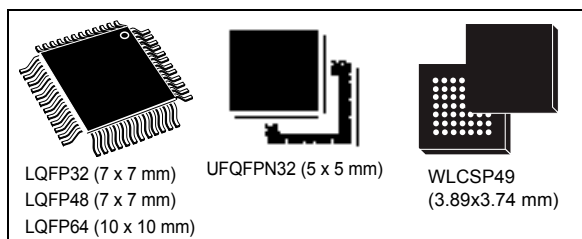


Arm® Cortex®-M4 32b MCU+FPU, up to 64KB Flash, 16KB SRAM,  
2 ADCs, 3 DACs, 3 comp., op-amp, 217ps 10-ch (HRTIM1)

Datasheet - production data

## Features

- Core: Arm® Cortex®-M4 32-bit CPU with FPU (72 MHz max), single-cycle multiplication and HW division DSP instruction
- Memories
  - Up to 64 Kbytes of Flash memory
  - Up to 12 Kbytes of SRAM with HW parity check
  - Routine booster: 4 Kbytes of SRAM on instruction and data bus with HW parity check (CCM)
- CRC calculation unit
- Reset and supply management
  - Low-power modes: Sleep, Stop, Standby
  - $V_{DD}$ ,  $V_{DDA}$  voltage range: 2.0 to 3.6 V
  - Power-on/Power-down reset (POR/PDR)
  - Programmable voltage detector (PVD)
  - $V_{BAT}$  supply for RTC and backup registers
- Clock management
  - 4 to 32 MHz crystal oscillator
  - 32 kHz oscillator for RTC with calibration
  - Internal 8 MHz RC (up to 64 MHz with PLL option)
  - Internal 40 kHz oscillator
- Up to 51 fast I/O ports, all mappable on external interrupt vectors, several 5 V-tolerant
- Interconnect matrix
- 7-channel DMA controller
- Up to two ADC 0.20  $\mu$ s (up to 21 channels) with selectable resolution of 12/10/8/6 bits, 0 to 3.6 V conversion range, single-ended / differential mode, separate analog supply from 2.0 to 3.6 V
- Temperature sensor
- Up to three 12-bit DAC channels with analog supply from 2.4 V to 3.6 V
- Three ultra-fast rail-to-rail analog comparators with analog supply from 2 to 3.6 V
- One operational amplifiers that can be used in PGA mode, all terminals accessible with analog supply from 2.4 to 3.6 V
- Up to 18 capacitive sensing channels supporting touchkeys, linear and rotary touch sensors
- Up to 12 timers
  - HRTIM: 6 x16-bit counters, 217 ps resolution, 10 PWM, 5 fault inputs, 10 ext event input, 1 synchro. input, 1 synchro. out
  - One 32-bit timer and one 16-bit timer with up to 4 IC/OC/PWM or pulse counter and quadrature (incremental) encoder input
  - One 16-bit 6-channel advanced-control timer, with up to 6 PWM channels, deadline generation and emergency stop
  - One 16-bit timer with 2 IC/OCs, 1 OCN/PWM, deadline generation, emergency stop
  - Two 16-bit timers with IC/OC/OCN/PWM, deadline generation and emergency stop
  - Two watchdog timers (independent, window)
  - SysTick timer: 24-bit downcounter
  - Up to two 16-bit basic timers to drive DAC
- Calendar RTC with alarm, periodic wakeup from Stop
- Communication interfaces
  - CAN interface (2.0 B Active) and one SPI



- One I<sup>2</sup>C with 20 mA current sink to support Fast mode plus, SMBus/PMBus
- Up to 3 USARTs, one with ISO/IEC 7816 interface, LIN, IrDA, modem control
- Debug mode: serial wire debug (SWD), JTAG
- 96-bit unique ID
- All packages ECOPACK<sup>®</sup>2 compliant

**Table 1. Device summary**

| Reference   | Part number       |
|-------------|-------------------|
| STM32F334Kx | STM32F334K4/K6/K8 |
| STM32F334Cx | STM32F334C4/C6/C8 |
| STM32F334Rx | STM32F334R6/R8    |

# Contents

|          |                                                                         |           |
|----------|-------------------------------------------------------------------------|-----------|
| <b>1</b> | <b>Introduction .....</b>                                               | <b>10</b> |
| <b>2</b> | <b>Description .....</b>                                                | <b>11</b> |
| <b>3</b> | <b>Functional overview .....</b>                                        | <b>14</b> |
| 3.1      | Arm® Cortex®-M4 core with FPU with embedded Flash memory and SRAM ..... | 14        |
| 3.2      | Memories .....                                                          | 14        |
| 3.2.1    | Embedded Flash memory .....                                             | 14        |
| 3.2.2    | Embedded SRAM .....                                                     | 14        |
| 3.2.3    | Boot modes .....                                                        | 15        |
| 3.3      | Cyclic redundancy check calculation unit (CRC) .....                    | 15        |
| 3.4      | Power management .....                                                  | 15        |
| 3.4.1    | Power supply schemes .....                                              | 15        |
| 3.4.2    | Power supply supervisor .....                                           | 15        |
| 3.4.3    | Voltage regulator .....                                                 | 16        |
| 3.4.4    | Low-power modes .....                                                   | 16        |
| 3.5      | Interconnect matrix .....                                               | 17        |
| 3.6      | Clocks and startup .....                                                | 18        |
| 3.7      | General-purpose inputs/outputs (GPIOs) .....                            | 20        |
| 3.8      | Direct memory access (DMA) .....                                        | 20        |
| 3.9      | Interrupts and events .....                                             | 20        |
| 3.9.1    | Nested vectored interrupt controller (NVIC) .....                       | 20        |
| 3.9.2    | Extended interrupt/event controller (EXTI) .....                        | 20        |
| 3.10     | Fast analog-to-digital converter (ADC) .....                            | 21        |
| 3.10.1   | Temperature sensor .....                                                | 21        |
| 3.10.2   | Internal voltage reference (VREFINT) .....                              | 21        |
| 3.10.3   | V <sub>BAT</sub> battery voltage monitoring .....                       | 22        |
| 3.10.4   | OPAMP2 reference voltage (VOPAMP2) .....                                | 22        |
| 3.11     | Digital-to-analog converter (DAC) .....                                 | 22        |
| 3.12     | Operational amplifier (OPAMP) .....                                     | 22        |
| 3.13     | Ultra-fast comparators (COMP) .....                                     | 23        |
| 3.14     | Timers and watchdogs .....                                              | 23        |

|          |                                                                        |           |
|----------|------------------------------------------------------------------------|-----------|
| 3.14.1   | 217 ps high-resolution timer (HRTIM1)                                  | 24        |
| 3.14.2   | Advanced timer (TIM1)                                                  | 24        |
| 3.14.3   | General-purpose timers (TIM2, TIM3, TIM15, TIM16 and TIM17)            | 25        |
| 3.14.4   | Basic timers (TIM6 and TIM7)                                           | 25        |
| 3.14.5   | Independent watchdog                                                   | 25        |
| 3.14.6   | Window watchdog                                                        | 25        |
| 3.14.7   | SysTick timer                                                          | 26        |
| 3.15     | Real-time clock (RTC) and backup registers                             | 26        |
| 3.16     | Communication interfaces                                               | 27        |
| 3.16.1   | Inter-integrated circuit interface (I <sup>2</sup> C)                  | 27        |
| 3.16.2   | Universal synchronous / asynchronous receivers / transmitters (USARTs) | 28        |
| 3.16.3   | Serial peripheral interface (SPI)                                      | 28        |
| 3.16.4   | Controller area network (CAN)                                          | 29        |
| 3.17     | Infrared transmitter                                                   | 29        |
| 3.18     | Touch sensing controller (TSC)                                         | 29        |
| 3.19     | Development support                                                    | 31        |
| 3.19.1   | Serial-wire JTAG debug port (SWJ-DP)                                   | 31        |
| <b>4</b> | <b>Pinout and pin descriptions</b>                                     | <b>32</b> |
| <b>5</b> | <b>Memory mapping</b>                                                  | <b>44</b> |
| <b>6</b> | <b>Electrical characteristics</b>                                      | <b>47</b> |
| 6.1      | Parameter conditions                                                   | 47        |
| 6.1.1    | Minimum and maximum values                                             | 47        |
| 6.1.2    | Typical values                                                         | 47        |
| 6.1.3    | Typical curves                                                         | 47        |
| 6.1.4    | Loading capacitor                                                      | 47        |
| 6.1.5    | Input voltage on a pin                                                 | 47        |
| 6.1.6    | Power-supply scheme                                                    | 48        |
| 6.1.7    | Measurement of the current consumption                                 | 49        |
| 6.2      | Absolute maximum ratings                                               | 50        |
| 6.3      | Operating conditions                                                   | 52        |
| 6.3.1    | General operating conditions                                           | 52        |
| 6.3.2    | Operating conditions at power-up / power-down                          | 53        |
| 6.3.3    | Characteristics of the embedded reset and power-control block          | 53        |

|          |                                             |            |
|----------|---------------------------------------------|------------|
| 6.3.4    | Embedded reference voltage                  | 54         |
| 6.3.5    | Supply current characteristics              | 55         |
| 6.3.6    | Wakeup time from low-power mode             | 66         |
| 6.3.7    | External clock source characteristics       | 66         |
| 6.3.8    | Internal clock source characteristics       | 70         |
| 6.3.9    | PLL characteristics                         | 72         |
| 6.3.10   | Memory characteristics                      | 73         |
| 6.3.11   | EMC characteristics                         | 73         |
| 6.3.12   | Electrical sensitivity characteristics      | 75         |
| 6.3.13   | I/O current injection characteristics       | 75         |
| 6.3.14   | I/O port characteristics                    | 76         |
| 6.3.15   | NRST pin characteristics                    | 81         |
| 6.3.16   | High-resolution timer (HRTIM)               | 82         |
| 6.3.17   | Timer characteristics                       | 85         |
| 6.3.18   | Communication interfaces                    | 86         |
| 6.3.19   | ADC characteristics                         | 89         |
| 6.3.20   | DAC electrical specifications               | 97         |
| 6.3.21   | Comparator characteristics                  | 99         |
| 6.3.22   | Operational amplifier characteristics       | 100        |
| 6.3.23   | Temperature sensor (TS) characteristics     | 103        |
| 6.3.24   | V <sub>BAT</sub> monitoring characteristics | 103        |
| <b>7</b> | <b>Package information</b>                  | <b>104</b> |
| 7.1      | Package mechanical data                     | 104        |
| 7.2      | LQFP32 package information                  | 105        |
| 7.3      | LQFP48 package information                  | 108        |
| 7.4      | LQFP64 package information                  | 111        |
| 7.5      | WLCSP49 package information                 | 114        |
| 7.6      | UFQFPN32 package information                | 117        |
| 7.7      | Thermal characteristics                     | 120        |
| 7.7.1    | Reference document                          | 120        |
| 7.7.2    | Selecting the product temperature range     | 120        |
| <b>8</b> | <b>Ordering information</b>                 | <b>122</b> |
| <b>9</b> | <b>Revision history</b>                     | <b>123</b> |

## List of tables

|           |                                                                                                           |    |
|-----------|-----------------------------------------------------------------------------------------------------------|----|
| Table 1.  | Device summary . . . . .                                                                                  | 2  |
| Table 2.  | STM32F334x4/6/8 family device features and peripheral counts . . . . .                                    | 11 |
| Table 3.  | V <sub>DDA</sub> ranges for analog peripherals . . . . .                                                  | 15 |
| Table 4.  | STM32F334x4/6/8 peripheral interconnect matrix . . . . .                                                  | 17 |
| Table 5.  | Timer feature comparison . . . . .                                                                        | 23 |
| Table 6.  | Comparison of I <sup>2</sup> C analog and digital filters . . . . .                                       | 27 |
| Table 7.  | STM32F334x4/6/8 I2C implementation . . . . .                                                              | 27 |
| Table 8.  | USART features . . . . .                                                                                  | 28 |
| Table 9.  | STM32F334x4/6/8 SPI implementation . . . . .                                                              | 28 |
| Table 10. | Capacitive sensing GPIOs available on STM32F334x4/6/8 devices . . . . .                                   | 30 |
| Table 11. | No. of capacitive sensing channels available on STM32F334x4/6/8 devices . . . . .                         | 31 |
| Table 12. | Legend/abbreviations used in the pinout table . . . . .                                                   | 36 |
| Table 13. | STM32F334x4/6/8 pin definitions . . . . .                                                                 | 36 |
| Table 14. | Alternate functions . . . . .                                                                             | 42 |
| Table 15. | STM32F334x4/6/8 peripheral register boundary addresses . . . . .                                          | 45 |
| Table 16. | Voltage characteristics . . . . .                                                                         | 50 |
| Table 17. | Current characteristics . . . . .                                                                         | 51 |
| Table 18. | Thermal characteristics . . . . .                                                                         | 51 |
| Table 19. | General operating conditions . . . . .                                                                    | 52 |
| Table 20. | Operating conditions at power-up / power-down . . . . .                                                   | 53 |
| Table 21. | Embedded reset and power control block characteristics . . . . .                                          | 53 |
| Table 22. | Programmable voltage detector characteristics . . . . .                                                   | 54 |
| Table 23. | Embedded internal reference voltage . . . . .                                                             | 54 |
| Table 24. | Internal reference voltage calibration values . . . . .                                                   | 55 |
| Table 25. | Typical and maximum current consumption from V <sub>DD</sub> supply at V <sub>DD</sub> = 3.6V . . . . .   | 56 |
| Table 26. | Typical and maximum current consumption from the V <sub>DDA</sub> supply . . . . .                        | 57 |
| Table 27. | Typical and maximum V <sub>DD</sub> consumption in Stop and Standby modes . . . . .                       | 57 |
| Table 28. | Typical and maximum V <sub>DDA</sub> consumption in Stop and Standby modes . . . . .                      | 58 |
| Table 29. | Typical and maximum current consumption from V <sub>BAT</sub> supply . . . . .                            | 58 |
| Table 30. | Typical current consumption in Run mode, code with data processing<br>running from Flash memory . . . . . | 60 |
| Table 31. | Typical current consumption in Sleep mode, code running from Flash or RAM . . . . .                       | 61 |
| Table 32. | Switching output I/O current consumption . . . . .                                                        | 63 |
| Table 33. | Peripheral current consumption . . . . .                                                                  | 64 |
| Table 34. | Low-power mode wakeup timings . . . . .                                                                   | 66 |
| Table 35. | Wakeup time using USART . . . . .                                                                         | 66 |
| Table 36. | High-speed external user clock characteristics . . . . .                                                  | 67 |
| Table 37. | Low-speed external user clock characteristics . . . . .                                                   | 67 |
| Table 38. | HSE oscillator characteristics . . . . .                                                                  | 68 |
| Table 39. | LSE oscillator characteristics (f <sub>LSE</sub> = 32.768 kHz) . . . . .                                  | 69 |
| Table 40. | HSI oscillator characteristics . . . . .                                                                  | 71 |
| Table 41. | LSI oscillator characteristics . . . . .                                                                  | 72 |
| Table 42. | PLL characteristics . . . . .                                                                             | 72 |
| Table 43. | Flash memory characteristics . . . . .                                                                    | 73 |
| Table 44. | Flash memory endurance and data retention . . . . .                                                       | 73 |
| Table 45. | EMS characteristics . . . . .                                                                             | 74 |
| Table 46. | EMI characteristics . . . . .                                                                             | 74 |
| Table 47. | ESD absolute maximum ratings . . . . .                                                                    | 75 |

|           |                                                                                                   |     |
|-----------|---------------------------------------------------------------------------------------------------|-----|
| Table 48. | Electrical sensitivities                                                                          | 75  |
| Table 49. | I/O current injection susceptibility                                                              | 76  |
| Table 50. | I/O static characteristics                                                                        | 76  |
| Table 51. | Output voltage characteristics                                                                    | 79  |
| Table 52. | I/O AC characteristics                                                                            | 80  |
| Table 53. | NRST pin characteristics                                                                          | 81  |
| Table 54. | HRTIM1 characteristics                                                                            | 82  |
| Table 55. | HRTIM output response to fault protection                                                         | 83  |
| Table 56. | HRTIM output response to external events 1 to 5 (Low-Latency mode)                                | 83  |
| Table 57. | HRTIM output response to external events 1 to 10 (Synchronous mode)                               | 83  |
| Table 58. | HRTIM synchronization input / output                                                              | 84  |
| Table 59. | TIMx characteristics                                                                              | 85  |
| Table 60. | IWDG min./max. timeout period at 40 kHz (LSI)                                                     | 86  |
| Table 61. | WWDG min./max. timeout value at 72 MHz (PCLK)                                                     | 86  |
| Table 62. | I <sup>2</sup> C analog filter characteristics                                                    | 87  |
| Table 63. | SPI characteristics                                                                               | 87  |
| Table 64. | ADC characteristics                                                                               | 89  |
| Table 65. | Maximum ADC RAIN                                                                                  | 91  |
| Table 66. | ADC accuracy - limited test conditions                                                            | 93  |
| Table 67. | ADC accuracy                                                                                      | 94  |
| Table 68. | ADC accuracy at 1MSPS                                                                             | 96  |
| Table 69. | DAC characteristics                                                                               | 97  |
| Table 70. | Comparator characteristics                                                                        | 99  |
| Table 71. | Operational amplifier characteristics                                                             | 100 |
| Table 72. | Temperature sensor (TS) characteristics                                                           | 103 |
| Table 73. | Temperature sensor (TS) calibration values                                                        | 103 |
| Table 74. | V <sub>BAT</sub> monitoring characteristics                                                       | 103 |
| Table 75. | LQFP32 mechanical data                                                                            | 105 |
| Table 76. | LQFP48 package mechanical data                                                                    | 108 |
| Table 77. | LQFP64 package mechanical data                                                                    | 111 |
| Table 78. | WLCSP - 49 ball, 3.89x3.74 mm, 0.5 mm pitch, wafer level chip scale, mechanical data              | 115 |
| Table 79. | WLCSP - 49 ball, 3.89x3.74 mm, 0.5 mm pitch, wafer level chip scale, recommended PCB design rules | 116 |
| Table 80. | UFQFPN - 32 pin, 5 x 5 mm 0.5 mm pitch ultra thin fine pitch quad flat mechanical data            | 118 |
| Table 81. | Package thermal characteristics                                                                   | 120 |
| Table 82. | Ordering information scheme                                                                       | 122 |
| Table 83. | Document revision history                                                                         | 123 |

## List of figures

|            |                                                                                            |     |
|------------|--------------------------------------------------------------------------------------------|-----|
| Figure 1.  | STM32F334x4/6/8 block diagram                                                              | 13  |
| Figure 2.  | Clock tree                                                                                 | 19  |
| Figure 3.  | Infrared transmitter                                                                       | 29  |
| Figure 4.  | LQFP32 pinout                                                                              | 32  |
| Figure 5.  | LQFP48 pinout                                                                              | 32  |
| Figure 6.  | LQFP64 pinout                                                                              | 33  |
| Figure 7.  | WLCSP49 ballout                                                                            | 34  |
| Figure 8.  | UFQFPN32 pinout                                                                            | 35  |
| Figure 9.  | STM32F334x4/6/8 memory map                                                                 | 44  |
| Figure 10. | Pin loading conditions                                                                     | 47  |
| Figure 11. | Pin input voltage                                                                          | 47  |
| Figure 12. | Power-supply scheme                                                                        | 48  |
| Figure 13. | Scheme of the current-consumption measurement                                              | 49  |
| Figure 14. | Typical $V_{BAT}$ current consumption (LSE and RTC ON/LSEDRV[1:0] = '00')                  | 59  |
| Figure 15. | High-speed external clock source AC timing diagram                                         | 67  |
| Figure 16. | Low-speed external clock source AC timing diagram                                          | 68  |
| Figure 17. | Typical application with an 8 MHz crystal                                                  | 69  |
| Figure 18. | Typical application with a 32.768 kHz crystal                                              | 70  |
| Figure 19. | HSI oscillator accuracy characterization results for soldered parts                        | 71  |
| Figure 20. | TC and TTA I/O input characteristics - CMOS port                                           | 77  |
| Figure 21. | TC and TTA I/O input characteristics - TTL port                                            | 78  |
| Figure 22. | 5V- tolerant (FT and FTf) I/O input characteristics - CMOS port                            | 78  |
| Figure 23. | 5V-tolerant (FT and FTf) I/O input characteristics - TTL port                              | 78  |
| Figure 24. | I/O AC characteristics definition                                                          | 81  |
| Figure 25. | Recommended NRST pin protection                                                            | 82  |
| Figure 26. | SPI timing diagram - slave mode and CPHA = 0                                               | 88  |
| Figure 27. | SPI timing diagram - slave mode and CPHA = 1 <sup>(1)</sup>                                | 88  |
| Figure 28. | SPI timing diagram - master mode <sup>(1)</sup>                                            | 89  |
| Figure 29. | ADC typical current consumption in single-ended and differential modes                     | 91  |
| Figure 30. | ADC accuracy characteristics                                                               | 96  |
| Figure 31. | Typical connection diagram using the ADC                                                   | 97  |
| Figure 32. | 12-bit buffered /non-buffered DAC                                                          | 99  |
| Figure 33. | Maximum $V_{REFINT}$ scaler startup time from power-down                                   | 100 |
| Figure 34. | OPAMP voltage noise versus frequency                                                       | 102 |
| Figure 35. | LQFP32 package outline                                                                     | 105 |
| Figure 36. | Recommended footprint for the LQFP32 package                                               | 106 |
| Figure 37. | LQFP32 marking example (package top view)                                                  | 107 |
| Figure 38. | LQFP48 package outline                                                                     | 108 |
| Figure 39. | Recommended footprint for the LQFP48 package                                               | 109 |
| Figure 40. | LQFP48 marking example (package top view)                                                  | 110 |
| Figure 41. | LQFP64 package outline                                                                     | 111 |
| Figure 42. | Recommended footprint for the LQFP64 package                                               | 112 |
| Figure 43. | LQFP64 marking example (package top view)                                                  | 113 |
| Figure 44. | WLCSP - 49 ball, 3.89x3.74 mm, 0.5 mm pitch, wafer level chip scale, package outline       | 114 |
| Figure 45. | WLCSP - 49 ball, 3.89x3.74 mm, 0.5 mm pitch, wafer level chip scale, recommended footprint | 115 |
| Figure 46. | WLCSP49 marking example (package top view)                                                 | 116 |

|            |                                                                                                    |     |
|------------|----------------------------------------------------------------------------------------------------|-----|
| Figure 47. | UFQFPN - 32 pin, 5 x 5 mm 0.5 mm pitch ultra thin fine pitch quad flat package outline. ....       | 117 |
| Figure 48. | UFQFPN - 32 pin, 5 x 5 mm 0.5 mm pitch ultra thin fine pitch quad flat recommended footprint. .... | 118 |
| Figure 49. | UFQFPN32 marking example (package top view) . ....                                                 | 119 |

# 1 Introduction

This datasheet provides the ordering information and the mechanical device characteristics of the STM32F334x4/6/8 microcontrollers.

This document must be read in conjunction with the STM32F334xx, reference manual (RM0364) available from the STMicroelectronics website [www.st.com](http://www.st.com).

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

- Arm<sup>®(a)</sup> Cortex<sup>®</sup>-M4 Processor Technical Reference Manual available from the [www.arm.com](http://www.arm.com) website.
- STM32F3xxx and STM32F4xxx Cortex<sup>®</sup>-M4 programming manual (PM0214) available from the [www.st.com](http://www.st.com) website.

arm

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## 2 Description

The STM32F334x4/6/8 family incorporates the high-performance Arm® Cortex®-M4 32-bit RISC core operating at up to 72 MHz frequency embedding a floating point unit (FPU), high-speed embedded memories (up to 64 Kbytes of Flash memory, up to 12 Kbytes of SRAM), and an extensive range of enhanced I/Os and peripherals connected to two APB buses.

The STM32F334x4/6/8 microcontrollers offer two fast 12-bit ADCs (5 Msps), up to three ultra-fast comparators, an operational amplifier, three DAC channels, a low-power RTC, one high-resolution timer, one general-purpose 32-bit timer, one timer dedicated to motor control, and four general-purpose 16-bit timers. They also feature standard and advanced communication interfaces: one I<sup>2</sup>C, one SPI, up to three USARTs and one CAN.

The STM32F334x4/6/8 family operates in the –40 to +85 °C and –40 to +105 °C temperature ranges from 2.0 to 3.6 V power supply. A comprehensive set of power-saving modes allow the design of low-power applications.

The STM32F334x4/6/8 family offers devices in 32, 48 and 64-pin packages.

Depending on the device chosen, different sets of peripherals are included.

