14$ MHz  | 0.107  | -                  | 17.1               | μs           |
|                      |   | -   | 1.5  | -                  | 239.5              | 1/ $f_{ADC}$ |
| $t_{STAB}^{(3)}$     | Power-up time                                   | -   | -  | -                  | 1                  | μs           |
| $t_{CONV}^{(3)}$     | Total conversion time (including sampling time) | $f_{ADC} = 14$ MHz  | 1  | -                  | 18                 | μs           |
|                      |   | -   | 14 to 252 ( $t_S$ for sampling +12.5 for successive approximation) |                    |                    | 1/ $f_{ADC}$ |

1. During conversion of the sampled value (12.5 x ADC clock period), an additional consumption of 100 μA on  $I_{DDA}$  and 60 μA on  $I_{DD}$  is present
2. Guaranteed by characterization results.
3. Guaranteed by design.
4. For external triggers, a delay of 1/ $f_{PCLK2}$  must be added to the latency specified in [Table 59](#)



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

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

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

**Table 60. R<sub>SRC</sub> max for f<sub>ADC</sub> = 14 MHz<sup>(1)</sup>**

| T <sub>s</sub> (cycles) | t <sub>s</sub> (μs) | R <sub>SRC</sub> max (kΩ) |
|-------------------------|---------------------|---------------------------|
| 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                | 50                        |
| 239.5                   | 17.1                | 50                        |

1. Guaranteed by design.

**Table 61. ADC accuracy<sup>(1)(2) (3)</sup>**

| Symbol | Parameter                    | Test conditions  | Typ  | Max <sup>(4)</sup> | Unit |
|--------|------------------------------|--|------|--------------------|------|
| ET     | Total unadjusted error       | f <sub>ADC</sub> = 14 MHz, R <sub>SRC</sub> < 10 kΩ<br>V <sub>DDA</sub> = 3 V to 3.6 V<br>T <sub>A</sub> = 25 °C           | ±1.3 | ±3                 | LSB  |
| EO     | Offset error                 |  | ±1   | ±2                 |      |
| EG     | Gain error                   |  | ±0.5 | ±1.5               |      |
| ED     | Differential linearity error |  | ±0.7 | ±1                 |      |
| EL     | Integral linearity error     |  | ±0.8 | ±1.5               |      |
| ET     | Total unadjusted error       | f <sub>ADC</sub> = 14 MHz, R <sub>SRC</sub> < 10 kΩ<br>V <sub>DDA</sub> = 2.7 V to 3.6 V<br>T <sub>A</sub> = -40 to 105 °C | ±3.3 | ±4                 | LSB  |
| EO     | Offset error                 |  | ±1.9 | ±2.8               |      |
| EG     | Gain error                   |  | ±2.8 | ±3                 |      |
| ED     | Differential linearity error |  | ±0.7 | ±1.3               |      |
| EL     | Integral linearity error     |  | ±1.2 | ±1.7               |      |
| ET     | Total unadjusted error       | f <sub>ADC</sub> = 14 MHz, R <sub>SRC</sub> < 10 kΩ<br>V <sub>DDA</sub> = 2.4 V to 3.6 V<br>T <sub>A</sub> = 25 °C         | ±3.3 | ±4                 | LSB  |
| EO     | Offset error                 |  | ±1.9 | ±2.8               |      |
| EG     | Gain error                   |  | ±2.8 | ±3                 |      |
| ED     | Differential linearity error |  | ±0.7 | ±1.3               |      |
| EL     | Integral linearity error     |  | ±1.2 | ±1.7               |      |

1. ADC DC accuracy values are measured after internal calibration.

2. ADC accuracy vs. negative injection current: Injecting a negative current on any 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 currents.  
Any positive injection current within the limits specified for  $I_{INJ(PIN)}$  and  $\Sigma I_{INJ(PIN)}$  in [Section 6.3.13](#) does not affect the ADC accuracy.
3. Better performance may be achieved in restricted  $V_{DDA}$ , frequency and temperature ranges.
4. Guaranteed by characterization results.

Figure 28. ADC accuracy characteristics

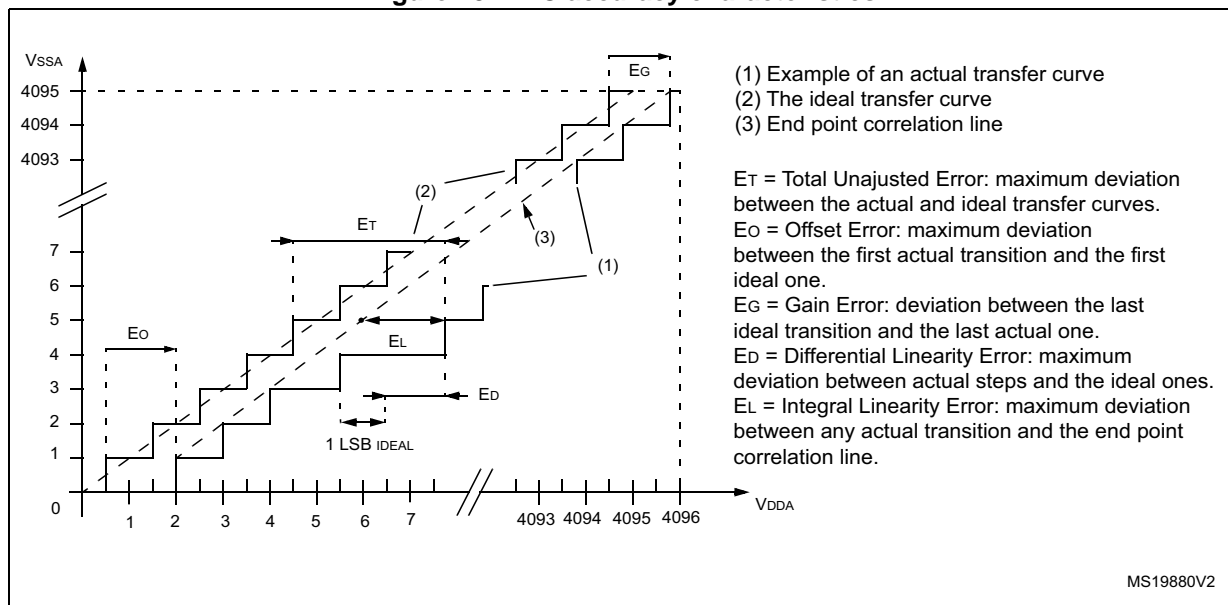
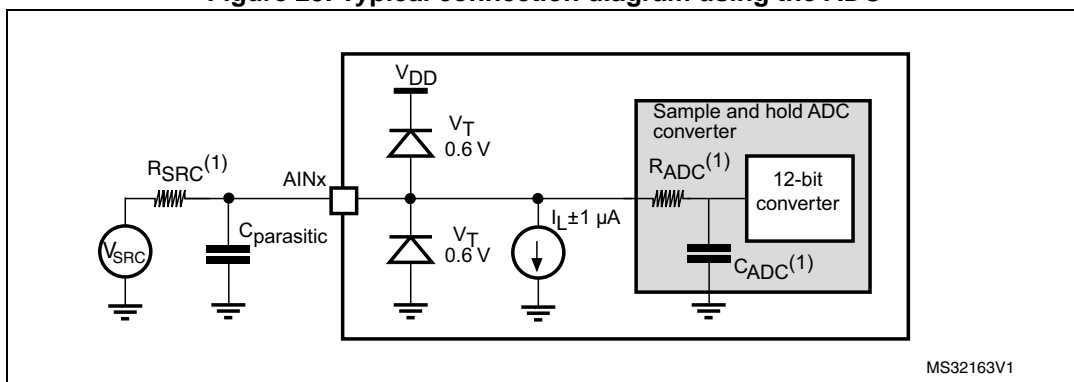


Figure 29. Typical connection diagram using the ADC



1. Refer to [Table 59](#) for the values of  $R_{SRC}$ ,  $R_{ADC}$  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 10](#). The 10 nF capacitor should be ceramic (good quality) and it should be placed as close as possible to the chip.

## 6.3.17 DAC electrical specifications

Table 62. DAC characteristics

| Symbol                     | Parameter   | Conditions  |                        | Min | Typ | Max                      | Unit       |
|----------------------------|---|---|------------------------|-----|-----|--------------------------|------------|
| $V_{DDA}$                  | Analog supply voltage   | -   |                        | 2.4 | -   | 3.6                      | V          |
| $V_{REF+}$                 | Reference supply voltage  | $V_{REF+}$ must always be below $V_{DDA}$   |                        | 2.4 | -   | 3.6                      | V          |
| $V_{SSA}$                  | Ground  |   | -                      | 0   | -   | 0                        | V          |
| $R_{LOAD}^{(1)}$           | Resistive load  | DAC output buffer ON  | Connected to $V_{SSA}$ | 5   | -   | -                        | k $\Omega$ |
|                            |   |   | Connected to $V_{DDA}$ | 25  | -   | -                        |            |
| $R_O^{(1)}$                | Output Impedance  | DAC output buffer OFF   |                        | -   | -   | 15                       | k $\Omega$ |
| $C_{LOAD}^{(1)}$           | Capacitive load   | Maximum capacitive load at DAC_OUT pin (when the buffer is ON).   |                        | -   | -   | 50                       | pF         |
| DAC_OUT min <sup>(1)</sup> | Lower DAC_OUT voltage with buffer ON  | It gives the maximum output excursion of the DAC.<br>It corresponds to 12-bit input code (0x0E0) to (0xF1C) at $V_{REF+} = 3.6$ V and (0x155) and (0xEAB) at $V_{REF+} = 2.4$ V |                        | 0.2 | -   | -                        | V          |
| DAC_OUT max <sup>(1)</sup> | Higher DAC_OUT voltage with buffer ON   |   |                        | -   | -   | $V_{DDA} - 0.2$          | V          |
| DAC_OUT min <sup>(1)</sup> | Lower DAC_OUT voltage with buffer OFF   | It gives the maximum output excursion of the DAC.   |                        | -   | 0.5 | -                        | mV         |
| DAC_OUT max <sup>(1)</sup> | Higher DAC_OUT voltage with buffer OFF  |   |                        | -   | -   | $V_{REF+} - 1\text{LSB}$ | V          |
| $I_{DDVREF+}^{(3)}$        | DAC DC current consumption in quiescent mode (Standby mode)   | With no load, worst code (0xF1C) at $V_{REF+} = 3.6$ V in terms of DC consumption on the inputs   |                        | -   | -   | 220                      | $\mu$ A    |
| $I_{DDA}^{(3)}$            | DAC DC current consumption in quiescent mode <sup>(2)</sup>   | With no load, middle code (0x800) on the inputs   |                        | -   | -   | 380                      | $\mu$ A    |
|                            |   | With no load, worst code (0xF1C) at $V_{REF+} = 3.6$ V in terms of DC consumption on the inputs   |                        | -   | -   | 480                      | $\mu$ A    |
| DNL <sup>(3)</sup>         | Differential non linearity<br>Difference between two consecutive code-1LSB)   | Given for the DAC in 10-bit configuration   |                        | -   | -   | $\pm 0.5$                | LSB        |
|                            |   | Given for the DAC in 12-bit configuration   |                        | -   | -   | $\pm 2$                  | LSB        |
| INL <sup>(3)</sup>         | Integral non linearity<br>(difference between measured value at Code i and the value at Code i on a line drawn between Code 0 and last Code 1023) | Given for the DAC in 10-bit configuration   |                        | -   | -   | $\pm 1$                  | LSB        |
|                            |   | Given for the DAC in 12-bit configuration   |                        | -   | -   | $\pm 4$                  | LSB        |

Table 62. DAC characteristics (continued)