**Table 2. STM32F334x4/6/8 family device features and peripheral counts**

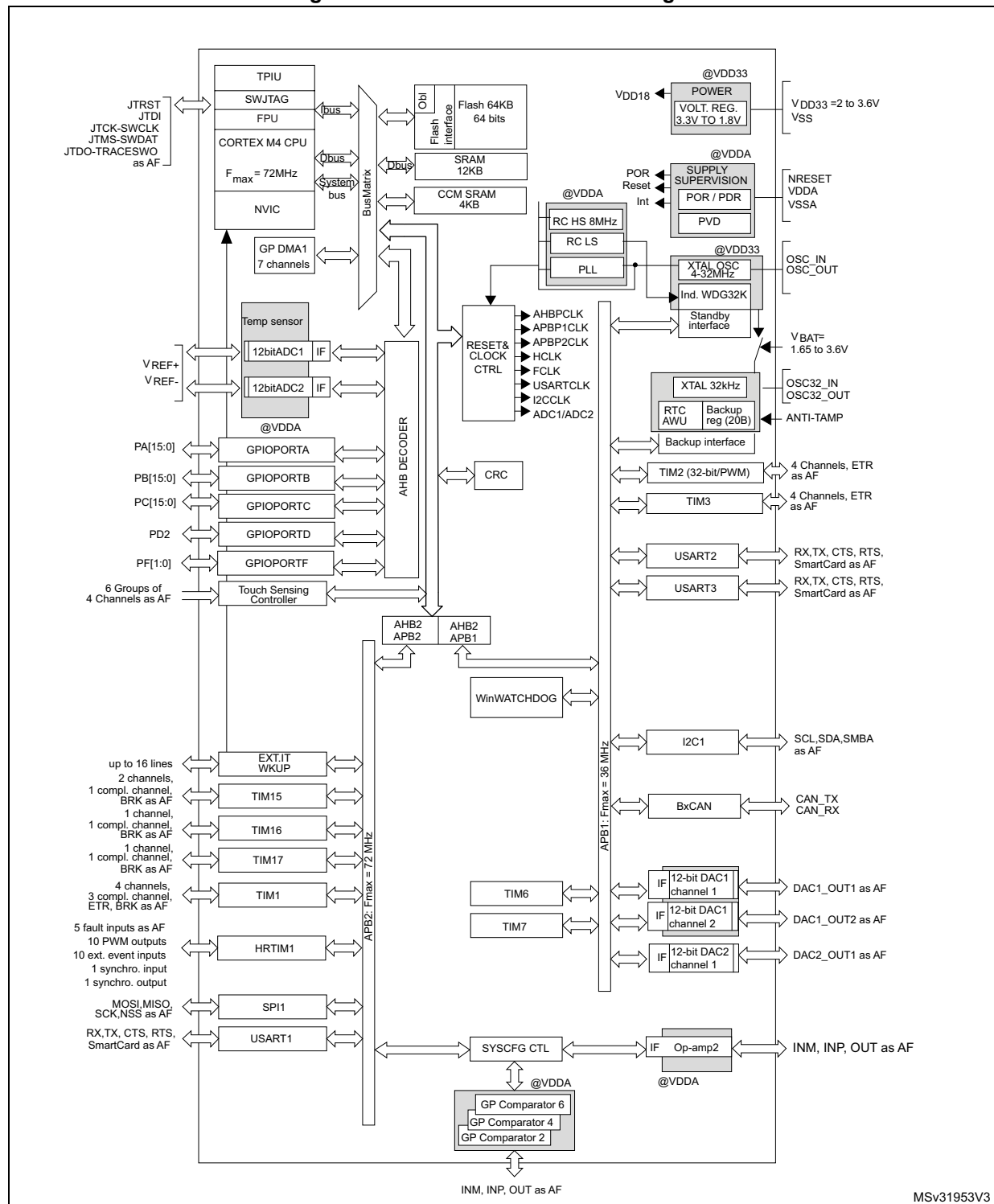
| Peripheral                                                     |                                       | STM32F334Kx              |    |    | STM32F334Cx |    |    | STM32F334Rx |    |    |
|----------------------------------------------------------------|---------------------------------------|--------------------------|----|----|-------------|----|----|-------------|----|----|
| Flash memory (Kbyte)                                           |                                       | 16                       | 32 | 64 | 16          | 32 | 64 | 16          | 32 | 64 |
| SRAM on data bus (Kbyte)                                       |                                       | 12                       |    |    |             |    |    |             |    |    |
| Core coupled memory SRAM on instruction bus (CCM SRAM) (Kbyte) |                                       | 4                        |    |    |             |    |    |             |    |    |
| Timers                                                         | High-resolution timer                 | 1 (16-bit / 10 channels) |    |    |             |    |    |             |    |    |
|                                                                | Advanced control                      | 1 (16-bit)               |    |    |             |    |    |             |    |    |
|                                                                | General purpose                       | 4 (16-bit)<br>1 (32 bit) |    |    |             |    |    |             |    |    |
|                                                                | Basic                                 | 2 (16-bit)               |    |    |             |    |    |             |    |    |
|                                                                | SysTick timer                         | 1                        |    |    |             |    |    |             |    |    |
|                                                                | Watchdog timers (independent, window) | 2                        |    |    |             |    |    |             |    |    |
|                                                                | PWM channels (all) <sup>(1)</sup>     | 20                       |    |    | 26          |    |    | 28          |    |    |
|                                                                | PWM channels (except complementary)   | 14                       |    |    | 20          |    |    | 22          |    |    |

Table 2. STM32F334x4/6/8 family device features and peripheral counts (continued)

| Peripheral                   |                               | STM32F334Kx                                                                                           | STM32F334Cx     | STM32F334Rx |
|------------------------------|-------------------------------|-------------------------------------------------------------------------------------------------------|-----------------|-------------|
| Comm.<br>interfaces          | SPI                           | 1                                                                                                     |                 |             |
|                              | I <sup>2</sup> C              | 1                                                                                                     |                 |             |
|                              | USART                         | 2                                                                                                     | 3               |             |
|                              | CAN                           | 1                                                                                                     |                 |             |
| GPIOs                        | Normal I/Os (TC, TTa)         | 10                                                                                                    | 20              | 26          |
|                              | 5-Volt tolerant I/Os (FT,FTf) | 15                                                                                                    | 17              | 25          |
| Capacitive sensing channels  |                               | 14                                                                                                    | 17              | 18          |
| DMA channels                 |                               | 7                                                                                                     |                 |             |
| 12-bit ADCs                  |                               | 2                                                                                                     | 2               | 2           |
| Number of channels           |                               | 10                                                                                                    | 15              | 21          |
| 12-bit DAC channels          |                               | 3                                                                                                     |                 |             |
| Ultra-fast analog comparator |                               | 2                                                                                                     | 3               |             |
| Operational amplifiers       |                               | 1                                                                                                     |                 |             |
| CPU frequency                |                               | 72 MHz                                                                                                |                 |             |
| Operating voltage            |                               | 2.0 to 3.6 V                                                                                          |                 |             |
| Operating temperature        |                               | Ambient operating temperature: - 40 to 85 °C / - 40 to 105 °C<br>Junction temperature: - 40 to 125 °C |                 |             |
| Packages                     |                               | LQFP32, UFQFPN32                                                                                      | LQFP48, WLCSP49 | LQFP64      |

1. This total considers also the PWMs generated on the complementary output channels.

Figure 1. STM32F334x4/6/8 block diagram



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

## 3 Functional overview

### 3.1 Arm® Cortex®-M4 core with FPU with embedded Flash memory and SRAM

The Arm Cortex-M4 processor with FPU is the latest generation of Arm processors for embedded systems. It has been developed to provide a low-cost platform that meets the needs of MCU implementation, with a reduced pin count and low-power consumption, while delivering outstanding computational performance and an advanced response to interrupts.

The Arm 32-bit Cortex-M4 RISC processor with FPU features exceptional code-efficiency, delivering the high performance expected from an Arm core, with memory sizes usually associated with 8- and 16-bit devices.

The processor supports a set of DSP instructions that allows 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 STM32F334x4/6/8 family is compatible with all Arm tools and software.

*Figure 1* shows the general block diagram of the STM32F334x4/6/8 family devices.

### 3.2 Memories

#### 3.2.1 Embedded Flash memory

All STM32F334x4/6/8 devices feature up to 64 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).

#### 3.2.2 Embedded SRAM

The STM32F334x4/6/8 devices feature up to 12 Kbytes of embedded SRAM with hardware parity check. The memory can be accessed in read/write at CPU clock speed with 0 wait states, allowing the CPU to achieve 90 Dhrystone Mips at 72 MHz when running code from CCM (core coupled memory) RAM.

The SRAM is organized as follows:

- 4 Kbytes of SRAM on instruction and data bus with parity check (core coupled memory or CCM) and used to execute critical routines or to access data
- 12 Kbytes of SRAM with parity check mapped on the data bus

### 3.2.3 Boot modes

At startup, BOOT0 pin and BOOT1 option bit are used to select one of the three boot options:

- Boot from user Flash memory
- 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 (PA2/PA3), I2C1 (PB6/PB7).

## 3.3 Cyclic redundancy check calculation unit (CRC)

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 to compute a signature of the software during runtime, to be compared with a reference signature generated at link-time and stored at a given memory location.

## 3.4 Power management

### 3.4.1 Power supply schemes

- $V_{SS}$ ,  $V_{DD}$  = 2.0 to 3.6 V: external power supply for I/Os and the internal regulator. It is provided externally through  $V_{DD}$  pins.
- $V_{SSA}$ ,  $V_{DDA}$  = 2.0 to 3.6 V: external analog power supply for ADC, DACs, comparators operational amplifiers, reset blocks, RCs and PLL. The minimum voltage to be applied to  $V_{DDA}$  differs from one analog peripherals to another. See [Table 3](#) below, summarizing the  $V_{DDA}$  ranges for analog peripherals. The  $V_{DDA}$  voltage level must be always greater or equal to the  $V_{DD}$  voltage level and must be provided first.
- $V_{DD18}$  = 1.65 to 1.95 V ( $V_{DD18}$  domain): power supply for digital core, SRAM and Flash memory.  $V_{DD18}$  is internally generated through an internal voltage regulator.

**Table 3.  $V_{DDA}$  ranges for analog peripherals**

| Analog peripheral | Min. $V_{DDA}$ supply | Max. $V_{DDA}$ supply |
|-------------------|-----------------------|-----------------------|
| ADC/COMP          | 2 V                   | 3.6 V                 |
| DAC/OPAMP         | 2.4 V                 | 3.6 V                 |

- $V_{BAT}$  = 1.65 to 3.6 V: power supply for RTC, external clock 32 kHz oscillator and backup registers (through power switch) when  $V_{DD}$  is not present.

### 3.4.2 Power supply supervisor

The device has an integrated power-on reset (POR) and power-down reset (PDR) circuits. They are always active, and ensure proper operation above a threshold of 2 V. The device

remains in reset mode when the monitored supply voltage is below a specified threshold, VPOR/PDR, without the need for an external reset circuit.

- The POR monitors only the  $V_{DD}$  supply voltage. During the startup phase it is required that  $V_{DDA}$  must arrive first and be greater than or equal to  $V_{DD}$ .
- The PDR monitors both the  $V_{DD}$  and  $V_{DDA}$  supply voltages, however the  $V_{DDA}$  power supply supervisor can be disabled (by programming a dedicated Option bit) to reduce the power consumption if the application design ensures that  $V_{DDA}$  is higher than or equal to  $V_{DD}$ .

The device features an embedded programmable voltage detector (PVD) that monitors the  $V_{DD}$  power supply and compares it to the  $V_{PVD}$  threshold. An interrupt can be generated when  $V_{DD}$  drops below the  $V_{PVD}$  threshold and/or when  $V_{DD}$  is higher than the  $V_{PVD}$  threshold. The interrupt service routine can then generate a warning message and/or put the MCU into a safe state. The PVD is enabled by software.

### 3.4.3 Voltage regulator

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

- The MR mode is used in the nominal regulation mode (Run)
- The LPR mode is used in Stop mode.
- The power-down mode is used in Standby mode: the regulator output is in high impedance, and the kernel circuitry is powered down thus inducing zero consumption.

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

### 3.4.4 Low-power modes

The STM32F334x4/6/8 supports three low-power modes to achieve the best compromise between low power consumption, short startup time and available wakeup sources:

- **Sleep mode**

In Sleep mode, only the CPU is stopped. All peripherals continue to operate and can wake up the CPU when an interrupt/event occurs.

- **Stop mode**

Stop mode achieves the lowest power consumption while retaining the content of SRAM and registers. All clocks in the 1.8 V domain are stopped, the PLL, the HSI RC and the HSE crystal oscillators are disabled. The voltage regulator can also be put either in normal or in low-power mode.

The device can be woken up from Stop mode by any of the EXTI line. The EXTI line source can be one of the 16 external lines, the PVD output, the RTC alarm, COMPx, I<sup>2</sup>C or USARTx.

- **Standby mode**

The Standby mode is used to achieve the lowest power consumption. The internal voltage regulator is switched off so that the entire 1.8 V domain is powered off. The PLL, the HSI RC and the HSE crystal oscillators are also switched off. After entering Standby mode, SRAM and register contents are lost except for registers in the Backup domain and Standby circuitry.

The device exits Standby mode when an external reset (NRST pin), an IWDG reset, a rising edge on the WKUP pin, or an RTC alarm occurs.

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

### 3.5 Interconnect matrix

Several peripherals have direct connections between them. This allows autonomous communication between peripherals, saving CPU resources thus power supply consumption. In addition, these hardware connections allow fast and predictable latency.

**Table 4. STM32F334x4/6/8 peripheral interconnect matrix**

| Interconnect source                                                   | Interconnect destination | Interconnect action                                            |
|-----------------------------------------------------------------------|--------------------------|----------------------------------------------------------------|
| TIMx                                                                  | TIMx                     | Timers synchronization or chaining                             |
|                                                                       | ADCx<br>DACx             | Conversion triggers                                            |
|                                                                       | DMA                      | Memory to memory transfer trigger                              |
|                                                                       | COMPx                    | Comparator output blanking                                     |
| COMPx                                                                 | TIMx                     | Timer input: ocrefclear input, input capture                   |
| ADCx                                                                  | TIM/HRTIM1               | Timer triggered by analog watchdog                             |
| GPIO<br>RTCCLK<br>HSE/32<br>MC0                                       | TIM16                    | Clock source used as input channel for HSI and LSI calibration |
| CSS<br>CPU (hard fault)<br>RAM (parity error)<br>COMPx<br>PVD<br>GPIO | TIM1<br>TIM15, 16, 17    | Timer break                                                    |
| GPIO                                                                  | TIMx                     | External trigger, timer break                                  |
|                                                                       | ADCx<br>DACx             | Conversion external trigger                                    |
| DACx                                                                  | COMPx                    | Comparator inverting input                                     |
| HRTIM1                                                                | DACx/ADCx                | Conversion trigger                                             |
| COMPx                                                                 | HRTIM1                   | COMPx output is an input event or a fault input for HRTIM1     |
| OPAMP2                                                                | HRTIM1                   | OPAMP2 output is an input event for HRTIM1                     |
| GPIO                                                                  | HRTIM1                   | External fault/event/ Synchro inputs for HRTIM1                |
| HRTIM1                                                                | GPIO                     | Synchro output for HRTIM1                                      |

**Note:** For more details about the interconnect actions, refer to the corresponding sections in the RM0364 reference manual.

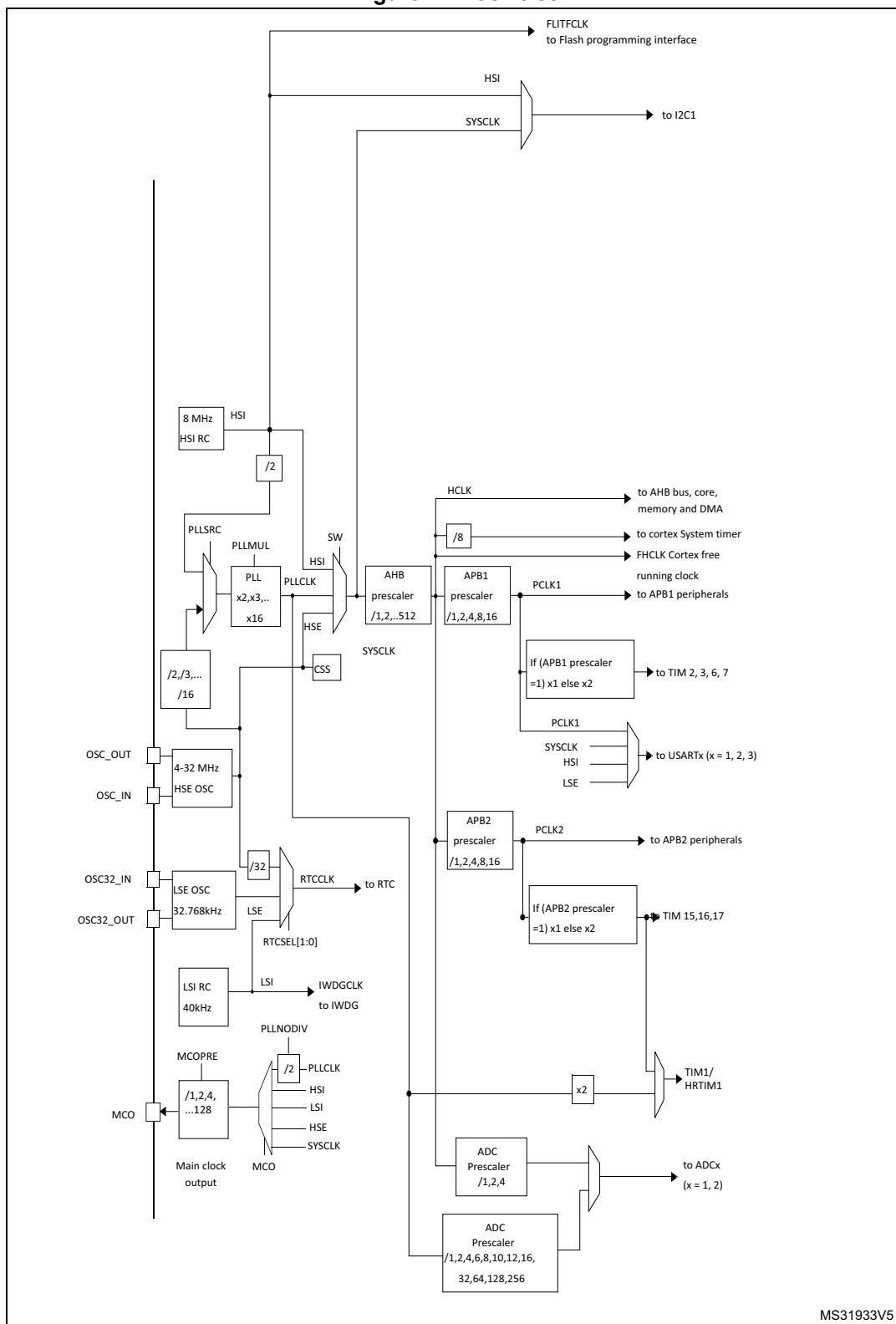
## 3.6 Clocks and startup

System clock selection is performed on startup, however the internal RC 8 MHz oscillator is selected on reset as default CPU clock. 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.

TIM1 and HRTIM1 maximum frequency is 144 MHz.

### Figure 2. Clock tree



### 3.7 General-purpose inputs/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 to avoid spurious writing to the I/Os registers.

Fast I/O handling allows I/O toggling up to 36 MHz.

### 3.8 Direct memory access (DMA)

The flexible 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 of the 7 DMA channels 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 DMA can be used with the main peripherals: SPI, I<sup>2</sup>C, USART, general-purpose timers, high-resolution timer, DAC and ADC.

### 3.9 Interrupts and events

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

The STM32F334x4/6/8 devices embed a nested vectored interrupt controller (NVIC) able to handle up to 60 interrupt channels that can be masked 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 on interrupt entry and restored on interrupt exit with no instruction overhead

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

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

The external interrupt/event controller consists of 27 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 51 GPIOs can be connected to the 16 external interrupt lines.

### 3.10 Fast analog-to-digital converter (ADC)

Two 5 MSPS fast analog-to-digital converters, with selectable resolution between 12 and 6 bit, are embedded in the STM32F334x4/6/8 family devices. The ADCs have up to 21 external channels. Some of the external channels are shared between ADC1 and ADC2, performing conversions in single-shot or scan modes. The channels can be configured to be either single-ended input or differential input. In scan mode, automatic conversion is performed on a selected group of analog inputs.

The ADCs also have internal channels: temperature sensor connected to ADC1 channel 16,  $V_{BAT}/2$  connected to ADC1 channel 17, voltage reference  $V_{REFINT}$  connected to both ADC1 and ADC2 channel 18 and VOPAMP2 connected to ADC2 channel 17.

Additional logic functions embedded in the ADC interface allow:

- Simultaneous sample and hold
- Interleaved sample and hold
- Single-shunt phase current reading techniques.

Three analog watchdogs are available per ADC. The ADC can be served by the DMA controller.

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

The events generated by the general-purpose timers (TIM2, TIM3, TIM6, TIM15), the advanced-control timer (TIM1) and the High-resolution timer (HRTIM1) can be internally connected to the ADC start trigger and injection trigger, respectively, to allow the application to synchronize A/D conversion and timers.

#### 3.10.1 Temperature sensor

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

The temperature sensor is internally connected to the ADC1\_IN16 input channel that 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.

#### 3.10.2 Internal voltage reference (VREFINT)

The internal voltage reference ( $V_{REFINT}$ ) provides a stable (bandgap) voltage output for the ADC and Comparators.  $V_{REFINT}$  is internally connected to the ADC1\_IN18 and ADC2\_IN18

input channels. 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.

### 3.10.3 $V_{BAT}$ battery voltage monitoring

This embedded hardware feature allows the application to measure the  $V_{BAT}$  battery voltage using the internal ADC channel  $ADC1\_IN17$ . 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 bridge divider by 2. As a consequence, the converted digital value is half the  $V_{BAT}$  voltage.

### 3.10.4 OPAMP2 reference voltage (VOPAMP2)

OPAMP2 reference voltage can be measured using ADC2 internal channel 17.

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

One 12-bit buffered DAC channel ( $DAC1\_OUT1$ ) and two 12-bit unbuffered DAC channels ( $DAC1\_OUT2$  and  $DAC2\_OUT1$ ) can be used to convert digital signals into analog voltage signal outputs. The chosen design structure is composed of integrated resistor strings and an amplifier in inverting configuration.

This digital interface supports the following features:

- Three DAC output channels
- 8-bit or 12-bit monotonic output
- Left or right data alignment in 12-bit mode
- Synchronized update capability
- Noise-wave generation (only on  $DAC1$ )
- Triangular-wave generation (only on  $DAC1$ )
- Dual DAC channel independent or simultaneous conversions
- DMA capability for each channel
- External triggers for conversion

## 3.12 Operational amplifier (OPAMP)

The STM32F334x4/6/8 embeds an operational amplifier (OPAMP2) with external or internal follower routing and PGA capability (or even amplifier and filter capability with external components). When an operational amplifier is selected, an external ADC channel is used to enable output measurement.

The operational amplifier features:

- 8 MHz GBP
- 0.5 mA output capability
- Rail-to-rail input/output
- In PGA mode, the gain can be programmed to 2, 4, 8 or 16.

### 3.13 Ultra-fast comparators (COMP)

The STM32F334x4/6/8 devices embed three ultra-fast rail-to-rail comparators (COMP2/4/6) that offer the features below:

- Programmable internal or external reference voltage
- Selectable output polarity.

The reference voltage can be one of the following:

- External I/O
- DAC output
- Internal reference voltage or submultiple (1/4, 1/2, 3/4). Refer to [Table 23: Embedded internal reference voltage](#) for values and parameters of the internal reference voltage.

All comparators can wake up from STOP mode, generate interrupts and breaks for the timers.

### 3.14 Timers and watchdogs

The STM32F334x4/6/8 includes advanced control timer, 5 general-purpose timers, basic timer, 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 |
|-----------------------|-----------------------|--------------------|-------------------|------------------------------------------|------------------------|--------------------------|-----------------------|
| High-resolution timer | HRTIM1 <sup>(1)</sup> | 16-bit             | Up                | /1 /2 /4<br>(x2 x4 x8 x16 x32, with DLL) | Yes                    | 10                       | Yes                   |
| Advanced control      | TIM1 <sup>(1)</sup>   | 16-bit             | Up, Down, Up/Down | Any integer between 1 and 65536          | Yes                    | 4                        | Yes                   |
| General-purpose       | TIM2                  | 32-bit             | Up, Down, Up/Down | Any integer between 1 and 65536          | Yes                    | 4                        | No                    |
| General-purpose       | TIM3                  | 16-bit             | Up, Down, Up/Down | Any integer between 1 and 65536          | Yes                    | 4                        | No                    |
| General-purpose       | TIM15                 | 16-bit             | Up                | Any integer between 1 and 65536          | Yes                    | 2                        | 1                     |
| General-purpose       | TIM16, TIM17          | 16-bit             | Up                | Any integer between 1 and 65536          | Yes                    | 1                        | 1                     |
| Basic                 | TIM6, TIM7            | 16-bit             | Up                | Any integer between 1 and 65536          | Yes                    | 0                        | No                    |

1. TIM1 can be clocked from the PLL x 2 running at 144 MHz .

### 3.14.1 217 ps high-resolution timer (HRTIM1)

The high-resolution timer (HRTIM1) allows generating digital signals with high-accuracy timings, such as PWM or phase-shifted pulses.

It consists of 6 timers, 1 master and 5 slaves, totaling 10 high-resolution outputs, which can be coupled by pairs for deadtime insertion. It also features 5 fault inputs for protection purposes and 10 inputs to handle external events such as current limitation, zero voltage or zero current switching.

HRTIM1 timer is made of a digital kernel clocked at 144 MHz followed by delay lines. Delay lines with closed loop control guarantee a 217 ps resolution whatever the voltage, temperature or chip-to-chip manufacturing process deviation. The high-resolution is available on the 10 outputs in all operating modes: variable duty cycle, variable frequency, and constant ON time.

The slave timers can be combined to control multistage complex converters or operate independently to manage multiple independent converters.

The waveforms are defined by a combination of user-defined timings and external events such as analog or digital feedbacks signals.

HRTIM1 timer includes options for blanking and filtering out spurious events or faults. It also offers specific modes and features to offload the CPU: DMA requests, burst mode controller, push-pull and resonant mode.

It supports many topologies including LLC, Full bridge phase shifted, buck or boost converters, either in voltage or current mode, as well as lighting application (fluorescent or LED). It can also be used as a general purpose timer, for instance to achieve high-resolution PWM-emulated DAC.

In debug mode, the HRTIM1 counters can be frozen and the PWM outputs enter safe state.

### 3.14.2 Advanced timer (TIM1)

The advanced-control timer can be seen as a three-phase PWM multiplexed on 6 channels. They have complementary PWM outputs with programmable inserted dead-times. They can also be seen as complete general-purpose timers. The 4 independent channels can be used for:

- Input capture
- Output compare
- PWM generation (edge or center-aligned modes) with full modulation capability (0-100%)
- One-pulse mode output

In debug mode, the advanced-control timer counter can be frozen and the PWM outputs disabled to turn off any power switches driven by these outputs.

Many features are shared with those of the general-purpose TIM timers (described in [Section 3.14.3](#)) using the same architecture, so the advanced-control timers can work together with the TIM timers via the Timer Link feature for synchronization or event chaining.

### 3.14.3 General-purpose timers (TIM2, TIM3, TIM15, TIM16 and TIM17)

There are up to three general-purpose timers embedded in the STM32F334x4/6/8 (see [Table 5](#) for differences) that can be synchronized. Each general-purpose timer can be used to generate PWM outputs, or act as a simple time base.

- TIM2 and TIM3

They are full-featured general-purpose timers:

- TIM2 has a 32-bit auto-reload up/down counter and 32-bit prescaler
- TIM3 has a 16-bit auto-reload up/down counter and 16-bit prescaler

These timers feature four 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.

- TIM15, 16 and 17

They are three general-purpose timers with mid-range features.

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

- TIM15 has two channels and one complementary channel
- TIM16 and TIM17 have one channel and one 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.

### 3.14.4 Basic timers (TIM6 and TIM7)

The basic timers are mainly used for DAC trigger generation. They can also be used as generic 16-bit timebases.

### 3.14.5 Independent watchdog

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

### 3.14.6 Window watchdog

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

### 3.14.7 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
- Auto reload capability
- Maskable system interrupt generation when the counter reaches 0.
- Programmable clock source

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

The RTC and the 5 backup registers are supplied through a switch that takes power from either the  $V_{DD}$  supply when present or the VBAT pin. The backup registers are five 32-bit registers used to store 20 bytes of user application data when  $V_{DD}$  power is not present.

They are not reset by a system or power reset, or when the device wakes up from Standby mode.

The RTC is an independent BCD timer/counter. It supports the following features:

- Calendar with subsecond, seconds, minutes, hours (12 or 24 format), week day, date, month, year, in BCD (binary-coded decimal) format.
- Reference clock detection: a more precise second source clock (50 or 60 Hz) can be used to enhance the calendar precision.
- Automatic correction for 28, 29 (leap year), 30, and 31 days of the month.
- Two programmable alarms with wakeup from Stop and Standby mode capability.
- 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.
- Two anti-tamper detection pins with programmable filter. The MCU can be woken up from Stop and Standby modes 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 and Standby modes on timestamp event detection.
- 17-bit Auto-reload counter for periodic interrupt with wakeup from STOP/STANDBY capability.