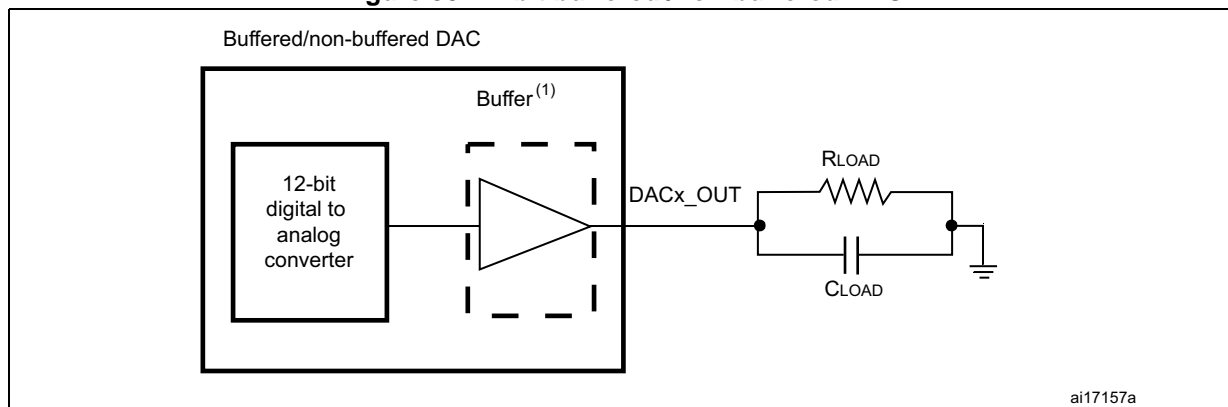
| Symbol                     | Parameter  | Conditions  | Min | Typ | Max  | Unit |
|----------------------------|--|---|-----|-----|------|------|
| Offset <sup>(3)</sup>      | Offset error<br>(difference between measured value at Code (0x800) and the ideal value = $V_{REF+}/2$ )  | -   | -   | -   | ±10  | mV   |
|                            |  | Given for the DAC in 10-bit at $V_{REF+} = 3.6\text{ V}$  | -   | -   | ±3   | LSB  |
|                            |  | Given for the DAC in 12-bit at $V_{REF+} = 3.6\text{ V}$  | -   | -   | ±12  | LSB  |
| Gain error <sup>(3)</sup>  | Gain error   | Given for the DAC in 12bit configuration  | -   | -   | ±0.5 | %    |
| $t_{SETTLING}^{(3)}$       | 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 ±1LSB) | $C_{LOAD} \leq 50\text{ pF}$ , $R_{LOAD} \geq 5\text{ k}\Omega$   | -   | 3   | 4    | µs   |
| Update rate <sup>(3)</sup> | Max frequency for a correct DAC_OUT change when small variation in the input code (from code i to i+1LSB)  | $C_{LOAD} \leq 50\text{ pF}$ , $R_{LOAD} \geq 5\text{ k}\Omega$   | -   | -   | 1    | MS/s |
| $t_{WAKEUP}^{(3)}$         | Wakeup time from off state (Setting the ENx bit in the DAC Control register)   | $C_{LOAD} \leq 50\text{ pF}$ , $R_{LOAD} \geq 5\text{ k}\Omega$<br>input code between lowest and highest possible ones. | -   | 6.5 | 10   | µs   |
| PSRR+ <sup>(1)</sup>       | Power supply rejection ratio (to $V_{DDA}$ ) (static DC measurement)   | No $R_{LOAD}$ , $C_{LOAD} = 50\text{ pF}$   | -   | -67 | -40  | dB   |

1. Guaranteed by design.

2. Quiescent mode refers to the state of the DAC keeping a steady value on the output, so no dynamic consumption is involved.

3. Guaranteed by characterization.

Figure 30. 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.

## 6.3.18 Comparator characteristics

Table 63. Comparator characteristics

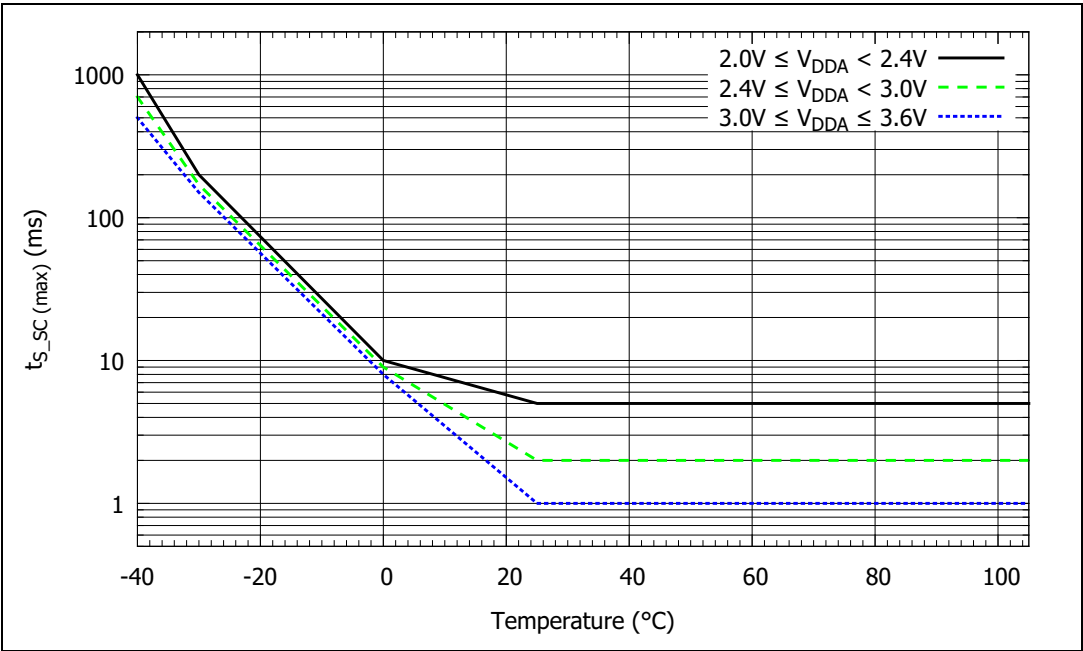
| Symbol           | Parameter   | Conditions   | Min                  | Typ | Max <sup>(1)</sup>  | Unit  |
|------------------|---|--|----------------------|-----|---------------------|-------|
| $V_{DDA}$        | Analog supply voltage                                       | $V_{REFINT}$ scaler not in use                             | 1.65                 | -   | 3.6                 | V     |
|                  |   | $V_{REFINT}$ scaler in use                                 | 2                    |     |                     |       |
| $V_{IN}$         | Comparator input voltage range                              | -  | 0                    | -   | $V_{DDA}$           | V     |
| $V_{BG}$         | $V_{REFINT}$ scaler input voltage                           | -  | -                    | 1.2 | -                   | V     |
| $V_{SC}$         | $V_{REFINT}$ scaler offset voltage                          | -  | -                    | ±5  | ±10                 | mV    |
| $t_{S\_SC}$      | Scaler startup time from power down                         | First $V_{REFINT}$ scaler activation after device power on | -                    | -   | 1000 <sup>(2)</sup> | ms    |
|                  |   | Next activations   |                      |     | 0.2                 |       |
| $t_{START}$      | Comparator startup time                                     | Startup time to reach propagation delay specification      | -                    | -   | 60                  | µs    |
| $t_D$            | Propagation delay for 200 mV step with 100 mV overdrive     | Ultra-low power mode                                       | -                    | 2   | 4.5                 | µs    |
|                  |   | Low power mode   | -                    | 0.7 | 1.5                 |       |
|                  |   | Medium power mode  | -                    | 0.3 | 0.6                 |       |
|                  |   | High speed mode  | $V_{DDA} \geq 2.7$ V |     | 50                  | ns    |
|                  |   |  | $V_{DDA} < 2.7$ V    |     | 100                 |       |
|                  | Propagation delay for full range step with 100 mV overdrive | Ultra-low power mode                                       | -                    | 2   | 7                   | µs    |
|                  |   | Low power mode   | -                    | 0.7 | 2.1                 |       |
|                  |   | Medium power mode  | -                    | 0.3 | 1.2                 |       |
|                  |   | High speed mode  | $V_{DDA} \geq 2.7$ V |     | 90                  | ns    |
|                  |   |  | $V_{DDA} < 2.7$ V    |     | 110                 |       |
|                  |   |  |                      |     | 300                 |       |
| $V_{offset}$     | Comparator offset error                                     | -  | -                    | ±4  | ±10                 | mV    |
| $dV_{offset}/dT$ | Offset error temperature coefficient                        | -  | -                    | 18  | -                   | µV/°C |
| $I_{DD(COMP)}$   | COMP current consumption                                    | Ultra-low power mode                                       | -                    | 1.2 | 1.5                 | µA    |
|                  |   | Low power mode   | -                    | 3   | 5                   |       |
|                  |   | Medium power mode  | -                    | 10  | 15                  |       |
|                  |   | High speed mode  | -                    | 75  | 100                 |       |

Table 63. Comparator characteristics (continued)

| Symbol           | Parameter             | Conditions                               |                       | Min | Typ | Max <sup>(1)</sup> | Unit |
|------------------|-----------------------|--|-----------------------|-----|-----|--------------------|------|
| $V_{\text{hys}}$ | Comparator hysteresis | No hysteresis<br>(COMPxHYST[1:0]=00)     | -                     | -   | 0   | -                  | mV   |
|                  |                       | Low hysteresis<br>(COMPxHYST[1:0]=01)    | High speed mode       | 3   | 8   | 13                 |      |
|                  |                       |  | All other power modes | 5   |     | 10                 |      |
|                  |                       | Medium hysteresis<br>(COMPxHYST[1:0]=10) | High speed mode       | 7   | 15  | 26                 |      |
|                  |                       |  | All other power modes | 9   |     | 19                 |      |
|                  |                       | High hysteresis<br>(COMPxHYST[1:0]=11)   | High speed mode       | 18  | 31  | 49                 |      |
|                  |                       |  | All other power modes | 19  |     | 40                 |      |
|                  |                       |  |                       |     |     |                    |      |

- 1. Guaranteed by design.
- 2. For more details and conditions see [Figure 31: Maximum VREFINT scaler startup time from power down](#)

Figure 31. Maximum  $V_{\text{REFINT}}$  scaler startup time from power down



### 6.3.19 Temperature sensor characteristics

**Table 64. Temperature sensor calibration values**

| Calibration value name | Description   | Memory address            |
|------------------------|---|---------------------------|
| TS_CAL1                | TS ADC raw data acquired at temperature of 30 °C ± 5 °C, V <sub>DDA</sub> = 3.3 V | 0x1FFF F7B8 - 0x1FFF F7B9 |
| TS_CAL2                | TS ADC raw data acquired at temperature of 110 °C ± 5 °C V <sub>DDA</sub> = 3.3 V | 0x1FFF F7C2 - 0x1FFF F7C3 |

**Table 65. TS characteristics**

| Symbol                                | Parameter                                      | Min  | Typ  | Max  | Unit  |
|---------------------------------------|--|------|------|------|-------|
| T <sub>L</sub>                        | V <sub>SENSE</sub> linearity with temperature  | -    | ±1   | ±2   | °C    |
| Avg_Slope <sup>(1)</sup>              | Average slope                                  | 4.0  | 4.3  | 4.6  | mV/°C |
| V <sub>25</sub>                       | Voltage at 25 °C                               | 1.34 | 1.43 | 1.52 | V     |
| t <sub>START</sub> <sup>(1)</sup>     | Startup time                                   | 4    | -    | 10   | µs    |
| T <sub>S_temp</sub> <sup>(2)(1)</sup> | ADC sampling time when reading the temperature | 17.1 | -    | -    | µs    |

1. Guaranteed by design.

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

### 6.3.20 V<sub>BAT</sub> monitoring characteristics

**Table 66. V<sub>BAT</sub> monitoring characteristics**

| Symbol                             | Parameter   | Min | Typ | Max | Unit |
|------------------------------------|---|-----|-----|-----|------|
| R                                  | Resistor bridge for V <sub>BAT</sub>                                | -   | 50  | -   | KΩ   |
| Q                                  | Ratio on V <sub>BAT</sub> measurement                               | -   | 2   | -   | -    |
| Er <sup>(1)</sup>                  | Error on Q  | -1  | -   | +1  | %    |
| T <sub>S_vbat</sub> <sup>(2)</sup> | ADC sampling time when reading the V <sub>BAT</sub><br>1mV accuracy | 5   | -   | -   | µs   |

1. Guaranteed by design.

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

### 6.3.21 Timer characteristics

The parameters given in [Table 67](#) are guaranteed by design.

Refer to [Section 6.3.13: I/O port characteristics](#) for details on the input/output alternate function characteristics (output compare, input capture, external clock, PWM output).

Table 67. TIMx<sup>(1)</sup> <sup>(2)</sup> characteristics

| Symbol           | Parameter                                    | Conditions                    | Min    | Max                  | Unit          |
|------------------|--|-------------------------------|--------|----------------------|---------------|
| $t_{res(TIM)}$   | Timer resolution time                        | -                             | 1      | -                    | $t_{TIMxCLK}$ |
|                  |  | $f_{TIMxCLK} = 72\text{ MHz}$ | 13.9   | -                    | ns            |
| $f_{EXT}$        | Timer external clock frequency on CH1 to CH4 | -                             | 0      | $f_{TIMxCLK}/2$      | MHz           |
|                  |  | $f_{TIMxCLK} = 72\text{ MHz}$ | 0      | 24                   | MHz           |
| $Res_{TIM}$      | Timer resolution                             | TIMx (except TIM2)            | -      | 16                   | bit           |
|                  |  | TIM2                          | -      | 32                   |               |
| $t_{COUNTER}$    | 16-bit counter clock period                  | -                             | 1      | 65536                | $t_{TIMxCLK}$ |
|                  |  | $f_{TIMxCLK} = 72\text{ MHz}$ | 0.0139 | 910                  | $\mu s$       |
| $t_{MAX\_COUNT}$ | Maximum possible count with 32-bit counter   | -                             | -      | $65536 \times 65536$ | $t_{TIMxCLK}$ |
|                  |  | $f_{TIMxCLK} = 72\text{ MHz}$ | -      | 59.65                | s             |

1. TIMx is used as a general term to refer to the TIM2, TIM3, TIM4, TIM5, TIM6, TIM7, TIM12, TIM13, TIM14, TIM15, TIM16, TIM17, TIM18 and TIM19 timers.
2. Guaranteed by characterization results.