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.

## 3.16 Communication interfaces

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

The devices feature an I<sup>2</sup>C bus interface that can operate in multimaster and slave mode. It can support standard (up to 100 kHz), fast (up to 400 kHz) and fast mode + (up to 1 MHz) modes.

It supports 7-bit and 10-bit addressing modes, multiple 7-bit slave addresses (2 addresses, 1 with configurable mask). It also includes 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, it provides hardware support for SMBUS 2.0 and PMBUS 1.1: ARP capability, Host notify protocol, hardware CRC (PEC) generation/verification, timeouts verifications and ALERT protocol management. It also has a clock domain independent from the CPU clock, allowing the I2C1 to wake up the MCU from Stop mode on address match.

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

The features available in I2C1 are showed below in [Table 7](#).

**Table 7. STM32F334x4/6/8 I2C implementation**

| I2C features <sup>(1)</sup>                                 | I2C1 |
|-------------------------------------------------------------|------|
| 7-bit addressing mode                                       | X    |
| 10-bit addressing mode                                      | X    |
| Standard mode (up to 100 kbit/s)                            | X    |
| Fast mode (up to 400 kbit/s)                                | X    |
| Fast Mode Plus with 20mA output drive I/Os (up to 1 Mbit/s) | X    |
| Independent clock                                           | X    |
| SMBus                                                       | X    |
| Wakeup from STOP                                            | X    |

1. X = supported.

### 3.16.2 Universal synchronous / asynchronous receivers / transmitters (USARTs)

The STM32F334x4/6/8 devices have three embedded universal synchronous receivers/transmitters (USART1, USART2 and USART3).

The USART interfaces are able to communicate at speeds of up to 9 Mbits/s.

USART1 provides hardware management of the CTS and RTS signals. It supports IrDA SIR ENDEC, the multiprocessor communication mode, the single-wire half-duplex communication mode and has LIN Master/Slave capability.

All USART interfaces can be served by the DMA controller.

The features available in the USART interfaces are showed below in [Table 8](#).

**Table 8. USART features**

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

1. X = supported.

### 3.16.3 Serial peripheral interface (SPI)

A SPI interface allows to communicate up to 18 Mbits/s in slave and master modes in full-duplex and simplex communication modes. The 3-bit prescaler gives 8 master mode frequencies and the frame size is configurable from 4 bits to 16 bits.

The features available in SPI1 are showed below in [Table 9](#).

**Table 9. STM32F334x4/6/8 SPI implementation**

| SPI features <sup>(1)</sup> | SPI1 |
|-----------------------------|------|
| Hardware CRC calculation    | X    |
| Rx/Tx FIFO                  | X    |

Table 9. STM32F334x4/6/8 SPI implementation (continued)

| SPI features <sup>(1)</sup> | SPI1 |
|-----------------------------|------|
| NSS pulse mode              | X    |
| TI mode                     | X    |

1. X = supported.

### 3.16.4 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.

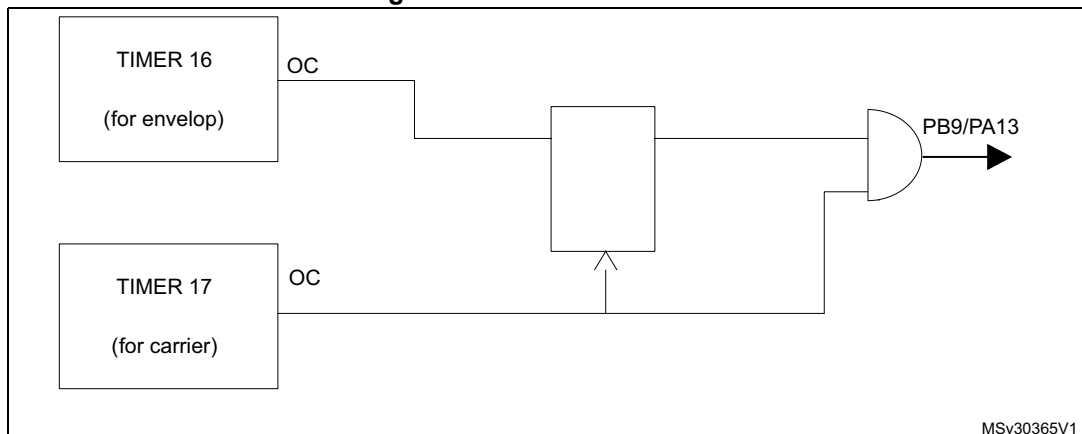
## 3.17 Infrared transmitter

The STM32F334x4/6/8 devices provide an infrared transmitter solution. The solution is based on internal connections between TIM16 and TIM17 as shown in the figure below.

TIM17 is used to provide the carrier frequency and TIM16 provides the main signal to be sent. The infrared output signal is available on PB9 or PA13.

To generate the infrared remote control signals, TIM16 channel 1 and TIM17 channel 1 must be properly configured to generate correct waveforms. All standard IR pulse modulation modes is obtained by programming the two timers of the output compare channels (see [Figure 3](#)).

Figure 3. Infrared transmitter



## 3.18 Touch sensing controller (TSC)

The STM32F334x4/6/8 devices provide a simple solution for adding capacitive sensing functionality to any application. These devices offer up to 18 capacitive sensing channels distributed over 6 analog I/Os group.

Capacitive sensing technology is able to detect the presence of a finger near an electrode that is protected from direct touch by a dielectric (glass, plastic and others). 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.

**Table 10. Capacitive sensing GPIOs available on STM32F334x4/6/8 devices**

| Group | Capacitive sensing group name | Pin name |
|-------|-------------------------------|----------|
| 1     | TSC_G1_IO1                    | PA0      |
|       | TSC_G1_IO2                    | PA1      |
|       | TSC_G1_IO3                    | PA2      |
|       | TSC_G1_IO4                    | PA3      |
| 2     | TSC_G2_IO1                    | PA4      |
|       | TSC_G2_IO2                    | PA5      |
|       | TSC_G2_IO3                    | PA6      |
|       | TSC_G2_IO4                    | PA7      |
| 3     | TSC_G3_IO1                    | PC5      |
|       | TSC_G3_IO2                    | PB0      |
|       | TSC_G3_IO3                    | PB1      |
|       | TSC_G3_IO4                    | PB2      |
| 4     | TSC_G4_IO1                    | PA9      |
|       | TSC_G4_IO2                    | PA10     |
|       | TSC_G4_IO3                    | PA13     |
|       | TSC_G4_IO4                    | PA14     |
| 5     | TSC_G5_IO1                    | PB3      |
|       | TSC_G5_IO2                    | PB4      |
|       | TSC_G5_IO3                    | PB6      |
|       | TSC_G5_IO4                    | PB7      |
| 6     | TSC_G6_IO1                    | PB11     |
|       | TSC_G6_IO2                    | PB12     |
|       | TSC_G6_IO3                    | PB13     |
|       | TSC_G6_IO4                    | PB14     |

Table 11. No. of capacitive sensing channels available on STM32F334x4/6/8 devices

| Analog I/O group                            | Number of capacitive sensing channels |              |              |
|---------------------------------------------|---------------------------------------|--------------|--------------|
|                                             | STM32F334xRx                          | STM32F334xCx | STM32F334xKx |
| G1                                          | 3                                     | 3            | 3            |
| G2                                          | 3                                     | 3            | 3            |
| G3                                          | 3                                     | 2            | 2            |
| G4                                          | 3                                     | 3            | 3            |
| G5                                          | 3                                     | 3            | 3            |
| G6                                          | 3                                     | 3            | 0            |
| Total number of capacitive sensing channels | 18                                    | 17           | 14           |

## 3.19 Development support

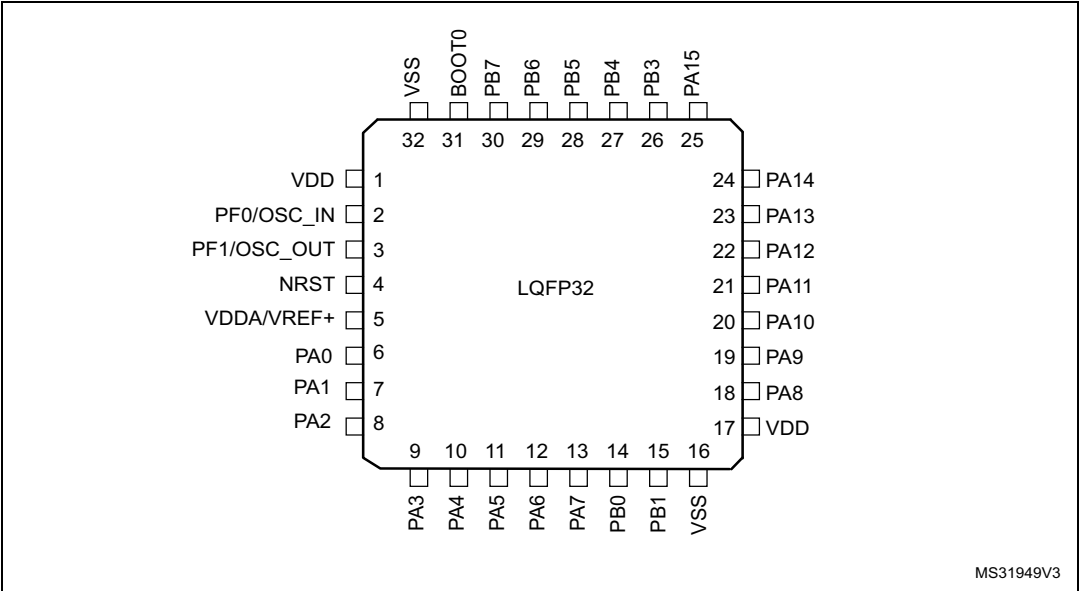
### 3.19.1 Serial-wire JTAG debug port (SWJ-DP)

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.

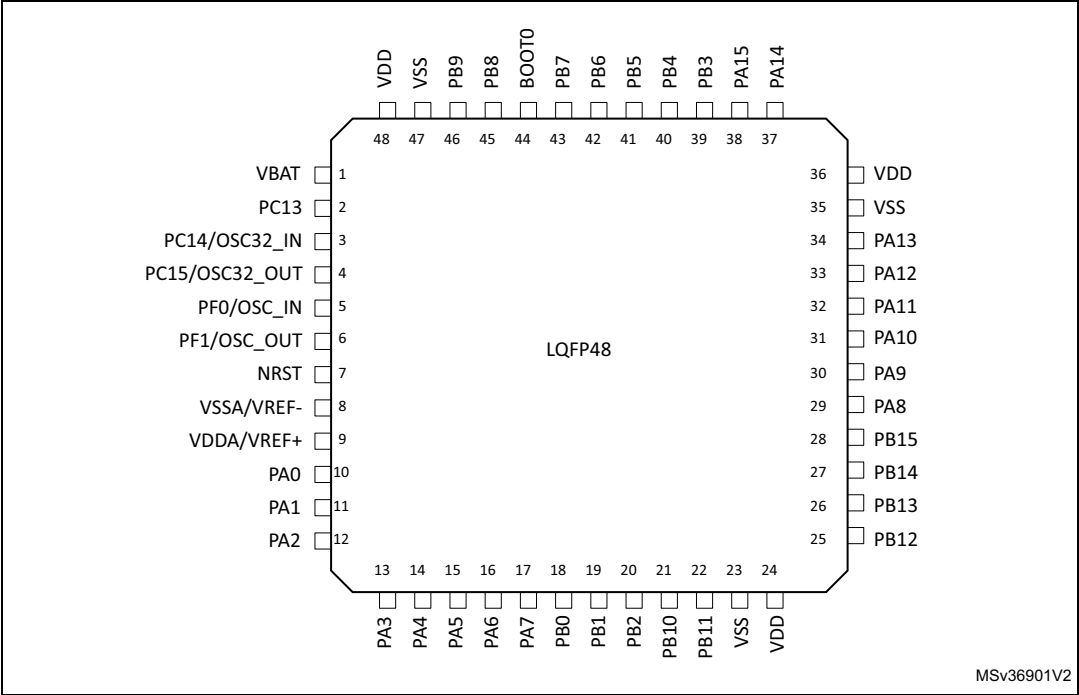
# 4 Pinout and pin descriptions

Figure 4. LQFP32 pinout



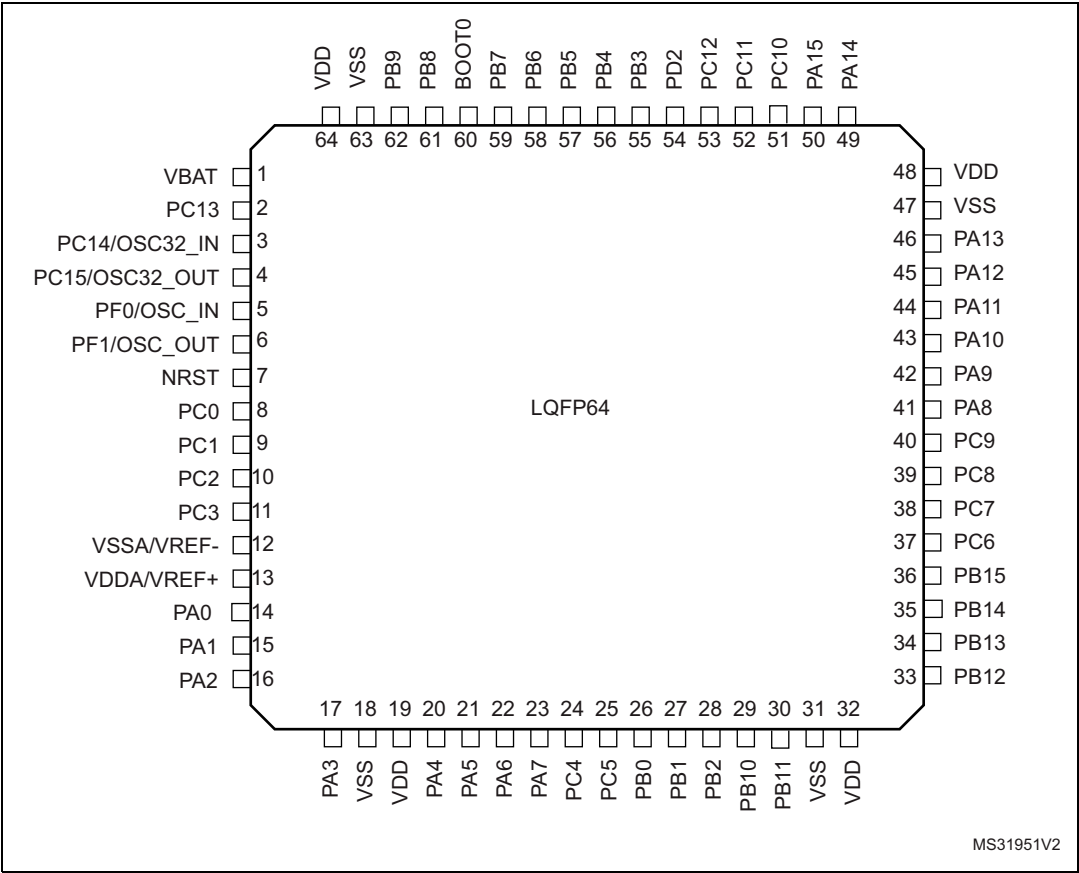
1. The above figure shows the package top view.

Figure 5. LQFP48 pinout



1. The above figure shows the package top view.

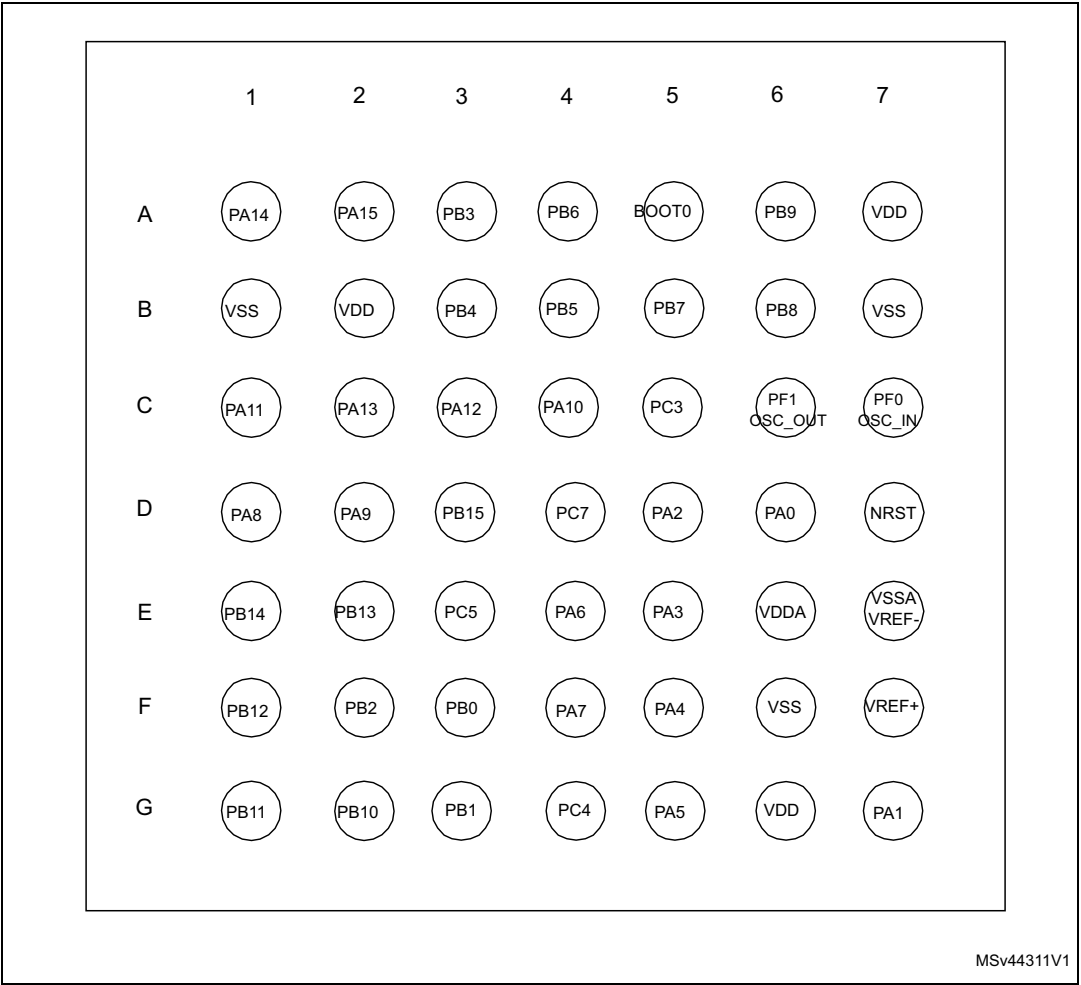
Figure 6. LQFP64 pinout



MS31951V2

1. The above figure shows the package top view.

Figure 7. WLCSP49 ballout



1. The above figure shows the package top view.

Figure 8. UFQFPN32 pinout

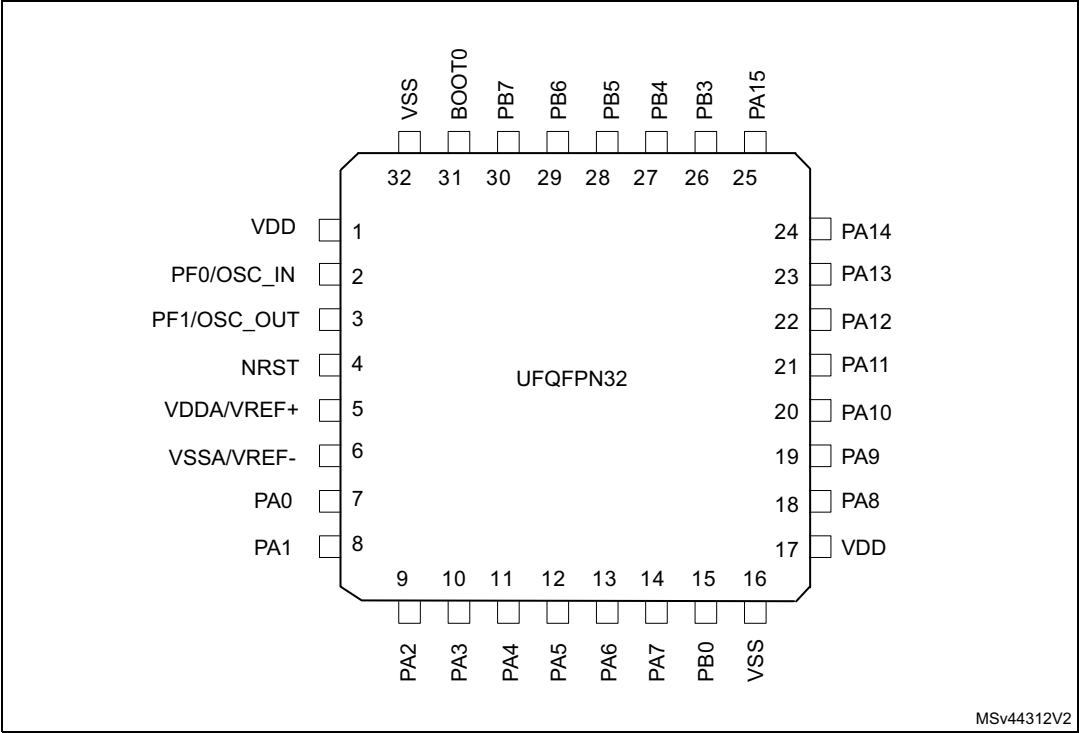


Table 12. Legend/abbreviations used in the pinout table

| 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                 |
|               |                      | TT                                                                                                                                    | 3.3 V tolerant I/O                                           |
|               |                      | TC                                                                                                                                    | Standard 3.3 V I/O                                           |
|               |                      | B                                                                                                                                     | Dedicated BOOT0 pin                                          |
|               |                      | RST                                                                                                                                   | Bi-directional 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 13. STM32F334x4/6/8 pin definitions

| Pin Number |        |        |        |         | Pin name<br>(function after reset) | Pin type | I/O structure | Pin functions                                              |                                    |
|------------|--------|--------|--------|---------|------------------------------------|----------|---------------|------------------------------------------------------------|------------------------------------|
| UFQFPN32   | LQFP32 | LQFP48 | LQFP64 | WLCSP49 |                                    |          |               | Alternate functions                                        | Additional functions               |
| -          | -      | 1      | 1      | -       | VBAT                               | S        | -             | Backup power supply                                        |                                    |
| -          | -      | 2      | 2      | -       | PC13 <sup>(1)</sup>                | I/O      | TC            | TIM1_CH1N                                                  | RTC_TAMP1/RTC_TS/<br>RTC_OUT/WKUP2 |
| -          | -      | 3      | 3      | -       | PC14 / OSC32_IN <sup>(1)</sup>     | I/O      | TC            | -                                                          | OSC32_IN                           |
| -          | -      | 4      | 4      | -       | PC15 / OSC32_OUT <sup>(1)</sup>    | I/O      | TC            | -                                                          | OSC32_OUT                          |
| 2          | 2      | 5      | 5      | C7      | PF0 / OSC_IN                       | I/O      | FT            | TIM1_CH3N                                                  | OSC_IN                             |
| 3          | 3      | 6      | 6      | C6      | PF1 / OSC_OUT                      | I/O      | FT            | -                                                          | OSC_OUT                            |
| 4          | 4      | 7      | 7      | D7      | NRST                               | I/O      | RST           | Device reset input / internal reset output<br>(active low) |                                    |
| -          | -      | -      | 8      | -       | PC0                                | I/O      | TTa           | EVENTOUT,<br>TIM1_CH1                                      | ADC12_IN6                          |

Table 13. STM32F334x4/6/8 pin definitions (continued)

| Pin Number |        |        |        |         | Pin name<br>(function after<br>reset) | Pin type | I/O structure | Pin functions                                                                  |                                                                            |
|------------|--------|--------|--------|---------|---------------------------------------|----------|---------------|--------------------------------------------------------------------------------|----------------------------------------------------------------------------|
| UFQFPN32   | LQFP32 | LQFP48 | LQFP64 | WLCSP49 |                                       |          |               | Alternate<br>functions                                                         | Additional functions                                                       |
| -          | -      | -      | 9      | -       | PC1                                   | I/O      | TTa           | EVENTOUT,<br>TIM1_CH2                                                          | ADC12_IN7                                                                  |
| -          | -      | -      | 10     | -       | PC2                                   | I/O      | TTa           | EVENTOUT,<br>TIM1_CH3                                                          | ADC12_IN8                                                                  |
| -          | -      | -      | 11     | C5      | PC3                                   | I/O      | TTa           | EVENTOUT,<br>TIM1_CH4,<br>TIM1_BKIN2                                           | ADC12_IN9                                                                  |
| 6          | -      | 8      | 12     | E7      | VSSA/VREF-                            | S        | -             | Analog ground/Negative reference voltage                                       |                                                                            |
| -          | -      | -      |        | F7      | VREF+                                 | S        | -             | -                                                                              | -                                                                          |
|            |        |        |        | E6      | VDDA                                  | S        | -             | -                                                                              | -                                                                          |
| 5          | 5      | 9      | 13     | -       | VDDA/VREF+                            | S        | -             | Analog power supply/Positive reference voltage                                 |                                                                            |
| 7          | 6      | 10     | 14     | D6      | PA0                                   | I/O      | TTa           | TIM2_CH1/<br>TIM2_ETR,<br>TSC_G1_IO1,<br>USART2_CTS,<br>EVENTOUT               | ADC1_IN1 <sup>(2)</sup> ,<br>RTC_TAMP2/WKUP1                               |
| 8          | 7      | 11     | 15     | G7      | PA1                                   | I/O      | TTa           | TIM2_CH2,<br>TSC_G1_IO2,<br>USART2_RTS_DE,<br>TIM15_CH1N,<br>EVENTOUT          | ADC1_IN2 <sup>(2)</sup> , RTC_REFIN                                        |
| 9          | 8      | 12     | 16     | D5      | PA2                                   | I/O      | TTa           | TIM2_CH3,<br>TSC_G1_IO3,<br>USART2_TX,<br>COMP2_OUT,<br>TIM15_CH1,<br>EVENTOUT | ADC1_IN3 <sup>(2)</sup> , COMP2_INM                                        |
| 10         | 9      | 13     | 17     | E5      | PA3                                   | I/O      | TTa           | TIM2_CH4,<br>TSC_G1_IO4,<br>USART2_RX,<br>TIM15_CH2,<br>EVENTOUT               | ADC1_IN4 <sup>(2)</sup>                                                    |
| -          | -      | -      | 18     | F6      | VSS                                   | S        | -             | -                                                                              | -                                                                          |
| -          | -      | -      | 19     | G6      | VDD                                   | S        | -             | -                                                                              | -                                                                          |
| 11         | 10     | 14     | 20     | F5      | PA4 <sup>(3)</sup>                    | I/O      | TTa           | TIM3_CH2,<br>TSC_G2_IO1,<br>SPI1_NSS,<br>USART2_CK,<br>EVENTOUT                | ADC2_IN1 <sup>(2)</sup> , DAC1_OUT1,<br>COMP2_INM, COMP4_INM,<br>COMP6_INM |
| 12         | 11     | 15     | 21     | G5      | PA5 <sup>(3)</sup>                    | I/O      | TTa           | TIM2_CH1/<br>TIM2_ETR,<br>TSC_G2_IO2,<br>SPI1_SCK,<br>EVENTOUT                 | ADC2_IN2 <sup>(2)</sup> , DAC1_OUT2,<br>OPAMP2_VINM                        |

Table 13. STM32F334x4/6/8 pin definitions (continued)

| Pin Number |        |        |        |         | Pin name<br>(function after<br>reset) | Pin type | I/O structure | Pin functions                                                                                 |                                                     |
|------------|--------|--------|--------|---------|---------------------------------------|----------|---------------|-----------------------------------------------------------------------------------------------|-----------------------------------------------------|
| UFQFPN32   | LQFP32 | LQFP48 | LQFP64 | WLCSP49 |                                       |          |               | Alternate<br>functions                                                                        | Additional functions                                |
| 13         | 12     | 16     | 22     | E4      | PA6 <sup>(3)</sup>                    | I/O      | TTa           | TIM16_CH1,<br>TIM3_CH1,<br>TSC_G2_IO3,<br>SPI1_MISO,<br>TIM1_BKIN,<br>OPAMP2_DIG,<br>EVENTOUT | ADC2_IN3 <sup>(2)</sup> , DAC2_OUT1,<br>OPAMP2_VOUT |
| 14         | 13     | 17     | 23     | F4      | PA7                                   | I/O      | TTa           | TIM17_CH1,<br>TIM3_CH2,<br>TSC_G2_IO4,<br>SPI1_MOSI,<br>TIM1_CH1N,<br>EVENTOUT                | ADC2_IN4 <sup>(2)</sup> , COMP2_INP,<br>OPAMP2_VINP |
| -          | -      | -      | 24     | G4      | PC4                                   | I/O      | TTa           | EVENTOUT,<br>TIM1_ETR,<br>USART1_TX                                                           | ADC2_IN5 <sup>(2)</sup>                             |
| -          | -      | -      | 25     | E3      | PC5                                   | I/O      | TTa           | EVENTOUT,<br>TIM15_BKIN,<br>TSC_G3_IO1,<br>USART1_RX                                          | ADC2_IN11, OPAMP2_VINM                              |
| 15         | 14     | 18     | 26     | F3      | PB0                                   | I/O      | TTa           | TIM3_CH3,<br>TSC_G3_IO2,<br>TIM1_CH2N,<br>EVENTOUT                                            | ADC1_IN11, COMP4_INP,<br>OPAMP2_VINP                |
| -          | 15     | 19     | 27     | G3      | PB1                                   | I/O      | TTa           | TIM3_CH4,<br>TSC_G3_IO3,<br>TIM1_CH3N,<br>COMP4_OUT,<br>HRTIM1_SCOUT,<br>EVENTOUT             | ADC1_IN12                                           |
| -          | -      | 20     | 28     | F2      | PB2                                   | I/O      | TTa           | TSC_G3_IO4,<br>HRTIM1_SCIN,<br>EVENTOUT                                                       | ADC2_IN12, COMP4_INM                                |
| -          | -      | 21     | 29     | G2      | PB10                                  | I/O      | TT            | TIM2_CH3,<br>TSC_SYNC,<br>USART3_TX,<br>HRTIM1_FLT3,<br>EVENTOUT                              | -                                                   |
| -          | -      | 22     | 30     | G1      | PB11                                  | I/O      | TTa           | TIM2_CH4,<br>TSC_G6_IO1,<br>USART3_RX,<br>HRTIM1_FLT4,<br>EVENTOUT                            | COMP6_INP                                           |
| 16         | 16     | 23     | 31     | -       | VSS                                   | S        | -             | Digital ground                                                                                |                                                     |
| 17         | 17     | 24     | 32     | B2      | VDD                                   | S        | -             | Digital power supply                                                                          |                                                     |
|            | -      | 25     | 33     | F1      | PB12                                  | I/O      | TTa           | TSC_G6_IO2,<br>TIM1_BKIN,<br>USART3_CK,<br>HRTIM1_CHC1,<br>EVENTOUT                           | ADC2_IN13                                           |
| -          | -      | 26     | 34     | E2      | PB13                                  | I/O      | TTa           | TSC_G6_IO3,<br>TIM1_CH1N,<br>USART3_CTS,<br>HRTIM1_CHC2,<br>EVENTOUT                          | ADC1_IN13                                           |

Table 13. STM32F334x4/6/8 pin definitions (continued)

| Pin Number |        |        |        |         | Pin name<br>(function after<br>reset) | Pin type | I/O structure | Pin functions                                                                                                |                                    |
|------------|--------|--------|--------|---------|---------------------------------------|----------|---------------|--------------------------------------------------------------------------------------------------------------|------------------------------------|
| UFQFPN32   | LQFP32 | LQFP48 | LQFP64 | WLCSP49 |                                       |          |               | Alternate<br>functions                                                                                       | Additional functions               |
| -          | -      | 27     | 35     | E1      | PB14                                  | I/O      | TTa           | TIM15_CH1,<br>TSC_G6_IO4,<br>TIM1_CH2N,<br>USART3_RTS_DE,<br>HRTIM1_CHD1,<br>EVENTOUT                        | ADC2_IN14, OPAMP2_VINP             |
| -          | -      | 28     | 36     | D3      | PB15                                  | I/O      | TTa           | TIM15_CH2,<br>TIM15_CH1N,<br>TIM1_CH3N,<br>HRTIM1_CHD2,<br>EVENTOUT                                          | ADC2_IN15, COMP6_INM,<br>RTC_REFIN |
| -          | -      | -      | 37     | -       | PC6                                   | I/O      | FT            | EVENTOUT,<br>TIM3_CH1,<br>HRTIM1_EEV10,<br>COMP6_OUT                                                         | -                                  |
| -          | -      | -      | 38     | D4      | PC7                                   | I/O      | FT            | EVENTOUT,<br>TIM3_CH2,<br>HRTIM1_FLT5                                                                        | -                                  |
| -          | -      | -      | 39     | -       | PC8                                   | I/O      | FT            | EVENTOUT,<br>TIM3_CH3,<br>HRTIM1_CHE1                                                                        | -                                  |
| -          | -      | -      | 40     | -       | PC9                                   | I/O      | FT            | EVENTOUT,<br>TIM3_CH4,<br>HRTIM1_CHE2                                                                        | -                                  |
| 18         | 18     | 29     | 41     | D1      | PA8                                   | I/O      | FT            | MCO, TIM1_CH1,<br>USART1_CK,<br>HRTIM1_CHA1,<br>EVENTOUT                                                     | -                                  |
| 19         | 19     | 30     | 42     | D2      | PA9                                   | I/O      | FT            | TSC_G4_IO1,<br>TIM1_CH2,<br>USART1_TX,<br>TIM15_BKIN,<br>TIM2_CH3,<br>HRTIM1_CHA2,<br>EVENTOUT               | -                                  |
| 20         | 20     | 31     | 43     | C4      | PA10                                  | I/O      | FT            | TIM17_BKIN,<br>TSC_G4_IO2,<br>TIM1_CH3,<br>USART1_RX,<br>COMP6_OUT,<br>TIM2_CH4,<br>HRTIM1_CHB1,<br>EVENTOUT | -                                  |
| 21         | 21     | 32     | 44     | C1      | PA11                                  | I/O      | FT            | TIM1_CH1N,<br>USART1_CTS,<br>CAN_RX,<br>TIM1_CH4,<br>TIM1_BKIN2,<br>HRTIM1_CHB2,<br>EVENTOUT                 | -                                  |
| 22         | 22     | 33     | 45     | C3      | PA12                                  | I/O      | FT            | TIM16_CH1,<br>TIM1_CH2N,<br>USART1_RTS_DE,<br>COMP2_OUT,<br>CAN_TX, TIM1_ETR,<br>HRTIM1_FLT1,<br>EVENTOUT    | -                                  |

Table 13. STM32F334x4/6/8 pin definitions (continued)

| Pin Number |        |        |        |         | Pin name<br>(function after<br>reset) | Pin type | I/O structure | Pin functions                                                                                                                    |                      |
|------------|--------|--------|--------|---------|---------------------------------------|----------|---------------|----------------------------------------------------------------------------------------------------------------------------------|----------------------|
| UFQFPN32   | LQFP32 | LQFP48 | LQFP64 | WLCSP49 |                                       |          |               | Alternate<br>functions                                                                                                           | Additional functions |
| 23         | 23     | 34     | 46     | C2      | PA13                                  | I/O      | FT            | JTMS/SWDAT,<br>TIM16_CH1N,<br>TSC_G4_IO3,<br>IR_OUT,<br>USART3_CTS,<br>EVENTOUT                                                  | -                    |
| -          | -      | 35     | 47     | B1      | VSS                                   | S        | -             | -                                                                                                                                | -                    |
| -          | -      | 36     | 48     | -       | VDD                                   | S        | -             | -                                                                                                                                | -                    |
| 24         | 24     | 37     | 49     | A1      | PA14                                  | I/O      | FTf           | JTCK/SWCLK,<br>TSC_G4_IO4,<br>I2C1_SDA,<br>TIM1_BKIN,<br>USART2_TX,<br>EVENTOUT                                                  | -                    |
| 25         | 25     | 38     | 50     | A2      | PA15                                  | I/O      | FTf           | JTDI,<br>TIM2_CH1/TIM2_ET<br>R, TSC_SYNC,<br>I2C1_SCL,<br>SPI1_NSS,<br>USART2_RX,<br>TIM1_BKIN,<br>HRTIM1_FLT2,<br>EVENTOUT      | -                    |
| -          | -      | -      | 51     | -       | PC10                                  | I/O      | FT            | EVENTOUT,<br>USART3_TX                                                                                                           | -                    |
| -          | -      | -      | 52     | -       | PC11                                  | I/O      | FT            | EVENTOUT,<br>HRTIM1_EEV2,<br>USART3_RX                                                                                           | -                    |
| -          | -      | -      | 53     | -       | PC12                                  | I/O      | FT            | EVENTOUT,<br>HRTIM1_EEV1,<br>USART3_CK                                                                                           | -                    |
| -          | -      | -      | 54     | -       | PD2                                   | I/O      | FT            | EVENTOUT,<br>TIM3_ETR                                                                                                            | -                    |
| 26         | 26     | 39     | 55     | A3      | PB3                                   | I/O      | FT            | JTDO/TRACE<br>SWO, TIM2_CH2,<br>TSC_G5_IO1,<br>SPI1_SCK,<br>USART2_TX,<br>TIM3_ETR,<br>HRTIM1_SCOUT,<br>HRTIM1_EEV9,<br>EVENTOUT | -                    |
| 27         | 27     | 40     | 56     | B3      | PB4                                   | I/O      | FT            | NJTRST,<br>TIM16_CH1,<br>TIM3_CH1,<br>TSC_G5_IO2,<br>SPI1_MISO,<br>USART2_RX,<br>TIM17_BKIN,<br>HRTIM1_EEV7,<br>EVENTOUT         | -                    |

Table 13. STM32F334x4/6/8 pin definitions (continued)

| Pin Number |        |        |        |         | Pin name<br>(function after<br>reset) | Pin type | I/O structure | Pin functions                                                                                                |                      |
|------------|--------|--------|--------|---------|---------------------------------------|----------|---------------|--------------------------------------------------------------------------------------------------------------|----------------------|
| UFQFPN32   | LQFP32 | LQFP48 | LQFP64 | WLCSP49 |                                       |          |               | Alternate<br>functions                                                                                       | Additional functions |
| 28         | 28     | 41     | 57     | B4      | PB5                                   | I/O      | FT            | TIM16_BKIN,<br>TIM3_CH2,<br>I2C1_SMBA,<br>SPI1_MOSI,<br>USART2_CK,<br>TIM17_CH1,<br>HRTIM1_EEV6,<br>EVENTOUT | -                    |
| 29         | 29     | 42     | 58     | A4      | PB6                                   | I/O      | FTf           | TIM16_CH1N,<br>TSC_G5_IO3,<br>I2C1_SCL,<br>USART1_TX,<br>HRTIM1_SCIN,<br>HRTIM1_EEV4,<br>EVENTOUT            | -                    |
| 30         | 30     | 43     | 59     | B5      | PB7                                   | I/O      | FTf           | TIM17_CH1N,<br>TSC_G5_IO4,<br>I2C1_SDA,<br>USART1_RX,<br>TIM3_CH4,<br>HRTIM1_EEV3,<br>EVENTOUT               | -                    |
| 31         | 31     | 44     | 60     | A5      | BOOT0                                 | I        | B             | -                                                                                                            | -                    |
| -          | -      | 45     | 61     | B6      | PB8                                   | I/O      | FTf           | TIM16_CH1,<br>TSC_SYNC,<br>I2C1_SCL,<br>USART3_RX,<br>CAN_RX,<br>TIM1_BKIN,<br>HRTIM1_EEV8,<br>EVENTOUT      | -                    |
| -          | -      | 46     | 62     | A6      | PB9                                   | I/O      | FTf           | TIM17_CH1,<br>I2C1_SDA, IR_OUT,<br>USART3_TX,<br>COMP2_OUT,<br>CAN_TX,<br>HRTIM1_EEV5,<br>EVENTOUT           | -                    |
| 32         | 32     | 47     | 63     | B7      | VSS                                   | S        | -             | -                                                                                                            | -                    |
| 1          | 1      | 48     | 64     | A7      | VDD                                   | S        | -             | -                                                                                                            | -                    |

- 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 reference manual.
- Fast ADC channel.
- These GPIOs offer a reduced touch sensing sensitivity. It is thus recommended to use them as sampling capacitor I/O.



Table 14. Alternate functions

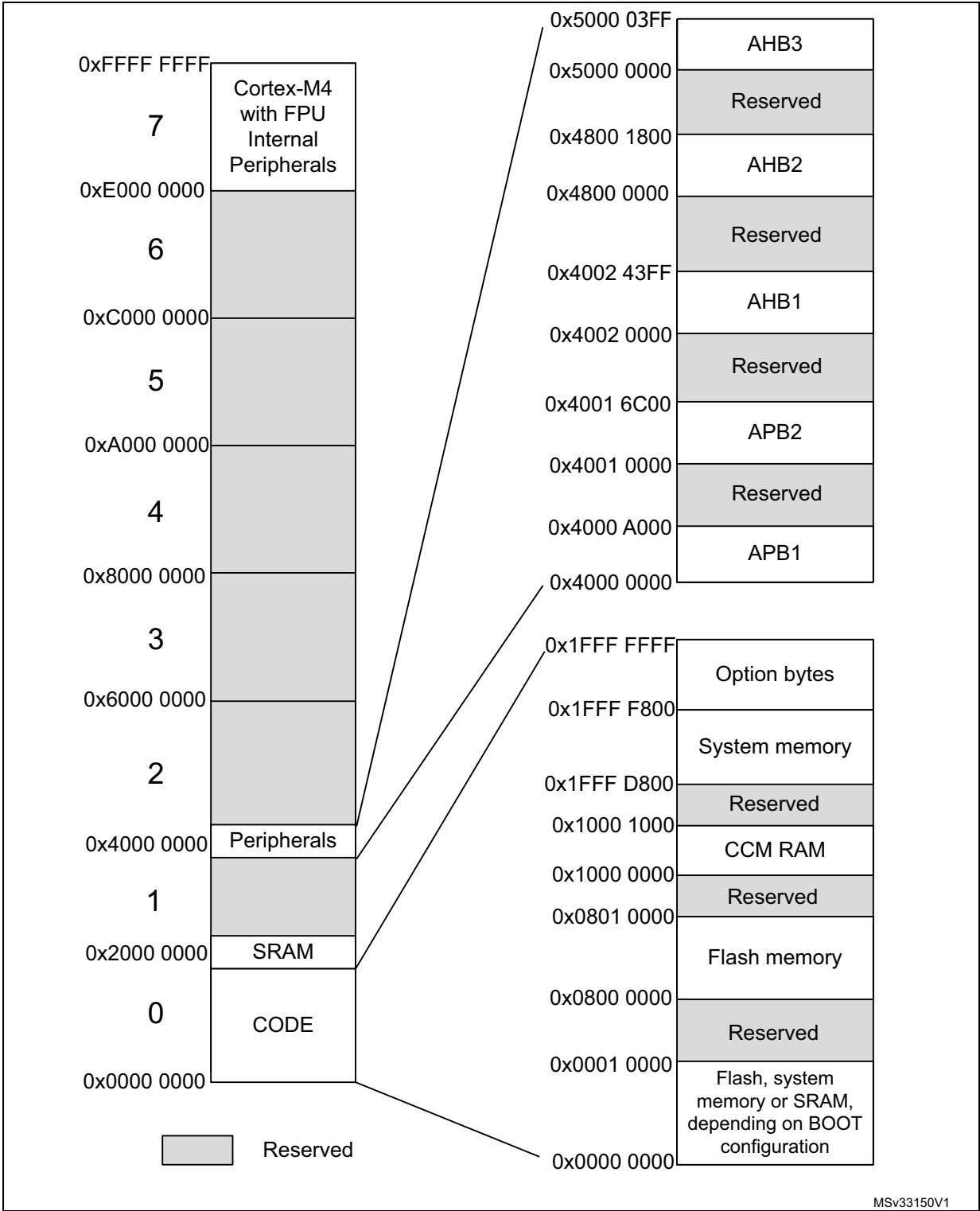
| Port   |      | AF0               | AF1                                  | AF2                           | AF3        | AF4       | AF5               | AF6               | AF7                                  | AF8                             | AF9                | AF10                | AF11     | AF12             | AF13              | AF14 | AF15     |
|--------|------|-------------------|--------------------------------------|-------------------------------|------------|-----------|-------------------|-------------------|--------------------------------------|---------------------------------|--------------------|---------------------|----------|------------------|-------------------|------|----------|
|        |      | SYS_AF            | TIM2/TIM15/<br>TIM16/TIM17/<br>EVENT | TIM1/TIM3/<br>TIM15/<br>TIM16 | HRTIM1/TSC | I2C1/TIM1 | SPI1/<br>Infrared | TIM1/<br>Infrared | USART1/USA<br>RT2/USART3/<br>GPCOMP6 | GPCOMP2/<br>GPCOMP4/<br>GPCOMP6 | CAN/TIM1/<br>TIM15 | TIM2/TIM3/TI<br>M17 | TIM1     | HRTIM1/<br>TIM1  | HRTIM1/<br>OPAMP2 | -    | EVENT    |
| Port A | PA0  | -                 | TIM2_CH1/TI<br>M2_ETR                | -                             | TSC_G1_IO1 | -         | -                 | -                 | USART2_CTS                           | -                               | -                  | -                   | -        | -                | -                 | -    | EVENTOUT |
|        | PA1  | -                 | TIM2_CH2                             | -                             | TSC_G1_IO2 | -         | -                 | -                 | USART2_RTS<br>_DE                    | -                               | TIM15_CH1N         | -                   | -        | -                | -                 | -    | EVENTOUT |
|        | PA2  | -                 | TIM2_CH3                             | -                             | TSC_G1_IO3 | -         | -                 | -                 | USART2_TX                            | COMP2_OUT                       | TIM15_CH1          | -                   | -        | -                | -                 | -    | EVENTOUT |
|        | PA3  | -                 | TIM2_CH4                             | -                             | TSC_G1_IO4 | -         | -                 | -                 | USART2_RX                            | -                               | TIM15_CH2          | -                   | -        | -                | -                 | -    | EVENTOUT |
|        | PA4  | -                 | -                                    | TIM3_CH2                      | TSC_G2_IO1 | -         | SPI1_NSS          | -                 | USART2_CK                            | -                               | -                  | -                   | -        | -                | -                 | -    | EVENTOUT |
|        | PA5  | -                 | TIM2_CH1/TI<br>M2_ETR                | -                             | TSC_G2_IO2 | -         | SPI1_SCK          | -                 | -                                    | -                               | -                  | -                   | -        | -                | -                 | -    | EVENTOUT |
|        | PA6  | -                 | TIM16_CH1                            | TIM3_CH1                      | TSC_G2_IO3 | -         | SPI1_MISO         | TIM1_BKIN         | -                                    | -                               | -                  | -                   | -        | -                | OPAMP2_DIG        | -    | EVENTOUT |
|        | PA7  | -                 | TIM17_CH1                            | TIM3_CH2                      | TSC_G2_IO4 | -         | SPI1_MOSI         | TIM1_CH1N         | -                                    | -                               | -                  | -                   | -        | -                | -                 | -    | EVENTOUT |
|        | PA8  | MCO               | -                                    | -                             | -          | -         | -                 | TIM1_CH1          | USART1_CK                            | -                               | -                  | -                   | -        | -                | HRTIM1_CHA1       | -    | EVENTOUT |
|        | PA9  | -                 | -                                    | -                             | TSC_G4_IO1 | -         | -                 | TIM1_CH2          | USART1_TX                            | -                               | TIM15_BKIN         | TIM2_CH3            | -        | -                | HRTIM1_CHA2       | -    | EVENTOUT |
|        | PA10 | -                 | TIM17_BKIN                           | -                             | TSC_G4_IO2 | -         | -                 | TIM1_CH3          | USART1_RX                            | COMP6_OUT                       | -                  | TIM2_CH4            | -        | -                | HRTIM1_CHB1       | -    | EVENTOUT |
|        | PA11 | -                 | -                                    | -                             | -          | -         | -                 | TIM1_CH1N         | USART1_CTS                           | -                               | CAN_RX             | -                   | TIM1_CH4 | TIM1_BKIN2       | HRTIM1_CHB2       | -    | EVENTOUT |
|        | PA12 | -                 | TIM16_CH1                            | -                             | -          | -         | -                 | TIM1_CH2N         | USART1_RTS<br>_DE                    | COMP2_OUT                       | CAN_TX             | -                   | TIM1_ETR | -                | HRTIM1_FLT1       | -    | EVENTOUT |
|        | PA13 | JTMS/SWDAT        | TIM16_CH1N                           | -                             | TSC_G4_IO3 | -         | IR_OUT            | -                 | USART3_CTS                           | -                               | -                  | -                   | -        | -                | -                 | -    | EVENTOUT |
|        | PA14 | JTCK/SWCLK        | -                                    | -                             | TSC_G4_IO4 | I2C1_SDA  | -                 | TIM1_BKIN         | USART2_TX                            | -                               | -                  | -                   | -        | -                | -                 | -    | EVENTOUT |
|        | PA15 | JTDI              | TIM2_CH1/<br>TIM2_ETR                | -                             | TSC_SYNC   | I2C1_SCL  | SPI1_NSS          | -                 | USART2_RX                            | -                               | TIM1_BKIN          | -                   | -        | -                | HRTIM1_FLT2       | -    | EVENTOUT |
| Port B | PB0  | -                 | -                                    | TIM3_CH3                      | TSC_G3_IO2 | -         | -                 | TIM1_CH2N         | -                                    | -                               | -                  | -                   | -        | -                | -                 | -    | EVENTOUT |
|        | PB1  | -                 | -                                    | TIM3_CH4                      | TSC_G3_IO3 | -         | -                 | TIM1_CH3N         | -                                    | COMP4_OUT                       | -                  | -                   | -        | -                | HRTIM1_SCOUT      | -    | EVENTOUT |
|        | PB2  | -                 | -                                    | -                             | TSC_G3_IO4 | -         | -                 | -                 | -                                    | -                               | -                  | -                   | -        | -                | HRTIM1_SCIN       | -    | EVENTOUT |
|        | PB3  | JTDO/TRACE<br>SWO | TIM2_CH2                             | -                             | TSC_G5_IO1 | -         | SPI1_SCK          | -                 | USART2_TX                            | -                               | -                  | TIM3_ETR            | -        | HRTIM1_<br>SCOUT | HRTIM1_EEV9       | -    | EVENTOUT |
|        | PB4  | NJTRST            | TIM16_CH1                            | TIM3_CH1                      | TSC_G5_IO2 | -         | SPI1_MISO         | -                 | USART2_RX                            | -                               | -                  | TIM17_BKIN          | -        | -                | HRTIM1_EEV7       | -    | EVENTOUT |
|        | PB5  | -                 | TIM16_BKIN                           | TIM3_CH2                      | -          | I2C1_SMBA | SPI1_MOSI         | -                 | USART2_CK                            | -                               | -                  | TIM17_CH1           | -        | -                | HRTIM1_EEV6       | -    | EVENTOUT |
|        | PB6  | -                 | TIM16_CH1N                           | -                             | TSC_G5_IO3 | I2C1_SCL  | -                 | -                 | USART1_TX                            | -                               | -                  | -                   | -        | HRTIM1_<br>SCIN  | HRTIM1_EEV4       | -    | EVENTOUT |
|        | PB7  | -                 | TIM17_CH1N                           | -                             | TSC_G5_IO4 | I2C1_SDA  | -                 | -                 | USART1_RX                            | -                               | -                  | TIM3_CH4            | -        | -                | HRTIM1_EEV3       | -    | EVENTOUT |
|        | PB8  | -                 | TIM16_CH1                            | -                             | TSC_SYNC   | I2C1_SCL  | -                 | -                 | USART3_RX                            | -                               | CAN_RX             | -                   | -        | TIM1_BKIN        | HRTIM1_EEV8       | -    | EVENTOUT |
|        | PB9  | -                 | TIM17_CH1                            | -                             | -          | I2C1_SDA  | -                 | IR_OUT            | USART3_TX                            | COMP2_OUT                       | CAN_TX             | -                   | -        | -                | HRTIM1_EEV5       | -    | EVENTOUT |