Table 68. IWDG min/max timeout period at 40 kHz (LSI) <sup>(1)</sup><sup>(2)</sup>

| Prescaler divider | PR[2:0] bits | Min timeout (ms) RL[11:0]=0x000 | Max timeout (ms) RL[11:0]=0xFFFF |
|-------------------|--------------|---------------------------------|----------------------------------|
| /4                | 0            | 0.1                             | 409.6                            |
| /8                | 1            | 0.2                             | 819.2                            |
| /16               | 2            | 0.4                             | 1638.4                           |
| /32               | 3            | 0.8                             | 3276.8                           |
| /64               | 4            | 1.6                             | 6553.6                           |
| /128              | 5            | 3.2                             | 13107.2                          |
| /256              | 7            | 6.4                             | 26214.4                          |

1. These timings are given for a 40 kHz clock but the microcontroller's internal RC frequency can vary from 30 to 60 kHz. Moreover, given an exact RC oscillator frequency, the exact timings still depend on the phasing of the APB interface clock versus the LSI clock so that there is always a full RC period of uncertainty.
2. Guaranteed by characterization results.

Table 69. WWDG min-max timeout value @72 MHz (PCLK)

| Prescaler | WDGTB | Min timeout value | Max timeout value |
|-----------|-------|-------------------|-------------------|
| 1         | 0     | 0.05687           | 3.6409            |
| 2         | 1     | 0.1137            | 7.2817            |
| 4         | 2     | 0.2275            | 14.564            |
| 8         | 3     | 0.4551            | 29.127            |



### 6.3.22 CAN (controller area network) interface

Refer to [Section 6.3.13: I/O port characteristics](#) for more details on the input/output alternate function characteristics (CAN\_TX and CAN\_RX).

### 6.3.23 SDADC characteristics

Table 70. SDADC characteristics <sup>(1)</sup>

| Symbol       | Parameter                             | Conditions   | Min                                  | Typ       | Max                                 | Unit    | Note                                       |
|--------------|---------------------------------------|--|--------------------------------------|-----------|-------------------------------------|---------|--|
| $V_{DDSDx}$  | Power supply                          | Slow mode ( $f_{ADC} = 1.5$ MHz)                           | 2.2                                  | -         | $V_{DDA}$                           | V       | -  |
|              |                                       | Normal mode ( $f_{ADC} = 6$ MHz)                           | 2.4                                  | -         | $V_{DDA}$                           |         | -  |
| $f_{ADC}$    | SDADC clock frequency                 | Slow mode ( $f_{ADC} = 1.5$ MHz)                           | 0.5                                  | 1.5       | 1.65                                | MHz     | -  |
|              |                                       | Normal mode ( $f_{ADC} = 6$ MHz)                           | 0.5                                  | 6         | 6.3                                 |         | -  |
| $V_{REFSD+}$ | Positive ref. voltage                 | -  | 1.1                                  | -         | $V_{DDSDx}$                         | V       | -  |
| $V_{REFSD-}$ | Negative ref. voltage                 | -  | -                                    | $V_{SSA}$ | -                                   | V       | -  |
| $I_{DDSDx}$  | Supply current ( $V_{DDSDx} = 3.3$ V) | Normal mode ( $f_{ADC} = 6$ MHz)                           | -                                    | 800       | 1200                                | $\mu$ A | -  |
|              |                                       | Slow mode ( $f_{ADC} = 1.5$ MHz)                           | -                                    | -         | 600                                 |         | -  |
|              |                                       | Standby  | -                                    | -         | 200                                 |         | -  |
|              |                                       | Power down   | -                                    | -         | 2.5                                 |         | -  |
|              |                                       | SD_ADC off   | -                                    | -         | 1                                   |         | -  |
| $V_{AIN}$    | Common input voltage range            | Single ended mode (zero reference)                         | $V_{REFSD-}$                         | -         | $V_{REFSD+}/\text{gain}$            | V       | Voltage on AINP or AINN pin                |
|              |                                       | Single ended offset mode                                   | $V_{REFSD-}$                         | -         | $V_{REFSD+}/(\text{gain} \times 2)$ |         |  |
|              |                                       | Differential mode  | $V_{SSA}$                            | -         | $V_{DDSDx}$                         |         |  |
| $V_{DIFF}$   | Differential input voltage            | Differential mode only                                     | $-V_{REFSD+}/(\text{gain} \times 2)$ | -         | $V_{REFSD+}/(\text{gain} \times 2)$ | -       | Differential voltage between AINP and AINN |
| $f_s$        | Sampling rate                         | Slow mode ( $f_{ADC} = 1.5$ MHz)                           | -                                    | 4.166     | -                                   | kHz     | $f_{ADC}/360$                              |
|              |                                       | Slow mode one channel only ( $f_{ADC} = 1.5$ MHz)          | -                                    | 12.5      | -                                   |         | $f_{ADC}/120$                              |
|              |                                       | Normal mode multiplexed channel ( $f_{ADC} = 6$ MHz)       | -                                    | 16.66     | -                                   |         | $f_{ADC}/360$                              |
|              |                                       | Normal mode one channel only, FAST= 1 ( $f_{ADC} = 6$ MHz) | -                                    | 50        | -                                   |         | $f_{ADC}/120$                              |
| $t_{CONV}$   | Conversion time                       | -  | -                                    | 1/ $f_s$  | -                                   | s       | -  |

Table 70. SDADC characteristics (continued)<sup>(1)</sup>

| Symbol                   | Parameter                     | Conditions  |          |                            |                          | Min                       | Typ  | Max  | Unit | Note   |                          |
|--------------------------|-------------------------------|---|----------|----------------------------|--------------------------|---------------------------|------|------|------|--|--------------------------|
| Rain                     | Analog input impedance        | One channel, gain = 0.5, f <sub>ADC</sub> = 1.5 MHz                     |          |                            |                          | -                         | 540  | -    | kΩ   | see reference manual for detailed description            |                          |
|                          |                               | One channel, gain = 0.5, f <sub>ADC</sub> = 6 MHz                       |          |                            |                          | -                         | 135  | -    |      |  |                          |
|                          |                               | One channel, gain = 8, f <sub>ADC</sub> = 6 MHz                         |          |                            |                          | -                         | 47   | -    |      |  |                          |
| t <sub>CALIB</sub>       | Calibration time              | f <sub>ADC</sub> = 6 MHz, one offset calibration                        |          |                            |                          | -                         | 5120 | -    | μs   | 30720/f <sub>ADC</sub>                                   |                          |
| t <sub>STAB</sub>        | Stabilization time            | From power down f <sub>ADC</sub> = 6 MHz                                |          |                            |                          | -                         | 100  | -    | μs   | 600/f <sub>ADC</sub> , 75/f <sub>ADC</sub> if SLOWCK = 1 |                          |
| t <sub>STANDBY</sub>     | Wakeup from standby time      | f <sub>ADC</sub> = 6 MHz  |          |                            |                          | -                         | 50   | -    | μs   | 300/f <sub>ADC</sub>                                     |                          |
|                          |                               | f <sub>ADC</sub> = 1.5 MHz  |          |                            |                          | -                         | 50   | -    |      | 75/f <sub>ADC</sub> if SLOWCK = 1                        |                          |
| EO                       | Offset error                  | Differential mode   | gain = 1 | f <sub>ADC</sub> = 1.5 MHz | V <sub>DDSDx</sub> = 3.3 | V <sub>REFSD+</sub> = 3.3 | -    | -    | 110  | μV   | after offset calibration |
|                          |                               |   |          | f <sub>ADC</sub> = 6 MHz   |                          | V <sub>REFSD+</sub> = 1.2 | -    | -    | 110  |  |                          |
|                          |                               |   | gain = 8 | f <sub>ADC</sub> = 6 MHz   |                          | V <sub>REFSD+</sub> = 3.3 | -    | -    | 100  |  |                          |
|                          |                               |   |          |                            |                          | V <sub>REFSD+</sub> = 1.2 | -    | -    | 70   |  |                          |
|                          |                               |   |          |                            |                          | V <sub>REFSD+</sub> = 3.3 | -    | -    | 100  |  |                          |
|                          |                               |   |          |                            |                          | V <sub>REFSD+</sub> = 3.3 | -    | -    | 90   |  |                          |
|                          |                               | Single ended mode   | gain = 1 | -                          |                          | V <sub>REFSD+</sub> = 1.2 | -    | -    | 2100 |  |                          |
|                          |                               |   |          |                            |                          | V <sub>REFSD+</sub> = 3.3 | -    | -    | 2000 |  |                          |
|                          |                               |   | gain = 8 |                            |                          | V <sub>REFSD+</sub> = 1.2 | -    | -    | 1500 |  |                          |
|                          |                               |   |          |                            |                          | V <sub>REFSD+</sub> = 3.3 | -    | -    | 1800 |  |                          |
| D <sub>voffsettemp</sub> | Offset drift with temperature | Differential or single ended mode, gain = 1, V <sub>DDSDx</sub> = 3.3 V |          |                            |                          | -                         | 10   | 15   | μV/K | -  |                          |
| EG                       | Gain error                    | All gains, differential mode, single ended mode                         |          |                            |                          | -2.4                      | -2.7 | -3.1 | %    | negative gain error = data result are greater than ideal |                          |

Table 70. SDADC characteristics (continued)<sup>(1)</sup>

| Symbol | Parameter                               | Conditions                                     |          |                          |                           | Min                       | Typ | Max | Unit   | Note |     |
|--------|---|--|----------|--------------------------|---------------------------|---------------------------|-----|-----|--------|------|-----|
| EGT    | Gain drift with temperature             | gain = 1, differential mode, single ended mode |          |                          |                           | -                         | 0   | -   | ppm /K | -    |     |
| EL     | Integral linearity error <sup>(2)</sup> | Differential mode                              | gain = 1 | V <sub>DDSDx</sub> = 3.3 | V <sub>REFSD+</sub> = 1.2 | -                         | -   | 16  | LSB    | -    |     |
|        |   |  |          |                          | V <sub>REFSD+</sub> = 3.3 | -                         | -   | 14  |        |      |     |
|        |   |  |          |                          | V <sub>REFSD+</sub> = 1.2 | -                         | -   | 26  |        |      |     |
|        |   |  |          |                          | V <sub>REFSD+</sub> = 3.3 | -                         | -   | 14  |        |      |     |
|        |   | Single ended mode                              | gain = 1 |                          | V <sub>REFSD+</sub> = 1.2 | -                         | -   | 31  |        |      |     |
|        |   |  |          |                          | V <sub>REFSD+</sub> = 3.3 | -                         | -   | 23  |        |      |     |
|        |   |  |          |                          | gain = 8                  | V <sub>REFSD+</sub> = 1.2 | -   | -   |        |      | 80  |
|        |   |  |          |                          |                           | V <sub>REFSD+</sub> = 3.3 | -   | -   |        |      | 35  |
| ED     | Differential linearity error            | Differential mode                              | gain = 1 | V <sub>DDSDx</sub> = 3.3 | V <sub>REFSD+</sub> = 1.2 | -                         | -   | 2.4 | LSB    | -    |     |
|        |   |  |          |                          | V <sub>REFSD+</sub> = 3.3 | -                         | -   | 1.8 |        |      |     |
|        |   |  |          |                          | V <sub>REFSD+</sub> = 1.2 | -                         | -   | 3.6 |        |      |     |
|        |   |  |          |                          | V <sub>REFSD+</sub> = 3.3 | -                         | -   | 2.9 |        |      |     |
|        |   | Single ended mode                              | gain = 1 |                          | V <sub>REFSD+</sub> = 1.2 | -                         | -   | 3.2 |        |      |     |
|        |   |  |          |                          | V <sub>REFSD+</sub> = 3.3 | -                         | -   | 2.8 |        |      |     |
|        |   |  |          |                          | gain = 8                  | V <sub>REFSD+</sub> = 1.2 | -   | -   |        |      | 4.1 |
|        |   |  |          |                          |                           | V <sub>REFSD+</sub> = 3.3 | -   | -   |        |      | 3.3 |