Table 14. Alternate functions (continued)

| Port   |      | AF0    | AF1                                  | AF2                           | AF3              | AF4       | AF5               | AF6               | AF7                                  | AF8                             | AF9                | AF10                | AF11 | AF12            | AF13              | AF14 | AF15     |
|--------|------|--------|--------------------------------------|-------------------------------|------------------|-----------|-------------------|-------------------|--------------------------------------|---------------------------------|--------------------|---------------------|------|-----------------|-------------------|------|----------|
|        |      | SYS_AF | TIM2/TIM15/<br>TIM16/TIM17/<br>EVENT | TIM1/TIM3/<br>TIM15/<br>TIM16 | HRTIM1/TSC       | I2C1/TIM1 | SPI1/<br>Infrared | TIM1/<br>Infrared | USART1/USA<br>RT2/USART3/<br>GPCOMP6 | GPCOMP2/<br>GPCOMP4/<br>GPCOMP6 | CAN/TIM1/<br>TIM15 | TIM2/TIM3/TI<br>M17 | TIM1 | HRTIM1/<br>TIM1 | HRTIM1/<br>OPAMP2 | -    | EVENT    |
| Port B | PB10 | -      | TIM2_CH3                             | -                             | TSC_SYNC         | -         | -                 | -                 | USART3_TX                            | -                               | -                  | -                   | -    | -               | HRTIM1_FLT3       | -    | EVENTOUT |
|        | PB11 | -      | TIM2_CH4                             | -                             | TSC_G6_IO1       | -         | -                 | -                 | USART3_RX                            | -                               | -                  | -                   | -    | -               | HRTIM1_FLT4       | -    | EVENTOUT |
|        | PB12 | -      | -                                    | -                             | TSC_G6_IO2       | -         | -                 | TIM1_BKIN         | USART3_CK                            | -                               | -                  | -                   | -    | -               | HRTIM1_CHC1       | -    | EVENTOUT |
|        | PB13 | -      | -                                    | -                             | TSC_G6_IO3       | -         | -                 | TIM1_CH1N         | USART3_CTS                           | -                               | -                  | -                   | -    | -               | HRTIM1_CHC2       | -    | EVENTOUT |
|        | PB14 | -      | TIM15_CH1                            | -                             | TSC_G6_IO4       | -         | -                 | TIM1_CH2N         | USART3_RTS<br>_DE                    | -                               | -                  | -                   | -    | -               | HRTIM1_CHD1       | -    | EVENTOUT |
|        | PB15 | -      | TIM15_CH2                            | TIM15_CH1N                    | -                | TIM1_CH3N | -                 | -                 | -                                    | -                               | -                  | -                   | -    | -               | HRTIM1_CHD2       | -    | EVENTOUT |
| Port C | PC0  | -      | EVENTOUT                             | TIM1_CH1                      | -                | -         | -                 | -                 | -                                    | -                               | -                  | -                   | -    | -               | -                 | -    | -        |
|        | -    | -      | -                                    | -                             | -                | -         | -                 | -                 | -                                    | -                               | -                  | -                   | -    | -               | -                 | -    | -        |
|        | PC2  | -      | EVENTOUT                             | TIM1_CH3                      | -                | -         | -                 | -                 | -                                    | -                               | -                  | -                   | -    | -               | -                 | -    | -        |
|        | PC3  | -      | EVENTOUT                             | TIM1_CH4                      | -                | -         | -                 | TIM1_BKIN2        | -                                    | -                               | -                  | -                   | -    | -               | -                 | -    | -        |
|        | PC4  | -      | EVENTOUT                             | TIM1_ETR                      | -                | -         | -                 | -                 | USART1_TX                            | -                               | -                  | -                   | -    | -               | -                 | -    | -        |
|        | PC5  | -      | EVENTOUT                             | TIM15_BKIN                    | TSC_G3_IO1       | -         | -                 | -                 | USART1_RX                            | -                               | -                  | -                   | -    | -               | -                 | -    | -        |
|        | PC6  | -      | EVENTOUT                             | TIM3_CH1                      | HRTIM1_<br>EEV10 | -         | -                 | -                 | COMP6_OUT                            | -                               | -                  | -                   | -    | -               | -                 | -    | -        |
|        | PC7  | -      | EVENTOUT                             | TIM3_CH2                      | HRTIM1_FLT5      | -         | -                 | -                 | -                                    | -                               | -                  | -                   | -    | -               | -                 | -    | -        |
|        | PC8  | -      | EVENTOUT                             | TIM3_CH3                      | HRTIM1_CHE1      | -         | -                 | -                 | -                                    | -                               | -                  | -                   | -    | -               | -                 | -    | -        |
|        | PC9  | -      | EVENTOUT                             | TIM3_CH4                      | HRTIM1_CHE2      | -         | -                 | -                 | -                                    | -                               | -                  | -                   | -    | -               | -                 | -    | -        |
|        | PC10 | -      | EVENTOUT                             | -                             | -                | -         | -                 | -                 | USART3_TX                            | -                               | -                  | -                   | -    | -               | -                 | -    | -        |
|        | PC11 | -      | EVENTOUT                             | -                             | HRTIM1_EEV2      | -         | -                 | -                 | USART3_RX                            | -                               | -                  | -                   | -    | -               | -                 | -    | -        |
|        | PC12 | -      | EVENTOUT                             | -                             | HRTIM1_EEV1      | -         | -                 | -                 | USART3_CK                            | -                               | -                  | -                   | -    | -               | -                 | -    | -        |
|        | PC13 | -      | -                                    | -                             | -                | TIM1_CH1N | -                 | -                 | -                                    | -                               | -                  | -                   | -    | -               | -                 | -    | -        |
|        | PC14 | -      | -                                    | -                             | -                | -         | -                 | -                 | -                                    | -                               | -                  | -                   | -    | -               | -                 | -    | -        |
|        | PC15 | -      | -                                    | -                             | -                | -         | -                 | -                 | -                                    | -                               | -                  | -                   | -    | -               | -                 | -    | -        |
| Port D | PD2  | -      | EVENTOUT                             | TIM3_ETR                      | -                | -         | -                 | -                 | -                                    | -                               | -                  | -                   | -    | -               | -                 | -    | -        |
| Port F | PF0  | -      | -                                    | -                             | -                | -         | -                 | TIM1_CH3N         | -                                    | -                               | -                  | -                   | -    | -               | -                 | -    | -        |
|        | PF1  | -      | -                                    | -                             | -                | -         | -                 | -                 | -                                    | -                               | -                  | -                   | -    | -               | -                 | -    | -        |

5 Memory mapping

Figure 9. STM32F334x4/6/8 memory map



MSv33150V1

Table 15. STM32F334x4/6/8 peripheral register boundary addresses

| Bus  | Boundary address          | Size (bytes) | Peripheral            |
|------|---------------------------|--------------|-----------------------|
| AHB3 | 0x5000 0000 - 0x5000 03FF | 1 K          | ADC1 - ADC2           |
| -    | 0x4800 1800 - 0x4FFF FFFF | ~132 M       | Reserved              |
| AHB2 | 0x4800 1400 - 0x4800 17FF | 1 K          | GPIOF                 |
| -    | 0x4800 1000 - 0x4800 13FF | 1 K          | Reserved              |
| AHB2 | 0x4800 0C00 - 0x4800 0FFF | 1 K          | GPIOD                 |
|      | 0x4800 0800 - 0x4800 0BFF | 1 K          | GPIOC                 |
|      | 0x4800 0400 - 0x4800 07FF | 1 K          | GPIOB                 |
|      | 0x4800 0000 - 0x4800 03FF | 1 K          | GPIOA                 |
| -    | 0x4002 4400 - 0x47FF FFFF | ~128 M       | Reserved              |
| AHB1 | 0x4002 4000 - 0x4002 43FF | 1 K          | TSC                   |
|      | 0x4002 3400 - 0x4002 3FFF | 3 K          | Reserved              |
|      | 0x4002 3000 - 0x4002 33FF | 1 K          | CRC                   |
|      | 0x4002 2400 - 0x4002 2FFF | 3 K          | Reserved              |
|      | 0x4002 2000 - 0x4002 23FF | 1 K          | Flash interface       |
|      | 0x4002 1400 - 0x4002 1FFF | 3 K          | Reserved              |
|      | 0x4002 1000 - 0x4002 13FF | 1 K          | RCC                   |
|      | 0x4002 0400 - 0x4002 0FFF | 3 K          | Reserved              |
|      | 0x4002 0000 - 0x4002 03FF | 1 K          | DMA1                  |
| -    | 0x4001 8000 - 0x4001 FFFF | 32 K         | Reserved              |
| APB2 | 0x4001 7400 - 0x4001 77FF | 1 K          | HRTIM1                |
|      | 0x4001 4C00 - 0x4001 73FF | 12 K         | Reserved              |
|      | 0x4001 4800 - 0x4001 4BFF | 1 K          | TIM17                 |
|      | 0x4001 4400 - 0x4001 47FF | 1 K          | TIM16                 |
|      | 0x4001 4000 - 0x4001 43FF | 1 K          | TIM15                 |
|      | 0x4001 3C00 - 0x4001 3FFF | 1 K          | Reserved              |
|      | 0x4001 3800 - 0x4001 3BFF | 1 K          | USART1                |
|      | 0x4001 3400 - 0x4001 37FF | 1 K          | Reserved              |
|      | 0x4001 3000 - 0x4001 33FF | 1 K          | SPI1                  |
|      | 0x4001 2C00 - 0x4001 2FFF | 1 K          | TIM1                  |
|      | 0x4001 0800 - 0x4001 2BFF | 9 K          | Reserved              |
|      | 0x4001 0400 - 0x4001 07FF | 1 K          | EXTI                  |
|      | 0x4001 0000 - 0x4001 03FF | 1 K          | SYSCFG + COMP + OPAMP |
| -    | 0x4000 9C00 - 0x4000 FFFF | 25 K         | Reserved              |

Table 15. STM32F334x4/6/8 peripheral register boundary addresses (continued)

| Bus  | Boundary address          | Size (bytes) | Peripheral                                                               |
|------|---------------------------|--------------|--------------------------------------------------------------------------|
| APB1 | 0x4000 9800 - 0x4000 9BFF | 1 K          | DAC2                                                                     |
|      | 0x4000 7800 - 0x4000 97FF | 8 K          | Reserved                                                                 |
|      | 0x4000 7400 - 0x4000 77FF | 1 K          | DAC1                                                                     |
|      | 0x4000 7000 - 0x4000 73FF | 1 K          | PWR                                                                      |
|      | 0x4000 6800 - 0x4000 6FFF | 2 K          | Reserved                                                                 |
|      | 0x4000 6400 - 0x4000 67FF | 1 K          | bxCAN                                                                    |
|      | 0x4000 5800 - 0x4000 63FF | 3 K          | Reserved                                                                 |
|      | 0x4000 5400 - 0x4000 57FF | 1 K          | I2C1                                                                     |
|      | 0x4000 4C00 - 0x4000 53FF | 2 K          | Reserved                                                                 |
|      | 0x4000 4800 - 0x4000 4BFF | 1 K          | USART3                                                                   |
|      | 0x4000 4400 - 0x4000 47FF | 1 K          | USART2                                                                   |
|      | 0x4000 3400 - 0x4000 43FF | 2 K          | Reserved                                                                 |
|      | 0x4000 3000 - 0x4000 33FF | 1 K          | IWDG                                                                     |
|      | 0x4000 2C00 - 0x4000 2FFF | 1 K          | WWDG                                                                     |
|      | 0x4000 2800 - 0x4000 2BFF | 1 K          | RTC                                                                      |
|      | 0x4000 1800 - 0x4000 27FF | 4 K          | Reserved                                                                 |
|      | 0x4000 1400 - 0x4000 17FF | 1 K          | TIM7                                                                     |
|      | 0x4000 1000 - 0x4000 13FF | 1 K          | TIM6                                                                     |
|      | 0x4000 0800 - 0x4000 0FFF | 2 K          | Reserved                                                                 |
|      | 0x4000 0400 - 0x4000 07FF | 1 K          | TIM3                                                                     |
|      | 0x4000 0000 - 0x4000 03FF | 1 K          | TIM2                                                                     |
| -    | 0x2000 3000 - 3FFF FFFF   | ~512 M       | Reserved                                                                 |
| -    | 0x2000 0000 - 0x2000 2FFF | 12 K         | SRAM                                                                     |
| -    | 0x1FFF F800 - 0x1FFF FFFF | 2 K          | Option bytes                                                             |
| -    | 0x1FFF D800 - 0x1FFF F7FF | 8 K          | System memory                                                            |
| -    | 0x1000 2000 - 0x1FFF D7FF | ~256 M       | Reserved                                                                 |
| -    | 0x1000 0000 - 0x1000 0FFF | 4 K          | CCM RAM                                                                  |
| -    | 0x0804 0000 - 0x0FFF FFFF | ~128 M       | Reserved                                                                 |
| -    | 0x0800 0000 - 0x0800 FFFF | 64 K         | Main Flash memory                                                        |
| -    | 0x0004 0000 - 0x07FF FFFF | ~128 M       | Reserved                                                                 |
| -    | 0x0000 000 - 0x0000 FFFF  | 64 K         | Main Flash memory, system memory or SRAM depending on BOOT configuration |

## 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 (mean  $\pm 3\sigma$ ).

#### 6.1.2 Typical values

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

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

#### 6.1.3 Typical curves

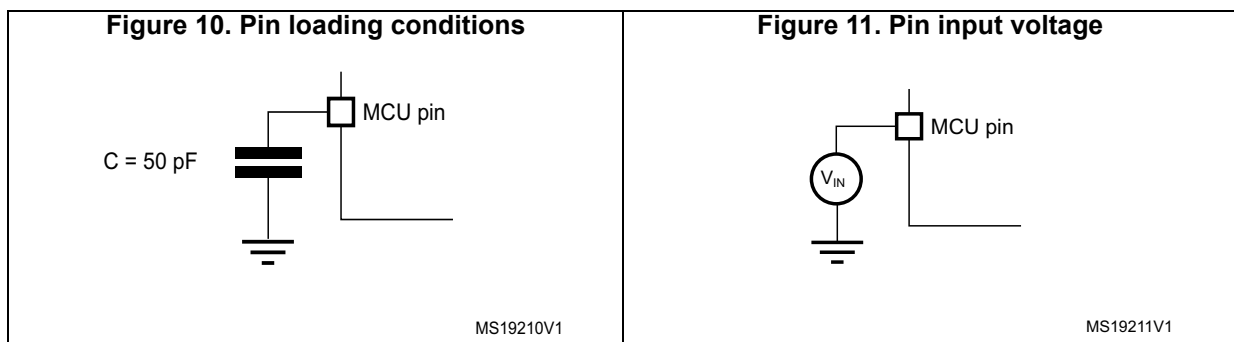
Unless otherwise specified, all typical curves are given only as design guidelines and are not tested.

#### 6.1.4 Loading capacitor

The loading conditions used for pin parameter measurement are shown in [Figure 10](#).

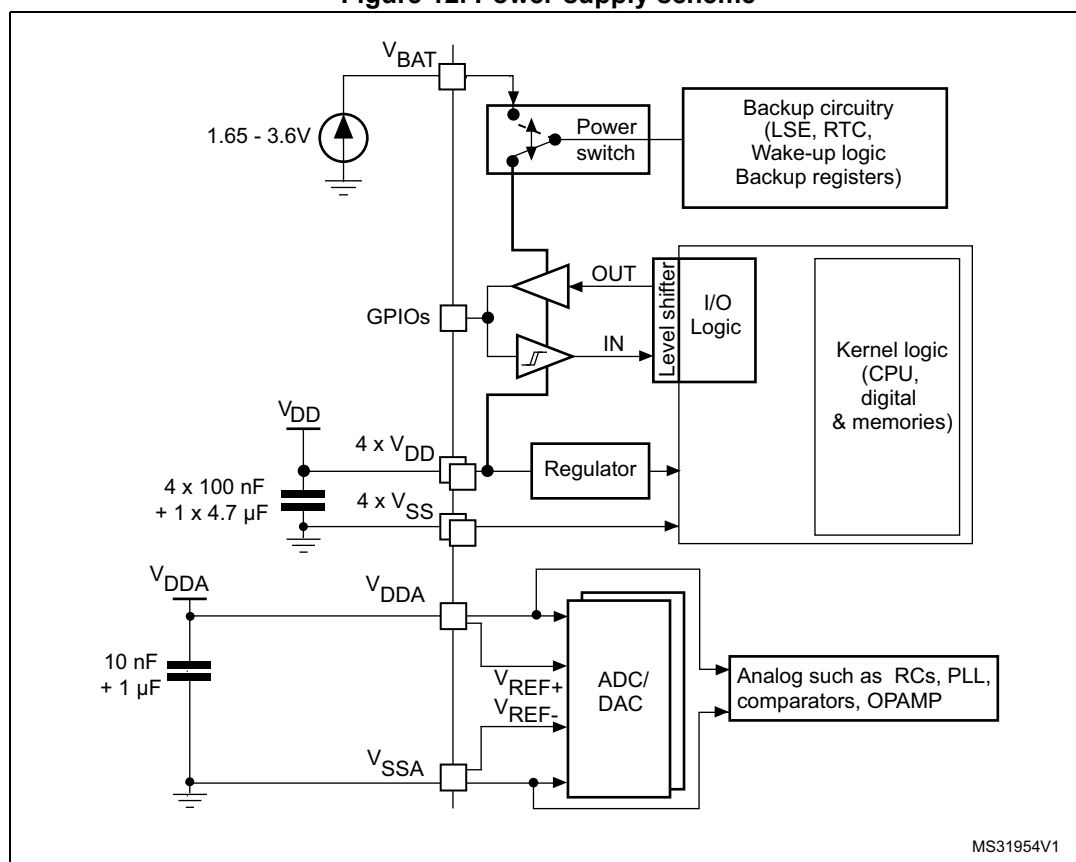
#### 6.1.5 Input voltage on a pin

The input voltage measurement on a pin of the device is described in [Figure 11](#).



### 6.1.6 Power-supply scheme

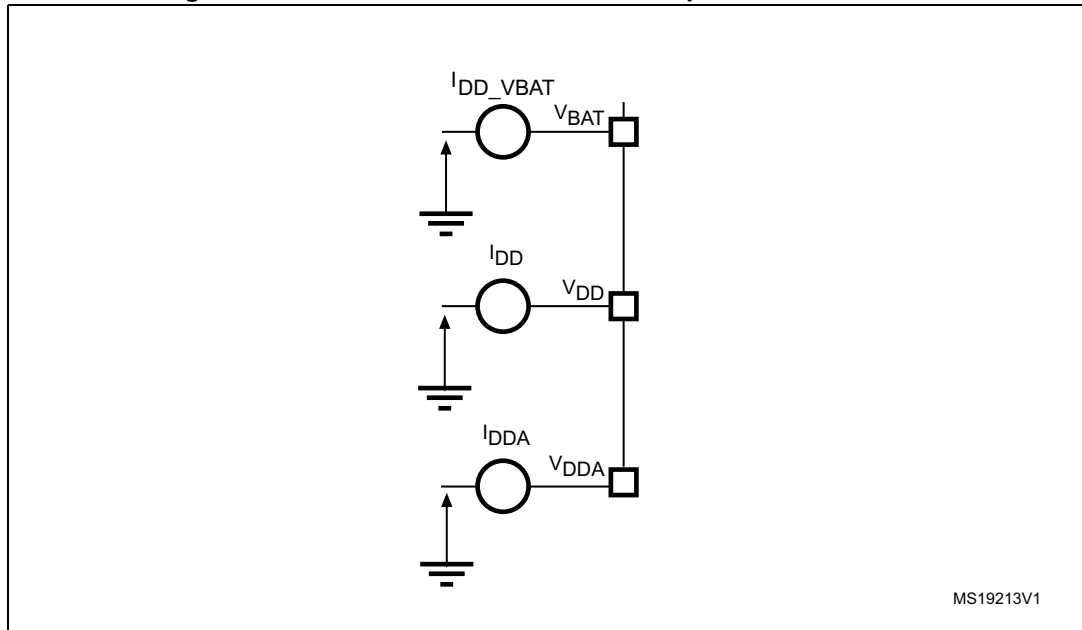
Figure 12. Power-supply scheme



**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 Measurement of the current consumption

Figure 13. Scheme of the current-consumption measurement



## 6.2 Absolute maximum ratings

Stresses above the absolute maximum ratings listed in [Table 16: Voltage characteristics](#), [Table 17: Current characteristics](#), and [Table 18: 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 the device reliability.

**Table 16. Voltage characteristics<sup>(1)</sup>**

| Symbol               | Ratings                                                                      | Min.                                                                       | Max.           | Unit |
|----------------------|------------------------------------------------------------------------------|----------------------------------------------------------------------------|----------------|------|
| $V_{DD}-V_{SS}$      | External main supply voltage (including $V_{DDA}$ , $V_{BAT}$ and $V_{DD}$ ) | -0.3                                                                       | 4.0            | V    |
| $V_{DD}-V_{DDA}$     | Allowed voltage difference for $V_{DD} > V_{DDA}$                            | -                                                                          | 0.4            |      |
| $V_{IN}^{(2)}$       | Input voltage on FT and FTf pins                                             | $V_{SS} - 0.3$                                                             | $V_{DD} + 4.0$ |      |
|                      | Input voltage on TTa and TT pins                                             | $V_{SS} - 0.3$                                                             | 4.0            |      |
|                      | Input voltage on any other pin                                               | $V_{SS} - 0.3$                                                             | 4.0            |      |
|                      | Input voltage on Boot0 pin                                                   | 0                                                                          | 9              |      |
| $ \Delta V_{DDx} $   | Variations between different $V_{DD}$ power pins                             | -                                                                          | 50             | mV   |
| $ V_{SSx} - V_{SS} $ | Variations between all the different ground pins <sup>(3)</sup>              | -                                                                          | 50             |      |
| $V_{ESD(HBM)}$       | Electrostatic discharge voltage (human body model)                           | see <a href="#">Section 6.3.12: 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. 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  $V_{DD}$ .
2.  $V_{IN}$  maximum must always be respected. Refer to [Table 17: Current characteristics](#) for the maximum allowed injected current values.
3. Include  $V_{REF-}$  pin.

Table 17. Current characteristics

| Symbol                | Ratings                                                                         | Max.    | Unit |
|-----------------------|---------------------------------------------------------------------------------|---------|------|
| $\Sigma I_{VDD}$      | Total current into sum of all VDD power lines (source) <sup>(1)</sup>           | 140     | mA   |
| $\Sigma I_{VSS}$      | Total current out of sum of all VSS ground lines (sink) <sup>(1)</sup>          | -140    |      |
| $I_{VDD}$             | Maximum current into each VDD power line (source) <sup>(1)</sup>                | 100     |      |
| $I_{VSS}$             | Maximum current out of each VSS_x ground line (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 I/Os and control pins <sup>(2)</sup>    | 80      |      |
|                       | Total output current sourced by sum of all I/Os and control pins <sup>(2)</sup> | -80     |      |
| $I_{INJ(PIN)}$        | Injected current on TT, FT, FTf and B pins <sup>(3)</sup>                       | -5 / +0 |      |
|                       | Injected current on TC and RST pin <sup>(4)</sup>                               | ±5      |      |
|                       | Injected current on TTa pins <sup>(5)</sup>                                     | ±5      |      |
| $\Sigma I_{INJ(PIN)}$ | Total injected current (sum of all I/O and control pins) <sup>(6)</sup>         | ±25     |      |

1. All main power ( $V_{DD}$ ,  $V_{DDA}$ ) and ground ( $V_{SS}$  and  $V_{SSA}$ ) pins must always be connected to the external power supply, in the permitted range.
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 16: 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 16: Voltage characteristics](#) for the maximum allowed input voltage values. Negative injection disturbs the analog performance of the device. See note 2.
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 18. 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 19. 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                                                                                  | -                                                      | 2    | 3.6           | V    |
| $V_{DD18}$  | Core, SRAM and Flash memory power supply                                                                    | -                                                      | 1.65 | 1.95          |      |
| $V_{DDA}$   | Analog operating voltage (OPAMP and DAC not used)                                                           | Must have a potential equal to or higher than $V_{DD}$ | 2    | 3.6           |      |
|             | Analog operating voltage (OPAMP and DAC used)                                                               |                                                        | 2.4  | 3.6           |      |
| $V_{BAT}$   | Backup operating voltage                                                                                    | -                                                      | 1.65 | 3.6           | V    |
| $V_{IN}$    | I/O input voltage                                                                                           | TC I/O                                                 | -0.3 | $V_{DD}+0.3$  | V    |
|             |                                                                                                             | TT I/O                                                 | -0.3 | 3.6           |      |
|             |                                                                                                             | TTa I/O                                                | -0.3 | $V_{DDA}+0.3$ |      |
|             |                                                                                                             | FT and FTf I/O <sup>(1)</sup>                          | -0.3 | 5.5           |      |
|             |                                                                                                             | BOOT0                                                  | 0    | 5.5           |      |
| PD          | Power dissipation at $T_A = 85\text{ °C}$ for suffix 6 or $T_A = 105\text{ °C}$ for suffix 7 <sup>(2)</sup> | LQFP64                                                 | -    | 444           | mW   |
|             |                                                                                                             | LQFP48                                                 | -    | 364           | mW   |
|             |                                                                                                             | LQFP32                                                 | -    | 333           | mW   |
|             |                                                                                                             | UFQFPN32                                               | -    | 540           | mW   |
|             |                                                                                                             | WLCSP49                                                | -    | 414           | mW   |
| $T_A$       | Ambient temperature for 6 suffix version                                                                    | Maximum power dissipation                              | -40  | 85            | °C   |
|             |                                                                                                             | Low power dissipation <sup>(3)</sup>                   | -40  | 105           |      |
|             | Ambient temperature for 7 suffix version                                                                    | Maximum power dissipation                              | -40  | 105           | °C   |
|             |                                                                                                             | Low power dissipation <sup>(3)</sup>                   | -40  | 125           |      |
| $T_J$       | Junction temperature range                                                                                  | 6 suffix version                                       | -40  | 105           | °C   |
|             |                                                                                                             | 7 suffix version                                       | -40  | 125           |      |

1. To sustain a voltage higher than  $V_{DD}+0.3\text{ V}$ , the internal pull-up/pull-down resistors must be disabled.

2. If  $T_A$  is lower, higher  $P_D$  values are allowed as long as  $T_J$  does not exceed  $T_{Jmax}$  (see [Table 81: Package thermal characteristics](#)).

3. In low power dissipation state,  $T_A$  can be extended to this range as long as  $T_J$  does not exceed  $T_{Jmax}$  (see [Section 7.7: Thermal characteristics](#)).

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

The parameters given in [Table 20](#) are derived from tests performed under the ambient temperature condition summarized in [Table 19](#).

**Table 20. 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 Characteristics of the embedded reset and power-control block

The parameters given in [Table 21](#) are derived from tests performed under ambient temperature and  $V_{DD}$  supply voltage conditions summarized in [Table 19](#).

**Table 21. Embedded reset and power control block characteristics**

| Symbol               | Parameter                           | Conditions   | Min.               | Typ. | Max. | Unit |
|----------------------|-------------------------------------|--------------|--------------------|------|------|------|
| $V_{POR/PDR}^{(1)}$  | Power on/power down reset threshold | Falling edge | 1.8 <sup>(2)</sup> | 1.88 | 1.96 | V    |
|                      |                                     | Rising edge  | 1.84               | 1.92 | 2.0  | V    |
| $V_{PDRhyst}^{(1)}$  | PDR hysteresis                      | -            | -                  | 40   | -    | mV   |
| $t_{RSTTEMPO}^{(3)}$ | POR reset temporization             | -            | 1.5                | 2.5  | 4.5  | ms   |

1. The PDR detector monitors  $V_{DD}$  and also  $V_{DDA}$  (if kept enabled in the option bytes). The POR detector monitors only  $V_{DD}$ .
2. The product behavior is guaranteed by design down to the minimum  $V_{POR/PDR}$  value.
3. Guaranteed by design, not tested in production.