Table 70. SDADC characteristics (continued)<sup>(1)</sup>

| Symbol             | Parameter             | Conditions        |          |                                    |                          |                                 | Min | Typ | Max | Unit | Note |
|--------------------|-----------------------|-------------------|----------|------------------------------------|--------------------------|---------------------------------|-----|-----|-----|------|------|
| SNR <sup>(5)</sup> | Signal to noise ratio | Differential mode | gain = 1 | $f_{\text{ADC}} = 1.5 \text{ MHz}$ | $V_{\text{DDSDx}} = 3.3$ | $V_{\text{REFSD+}} = 3.3^{(3)}$ | 84  | 85  | -   | dB   | -    |
|                    |                       |                   |          | $f_{\text{ADC}} = 6 \text{ MHz}$   |                          | $V_{\text{REFSD+}} = 1.2^{(4)}$ | 86  | 88  | -   |      |      |
|                    |                       |                   |          |                                    |                          | $V_{\text{REFSD+}} = 3.3$       | 88  | 92  | -   |      |      |
|                    |                       |                   | gain = 8 | $f_{\text{ADC}} = 6 \text{ MHz}$   |                          | $V_{\text{REFSD+}} = 1.2^{(4)}$ | 76  | 78  | -   |      |      |
|                    |                       |                   |          |                                    |                          | $V_{\text{REFSD+}} = 3.3$       | 82  | 86  | -   |      |      |
|                    |                       |                   |          | $f_{\text{ADC}} = 1.5 \text{ MHz}$ |                          | $V_{\text{REFSD+}} = 3.3^{(3)}$ | 76  | 80  | -   |      |      |
|                    |                       | Single ended mode | gain = 1 | $f_{\text{ADC}} = 1.5 \text{ MHz}$ |                          | $V_{\text{REFSD+}} = 3.3$       | 80  | 84  | -   |      |      |
|                    |                       |                   |          | $f_{\text{ADC}} = 6 \text{ MHz}$   |                          | $V_{\text{REFSD+}} = 1.2^{(4)}$ | 77  | 81  | -   |      |      |
|                    |                       |                   |          |                                    |                          | $V_{\text{REFSD+}} = 3.3$       | 85  | 90  | -   |      |      |
|                    |                       |                   | gain = 8 | $f_{\text{ADC}} = 6 \text{ MHz}$   |                          | $V_{\text{REFSD+}} = 1.2^{(4)}$ | 66  | 71  | -   |      |      |
|                    |                       |                   |          |                                    |                          | $V_{\text{REFSD+}} = 3.3$       | 74  | 78  | -   |      |      |

Table 70. SDADC characteristics (continued)<sup>(1)</sup>

| Symbol               | Parameter                            | Conditions        |          |                                    |                          |                                 | Min | Typ | Max | Unit | Note                      |
|----------------------|--------------------------------------|-------------------|----------|------------------------------------|--------------------------|---------------------------------|-----|-----|-----|------|---------------------------|
| SINAD <sup>(5)</sup> | Signal to noise and distortion ratio | Differential mode | gain = 1 | $f_{\text{ADC}} = 1.5 \text{ MHz}$ | $V_{\text{DDSDx}} = 3.3$ | $V_{\text{REFSD+}} = 3.3^{(3)}$ | 76  | 77  | -   | dB   | ENOB = SINAD/6.02 - 0.292 |
|                      |                                      |                   |          | $f_{\text{ADC}} = 6 \text{ MHz}$   |                          | $V_{\text{REFSD+}} = 1.2^{(4)}$ | 75  | 76  | -   |      |                           |
|                      |                                      |                   | gain = 8 | $f_{\text{ADC}} = 6 \text{ MHz}$   |                          | $V_{\text{REFSD+}} = 3.3$       | 76  | 77  | -   |      |                           |
|                      |                                      |                   |          | $f_{\text{ADC}} = 6 \text{ MHz}$   |                          | $V_{\text{REFSD+}} = 1.2^{(4)}$ | 70  | 74  | -   |      |                           |
|                      |                                      |                   |          | $f_{\text{ADC}} = 1.5 \text{ MHz}$ |                          | $V_{\text{REFSD+}} = 3.3$       | 79  | 85  | -   |      |                           |
|                      |                                      | Single ended mode | gain = 1 | $f_{\text{ADC}} = 1.5 \text{ MHz}$ |                          | $V_{\text{REFSD+}} = 3.3^{(3)}$ | 75  | 81  | -   |      |                           |
|                      |                                      |                   |          | $f_{\text{ADC}} = 6 \text{ MHz}$   |                          | $V_{\text{REFSD+}} = 1.2^{(4)}$ | 72  | 73  | -   |      |                           |
|                      |                                      |                   | gain = 8 | $f_{\text{ADC}} = 6 \text{ MHz}$   |                          | $V_{\text{REFSD+}} = 3.3$       | 68  | 71  | -   |      |                           |
|                      |                                      |                   |          | $f_{\text{ADC}} = 6 \text{ MHz}$   |                          | $V_{\text{REFSD+}} = 1.2^{(4)}$ | 72  | 73  | -   |      |                           |
|                      |                                      |                   |          | $f_{\text{ADC}} = 6 \text{ MHz}$   |                          | $V_{\text{REF}} = 3.3$          | 60  | 64  | -   |      |                           |
| THD <sup>(5)</sup>   | Total harmonic distortion            | Differential mode | gain = 1 | $f_{\text{ADC}} = 1.5 \text{ MHz}$ | $V_{\text{DDSDx}} = 3.3$ | $V_{\text{REFSD+}} = 3.3^{(3)}$ | -   | -77 | -76 | dB   | -                         |
|                      |                                      |                   |          | $f_{\text{ADC}} = 6 \text{ MHz}$   |                          | $V_{\text{REFSD+}} = 1.2^{(4)}$ | -   | -77 | -76 |      |                           |
|                      |                                      |                   | gain = 8 | $f_{\text{ADC}} = 6 \text{ MHz}$   |                          | $V_{\text{REFSD+}} = 3.3$       | -   | -77 | -76 |      |                           |
|                      |                                      |                   |          | $f_{\text{ADC}} = 6 \text{ MHz}$   |                          | $V_{\text{REFSD+}} = 1.2^{(4)}$ | -   | -85 | -70 |      |                           |
|                      |                                      |                   |          | $f_{\text{ADC}} = 1.5 \text{ MHz}$ |                          | $V_{\text{REFSD+}} = 3.3$       | -   | -93 | -80 |      |                           |
|                      |                                      | Single ended mode | gain = 1 | $f_{\text{ADC}} = 1.5 \text{ MHz}$ |                          | $V_{\text{REFSD+}} = 3.3^{(3)}$ | -   | -93 | -83 |      |                           |
|                      |                                      |                   |          | $f_{\text{ADC}} = 6 \text{ MHz}$   |                          | $V_{\text{REFSD+}} = 1.2^{(4)}$ | -   | -72 | -68 |      |                           |
|                      |                                      |                   | gain = 8 | $f_{\text{ADC}} = 6 \text{ MHz}$   |                          | $V_{\text{REFSD+}} = 3.3$       | -   | -74 | -72 |      |                           |
|                      |                                      |                   |          | $f_{\text{ADC}} = 6 \text{ MHz}$   |                          | $V_{\text{REFSD+}} = 1.2^{(4)}$ | -   | -66 | -61 |      |                           |
|                      |                                      |                   |          | $f_{\text{ADC}} = 6 \text{ MHz}$   |                          | $V_{\text{REFSD+}} = 3.3$       | -   | -75 | -70 |      |                           |

1. Guaranteed by characterization results.
2. Integral linearity error can be improved by software calibration of SDADC transfer curve (2-nd order polynomial calibration).
3. For  $f_{ADC}$  lower than 5 MHz, there will be a performance degradation of around 2 dB due to flicker noise increase.
4. If the reference value is lower than 2.4 V, there will be a performance degradation proportional to the reference supply drop, according to this formula:  $20 \cdot \log_{10}(V_{REF}/2.4)$  dB
5. SNR, THD, SINAD parameters are valid for frequency bandwidth 20Hz - 1kHz. Input signal frequency is 300Hz (for  $f_{ADC}=6\text{MHz}$ ) and 100Hz (for  $f_{ADC}=1.5\text{MHz}$ ).

Table 71. VREFSD+ pin characteristics<sup>(1)</sup>

| Symbol              | Parameter                             | Conditions   | Min  | Typ | Max   | Unit       | Note   |
|---------------------|---------------------------------------|--|------|-----|-------|------------|--|
| $V_{REFINT}$        | Internal reference voltage            | Buffered embedded reference voltage (1.2 V)        | -    | 1.2 | -     | V          | See <a href="#">Section 6.3.3: Embedded reference voltage on page 59</a> |
|                     |                                       | Embedded reference voltage amplified by factor 1.5 | -    | 1.8 | -     | V          | -  |
| $C_{VREFSD+}^{(2)}$ | Reference voltage filtering capacitor | $V_{REFSD+} = V_{REFINT}$                          | 1000 | -   | 10000 | nF         | -  |
| $R_{VREFSD+}$       | Reference voltage input impedance     | Normal mode ( $f_{ADC} = 6 \text{ MHz}$ )          | -    | 238 | -     | k $\Omega$ | See RM0313 reference manual for detailed description                     |
|                     |                                       | Slow mode ( $f_{ADC} = 1.5 \text{ MHz}$ )          | -    | 952 | -     |            |  |

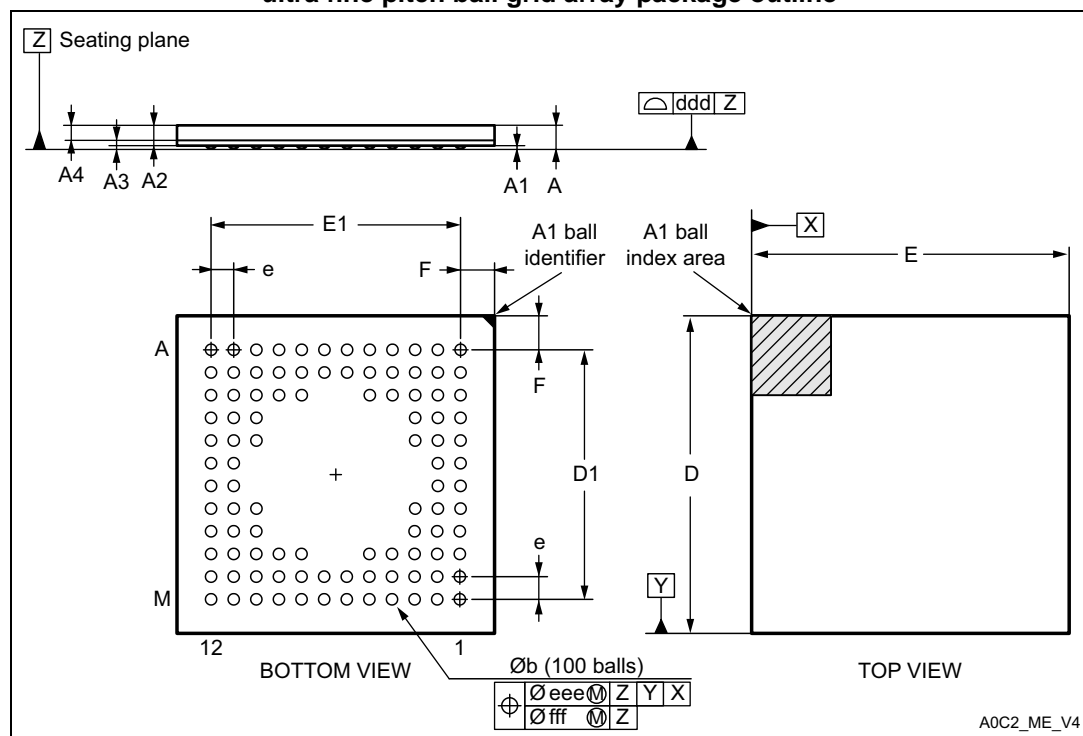
1. Guaranteed by characterization results.
2. If internal reference voltage is selected then this capacitor is charged through internal resistance - typ. 300 ohm. If internal reference source is selected through the reference voltage selection bits (REFV<>"00" in SDADC\_CR1 register), the application must first configure REFV bits and then wait for capacitor charging. Recommended waiting time is 3 ms if 1  $\mu\text{F}$  capacitor is used.

## 7 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.

### 7.1 UFBGA100 package information

**Figure 32. UFBGA100 - 100-pin, 7 x 7 mm, 0.50 mm pitch, ultra fine pitch ball grid array package outline**



1. Drawing is not to scale.

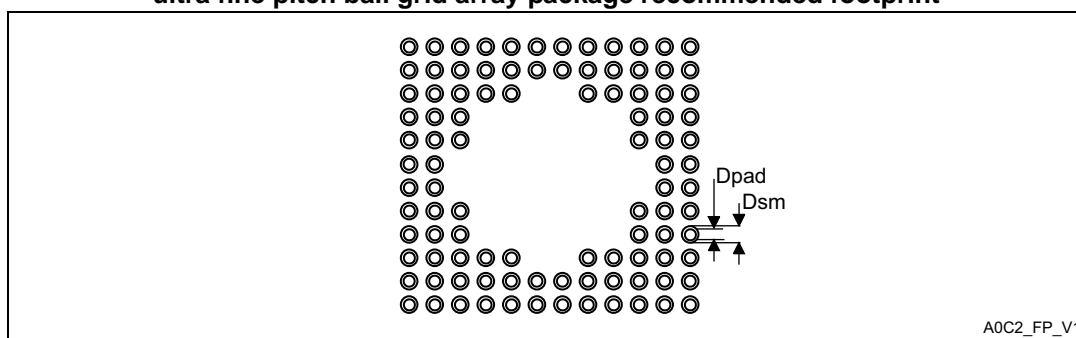
**Table 72. UFBGA100 - 100-pin, 7 x 7 mm, 0.50 mm pitch, ultra fine pitch ball grid array package mechanical data**

| Symbol | millimeters |       |       | inches <sup>(1)</sup> |        |        |
|--------|-------------|-------|-------|-----------------------|--------|--------|
|        | Min.        | Typ.  | Max.  | Min.                  | Typ.   | Max.   |
| A      | 0.460       | 0.530 | 0.600 | 0.0181                | 0.0209 | 0.0236 |
| A1     | 0.050       | 0.080 | 0.110 | 0.0020                | 0.0031 | 0.0043 |
| A2     | 0.400       | 0.450 | 0.500 | 0.0157                | 0.0177 | 0.0197 |
| A3     | -           | 0.130 | -     | -                     | 0.0051 | -      |
| A4     | 0.270       | 0.320 | 0.370 | 0.0106                | 0.0126 | 0.0146 |
| b      | 0.200       | 0.250 | 0.300 | 0.0079                | 0.0098 | 0.0118 |

**Table 72. UFBGA100 - 100-pin, 7 x 7 mm, 0.50 mm pitch, ultra fine pitch ball grid array package mechanical data (continued)**

| Symbol | millimeters |       |       | inches <sup>(1)</sup> |        |        |
|--------|-------------|-------|-------|-----------------------|--------|--------|
|        | Min.        | Typ.  | Max.  | Min.                  | Typ.   | Max.   |
| D      | 6.950       | 7.000 | 7.050 | 0.2736                | 0.2756 | 0.2776 |
| D1     | 5.450       | 5.500 | 5.550 | 0.2146                | 0.2165 | 0.2185 |
| E      | 6.950       | 7.000 | 7.050 | 0.2736                | 0.2756 | 0.2776 |
| E1     | 5.450       | 5.500 | 5.550 | 0.2146                | 0.2165 | 0.2185 |
| e      | -           | 0.500 | -     | -                     | 0.0197 | -      |
| F      | 0.700       | 0.750 | 0.800 | 0.0276                | 0.0295 | 0.0315 |
| ddd    | -           | -     | 0.100 | -                     | -      | 0.0039 |
| eee    | -           | -     | 0.150 | -                     | -      | 0.0059 |
| fff    | -           | -     | 0.050 | -                     | -      | 0.0020 |

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

**Figure 33. UFBGA100 - 100-pin, 7 x 7 mm, 0.50 mm pitch, ultra fine pitch ball grid array package recommended footprint****Table 73. UFBGA100 recommended PCB design rules (0.5 mm pitch BGA)**

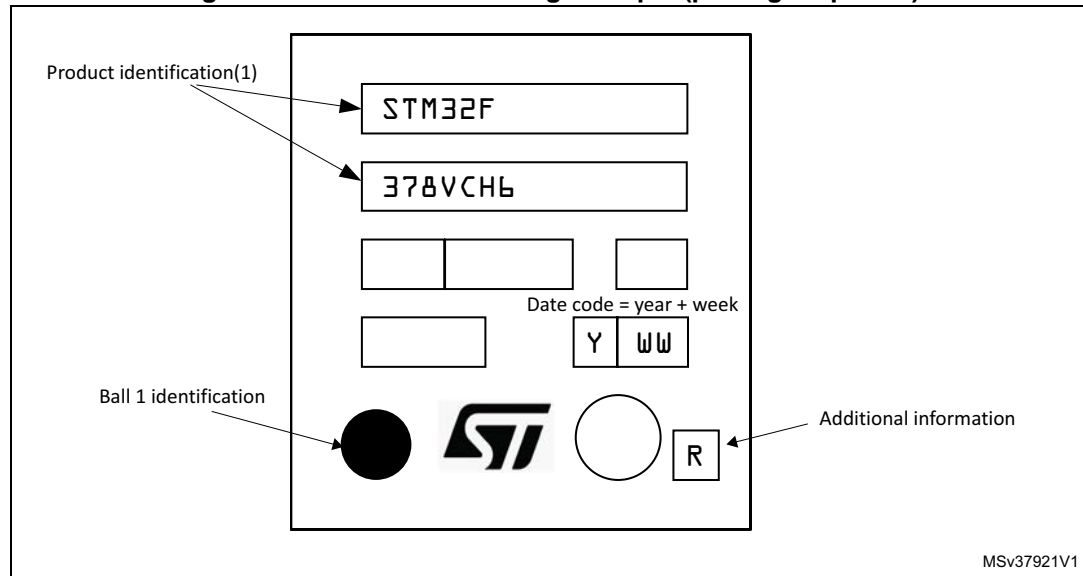
| Dimension         | Recommended values   |
|-------------------|--|
| Pitch             | 0.5  |
| Dpad              | 0.280 mm   |
| Dsm               | 0.370 mm typ. (depends on the soldermask registration tolerance) |
| Stencil opening   | 0.280 mm   |
| Stencil thickness | Between 0.100 mm and 0.125 mm                                    |



### Device Marking for UFBGA100

The following figure gives an example of topside marking orientation versus ball 1 identifier location.

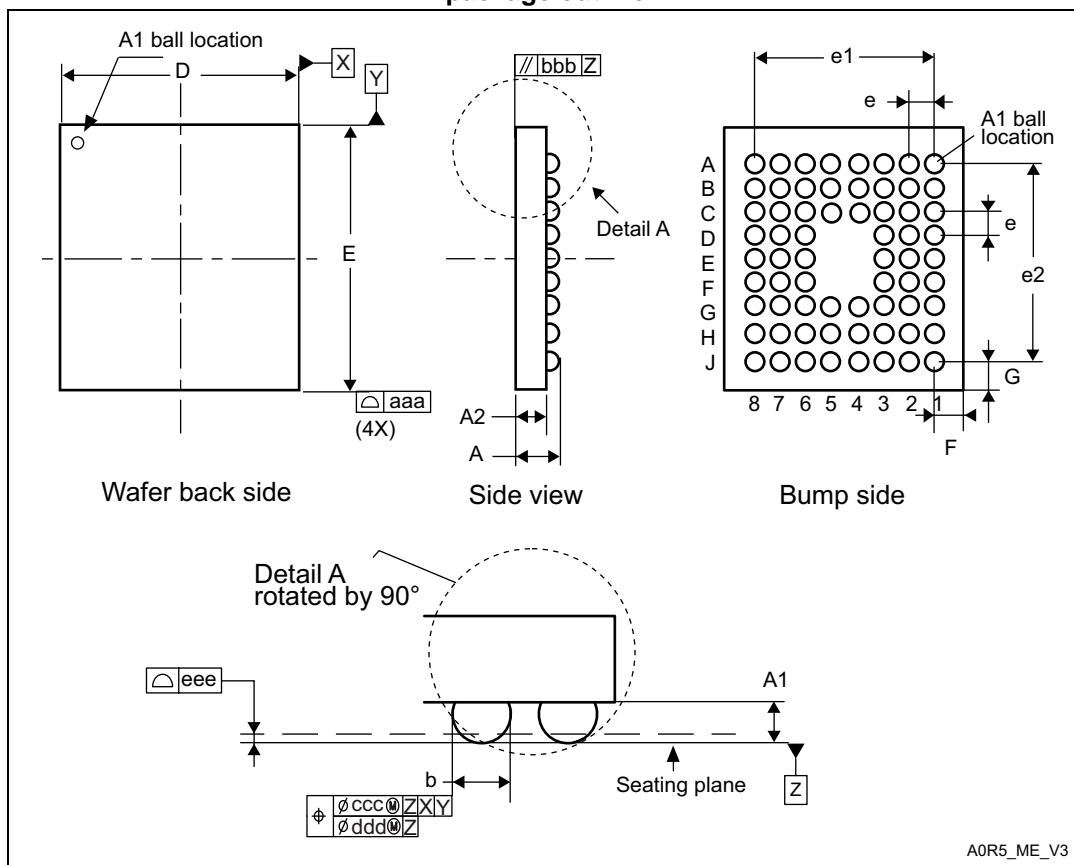
**Figure 34. UFBGA100 marking example (package top view)**



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.

## 7.2 WLCSP66 package information

Figure 35. WLCSP66 - 66-pin, 3.767 x 4.229 mm, 0.4 mm pitch wafer level chip scale package outline



1. Drawing is not to scale.

Table 74. WLCSP66 - 66-pin, 3.767 x 4.229 mm, 0.4 mm pitch wafer level chip scale package mechanical data

| Symbol           | millimeters |       |       | inches <sup>(1)</sup> |        |        |
|------------------|-------------|-------|-------|-----------------------|--------|--------|
|                  | Min         | Typ   | Max   | Min                   | Typ    | Max    |
| A                | 0.540       | 0.570 | 0.600 | 0.0213                | 0.0224 | 0.0236 |
| A1               | -           | 0.190 | -     | -                     | 0.0075 | -      |
| A2               | -           | 0.380 | -     | -                     | 0.0150 | -      |
| b <sup>(2)</sup> | 0.240       | 0.270 | 0.300 | 0.0094                | 0.0106 | 0.0118 |
| D                | 3.732       | 3.767 | 3.802 | 0.1469                | 0.1483 | 0.1497 |
| E                | 4.194       | 4.229 | 4.264 | 0.1651                | 0.1665 | 0.1679 |
| e                | -           | 0.400 | -     | -                     | 0.0157 | -      |
| e1               | -           | 2.800 | -     | -                     | 0.1102 | -      |
| e2               | -           | 3.200 | -     | -                     | 0.1260 | -      |

**Table 74. WLCSP66 - 66-pin, 3.767 x 4.229 mm, 0.4 mm pitch wafer level chip scale package mechanical data (continued)**

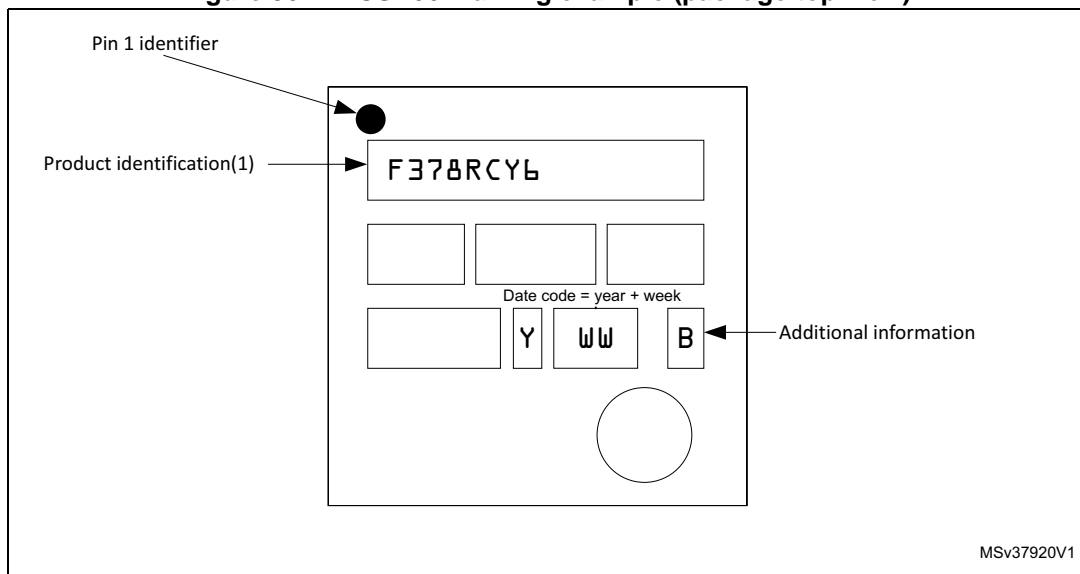
| Symbol | millimeters |       |       | inches <sup>(1)</sup> |        |        |
|--------|-------------|-------|-------|-----------------------|--------|--------|
|        | Min         | Typ   | Max   | Min                   | Typ    | Max    |
| F      | -           | 0.484 | -     | -                     | 0.0191 | -      |
| G      | -           | 0.515 | -     | -                     | 0.0203 | -      |
| aaa    | -           | -     | 0.100 | -                     | -      | 0.0039 |
| bbb    | -           | -     | 0.100 | -                     | -      | 0.0039 |
| ccc    | -           | -     | 0.100 | -                     | -      | 0.0039 |
| ddd    | -           | -     | 0.050 | -                     | -      | 0.0020 |
| eee    | -           | -     | 0.050 | -                     | -      | 0.0020 |

1. Values in inches are converted from mm and rounded to 4 decimal digits.
2. Dimension is measured at the maximum bump diameter parallel to primary datum Z.