Table 22. Programmable voltage detector characteristics

| Symbol                              | Parameter               | Conditions   | Min. <sup>(1)</sup> | Typ. | Max. <sup>(1)</sup> | Unit |
|-------------------------------------|-------------------------|--------------|---------------------|------|---------------------|------|
| V <sub>PVD0</sub>                   | PVD threshold 0         | Rising edge  | 2.1                 | 2.18 | 2.26                | V    |
|                                     |                         | Falling edge | 2                   | 2.08 | 2.16                |      |
| V <sub>PVD1</sub>                   | PVD threshold 1         | Rising edge  | 2.19                | 2.28 | 2.37                |      |
|                                     |                         | Falling edge | 2.09                | 2.18 | 2.27                |      |
| V <sub>PVD2</sub>                   | PVD threshold 2         | Rising edge  | 2.28                | 2.38 | 2.48                |      |
|                                     |                         | Falling edge | 2.18                | 2.28 | 2.38                |      |
| V <sub>PVD3</sub>                   | PVD threshold 3         | Rising edge  | 2.38                | 2.48 | 2.58                |      |
|                                     |                         | Falling edge | 2.28                | 2.38 | 2.48                |      |
| V <sub>PVD4</sub>                   | PVD threshold 4         | Rising edge  | 2.47                | 2.58 | 2.69                |      |
|                                     |                         | Falling edge | 2.37                | 2.48 | 2.59                |      |
| V <sub>PVD5</sub>                   | PVD threshold 5         | Rising edge  | 2.57                | 2.68 | 2.79                |      |
|                                     |                         | Falling edge | 2.47                | 2.58 | 2.69                |      |
| V <sub>PVD6</sub>                   | PVD threshold 6         | Rising edge  | 2.66                | 2.78 | 2.9                 |      |
|                                     |                         | Falling edge | 2.56                | 2.68 | 2.8                 |      |
| V <sub>PVD7</sub>                   | PVD threshold 7         | Rising edge  | 2.76                | 2.88 | 3                   |      |
|                                     |                         | Falling edge | 2.66                | 2.78 | 2.9                 |      |
| V <sub>PVDhyst</sub> <sup>(2)</sup> | PVD hysteresis          | -            | -                   | 100  | -                   | mV   |
| ID <sub>D</sub> (PVD)               | PVD current consumption | -            | -                   | 0.15 | 0.26                | μA   |

1. Data based on characterization results only, not tested in production.

2. Guaranteed by design, not tested in production.

### 6.3.4 Embedded reference voltage

The parameters given in [Table 23](#) are derived from tests performed under ambient temperature and V<sub>DD</sub> supply voltage conditions summarized in [Table 19](#).

Table 23. Embedded internal reference voltage

| Symbol                 | Parameter                                                     | Conditions                        | Min. | Typ. | Max.               | Unit   |
|------------------------|---------------------------------------------------------------|-----------------------------------|------|------|--------------------|--------|
| V <sub>REFINT</sub>    | Internal reference voltage                                    | -40 °C < T <sub>A</sub> < +105 °C | 1.20 | 1.23 | 1.25               | V      |
| T <sub>S_vrefint</sub> | ADC sampling time when reading the internal reference voltage | -                                 | 2.2  | -    | -                  | μs     |
| V <sub>RERINT</sub>    | Internal reference voltage spread over the temperature range  | V <sub>DD</sub> = 31.8 V ±10 mV   | -    | -    | 10 <sup>(1)</sup>  | mV     |
| T <sub>Coeff</sub>     | Temperature coefficient                                       | -                                 | -    | -    | 100 <sup>(1)</sup> | ppm/°C |

1. Guaranteed by design, not tested in production.

Table 24. Internal reference voltage calibration values

| Calibration value name  | Description                                                           | Memory address            |
|-------------------------|-----------------------------------------------------------------------|---------------------------|
| V <sub>REFINT_CAL</sub> | Raw data acquired at temperature of 30 °C<br>V <sub>DDA</sub> = 3.3 V | 0x1FFF F7BA - 0x1FFF F7BB |

### 6.3.5 Supply current characteristics

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

The current consumption is measured as described in [Figure 13: Scheme of the current-consumption measurement](#).

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

*Note:* The total current consumption is the sum of the IDD and IDDA values.

#### 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<sub>DD</sub> or V<sub>SS</sub> (no load)
- All peripherals are disabled except when explicitly mentioned
- The Flash memory access time is adjusted to the f<sub>HCLK</sub> frequency (0 wait state from 0 to 24 MHz, 1 wait state from 24 to 48 MHz and 2 wait states from 48 to 72 MHz)
- Prefetch in ON (reminder: this bit must be set before clock setting and bus prescaling)
- When the peripherals are enabled f<sub>PCLK2</sub> = f<sub>HCLK</sub> and f<sub>PCLK1</sub> = f<sub>HCLK</sub>/2
- When f<sub>HCLK</sub> > 8 MHz, the PLL is ON and the PLL input is equal to HSI/2 (4 MHz) or HSE (8 MHz) in bypass mode.

The parameters given in [Table 25](#) to [Table 29](#) are derived from tests performed under ambient temperature and supply voltage conditions summarized in [Table 19](#).

Table 25. Typical and maximum current consumption from V<sub>DD</sub> supply at V<sub>DD</sub> = 3.6V

| Symbol          | Parameter                                                 | Conditions                  | f <sub>HCLK</sub> | All peripherals enabled |                                      |       |        | All peripherals disabled |                                      |       |        | Unit |  |
|-----------------|-----------------------------------------------------------|-----------------------------|-------------------|-------------------------|--------------------------------------|-------|--------|--------------------------|--------------------------------------|-------|--------|------|--|
|                 |                                                           |                             |                   | Typ.                    | Max. @ T <sub>A</sub> <sup>(1)</sup> |       |        | Typ.                     | Max. @ T <sub>A</sub> <sup>(1)</sup> |       |        |      |  |
|                 |                                                           |                             |                   |                         | 25 °C                                | 85 °C | 105 °C |                          | 25 °C                                | 85 °C | 105 °C |      |  |
| I <sub>DD</sub> | Supply current in Run mode, executing from Flash          | External clock (HSE bypass) | 72 MHz            | 71.4                    | 77.9                                 | 79.1  | 80.0   | 27.1                     | 32.2                                 | 32.4  | 32.4   | mA   |  |
|                 |                                                           |                             | 64 MHz            | 63.9                    | 70.6                                 | 71.3  | 71.5   | 24.2                     | 27.0                                 | 27.5  | 27.7   |      |  |
|                 |                                                           |                             | 48 MHz            | 49.5                    | 56.6                                 | 57.1  | 57.7   | 18.7                     | 21.4                                 | 21.6  | 21.9   |      |  |
|                 |                                                           |                             | 32 MHz            | 34.0                    | 38.6                                 | 38.9  | 39.2   | 12.9                     | 14.6                                 | 14.9  | 15.9   |      |  |
|                 |                                                           |                             | 24 MHz            | 25.9                    | 30.2                                 | 30.4  | 30.6   | 10.0                     | 11.1                                 | 11.2  | 12.3   |      |  |
|                 |                                                           |                             | 8 MHz             | 9.3                     | 14.1                                 | 14.3  | 14.4   | 3.3                      | 4.0                                  | 4.4   | 5.1    |      |  |
|                 |                                                           |                             | 1 MHz             | 3.5                     | 8.9                                  | 9.1   | 9.5    | 0.7                      | 0.9                                  | 1.0   | 1.2    |      |  |
|                 |                                                           | Internal clock (HSI)        | 64 MHz            | 61.6                    | 68.1                                 | 68.8  | 70.1   | 24.1                     | 27.0                                 | 27.1  | 27.2   |      |  |
|                 |                                                           |                             | 48 MHz            | 48.1                    | 54.6                                 | 54.8  | 55.1   | 18.6                     | 21.6                                 | 21.7  | 21.9   |      |  |
|                 |                                                           |                             | 32 MHz            | 33.3                    | 37.8                                 | 37.9  | 38.0   | 12.7                     | 14.4                                 | 14.9  | 16.0   |      |  |
|                 |                                                           |                             | 24 MHz            | 25.7                    | 29.8                                 | 29.8  | 30.0   | 10.0                     | 11.1                                 | 11.2  | 12.3   |      |  |
|                 |                                                           |                             | 8 MHz             | 9.7                     | 12.2                                 | 12.3  | 12.8   | 3.4                      | 3.8                                  | 4.2   | 5.0    |      |  |
|                 | Supply current in Run mode, executing from RAM            | External clock (HSE bypass) | 72 MHz            | 71.3                    | 77.8                                 | 78.7  | 78.9   | 27.6                     | 32.1                                 | 32.2  | 32.3   |      |  |
|                 |                                                           |                             | 64 MHz            | 63.8                    | 70.5                                 | 70.7  | 70.9   | 24.5                     | 27.2                                 | 27.6  | 27.7   |      |  |
|                 |                                                           |                             | 48 MHz            | 49.3                    | 56.5                                 | 56.9  | 57.4   | 18.1                     | 21.6                                 | 21.8  | 21.8   |      |  |
|                 |                                                           |                             | 32 MHz            | 33.9                    | 37.7                                 | 37.9  | 38.0   | 12.9                     | 14.9                                 | 14.9  | 15.9   |      |  |
|                 |                                                           |                             | 24 MHz            | 25.8                    | 28.8                                 | 29.0  | 29.2   | 9.8                      | 11.1                                 | 11.3  | 11.5   |      |  |
|                 |                                                           |                             | 8 MHz             | 9.0                     | 13.2                                 | 13.3  | 13.8   | 3.2                      | 3.6                                  | 4.0   | 4.6    |      |  |
|                 |                                                           |                             | 1 MHz             | 3.2                     | 7.6                                  | 7.8   | 8.0    | 0.3                      | 0.4                                  | 0.8   | 1.2    |      |  |
|                 |                                                           | Internal clock (HSI)        | 64 MHz            | 61.3                    | 66.9                                 | 67.3  | 67.8   | 24.1                     | 26.9                                 | 27.0  | 27.1   |      |  |
|                 |                                                           |                             | 48 MHz            | 48.0                    | 52.4                                 | 52.6  | 53.1   | 19.1                     | 21.6                                 | 21.6  | 22.1   |      |  |
|                 |                                                           |                             | 32 MHz            | 33.1                    | 35.6                                 | 35.8  | 36.6   | 12.6                     | 14.8                                 | 14.9  | 15.9   |      |  |
|                 |                                                           |                             | 24 MHz            | 25.6                    | 28.5                                 | 28.7  | 28.8   | 9.8                      | 11.1                                 | 11.3  | 11.5   |      |  |
|                 |                                                           |                             | 8 MHz             | 9.7                     | 11.6                                 | 11.6  | 11.7   | 3.0                      | 3.1                                  | 4.1   | 4.7    |      |  |
| I <sub>DD</sub> | Supply current in Sleep mode, executing from Flash or RAM | External clock (HSE bypass) | 72 MHz            | 55.5                    | 58.7                                 | 61.1  | 61.9   | 7.0                      | 7.3                                  | 8.4   | 8.5    | mA   |  |
|                 |                                                           |                             | 64 MHz            | 49.8                    | 52.7                                 | 54.5  | 54.8   | 6.3                      | 6.7                                  | 7.0   | 7.8    |      |  |
|                 |                                                           |                             | 48 MHz            | 38.5                    | 40.6                                 | 41.7  | 41.8   | 4.6                      | 5.1                                  | 5.6   | 5.9    |      |  |
|                 |                                                           |                             | 32 MHz            | 26.9                    | 28.8                                 | 29.2  | 29.5   | 3.0                      | 3.3                                  | 4.0   | 4.5    |      |  |
|                 |                                                           |                             | 24 MHz            | 19.1                    | 23.2                                 | 23.7  | 23.9   | 2.4                      | 2.5                                  | 3.2   | 3.8    |      |  |
|                 |                                                           |                             | 8 MHz             | 7.1                     | 11.5                                 | 11.7  | 11.9   | 0.6                      | 0.9                                  | 1.2   | 2.1    |      |  |
|                 |                                                           |                             | 1 MHz             | 3.0                     | 7.4                                  | 7.7   | 7.9    | 0.3                      | 0.3                                  | 0.4   | 1.2    |      |  |
|                 |                                                           | Internal clock (HSI)        | 64 MHz            | 47.7                    | 52.4                                 | 52.6  | 52.8   | 5.4                      | 6.5                                  | 6.8   | 7.5    |      |  |
|                 |                                                           |                             | 48 MHz            | 35.0                    | 40.4                                 | 40.6  | 40.8   | 4.3                      | 4.7                                  | 5.2   | 5.7    |      |  |
|                 |                                                           |                             | 32 MHz            | 23.7                    | 27.7                                 | 28.3  | 28.8   | 2.9                      | 3.1                                  | 3.2   | 4.4    |      |  |
|                 |                                                           |                             | 24 MHz            | 18.5                    | 23.8                                 | 24.0  | 24.2   | 1.3                      | 1.7                                  | 2.2   | 2.7    |      |  |
|                 |                                                           |                             | 8 MHz             | 7.5                     | 9.6                                  | 9.7   | 9.7    | 0.5                      | 0.7                                  | 1.1   | 2.0    |      |  |
|                 |                                                           |                             |                   |                         |                                      |       |        |                          |                                      |       |        |      |  |
|                 |                                                           |                             |                   |                         |                                      |       |        |                          |                                      |       |        |      |  |
|                 |                                                           |                             |                   |                         |                                      |       |        |                          |                                      |       |        |      |  |
|                 |                                                           |                             |                   |                         |                                      |       |        |                          |                                      |       |        |      |  |
|                 |                                                           |                             |                   |                         |                                      |       |        |                          |                                      |       |        |      |  |

1. Data based on characterization results, not tested in production unless otherwise specified.

Table 26. Typical and maximum current consumption from the  $V_{DDA}$  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/Sleep mode, code executing from Flash or RAM | HSE bypass        | 72 MHz            | 224                      | 252                                  | 265   | 269    | 245                      | 272                                  | 288   | 295    | μA   |
|                  |                                                                    |                   | 64 MHz            | 196                      | 225                                  | 237   | 241    | 214                      | 243                                  | 257   | 263    |      |
|                  |                                                                    |                   | 48 MHz            | 147                      | 174                                  | 183   | 186    | 159                      | 186                                  | 196   | 201    |      |
|                  |                                                                    |                   | 32 MHz            | 100                      | 126                                  | 133   | 135    | 109                      | 133                                  | 142   | 145    |      |
|                  |                                                                    |                   | 24 MHz            | 79                       | 102                                  | 107   | 108    | 85                       | 108                                  | 113   | 116    |      |
|                  |                                                                    |                   | 8 MHz             | 3                        | 5                                    | 5     | 6      | 4                        | 6                                    | 6     | 7      |      |
|                  |                                                                    |                   | 1 MHz             | 3                        | 5                                    | 5     | 6      | 3                        | 5                                    | 6     | 6      |      |
|                  |                                                                    | HSI clock         | 64 MHz            | 259                      | 288                                  | 304   | 309    | 285                      | 315                                  | 332   | 338    |      |
|                  |                                                                    |                   | 48 MHz            | 208                      | 239                                  | 251   | 254    | 230                      | 258                                  | 271   | 277    |      |
|                  |                                                                    |                   | 32 MHz            | 162                      | 190                                  | 198   | 202    | 179                      | 206                                  | 216   | 219    |      |
|                  |                                                                    |                   | 24 MHz            | 140                      | 168                                  | 175   | 178    | 155                      | 181                                  | 188   | 191    |      |
|                  |                                                                    |                   | 8 MHz             | 62                       | 85                                   | 88    | 89     | 71                       | 94                                   | 96    | 98     |      |

1. Current consumption from the  $V_{DDA}$  supply is independent of whether the peripherals are on or off. Furthermore when the PLL is off,  $I_{DDA}$  is independent from the frequency.

2. Data based on characterization results, not tested in production.

Table 27. Typical and maximum  $V_{DD}$  consumption in Stop and Standby modes

| Symbol   | Parameter                      | Conditions                                       | Typ. @ $V_{DD}$ ( $V_{DD}=V_{DDA}$ ) |       |       |       |       |       | Max. <sup>(1)</sup>      |                          |                           | Unit          |
|----------|--------------------------------|--------------------------------------------------|--------------------------------------|-------|-------|-------|-------|-------|--------------------------|--------------------------|---------------------------|---------------|
|          |                                |                                                  | 2.0 V                                | 2.4 V | 2.7 V | 3.0 V | 3.3 V | 3.6 V | $T_A = 25^\circ\text{C}$ | $T_A = 85^\circ\text{C}$ | $T_A = 105^\circ\text{C}$ |               |
| $I_{DD}$ | Supply current in Stop mode    | Regulator in run mode, all oscillators OFF       | 17.51                                | 17.68 | 17.84 | 18.17 | 18.57 | 19.39 | 30.6                     | 232.5                    | 612.2                     | $\mu\text{A}$ |
|          |                                | Regulator in low-power mode, all oscillators OFF | 6.44                                 | 6.51  | 6.60  | 6.73  | 6.96  | 7.20  | 20.0                     | 246.4                    | 585.0                     |               |
|          | Supply current in Standby mode | LSI ON and IWDG ON                               | 0.73                                 | 0.89  | 1.02  | 1.14  | 1.28  | 1.44  | -                        | -                        | -                         |               |
|          |                                | LSI OFF and IWDG OFF                             | 0.55                                 | 0.66  | 0.75  | 0.85  | 0.93  | 1.01  | 4.9                      | 7.0                      | 7.9                       |               |

1. Data based on characterization results, not tested in production unless otherwise specified.

Table 28. Typical and maximum  $V_{DDA}$  consumption in Stop and Standby modes

| Symbol    | Parameter                      | Conditions                                                                       | Typ. @ $V_{DD}$ ( $V_{DD} = V_{DDA}$ ) |       |       |       |       |       | Max. <sup>(1)</sup>      |                          |                           | Unit          |
|-----------|--------------------------------|----------------------------------------------------------------------------------|----------------------------------------|-------|-------|-------|-------|-------|--------------------------|--------------------------|---------------------------|---------------|
|           |                                |                                                                                  | 2.0 V                                  | 2.4 V | 2.7 V | 3.0 V | 3.3 V | 3.6 V | $T_A = 25^\circ\text{C}$ | $T_A = 85^\circ\text{C}$ | $T_A = 105^\circ\text{C}$ |               |
| $I_{DDA}$ | Supply current in Stop mode    | $V_{DDA}$ supervisor ON<br>Regulator in run/low-power mode, all oscillators OFF  | 1.67                                   | 1.79  | 1.91  | 2.04  | 2.19  | 2.35  | 2.5                      | 5.9                      | 6.2                       | $\mu\text{A}$ |
|           | Supply current in Standby mode | LSI ON and IWDG ON                                                               | 2.06                                   | 2.24  | 2.41  | 2.60  | 2.80  | 3.04  | -                        | -                        | -                         |               |
|           |                                | LSI OFF and IWDG OFF                                                             | 1.54                                   | 1.68  | 1.78  | 1.92  | 2.06  | 2.22  | 2.6                      | 3.0                      | 3.8                       |               |
|           | Supply current in Stop mode    | $V_{DDA}$ supervisor OFF<br>Regulator in run/low-power mode, all oscillators OFF | 0.97                                   | 0.99  | 1.03  | 1.07  | 1.14  | 1.22  | -                        | -                        | -                         |               |
|           | Supply current in Standby mode | LSI ON and IWDG ON                                                               | 1.36                                   | 1.44  | 1.52  | 1.62  | 1.76  | 1.91  | -                        | -                        | -                         |               |
|           |                                | LSI OFF and IWDG OFF                                                             | 0.86                                   | 0.88  | 0.91  | 0.95  | 1.03  | 1.09  | -                        | -                        | -                         |               |

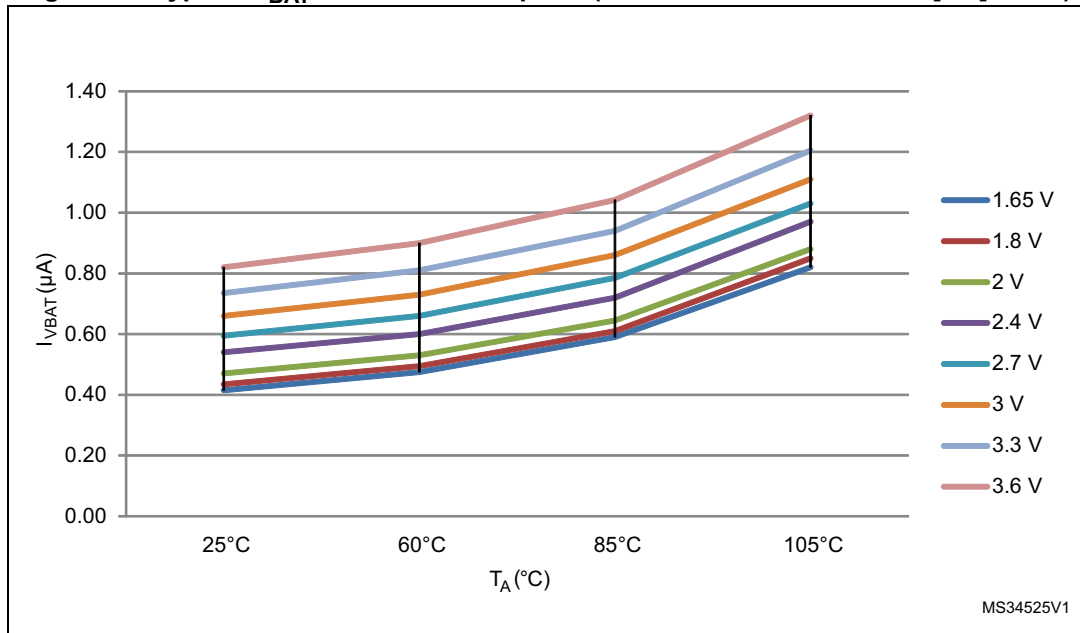
1. Data based on characterization results, not tested in production.

Table 29. Typical and maximum current consumption from  $V_{BAT}$  supply

| Symbol         | Parameter                    | Conditions <sup>(1)</sup>                                               | Typ. @ $V_{BAT}$ |      |      |      |      |      |      |      | Max.<br>@ $V_{BAT} = 3.6\text{V}^{(2)}$ |                          |                           | Unit          |
|----------------|------------------------------|-------------------------------------------------------------------------|------------------|------|------|------|------|------|------|------|-----------------------------------------|--------------------------|---------------------------|---------------|
|                |                              |                                                                         | 1.65V            | 1.8V | 2V   | 2.4V | 2.7V | 3V   | 3.3V | 3.6V | $T_A = 25^\circ\text{C}$                | $T_A = 85^\circ\text{C}$ | $T_A = 105^\circ\text{C}$ |               |
| $I_{DD\_VBAT}$ | Backup domain supply current | LSE & RTC ON; "Xtal mode" lower driving capability; LSEDRV[1:0] = '00'  | 0.42             | 0.44 | 0.47 | 0.54 | 0.60 | 0.66 | 0.74 | 0.82 | -                                       | -                        | -                         | $\mu\text{A}$ |
|                |                              | LSE & RTC ON; "Xtal mode" higher driving capability; LSEDRV[1:0] = '11' | 0.71             | 0.74 | 0.77 | 0.85 | 0.91 | 0.98 | 1.06 | 1.16 | -                                       | -                        | -                         |               |

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

2. Data based on characterization results, not tested in production.

**Figure 14. Typical  $V_{BAT}$  current consumption (LSE and RTC ON/LSEDRV[1:0] = '00')**

### Typical current consumption

The MCU is placed under the following conditions:

- $V_{DD} = V_{DDA} = 3.3$  V
- All I/O pins available on each package 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), and Flash 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.
- Typical current consumption in Run mode, code with data processing running from Flash

**Table 30. Typical current consumption in Run mode, code with data processing running from Flash memory**

| Symbol                              | Parameter                                               | Conditions                                                             | f <sub>HCLK</sub> | Typ.                |                      | Unit |
|-------------------------------------|---------------------------------------------------------|------------------------------------------------------------------------|-------------------|---------------------|----------------------|------|
|                                     |                                                         |                                                                        |                   | Peripherals enabled | Peripherals disabled |      |
| I <sub>DD</sub>                     | Supply current in Run mode from V <sub>DD</sub> supply  | Running from HSE crystal clock 8 MHz, code executing from Flash memory | 72 MHz            | 70.6                | 25.2                 | mA   |
|                                     |                                                         |                                                                        | 64 MHz            | 60.3                | 22.6                 |      |
|                                     |                                                         |                                                                        | 48 MHz            | 46.0                | 17.3                 |      |
|                                     |                                                         |                                                                        | 32 MHz            | 31.3                | 12.0                 |      |
|                                     |                                                         |                                                                        | 24 MHz            | 25.0                | 9.3                  |      |
|                                     |                                                         |                                                                        | 16 MHz            | 16.2                | 6.5                  |      |
|                                     |                                                         |                                                                        | 8 MHz             | 8.4                 | 3.55                 |      |
|                                     |                                                         |                                                                        | 4 MHz             | 4.75                | 2.21                 |      |
|                                     |                                                         |                                                                        | 2 MHz             | 2.81                | 1.52                 |      |
|                                     |                                                         |                                                                        | 1 MHz             | 1.82                | 1.17                 |      |
|                                     |                                                         |                                                                        | 500 kHz           | 1.34                | 0.94                 |      |
|                                     |                                                         |                                                                        | 125 kHz           | 0.93                | 0.82                 |      |
| I <sub>DDA</sub> <sup>(1) (2)</sup> | Supply current in Run mode from V <sub>DDA</sub> supply |                                                                        | 72 MHz            | 240.0               | 234.0                | μA   |
|                                     |                                                         |                                                                        | 64 MHz            | 209.9               | 208.6                |      |
|                                     |                                                         |                                                                        | 48 MHz            | 154.5               | 153.5                |      |
|                                     |                                                         |                                                                        | 32 MHz            | 104.1               | 103.6                |      |
|                                     |                                                         |                                                                        | 24 MHz            | 80.2                | 80.0                 |      |
|                                     |                                                         |                                                                        | 16 MHz            | 56.8                | 56.6                 |      |
|                                     |                                                         |                                                                        | 8 MHz             | 1.14                | 1.14                 |      |
|                                     |                                                         |                                                                        | 4 MHz             | 1.14                | 1.14                 |      |
|                                     |                                                         |                                                                        | 2 MHz             | 1.14                | 1.14                 |      |
|                                     |                                                         |                                                                        | 1 MHz             | 1.14                | 1.14                 |      |
|                                     |                                                         |                                                                        | 500 kHz           | 1.14                | 1.14                 |      |
|                                     |                                                         |                                                                        | 125 kHz           | 1.14                | 1.14                 |      |

1.  $V_{DDA}$  supervisor is OFF.

2. When peripherals are enabled, the power consumption of the analog part of peripherals such as ADC, DAC, Comparators, OpAmp and others, is not included. Refer to the tables of characteristics in the subsequent sections.