### Device Marking for WLCSP66

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

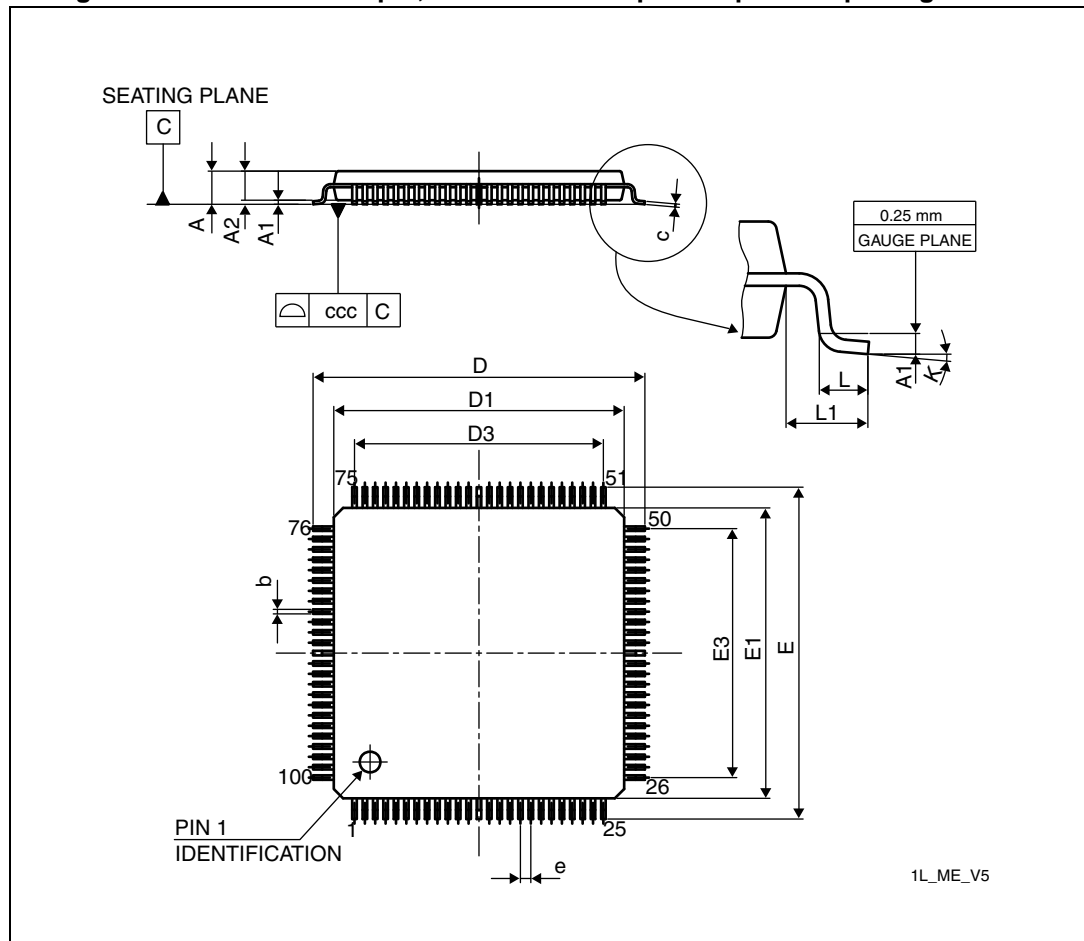
**Figure 36. WLCSP66 marking example (package top view)**



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.

### 7.3 LQFP100 package information

Figure 37. LQFP100 - 100-pin, 14 x 14 mm low-profile quad flat package outline



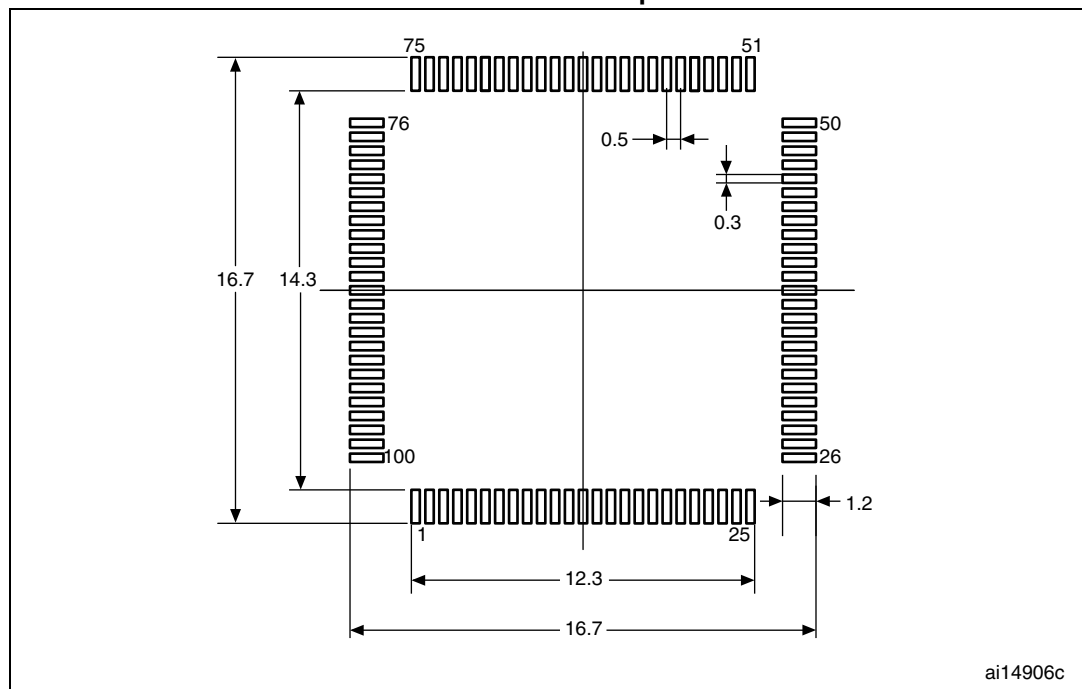
1. Drawing is not to scale.

**Table 75. LQPF100 - 100-pin, 14 x 14 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      | 15.800      | 16.000 | 16.200 | 0.6220                | 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 | 0.6220                | 0.6299 | 0.6378 |
| E1     | 13.800      | 14.000 | 14.200 | 0.5433                | 0.5512 | 0.5591 |
| 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      | 0.0°        | 3.5°   | 7.0°   | 0.0°                  | 3.5°   | 7.0°   |
| ccc    | -           | -      | 0.080  | -                     | -      | 0.0031 |

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

**Figure 38. LQFP100 - 100-pin, 14 x 14 mm low-profile quad flat recommended footprint**

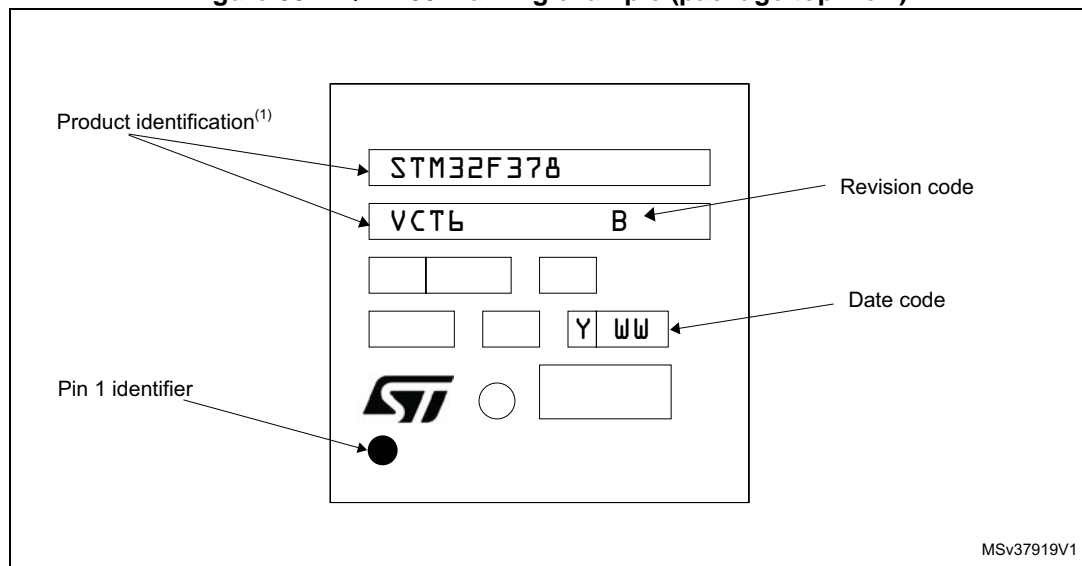


1. Dimensions are expressed in millimeters.

### Device marking for LQFP100

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

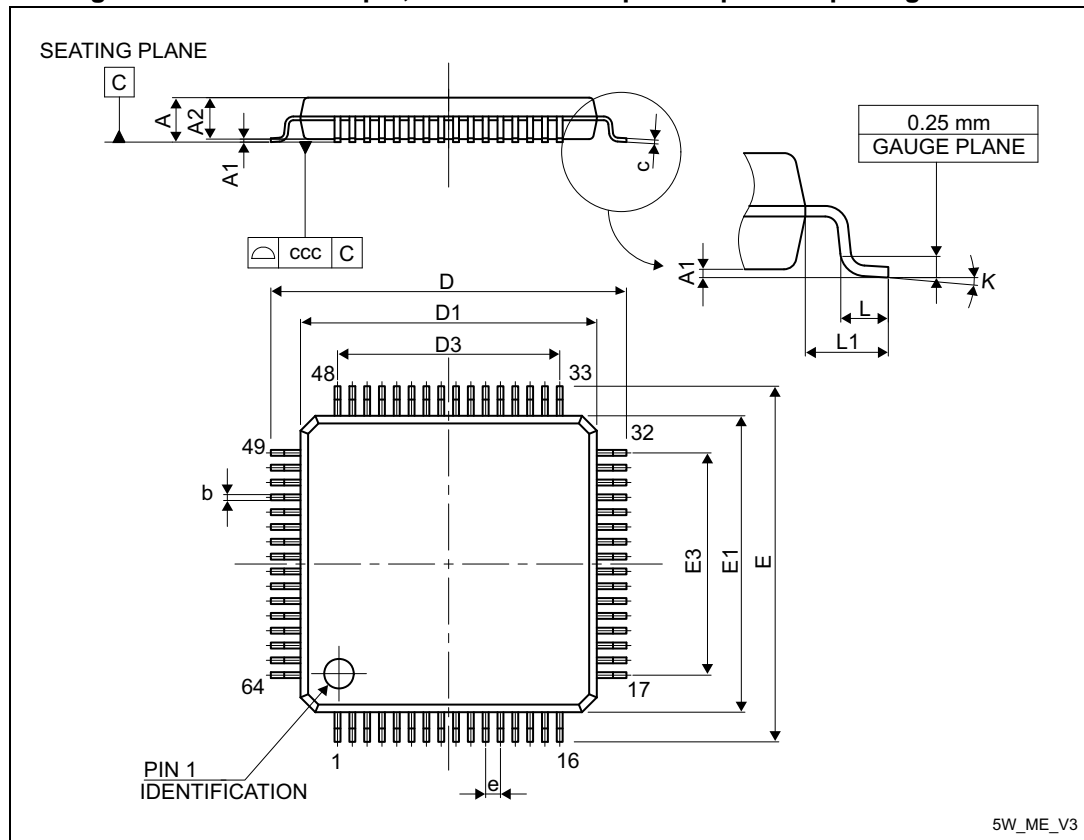
**Figure 39. LQFP100 marking example (package top view)**



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.