Table 31. 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 | 72 MHz            | 51.8                | 6.3                  | mA   |
|                                     |                                                           |                                                                        | 64 MHz            | 46.4                | 5.7                  |      |
|                                     |                                                           |                                                                        | 48 MHz            | 35.0                | 4.40                 |      |
|                                     |                                                           |                                                                        | 32 MHz            | 23.7                | 3.13                 |      |
|                                     |                                                           |                                                                        | 24 MHz            | 18.0                | 2.49                 |      |
|                                     |                                                           |                                                                        | 16 MHz            | 12.2                | 1.85                 |      |
|                                     |                                                           |                                                                        | 8 MHz             | 6.2                 | 0.99                 |      |
|                                     |                                                           |                                                                        | 4 MHz             | 3.68                | 0.88                 |      |
|                                     |                                                           |                                                                        | 2 MHz             | 2.26                | 0.80                 |      |
|                                     |                                                           |                                                                        | 1 MHz             | 1.55                | 0.76                 |      |
|                                     |                                                           |                                                                        | 500 kHz           | 1.20                | 0.74                 |      |
|                                     |                                                           |                                                                        | 125 kHz           | 0.89                | 0.72                 |      |
| I <sub>DDA</sub> <sup>(1) (2)</sup> | Supply current in Sleep mode from V <sub>DDA</sub> supply |                                                                        | 72 MHz            | 239.0               | 236.7                | μA   |
|                                     |                                                           |                                                                        | 64 MHz            | 209.4               | 207.8                |      |
|                                     |                                                           |                                                                        | 48 MHz            | 154.0               | 152.9                |      |
|                                     |                                                           |                                                                        | 32 MHz            | 103.7               | 103.2                |      |
|                                     |                                                           |                                                                        | 24 MHz            | 80.1                | 79.8                 |      |
|                                     |                                                           |                                                                        | 16 MHz            | 56.7                | 56.6                 |      |
|                                     |                                                           |                                                                        | 8 MHz             | 1.14                | 1.14                 |      |
|                                     |                                                           |                                                                        | 4 MHz             | 1.14                | 1.14                 |      |
|                                     |                                                           |                                                                        | 2 MHz             | 1.14                | 1.14                 |      |
|                                     |                                                           |                                                                        | 1 MHz             | 1.14                | 1.14                 |      |
|                                     |                                                           |                                                                        | 500 kHz           | 1.14                | 1.14                 |      |
|                                     |                                                           |                                                                        | 125 kHz           | 1.14                | 1.14                 |      |

1.  $V_{DDA}$  supervisor is OFF.

2. When peripherals are enabled, the power consumption of the analog part of peripherals such as ADC, DAC, Comparators, OpAmp and others, is not included. Refer to the tables of characteristics in the subsequent sections.

## 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 input pins that must 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.

### I/O dynamic current consumption

In addition to the internal peripheral current consumption (see [Table 33: 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:  $C = C_{INT} + C_{EXT} + C_S$

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

**Table 32. 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 | $V_{DD} = 3.3\text{ V}$<br>$C_{ext} = 0\text{ pF}$<br>$C = C_{INT} + C_{EXT} + C_S$  | 2 MHz                                     | 0.90 | mA   |
|                 |                         |                                                                                      | 4 MHz                                     | 0.93 |      |
|                 |                         |                                                                                      | 8 MHz                                     | 1.16 |      |
|                 |                         |                                                                                      | 18 MHz                                    | 1.60 |      |
|                 |                         |                                                                                      | 36 MHz                                    | 2.51 |      |
|                 |                         | $V_{DD} = 3.3\text{ V}$<br>$C_{ext} = 10\text{ pF}$<br>$C = C_{INT} + C_{EXT} + C_S$ | 2 MHz                                     | 0.93 |      |
|                 |                         |                                                                                      | 4 MHz                                     | 1.06 |      |
|                 |                         |                                                                                      | 8 MHz                                     | 1.47 |      |
|                 |                         |                                                                                      | 18 MHz                                    | 2.26 |      |
|                 |                         |                                                                                      | 36 MHz                                    | 3.39 |      |
|                 |                         | $V_{DD} = 3.3\text{ V}$<br>$C_{ext} = 22\text{ pF}$<br>$C = C_{INT} + C_{EXT} + C_S$ | 2 MHz                                     | 1.03 |      |
|                 |                         |                                                                                      | 4 MHz                                     | 1.30 |      |
|                 |                         |                                                                                      | 8 MHz                                     | 1.79 |      |
|                 |                         |                                                                                      | 18 MHz                                    | 3.01 |      |
|                 |                         |                                                                                      | 36 MHz                                    | 5.99 |      |
|                 |                         | $V_{DD} = 3.3\text{ V}$<br>$C_{ext} = 33\text{ pF}$<br>$C = C_{INT} + C_{EXT} + C_S$ | 2 MHz                                     | 1.10 |      |
|                 |                         |                                                                                      | 4 MHz                                     | 1.31 |      |
|                 |                         |                                                                                      | 8 MHz                                     | 2.06 |      |
|                 |                         |                                                                                      | 18 MHz                                    | 3.47 |      |
|                 |                         |                                                                                      | 36 MHz                                    | 8.35 |      |
|                 |                         | $V_{DD} = 3.3\text{ V}$<br>$C_{ext} = 47\text{ pF}$<br>$C = C_{INT} + C_{EXT} + C_S$ | 2 MHz                                     | 1.20 |      |
|                 |                         |                                                                                      | 4 MHz                                     | 1.54 |      |
|                 |                         |                                                                                      | 8 MHz                                     | 2.46 |      |
|                 |                         |                                                                                      | 18 MHz                                    | 4.51 |      |
|                 |                         |                                                                                      | 36 MHz                                    | 9.98 |      |

1. CS = 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  $V_{DD} = V_{DDA} = 3.3\text{ V}$

**Table 33. Peripheral current consumption**

| Peripheral                 | Typical consumption <sup>(1)</sup> | Unit              |
|----------------------------|------------------------------------|-------------------|
|                            | $I_{DD}$                           |                   |
| BusMatrix <sup>(2)</sup>   | 11.1                               | $\mu\text{A/MHz}$ |
| DMA1                       | 8.0                                |                   |
| CRC                        | 2.1                                |                   |
| GPIOA                      | 8.7                                |                   |
| GPIOB                      | 8.4                                |                   |
| GPIOC                      | 8.4                                |                   |
| GIOD                       | 2.6                                |                   |
| GPIOF                      | 1.7                                |                   |
| TSC                        | 4.7                                |                   |
| ADC1&2                     | 17.4                               |                   |
| APB2-Bridge <sup>(3)</sup> | 3.3                                |                   |
| SYSCFG                     | 4.2                                |                   |
| TIM1                       | 32.3                               |                   |
| USART1                     | 20.3                               |                   |
| TIM15                      | 13.8                               |                   |
| TIM16                      | 9.7                                |                   |
| TIM17                      | 10.3                               |                   |
| HRTIM                      | 324.2                              |                   |
| APB1-Bridge <sup>(3)</sup> | 5.3                                |                   |
| TIM2                       | 43.4                               |                   |
| TIM3                       | 34.0                               |                   |
| TIM6                       | 9.7                                |                   |
| TIM7                       | 10.3                               |                   |
| WWDG                       | 6.9                                |                   |
| USART2                     | 18.8                               |                   |
| USART3                     | 19.1                               |                   |

Table 33. Peripheral current consumption (continued)

| Peripheral | Typical consumption <sup>(1)</sup> | Unit   |
|------------|------------------------------------|--------|
|            | I <sub>DD</sub>                    |        |
| I2C1       | 13.3                               | μA/MHz |
| CAN        | 31.3                               |        |
| PWR        | 4.7                                |        |
| DAC        | 15.4                               |        |
| DAC2       | 8.6                                |        |
| SPI1       | 8.2                                |        |

1. The power consumption of the analog part (I<sub>DDA</sub>) of peripherals such as ADC, DAC, Comparators, OpAmp and others, is not included. Refer to the tables of characteristics in the subsequent sections.
2. BusMatrix is automatically active when at least one master is ON (CPU or DMA1).
3. The APBx bridge is automatically active when at least one peripheral is ON on the same bus.

### 6.3.6 Wakeup time from low-power mode

The wakeup times given in [Table 34](#) are measured starting from the wakeup event trigger up to the first instruction executed by the CPU:

- For Stop or Sleep mode: the wakeup event is WFE.
- WKUP1 (PA0) pin is used to wake up from Standby, Stop and Sleep modes.

All timings are derived from tests performed under ambient temperature and  $V_{DD}$  supply voltage conditions summarized in [Table 19](#).

**Table 34. Low-power mode wakeup timings**

| Symbol                | Parameter                | Conditions                  | Typ. @ $V_{DD}$ , $V_{DD} = V_{DDA}$ |       |       |      |       |       | Max. | Unit             |
|-----------------------|--------------------------|-----------------------------|--------------------------------------|-------|-------|------|-------|-------|------|------------------|
|                       |                          |                             | 2.0 V                                | 2.4 V | 2.7 V | 3 V  | 3.3 V | 3.6 V |      |                  |
| $t_{WUSTOP}$          | Wakeup from Stop mode    | Regulator in run mode       | 4.3                                  | 4.1   | 4.0   | 3.9  | 3.8   | 3.7   | 4.5  | $\mu s$          |
|                       |                          | Regulator in low-power mode | 7.8                                  | 6.7   | 6.1   | 5.9  | 5.5   | 5.3   | 9    |                  |
| $t_{WUSTANDBY}^{(1)}$ | Wakeup from Standby mode | LSI and IWDG OFF            | 74.4                                 | 64.3  | 60.0  | 56.9 | 54.3  | 51.1  | 103  |                  |
| $t_{WUSLEEP}$         | Wakeup from Sleep mode   | -                           | 6                                    |       |       |      |       |       | -    | CPU clock cycles |

1. Data based on characterization results, not tested in production.

**Table 35. Wakeup time using USART<sup>(1)</sup>**

| Symbol        | Parameter                                                                                                                    | Conditions                                      | Typ | Max    | Unit    |
|---------------|------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------|-----|--------|---------|
| $t_{WUUSART}$ | Wakeup time needed to calculate the maximum USART baudrate allowing to wake up from stop mode when USART clock source is HSI | Stop mode with main regulator in low power mode | -   | 13.125 | $\mu s$ |
|               |                                                                                                                              | Stop mode with main regulator in run mode       | -   | 3.125  |         |

1. Guaranteed by design.

### 6.3.7 External clock source characteristics

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

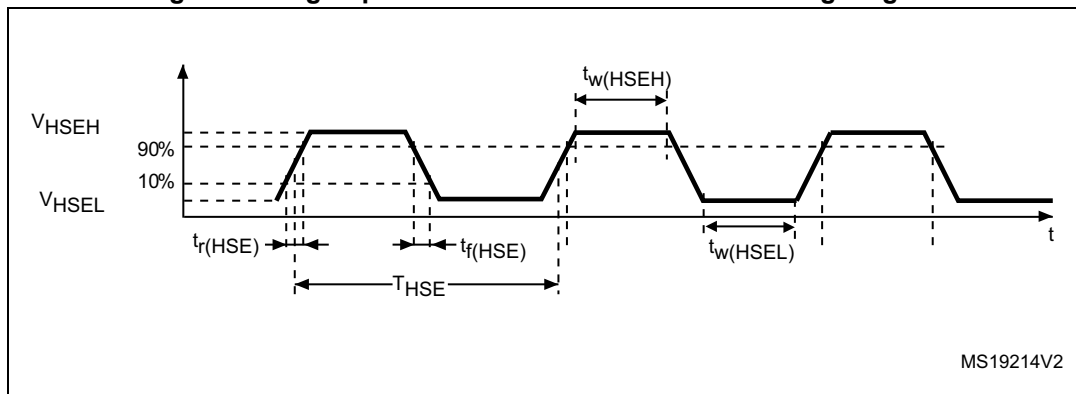
In bypass mode the HSE oscillator is switched off and the input pin is a standard GPIO. The external clock signal has to respect the I/O characteristics in [Section 6.3.14](#). However, the recommended clock input waveform is shown in [Figure 15](#).

Table 36. High-speed external user clock characteristics

| Symbol                         | Parameter                                           | Conditions | Min.        | Typ. | Max.        | Unit |
|--------------------------------|-----------------------------------------------------|------------|-------------|------|-------------|------|
| $f_{HSE\_ext}$                 | User external clock source frequency <sup>(1)</sup> | -          | 1           | 8    | 32          | MHz  |
| $V_{HSEH}$                     | OSC_IN input pin high-level voltage                 |            | $0.7V_{DD}$ | -    | $V_{DD}$    | V    |
| $V_{HSEL}$                     | OSC_IN input pin low-level voltage                  |            | $V_{SS}$    | -    | $0.3V_{DD}$ |      |
| $t_{w(HSEH)}$<br>$t_{w(HSEL)}$ | OSC_IN high or low time <sup>(1)</sup>              |            | 15          | -    | -           | ns   |
| $t_r(HSE)$<br>$t_f(HSE)$       | OSC_IN rise or fall time <sup>(1)</sup>             |            | -           | -    | 20          |      |

1. Guaranteed by design, not tested in production.

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



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

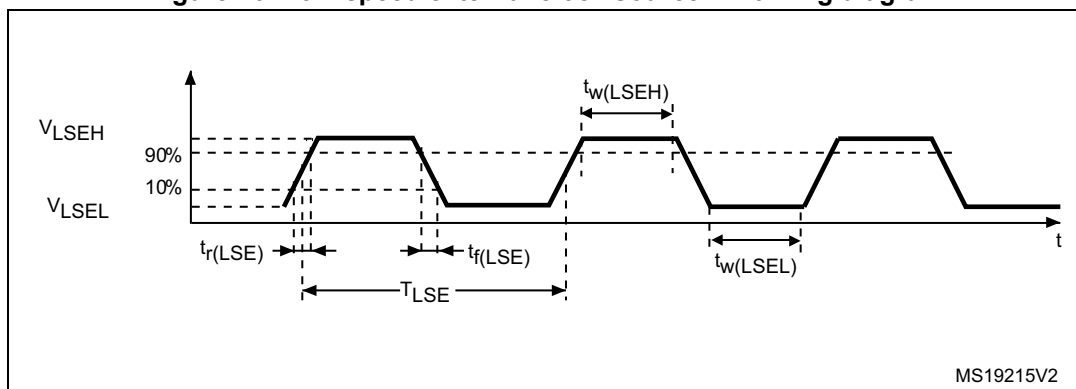
In bypass mode the LSE oscillator is switched off and the input pin is a standard GPIO. The external clock signal has to respect the I/O characteristics in [Section 6.3.14](#). However, the recommended clock input waveform is shown in [Figure 16](#).

Table 37. Low-speed external user clock characteristics

| Symbol                         | Parameter                                           | Conditions | Min.        | Typ.   | Max.        | Unit |
|--------------------------------|-----------------------------------------------------|------------|-------------|--------|-------------|------|
| $f_{LSE\_ext}$                 | User External clock source frequency <sup>(1)</sup> | -          | -           | 32.768 | 1000        | kHz  |
| $V_{LSEH}$                     | OSC32_IN input pin high-level voltage               |            | $0.7V_{DD}$ | -      | $V_{DD}$    | V    |
| $V_{LSEL}$                     | OSC32_IN input pin low-level voltage                |            | $V_{SS}$    | -      | $0.3V_{DD}$ |      |
| $t_{w(LSEH)}$<br>$t_{w(LSEL)}$ | OSC32_IN high or low time <sup>(1)</sup>            |            | 450         | -      | -           | ns   |
| $t_r(LSE)$<br>$t_f(LSE)$       | OSC32_IN rise or fall time <sup>(1)</sup>           |            | -           | -      | 50          |      |

1. Guaranteed by design, not tested in production.

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



MS19215V2

### 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 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

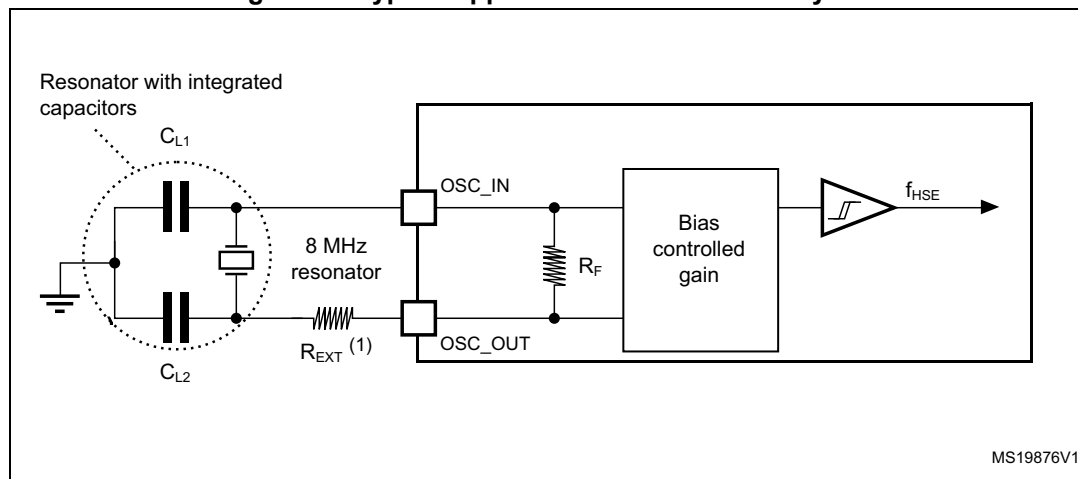
| Symbol              | Parameter                   | Conditions <sup>(1)</sup>                                                | Min. <sup>(2)</sup> | Typ. | Max. <sup>(2)</sup> | Unit       |
|---------------------|-----------------------------|--------------------------------------------------------------------------|---------------------|------|---------------------|------------|
| $f_{OSC\_IN}$       | 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         |
|                     |                             | $V_{DD}=3.3\text{ V}$ , $R_m=30\Omega$ , $CL=10\text{ pF}@8\text{ MHz}$  | -                   | 0.4  | -                   |            |
|                     |                             | $V_{DD}=3.3\text{ V}$ , $R_m=45\Omega$ , $CL=10\text{ pF}@8\text{ MHz}$  | -                   | 0.5  | -                   |            |
|                     |                             | $V_{DD}=3.3\text{ V}$ , $R_m=30\Omega$ , $CL=5\text{ pF}@32\text{ MHz}$  | -                   | 0.8  | -                   |            |
|                     |                             | $V_{DD}=3.3\text{ V}$ , $R_m=30\Omega$ , $CL=10\text{ pF}@32\text{ MHz}$ | -                   | 1    | -                   |            |
|                     |                             | $V_{DD}=3.3\text{ V}$ , $R_m=30\Omega$ , $CL=20\text{ pF}@32\text{ MHz}$ | -                   | 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, not tested in production.
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 25 pF range (typ.), designed for high-frequency applications, and selected to match the requirements of the crystal or resonator (see [Figure 17](#)).  $C_{L1}$  and  $C_{L2}$  are usually the same size. The crystal manufacturer typically specifies a load capacitance which is the series combination of  $C_{L1}$  and  $C_{L2}$ . PCB and MCU pin capacitance must be included (10 pF can be used as a rough estimate of the combined pin and board capacitance) when sizing  $C_{L1}$  and  $C_{L2}$ .

**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 17. Typical application with an 8 MHz crystal**



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

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

The low-speed external (LSE) clock can be supplied with a 32.768 kHz crystal/ceramic resonator oscillator. All the information given in this paragraph are based on 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 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                 |         |

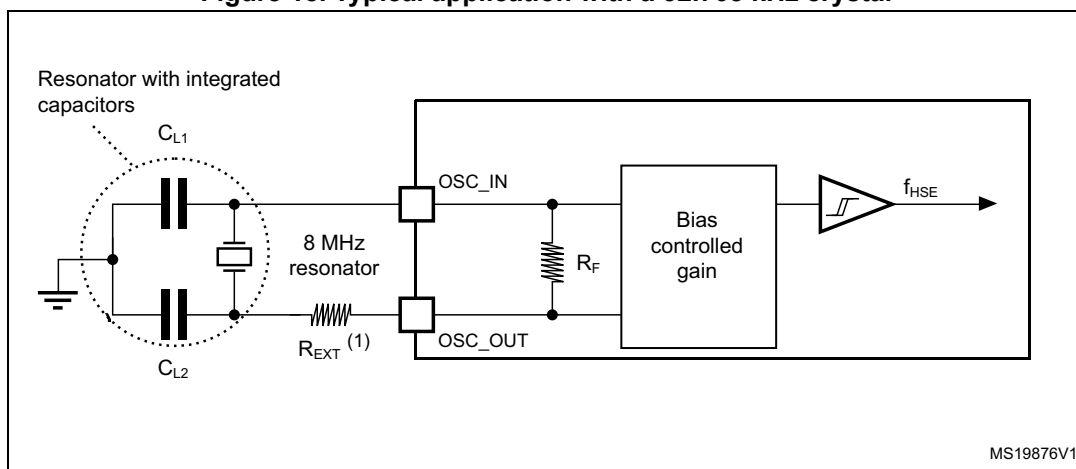
Table 39. LSE oscillator characteristics ( $f_{LSE} = 32.768$  kHz) (continued)

| Symbol                       | Parameter                   | Conditions <sup>(1)</sup>                        | Min. <sup>(2)</sup> | Typ. | Max. <sup>(2)</sup> | Unit      |
|------------------------------|-----------------------------|--------------------------------------------------|---------------------|------|---------------------|-----------|
| $g_m$                        | 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                  | -    | -                   |           |
| $t_{SU(LSE)}$ <sup>(3)</sup> | 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, not tested in production.
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 at the ST website [www.st.com](http://www.st.com).

Figure 18. 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.

### 6.3.8 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 19](#).

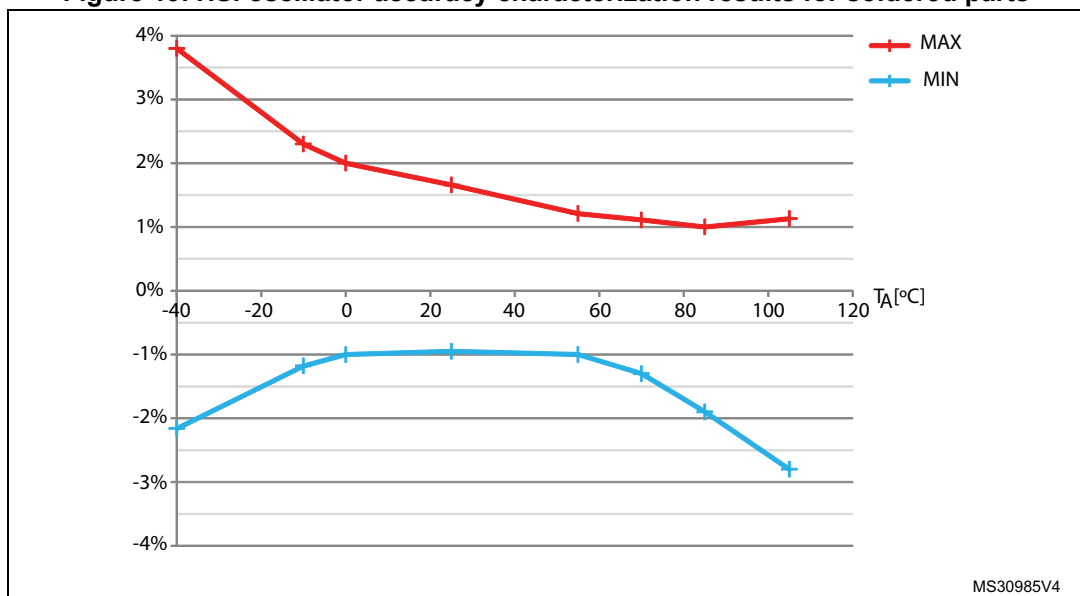
## High-speed internal (HSI) RC oscillator

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 $105\text{ }^{\circ}\text{C}$      | -2.8 <sup>(3)</sup> | -    | 3.8 <sup>(3)</sup> | %             |
|                       |                                                     | $T_A = -10$ to $85\text{ }^{\circ}\text{C}$       | -1.9 <sup>(3)</sup> | -    | 2.3 <sup>(3)</sup> |               |
|                       |                                                     | $T_A = 0$ to $85\text{ }^{\circ}\text{C}$         | -1.9 <sup>(3)</sup> | -    | 2 <sup>(3)</sup>   |               |
|                       |                                                     | $T_A = 0$ to $70\text{ }^{\circ}\text{C}$         | -1.3 <sup>(3)</sup> | -    | 2 <sup>(3)</sup>   |               |
|                       |                                                     | $T_A = 0$ to $55\text{ }^{\circ}\text{C}$         | -1 <sup>(3)</sup>   | -    | 2 <sup>(3)</sup>   |               |
|                       |                                                     | $T_A = 25\text{ }^{\circ}\text{C}$ <sup>(4)</sup> | -1                  | -    | 1                  |               |
| $t_{\text{su(HSI)}}$  | HSI oscillator startup time                         | -                                                 | 1 <sup>(2)</sup>    | -    | 2 <sup>(2)</sup>   | $\mu\text{s}$ |
| $I_{\text{DDA(HSI)}}$ | HSI oscillator power consumption                    | -                                                 | -                   | 80   | 100 <sup>(2)</sup> | $\mu\text{A}$ |

1.  $V_{\text{DDA}} = 3.3\text{ V}$ ,  $T_A = -40$  to  $105\text{ }^{\circ}\text{C}$  unless otherwise specified.
2. Guaranteed by design, not tested in production.
3. Data based on characterization results, not tested in production.
4. Factory calibrated, parts not soldered

Figure 19. HSI oscillator accuracy characterization results for soldered parts



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

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

| Symbol              | Parameter                        | Min. | Typ. | Max. | Unit    |
|---------------------|----------------------------------|------|------|------|---------|
| $f_{LSI}$           | Frequency                        | 30   | 40   | 50   | kHz     |
| $t_{su(LSI)}^{(2)}$ | LSI oscillator startup time      | -    | -    | 85   | $\mu$ s |
| $I_{DD(LSI)}^{(2)}$ | LSI oscillator power consumption | -    | 0.75 | 1.2  | $\mu$ A |

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

2. Guaranteed by design, not tested in production.

### 6.3.9 PLL characteristics

The parameters given in [Table 42](#) are derived from tests performed under ambient temperature and supply voltage conditions summarized in [Table 19](#).

**Table 42. PLL characteristics**

| Symbol         | Parameter                      | Value             |      |                    | Unit    |
|----------------|--------------------------------|-------------------|------|--------------------|---------|
|                |                                | Min.              | Typ. | Max.               |         |
| $f_{PLL\_IN}$  | 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>  | %       |
| $f_{PLL\_OUT}$ | PLL multiplier output clock    | 16 <sup>(2)</sup> | -    | 72                 | MHz     |
| $t_{LOCK}$     | PLL lock time                  | -                 | -    | 200 <sup>(2)</sup> | $\mu$ s |
| 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  $f_{PLL\_OUT}$ .