## 7.4 LQFP64 package information

Figure 40. LQFP64 - 64-pin, 10 x 10 mm low-profile quad flat package outline



1. Drawing is not to scale.

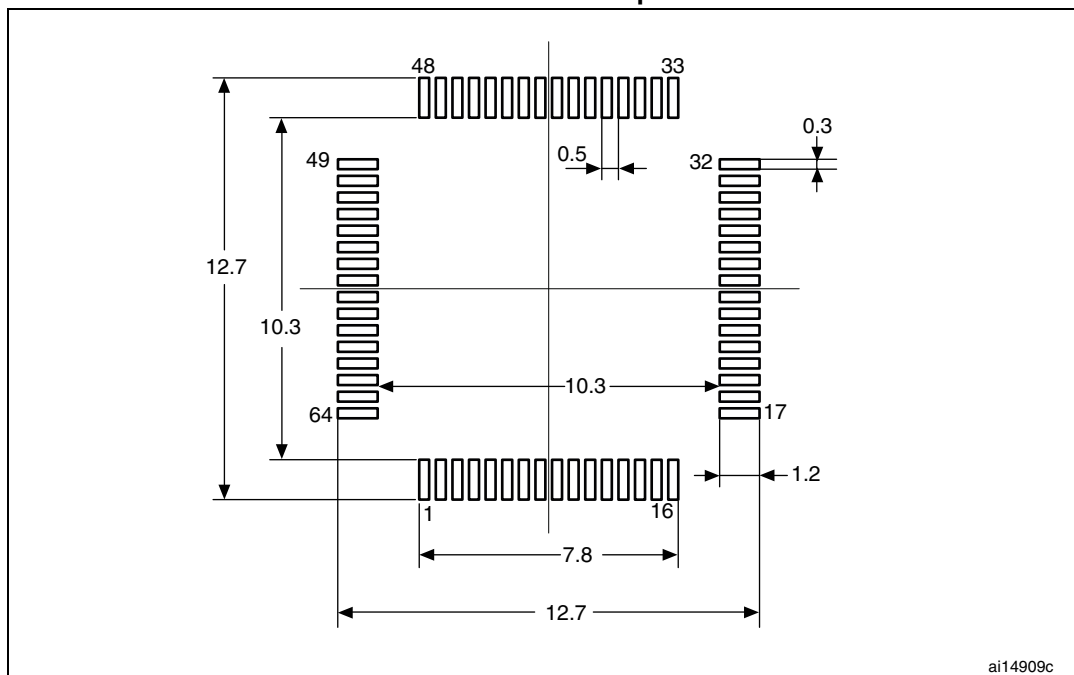
**Table 76. LQFP64 - 64-pin, 10 x 10 mm low-profile quad flat package mechanical data**

| 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      | -           | 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 | -      |
| e      | -           | 0.500  | -     | -                     | 0.0197 | -      |
| K      | 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 41. LQFP64 - 64-pin, 10 x 10 mm low-profile quad flat package recommended footprint**

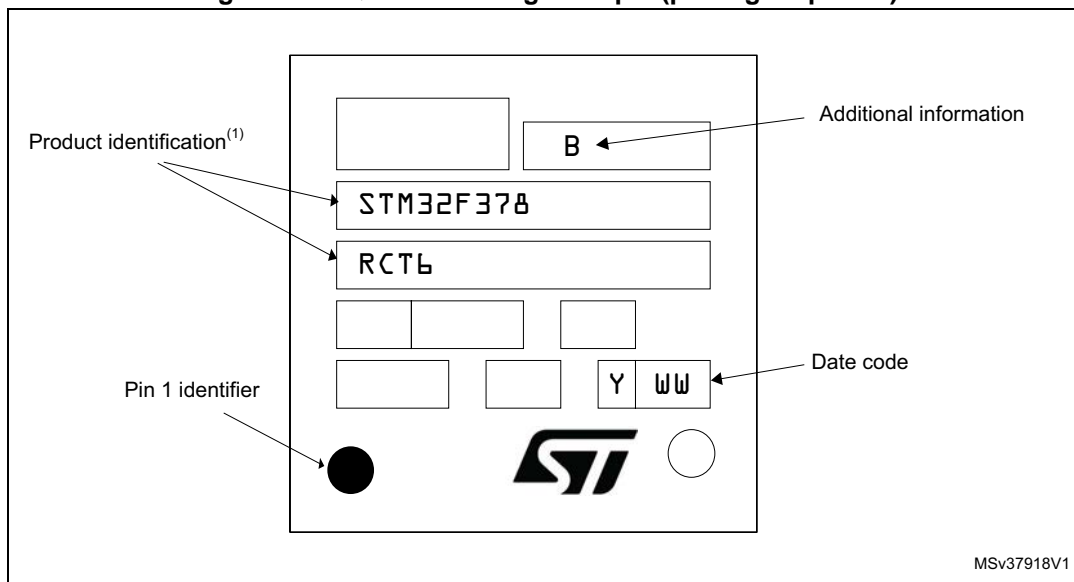


1. Dimensions are expressed in millimeters.

### Device marking for LQFP64

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

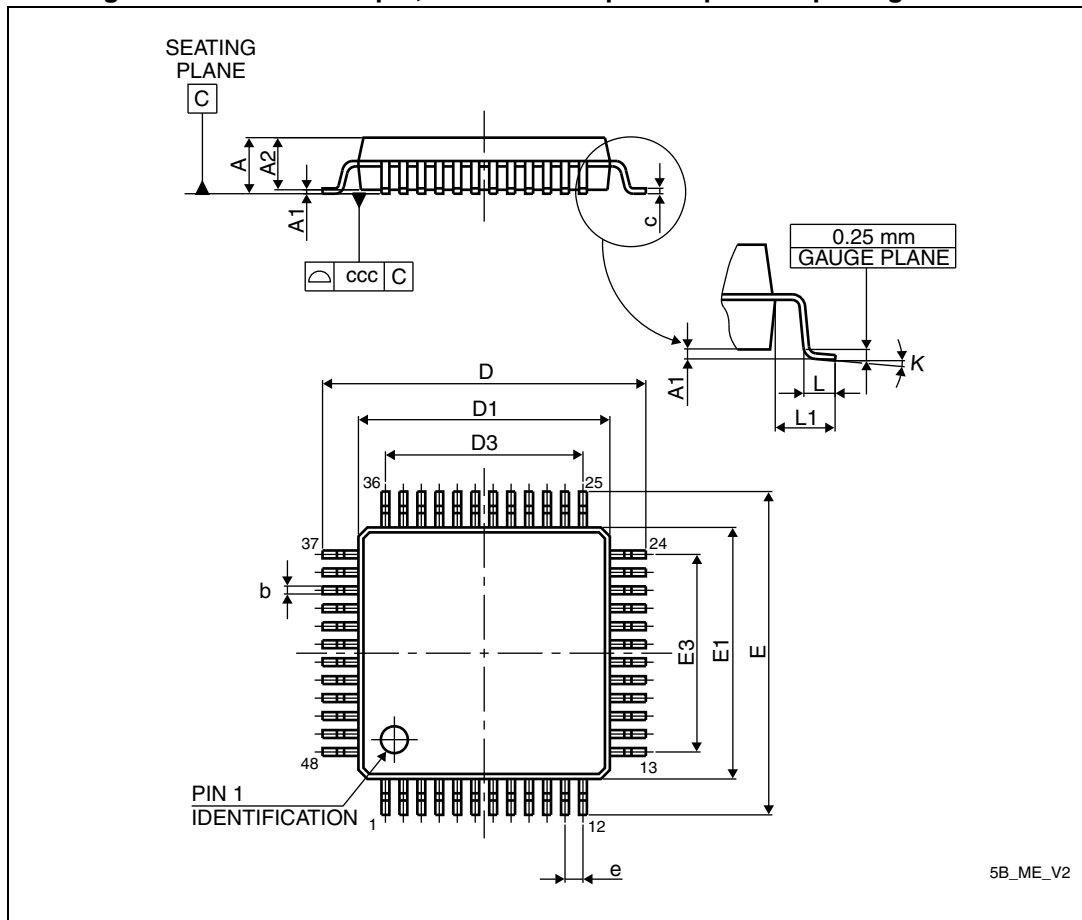
**Figure 42. LQFP64 marking example (package top view)**



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.

## 7.5 LQFP48 package information

Figure 43. LQFP48 - 48-pin, 7 x 7 mm low-profile quad flat package outline



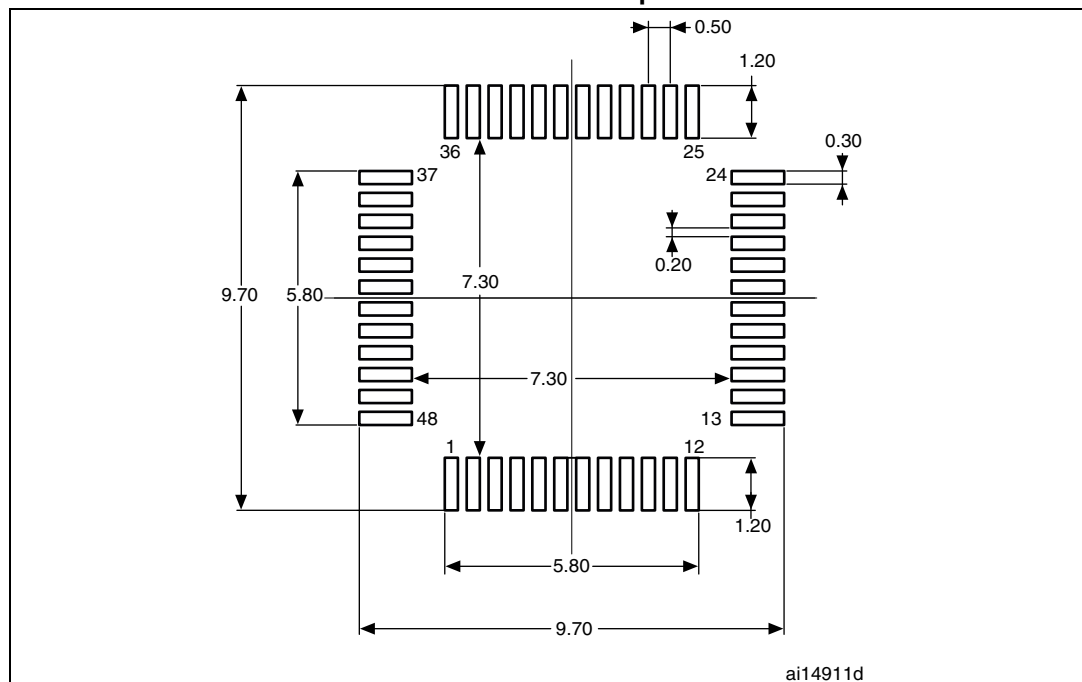
1. Drawing is not to scale.

**Table 77. LQFP48 - 48-pin, 7 x 7 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      | 8.800       | 9.000 | 9.200 | 0.3465                | 0.3543 | 0.3622 |
| D1     | 6.800       | 7.000 | 7.200 | 0.2677                | 0.2756 | 0.2835 |
| D3     | -           | 5.500 | -     | -                     | 0.2165 | -      |
| E      | 8.800       | 9.000 | 9.200 | 0.3465                | 0.3543 | 0.3622 |
| E1     | 6.800       | 7.000 | 7.200 | 0.2677                | 0.2756 | 0.2835 |
| E3     | -           | 5.500 | -     | -                     | 0.2165 | -      |
| 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 44. LQFP48 - 48-pin, 7 x 7 mm low-profile quad flat package recommended footprint**

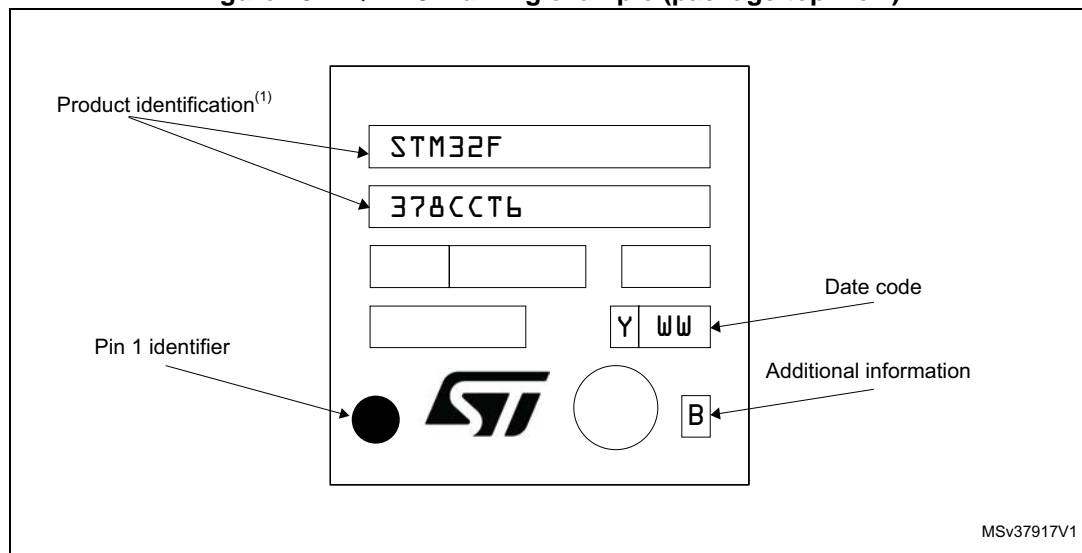


1. Dimensions are expressed in millimeters.

### Device marking for LQFP48

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

**Figure 45. LQFP48 marking example (package top view)**



1. Samples marked "ES" are to be considered as "Engineering Samples": i.e. they are intended to be sent to customer for electrical compatibility evaluation and may be used to start customer qualification where specifically authorized by ST in writing. In no event ST will be liable for any customer usage in production. Only if ST has authorized in writing the customer qualification Engineering Samples can be used for reliability qualification trials.

## 7.6 Thermal characteristics

The maximum chip junction temperature ( $T_{Jmax}$ ) must never exceed the values given in [Table 22: General operating conditions](#).

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

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

Where:

- $T_A$  max is the maximum ambient temperature in °C,
- $Q_{JA}$  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:

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

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 78. Package thermal characteristics**

| Symbol        | Parameter   | Value | Unit |
|---------------|---|-------|------|
| $\Theta_{JA}$ | <b>Thermal resistance junction-ambient</b><br>LQFP64 - 10 × 10 mm / 0.5 mm pitch  | 45    | °C/W |
|               | <b>Thermal resistance junction-ambient</b><br>LQFP48 - 7 × 7 mm                   | 55    |      |
|               | <b>Thermal resistance junction-ambient</b><br>LQFP100 - 14 × 14 mm / 0.5 mm pitch | 46    |      |
|               | <b>Thermal resistance junction-ambient</b><br>BGA100 - 7 × 7 mm                   | 59    |      |
|               | <b>Thermal resistance junction-ambient</b><br>WLCSP66 - 0.400 mm                  | 53    |      |

### 7.6.1 Reference document

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

## 7.6.2 Selecting the product temperature range

When ordering the microcontroller, the temperature range is specified in the ordering information scheme shown in [Section 8: Part numbering](#).

Each temperature range suffix corresponds to a specific guaranteed ambient temperature at maximum dissipation and, to a specific maximum junction temperature.

As applications do not commonly use the STM32F378xx at maximum dissipation, it is useful to calculate the exact power consumption and junction temperature to determine which temperature range will be best suited to the application.

The following examples show how to calculate the temperature range needed for a given application.

### Example 1: High-performance application

Assuming the following application conditions:

Maximum ambient temperature  $T_{Amax} = 82\text{ °C}$  (measured according to JESD51-2),  
 $I_{DDmax} = 50\text{ mA}$ ,  $V_{DD} = 1.8\text{ V}$ , maximum 3 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 2 I/Os used at the same time in output at low level with  $I_{OL} = 20\text{ mA}$ ,  $V_{OL} = 1.3\text{ V}$

$$P_{INTmax} = 50\text{ mA} \times 1.8\text{ V} = 90\text{ mW}$$

$$P_{IOmax} = 3 \times 8\text{ mA} \times 0.4\text{ V} + 2 \times 20\text{ mA} \times 1.3\text{ V} = 61.6\text{ mW}$$

This gives:  $P_{INTmax} = 90\text{ mW}$  and  $P_{IOmax} = 61.6\text{ mW}$ :

$$P_{Dmax} = 90 + 61.6 = 151.6\text{ mW}$$

Thus:  $P_{Dmax} = 151.6\text{ mW}$

Using the values obtained in [Table 78](#)  $T_{Jmax}$  is calculated as follows:

– For LQFP64,  $45\text{ °C/W}$

$$T_{Jmax} = 82\text{ °C} + (45\text{ °C/W} \times 151.6\text{ mW}) = 82\text{ °C} + 6.8\text{ °C} = 88.8\text{ °C}$$

This is within the range of the suffix 6 version parts ( $-40 < T_J < 105\text{ °C}$ ).

In this case, parts must be ordered at least with the temperature range suffix 6 (see [Section 8: Part numbering](#)).

### Example 2: High-temperature application

Using the same rules, it is possible to address applications that run at high ambient temperatures with a low dissipation, as long as junction temperature  $T_J$  remains within the specified range.

Assuming the following application conditions:

Maximum ambient temperature  $T_{Amax} = 115\text{ °C}$  (measured according to JESD51-2),  
 $I_{DDmax} = 20\text{ mA}$ ,  $V_{DD} = 1.8\text{ V}$ , maximum 9 I/Os used at the same time in output at low level with  $I_{OL} = 8\text{ mA}$ ,  $V_{OL} = 0.4\text{ V}$

$$P_{INTmax} = 20\text{ mA} \times 1.8\text{ V} = 36\text{ mW}$$

$$P_{IOmax} = 9 \times 8\text{ mA} \times 0.4\text{ V} = 28.8\text{ mW}$$

This gives:  $P_{INTmax} = 36\text{ mW}$  and  $P_{IOmax} = 28.8\text{ mW}$ :

$$P_{Dmax} = 36 + 28.8 = 64.8\text{ mW}$$

Thus:  $P_{Dmax} = 64.8\text{ mW}$

Using the values obtained in [Table 78](#)  $T_{Jmax}$  is calculated as follows:

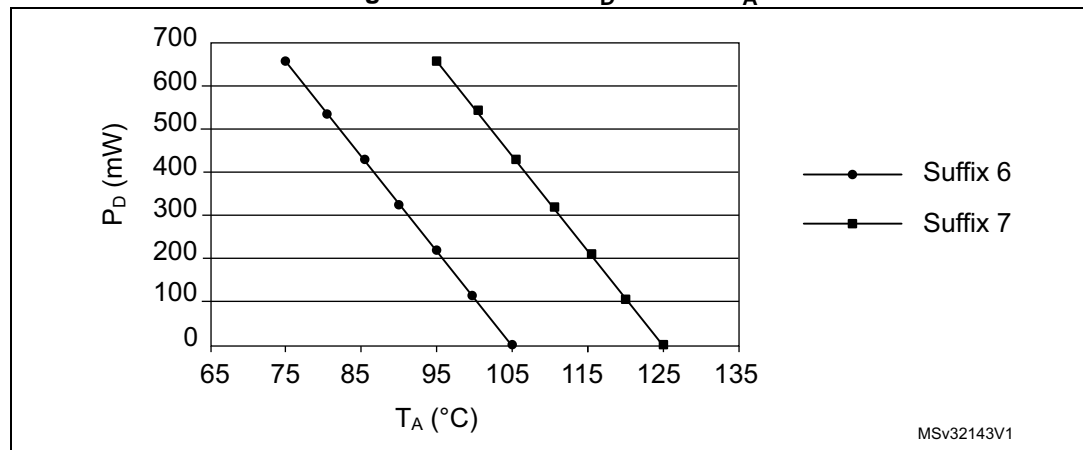
– For LQFP100, 46°C/W

$$T_{Jmax} = 115\text{ °C} + (46\text{ °C/W} \times 64.8\text{ mW}) = 115\text{ °C} + 2.98\text{ °C} = 118\text{ °C}$$

This is within the range of the suffix 7 version parts ( $-40 < T_J < 125\text{ °C}$ ).

In this case, parts must be ordered at least with the temperature range suffix 7 (see [Section 8: Part numbering](#)).

**Figure 46. LQFP64  $P_D$  max vs.  $T_A$**



# 8 Part numbering

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

Table 79. Ordering information scheme

|   |       |   |     |   |   |   |   |   |  |  |  |  |  |  |  |  |
|---|-------|---|-----|---|---|---|---|---|--|--|--|--|--|--|--|--|
| Example:  | STM32 | F | 378 | R | C | T | 6 | x |  |  |  |  |  |  |  |  |
| Device family                                   |       |   |     |   |   |   |   |   |  |  |  |  |  |  |  |  |
| STM32 = ARM-based 32-bit microcontroller        |       |   |     |   |   |   |   |   |  |  |  |  |  |  |  |  |
| Product type                                    |       |   |     |   |   |   |   |   |  |  |  |  |  |  |  |  |
| F = General-purpose                             |       |   |     |   |   |   |   |   |  |  |  |  |  |  |  |  |
| Sub-family                                      |       |   |     |   |   |   |   |   |  |  |  |  |  |  |  |  |
| 378 = STM32F378xx                               |       |   |     |   |   |   |   |   |  |  |  |  |  |  |  |  |
| Pin count                                       |       |   |     |   |   |   |   |   |  |  |  |  |  |  |  |  |
| C = 48 pins                                     |       |   |     |   |   |   |   |   |  |  |  |  |  |  |  |  |
| R = 64/66 pins                                  |       |   |     |   |   |   |   |   |  |  |  |  |  |  |  |  |
| V = 100 pins                                    |       |   |     |   |   |   |   |   |  |  |  |  |  |  |  |  |
| Code size                                       |       |   |     |   |   |   |   |   |  |  |  |  |  |  |  |  |
| C = 256 Kbytes of Flash memory                  |       |   |     |   |   |   |   |   |  |  |  |  |  |  |  |  |
| Package   |       |   |     |   |   |   |   |   |  |  |  |  |  |  |  |  |
| T = LQFP  |       |   |     |   |   |   |   |   |  |  |  |  |  |  |  |  |
| H = BGA   |       |   |     |   |   |   |   |   |  |  |  |  |  |  |  |  |
| Y = WLCSP                                       |       |   |     |   |   |   |   |   |  |  |  |  |  |  |  |  |
| Temperature range                               |       |   |     |   |   |   |   |   |  |  |  |  |  |  |  |  |
| 6 = Industrial temperature range, −40 to 85 °C  |       |   |     |   |   |   |   |   |  |  |  |  |  |  |  |  |
| 7 = Industrial temperature range, −40 to 105 °C |       |   |     |   |   |   |   |   |  |  |  |  |  |  |  |  |
| Options   |       |   |     |   |   |   |   |   |  |  |  |  |  |  |  |  |
| xxx = programmed parts                          |       |   |     |   |   |   |   |   |  |  |  |  |  |  |  |  |
| TR = tape and reel                              |       |   |     |   |   |   |   |   |  |  |  |  |  |  |  |  |



## 9 Revision history

**Table 80. Document revision history**

| Date        | Revision | Changes  |
|-------------|----------|--|
| 04-Mar-2014 | 1        | Initial release.   |
| 09-Apr-2014 | 2        | Removed sub-set part number (64KB and 128KB).<br>Updated <a href="#">Part numbering on page 128</a>  |
| 21-Jul-2015 | 3        | <p>Updated <a href="#">Section 7</a><br/> Updated <a href="#">Section 3.13</a><br/> Updated <a href="#">Section 3.7.1</a>, <a href="#">Section 3.7.3</a><br/> Updated <a href="#">Table 2: Device overview</a>, <a href="#">Table 11: STM32F378xx pin definitions</a>, <a href="#">Table 22: General operating conditions</a>, <a href="#">Table 47: ESD absolute maximum ratings</a>, <a href="#">Table 70: SDADC characteristics</a>, <a href="#">Table 74: WLCSP66 - 66-pin, 3.767 x 4.229 mm, 0.4 mm pitch wafer level chip scale package mechanical data</a> and <a href="#">Table 75: LQPF100 - 100-pin, 14 x 14 mm low-profile quad flat package mechanical data</a>, <a href="#">Table 78: Package thermal characteristics</a> and <a href="#">Table 79: Ordering information scheme</a><br/> Updated <a href="#">Figure 5: STM32F378xx UFBGA100 ballout</a>, <a href="#">Figure 10: Power supply scheme</a>, <a href="#">Figure 35: WLCSP66 - 66-pin, 3.767 x 4.229 mm, 0.4 mm pitch wafer level chip scale package outline</a>, <a href="#">Figure 36: WLCSP66 marking example (package top view)</a>, <a href="#">Figure 38: LQFP100 - 100-pin, 14 x 14 mm low-profile quad flat recommended footprint</a>, <a href="#">Figure 39: LQFP100 marking example (package top view)</a>, <a href="#">Figure 40: LQFP64 - 64-pin, 10 x 10 mm low-profile quad flat package outline</a>, <a href="#">Figure 41: LQFP64 - 64-pin, 10 x 10 mm low-profile quad flat package recommended footprint</a>, <a href="#">Figure 42: LQFP64 marking example (package top view)</a>, <a href="#">Figure 44: LQFP48 - 48-pin, 7 x 7 mm low-profile quad flat package recommended footprint</a>, <a href="#">Figure 45: LQFP48 marking example (package top view)</a>.<br/> Added <a href="#">Table 30: Typical and maximum current consumption from VBAT supply</a>, <a href="#">Table 63: Comparator characteristics</a>, <a href="#">Table 73: UFBGA100 recommended PCB design rules (0.5 mm pitch BGA)</a><br/> Added <a href="#">Figure 12: Typical VBAT current consumption (LSE and RTC ON/LSEDRV[1:0]='00')</a>, <a href="#">Figure 31: Maximum VREFINT scaler startup time from power down</a> and <a href="#">Figure 33: UFBGA100 - 100-pin, 7 x 7 mm, 0.50 mm pitch, ultra fine pitch ball grid array package recommended footprint</a>.</p> |

Table 80. Document revision history (continued)

| Date        | Revision | Changes  |
|-------------|----------|--|
| 10-Jun-2016 | 4        | <p>Updated:</p> <ul style="list-style-type: none"> <li>– <a href="#">Table 3: Capacitive sensing GPIOs available on STM32F378xx devices</a></li> <li>– <a href="#">Table 19: Voltage characteristics</a></li> <li>– <a href="#">Table 25: Embedded internal reference voltage</a></li> <li>– <a href="#">Table 39: LSE oscillator characteristics (fLSE = 32.768 kHz)</a></li> <li>– <a href="#">Table 47: ESD absolute maximum ratings</a></li> <li>– <a href="#">Table 59: ADC characteristics</a></li> <li>– <a href="#">Table 62: DAC characteristics</a></li> <li>– <a href="#">Table 64: Temperature sensor calibration values</a></li> <li>– <a href="#">Table 70: SDADC characteristics</a></li> <li>– <a href="#">Table 78: Package thermal characteristics</a></li> <li>– <a href="#">Figure 18: TC and TTa I/O input characteristics</a></li> <li>– <a href="#">Figure 19: Five volt tolerant (FT and FTf) I/O input characteristics</a></li> </ul> <p>Removed:</p> <ul style="list-style-type: none"> <li>– <a href="#">Figure 19: TC and TTa I/O input characteristics - TTL port</a></li> <li>– <a href="#">Figure 21: Five volt tolerant (FT and FTf) I/O input characteristics - TTL port</a></li> </ul> |

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