2. Guaranteed by design, not tested in production.

### 6.3.10 Memory characteristics

#### Flash memory

The characteristics are given at  $T_A = -40$  to  $105\text{ }^{\circ}\text{C}$  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 $+105\text{ }^{\circ}\text{C}$ | 40   | 53.5 | 60                  | $\mu\text{s}$ |
| $t_{\text{ERASE}}$ | Page (2 KB) erase time  | $T_A = -40$ to $+105\text{ }^{\circ}\text{C}$ | 20   | -    | 40                  | ms            |
| $t_{\text{ME}}$    | Mass erase time         | $T_A = -40$ to $+105\text{ }^{\circ}\text{C}$ | 20   | -    | 40                  | ms            |
| $I_{\text{DD}}$    | Supply current          | Write mode                                    | -    | -    | 10                  | mA            |
|                    |                         | Erase mode                                    | -    | -    | 12                  | mA            |

1. Guaranteed by design, not tested in production.

**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 $+85\text{ }^{\circ}\text{C}$ (6 suffix versions)<br>$T_A = -40$ to $+105\text{ }^{\circ}\text{C}$ (7 suffix versions) | 10                  | kcycles |
| $t_{\text{RET}}$ | Data retention | 1 kcycle <sup>(2)</sup> at $T_A = 85\text{ }^{\circ}\text{C}$                                                                         | 30                  | Years   |
|                  |                | 1 kcycle <sup>(2)</sup> at $T_A = 105\text{ }^{\circ}\text{C}$                                                                        | 10                  |         |
|                  |                | 10 kcycles <sup>(2)</sup> at $T_A = 55\text{ }^{\circ}\text{C}$                                                                       | 20                  |         |

1. Data based on characterization results, not tested in production.

2. Cycling performed over the whole temperature range.

### 6.3.11 EMC characteristics

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

#### Functional EMS (electromagnetic susceptibility)

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

- **Electrostatic discharge (ESD)** (positive and negative) is applied to all device pins until a functional disturbance occurs. This test is compliant with the IEC 61000-4-2 standard.
- **FTB:** A Burst of Fast Transient voltage (positive and negative) is applied to  $V_{\text{DD}}$  and  $V_{\text{SS}}$  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 “*EMC design guide for ST microcontrollers*” 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                                                    | $V_{DD} = 3.3\text{ V}$ , LQFP64, $T_A = +25^\circ\text{C}$ ,<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 | $V_{DD} = 3.3\text{ V}$ , LQFP64, $T_A = +25^\circ\text{C}$ ,<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 must 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 (for example 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 the “*Software techniques for improving microcontrollers EMC performance*” 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 the IEC 61967-2 standard that specifies the test board and the pin loading.

Table 46. EMI characteristics

| Symbol    | Parameter  | Conditions                                                                                           | Monitored frequency band | Max vs. [ $f_{HSE}/f_{HCLK}$ ] | Unit |
|-----------|------------|------------------------------------------------------------------------------------------------------|--------------------------|--------------------------------|------|
|           |            |                                                                                                      |                          | 8/72 MHz                       |      |
| $S_{EMI}$ | Peak level | $V_{DD} = 3.6\text{ V}$ , $T_A = 25^\circ\text{C}$ ,<br>LQFP64 package<br>compliant with IEC 61967-2 | 0.1 to 30 MHz            | 5                              | dBμV |
|           |            |                                                                                                      | 30 to 130 MHz            | 9                              |      |
|           |            |                                                                                                      | 130 MHz to 1GHz          | 31                             |      |
|           |            |                                                                                                      | SAE EMI Level            | 4                              | -    |

### 6.3.12 Electrical sensitivity characteristics

Based on three different tests (ESD, LU) using specific measurement methods, the device is stressed 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  $\times$  (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 |
|--------------------|-------------------------------------------------------|--------------------------------------------------------------------|-------|------------------------------|------|
| $V_{ESD}$<br>(HBM) | Electrostatic discharge voltage (human body model)    | $T_A = +25\text{ }^{\circ}\text{C}$ ,<br>conforming to JESD22-A114 | 2     | 2000                         | V    |
| $V_{ESD}$<br>(CDM) | Electrostatic discharge voltage (charge device model) | $T_A = +25\text{ }^{\circ}\text{C}$ ,<br>conforming to JESD22-C101 | II    | 250                          |      |

1. Data based on characterization results, not tested in production.

#### 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 |

### 6.3.13 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) must be avoided during normal product operation. However, 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  $-5\ \mu\text{A}/+0\ \mu\text{A}$  range), or other functional failure (for example reset occurrence or oscillator frequency deviation). The test results are given in the table below.

Table 49. I/O current injection susceptibility

| Symbol           | Description                                                                                                                                                                                                                           | Functional susceptibility |                                | Unit |
|------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------|--------------------------------|------|
|                  |                                                                                                                                                                                                                                       | Negative injection        | Positive injection             |      |
| $I_{\text{INJ}}$ | Injected current on BOOT0                                                                                                                                                                                                             | - 0                       | NA (Injection is not possible) | mA   |
|                  | Injected current on PC0, PC1, PC2, PC3 (TTa pins) and PF1 pin (FT pin)                                                                                                                                                                | -0                        | +5                             |      |
|                  | Injected current on PA0, PA1, PA2, PA3, PA4, PA5, PA6, PA7, PC4, PC5, PB0, PB1, PB2, PB12, PB13, PB14, PB15 with induced leakage current on other pins from this group less than $-100\ \mu\text{A}$ or more than $+900\ \mu\text{A}$ | -5                        | +5                             |      |
|                  | Injected current on PB11, other TT, FT, and FTf pins                                                                                                                                                                                  | - 5                       | Injection is not possible      |      |
|                  | Injected current on all other TC, TTa and RESET pins                                                                                                                                                                                  | - 5                       | +5                             |      |

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

### 6.3.14 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 19](#). All I/Os are CMOS and TTL compliant.

Table 50. I/O static characteristics

| Symbol          | Parameter                | Conditions            | Min.                                | Typ. | Max.                              | Unit |
|-----------------|--------------------------|-----------------------|-------------------------------------|------|-----------------------------------|------|
| $V_{\text{IL}}$ | Low-level input voltage  | TT, TC and TTa I/O    | -                                   | -    | $0.3 V_{\text{DD}} + 0.07^{(1)}$  | V    |
|                 |                          | FT and FTf I/O        | -                                   | -    | $0.475 V_{\text{DD}} - 0.2^{(1)}$ |      |
|                 |                          | BOOT0                 | -                                   | -    | $0.3 V_{\text{DD}} - 0.3^{(1)}$   |      |
|                 |                          | All I/Os except BOOT0 | -                                   | -    | $0.3 V_{\text{DD}}^{(2)}$         |      |
| $V_{\text{IH}}$ | High-level input voltage | TTa and TT I/O        | $0.445 V_{\text{DD}} + 0.398^{(1)}$ | -    | -                                 |      |
|                 |                          | FT and FTf I/O        | $0.5 V_{\text{DD}} + 0.2^{(1)}$     | -    | -                                 |      |
|                 |                          | BOOT0                 | $0.2 V_{\text{DD}} + 0.95^{(1)}$    | -    | -                                 |      |
|                 |                          | All I/Os except BOOT0 | $0.7 V_{\text{DD}}^{(2)}$           | -    | -                                 |      |

Table 50. I/O static characteristics (continued)

| Symbol           | Parameter                                         | Conditions                                                                                           | Min. | Typ.               | Max.      | Unit             |
|------------------|---------------------------------------------------|------------------------------------------------------------------------------------------------------|------|--------------------|-----------|------------------|
| $V_{\text{hys}}$ | Schmitt trigger hysteresis                        | TT, TC and TTa I/O                                                                                   | -    | 200 <sup>(1)</sup> | -         | mV               |
|                  |                                                   | FT and FTf I/O                                                                                       | -    | 100 <sup>(1)</sup> | -         |                  |
|                  |                                                   | BOOT0                                                                                                | -    | 300 <sup>(1)</sup> | -         |                  |
| $I_{\text{lk}}$  | Input leakage current <sup>(3)</sup>              | TC, FT, TT, FTf and TTa I/O in digital mode<br>$V_{\text{SS}} \leq V_{\text{IN}} \leq V_{\text{DD}}$ | -    | -                  | $\pm 0.1$ | $\mu\text{A}$    |
|                  |                                                   | TTa I/O in digital mode<br>$V_{\text{DD}} \leq V_{\text{IN}} \leq V_{\text{DDA}}$                    | -    | -                  | 1         |                  |
|                  |                                                   | TTa I/O in analog mode<br>$V_{\text{SS}} \leq V_{\text{IN}} \leq V_{\text{DDA}}$                     | -    | -                  | $\pm 0.2$ |                  |
|                  |                                                   | FT and FTf I/O <sup>(4)</sup><br>$V_{\text{DD}} \leq V_{\text{IN}} \leq 5\text{ V}$                  | -    | -                  | 10        |                  |
| $R_{\text{PU}}$  | Weak pull-up equivalent resistor <sup>(5)</sup>   | $V_{\text{IN}} = V_{\text{SS}}$                                                                      | 25   | 40                 | 55        | $\text{k}\Omega$ |
| $R_{\text{PD}}$  | Weak pull-down equivalent resistor <sup>(5)</sup> | $V_{\text{IN}} = V_{\text{DD}}$                                                                      | 25   | 40                 | 55        | $\text{k}\Omega$ |
| $C_{\text{IO}}$  | I/O pin capacitance                               | -                                                                                                    | -    | 5                  | -         | pF               |

1. Data based on design simulation.

2. Tested in production.

3. Leakage could be higher than the maximum value. If negative current is injected on adjacent pins. Refer to [Table 49: I/O current injection susceptibility](#).

4. To sustain a voltage higher than  $V_{\text{DD}} + 0.3\text{ V}$ , the internal pull-up/pull-down resistors must be disabled.

5. Pull-up and pull-down resistors are designed with a true resistance in series with a switchable PMOS/NMOS. This PMOS/NMOS contribution to the series resistance is minimum (~10% order).

All I/Os are CMOS and TTL compliant (no software configuration required). Their characteristics cover more than the strict CMOS-technology or TTL parameters. The coverage of these requirements is shown in [Figure 20](#) and [Figure 21](#) for standard I/Os.

Figure 20. TC and TTa I/O input characteristics - CMOS port

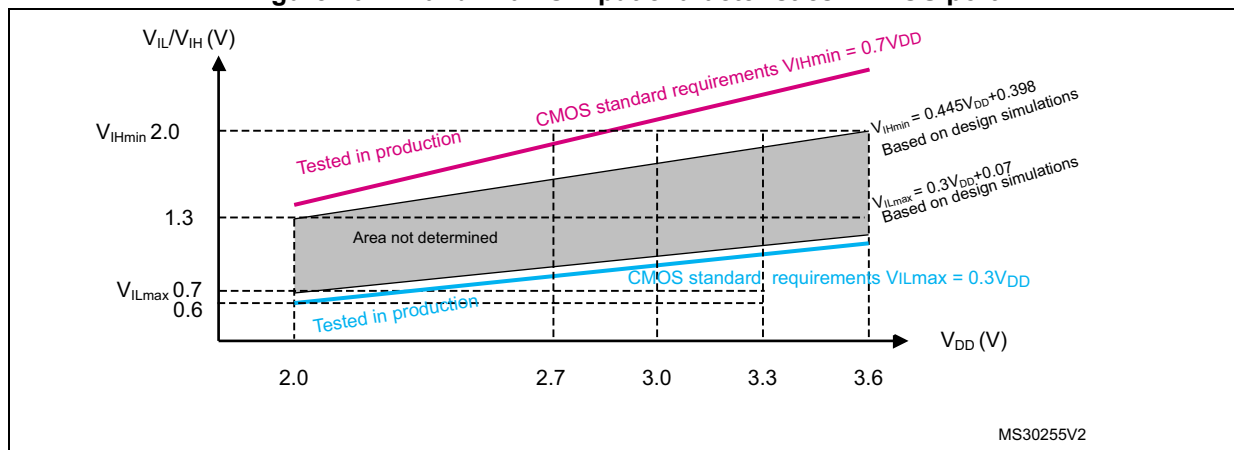


Figure 21. TC and TtA I/O input characteristics - TTL port

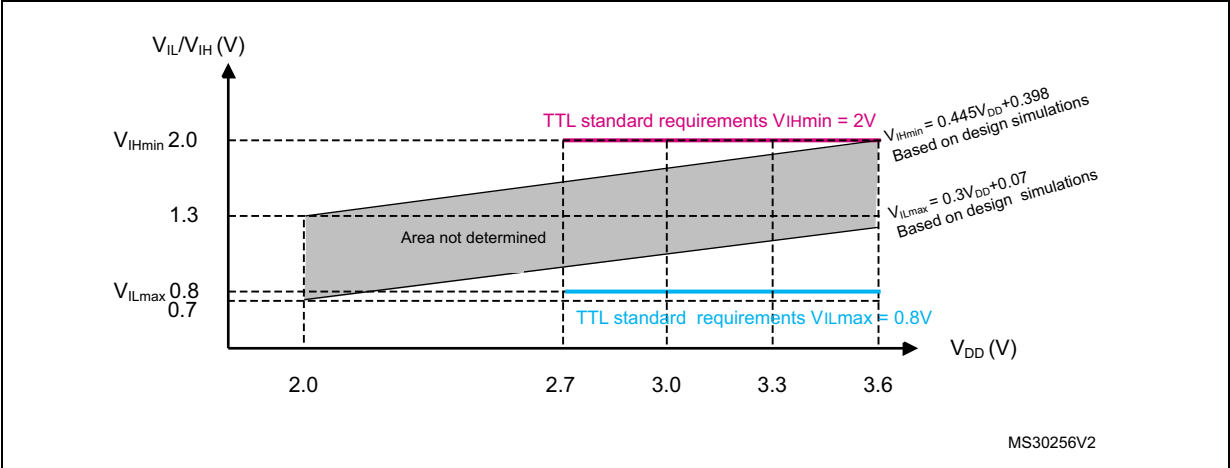


Figure 22. 5V- tolerant (FT and FTf) I/O input characteristics - CMOS port

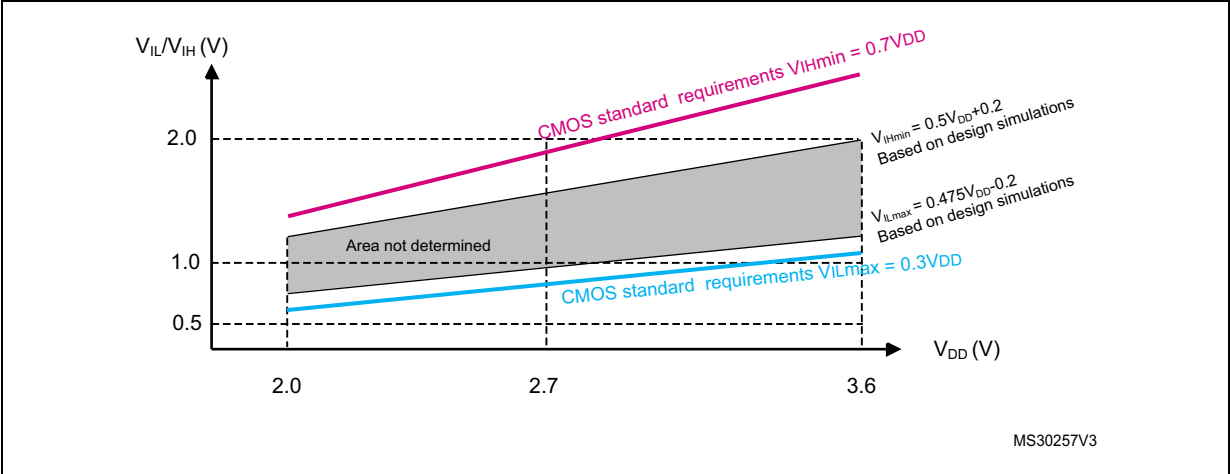
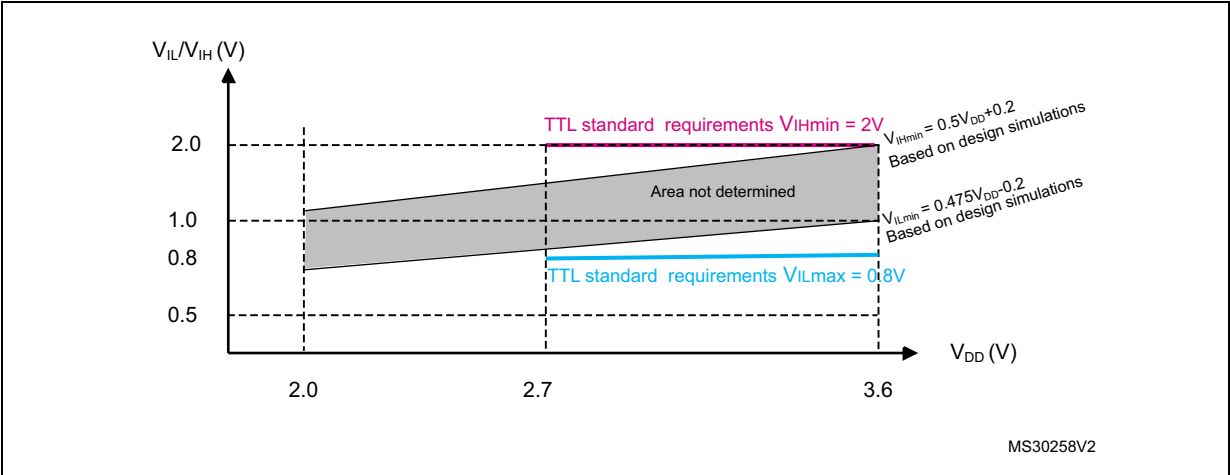


Figure 23. 5V-tolerant (FT and FTf) I/O input characteristics - TTL port



### Output driving current

The GPIOs (general-purpose input/output) 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  $V_{DD}$ , plus the maximum Run consumption of the MCU sourced on  $V_{DD}$ , cannot exceed the absolute maximum rating  $\Sigma I_{VDD}$  (see [Table 17](#)).
- The sum of the currents sunk by all the I/Os on  $V_{SS}$  plus the maximum Run consumption of the MCU sunk on  $V_{SS}$  cannot exceed the absolute maximum rating  $\Sigma I_{VSS}$  (see [Table 17](#)).

### Output voltage levels

Unless otherwise specified, the parameters given in [Table 47: ESD absolute maximum ratings](#) are derived from tests performed under ambient temperature and  $V_{DD}$  supply voltage conditions summarized in [Table 19](#). All I/Os (FT, TTa and TC unless otherwise specified) are CMOS and TTL compliant.

**Table 51. Output voltage characteristics**

| Symbol               | Parameter                                               | Conditions                                                                             | Min.         | Max. | Unit |
|----------------------|---------------------------------------------------------|----------------------------------------------------------------------------------------|--------------|------|------|
| $V_{OL}^{(1)}$       | Low-level output voltage for an I/O pin                 | CMOS port <sup>(2)</sup><br>$I_{IO} = +8$ mA<br>$2.7\text{ V} < V_{DD} < 3.6\text{ V}$ | -            | 0.4  | V    |
| $V_{OH}^{(3)}$       | High-level output voltage for an I/O pin                |                                                                                        | $V_{DD}-0.4$ | -    |      |
| $V_{OL}^{(1)}$       | Low-level output voltage for an I/O pin                 | TTL port <sup>(2)</sup><br>$I_{IO} = +8$ mA<br>$2.7\text{ V} < V_{DD} < 3.6\text{ V}$  | -            | 0.4  |      |
| $V_{OH}^{(3)}$       | High-level output voltage for an I/O pin                |                                                                                        | 2.4          | -    |      |
| $V_{OL}^{(1)(4)}$    | Low-level output voltage for an I/O pin                 | $I_{IO} = +20$ mA<br>$2.7\text{ V} < V_{DD} < 3.6\text{ V}$                            | -            | 1.3  |      |
| $V_{OH}^{(3)(4)}$    | High-level output voltage for an I/O pin                |                                                                                        | $V_{DD}-1.3$ | -    |      |
| $V_{OL}^{(1)(4)}$    | Low-level output voltage for an I/O pin                 | $I_{IO} = +6$ mA<br>$2\text{ V} < V_{DD} < 2.7\text{ V}$                               | -            | 0.4  |      |
| $V_{OH}^{(3)(4)}$    | High-level output voltage for an I/O pin                |                                                                                        | $V_{DD}-0.4$ | -    |      |
| $V_{OLFM+}^{(1)(4)}$ | Low-level output voltage for an FTf I/O pin in FM+ mode | $I_{IO} = +20$ mA<br>$2.7\text{ V} < V_{DD} < 3.6\text{ V}$                            | -            | 0.4  |      |

1. The  $I_{IO}$  current sunk by the device must always respect the absolute maximum rating specified in [Table 17](#) and the sum of  $I_{IO}$  (I/O ports and control pins) must not exceed  $\Sigma I_{IO(PIN)}$ .
2. TTL and CMOS outputs are compatible with JEDEC standards JESD36 and JESD52.
3. The  $I_{IO}$  current sourced by the device must always respect the absolute maximum rating specified in [Table 17](#) and the sum of  $I_{IO}$  (I/O ports and control pins) must not exceed  $\Sigma I_{IO(PIN)}$ .
4. Data based on design simulation.

### Input/output AC characteristics

The definition and values of input/output AC characteristics are given in [Figure 24](#) and

Table 66, respectively.

Unless otherwise specified, the parameters given are derived from tests performed under ambient temperature and  $V_{DD}$  supply voltage conditions summarized in Table 19.

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>                                | $C_L = 50 \text{ pF}$ , $V_{DD} = 2 \text{ V to } 3.6 \text{ V}$   | -    | 2 <sup>(3)</sup>   | MHz  |
|                                        | $t_{f(\text{IO})\text{out}}$    | Output high to low level fall time                              | $C_L = 50 \text{ pF}$ , $V_{DD} = 2 \text{ V to } 3.6 \text{ V}$   | -    | 125 <sup>(3)</sup> | ns   |
|                                        | $t_{r(\text{IO})\text{out}}$    | Output low to high level rise time                              |                                                                    | -    | 125 <sup>(3)</sup> |      |
| 01                                     | $f_{\max(\text{IO})\text{out}}$ | Maximum frequency <sup>(2)</sup>                                | $C_L = 50 \text{ pF}$ , $V_{DD} = 2 \text{ V to } 3.6 \text{ V}$   | -    | 10 <sup>(3)</sup>  | MHz  |
|                                        | $t_{f(\text{IO})\text{out}}$    | Output high to low level fall time                              | $C_L = 50 \text{ pF}$ , $V_{DD} = 2 \text{ V to } 3.6 \text{ V}$   | -    | 25 <sup>(3)</sup>  | ns   |
|                                        | $t_{r(\text{IO})\text{out}}$    | Output low to high level rise time                              |                                                                    | -    | 25 <sup>(3)</sup>  |      |
| 11                                     | $f_{\max(\text{IO})\text{out}}$ | Maximum frequency <sup>(2)</sup>                                | $C_L = 30 \text{ pF}$ , $V_{DD} = 2.7 \text{ V to } 3.6 \text{ V}$ | -    | 50 <sup>(3)</sup>  | MHz  |
|                                        |                                 |                                                                 | $C_L = 50 \text{ pF}$ , $V_{DD} = 2.7 \text{ V to } 3.6 \text{ V}$ | -    | 30 <sup>(3)</sup>  | MHz  |
|                                        |                                 |                                                                 | $C_L = 50 \text{ pF}$ , $V_{DD} = 2 \text{ V to } 2.7 \text{ V}$   | -    | 20 <sup>(3)</sup>  | MHz  |
|                                        | $t_{f(\text{IO})\text{out}}$    | Output high to low level fall time                              | $C_L = 30 \text{ pF}$ , $V_{DD} = 2.7 \text{ V to } 3.6 \text{ V}$ | -    | 5 <sup>(3)</sup>   | ns   |
|                                        |                                 |                                                                 | $C_L = 50 \text{ pF}$ , $V_{DD} = 2.7 \text{ V to } 3.6 \text{ V}$ | -    | 8 <sup>(3)</sup>   |      |
|                                        |                                 |                                                                 | $C_L = 50 \text{ pF}$ , $V_{DD} = 2 \text{ V to } 2.7 \text{ V}$   | -    | 12 <sup>(3)</sup>  |      |
|                                        | $t_{r(\text{IO})\text{out}}$    | Output low to high level rise time                              | $C_L = 30 \text{ pF}$ , $V_{DD} = 2.7 \text{ V to } 3.6 \text{ V}$ | -    | 5 <sup>(3)</sup>   |      |
|                                        |                                 |                                                                 | $C_L = 50 \text{ pF}$ , $V_{DD} = 2.7 \text{ V to } 3.6 \text{ V}$ | -    | 8 <sup>(3)</sup>   |      |
|                                        |                                 |                                                                 | $C_L = 50 \text{ pF}$ , $V_{DD} = 2 \text{ V to } 2.7 \text{ V}$   | -    | 12 <sup>(3)</sup>  |      |
| FM+ configuration <sup>(4)</sup>       | $f_{\max(\text{IO})\text{out}}$ | Maximum frequency <sup>(2)</sup>                                | $C_L = 50 \text{ pF}$ , $V_{DD} = 2 \text{ V to } 3.6 \text{ V}$   | -    | 2 <sup>(4)</sup>   | MHz  |
|                                        | $t_{f(\text{IO})\text{out}}$    | Output high to low level fall time                              |                                                                    | -    | 12 <sup>(4)</sup>  | ns   |
|                                        | $t_{r(\text{IO})\text{out}}$    | Output low to high level rise time                              |                                                                    | -    | 34 <sup>(4)</sup>  |      |
| -                                      | $t_{\text{EXTI}pw}$             | Pulse width of external signals detected by the EXTI controller | -                                                                  | 10   | -                  | ns   |

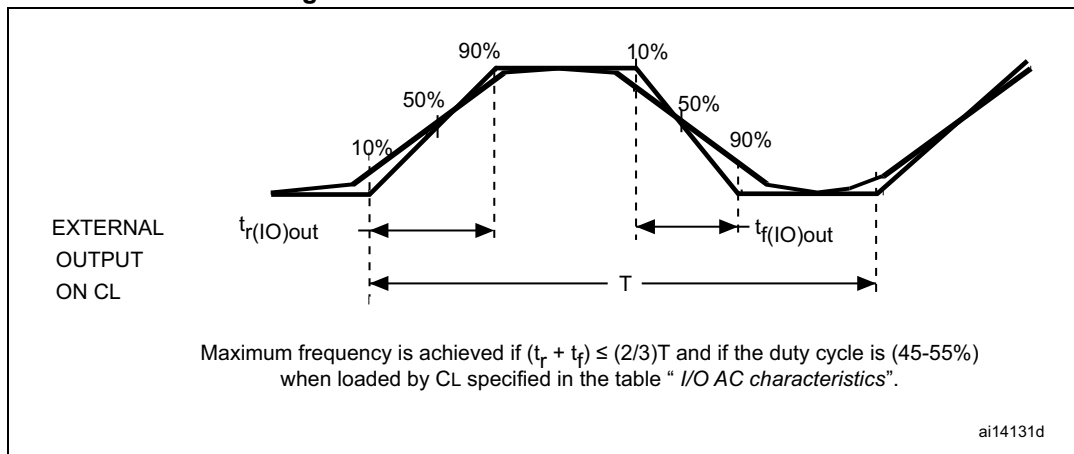
1. The I/O speed is configured using the OSPEEDRx[1:0] bits. Refer to the RM0364 reference manual for a description of GPIO Port configuration register.

2. The maximum frequency is defined in Figure 24.

3. Guaranteed by design, not tested in production.

4. The I/O speed configuration is bypassed in FM+ I/O mode. Refer to the RM0364 reference manual for a description of FM+ I/O mode configuration.

Figure 24. I/O AC characteristics definition



### 6.3.15 NRST pin characteristics

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

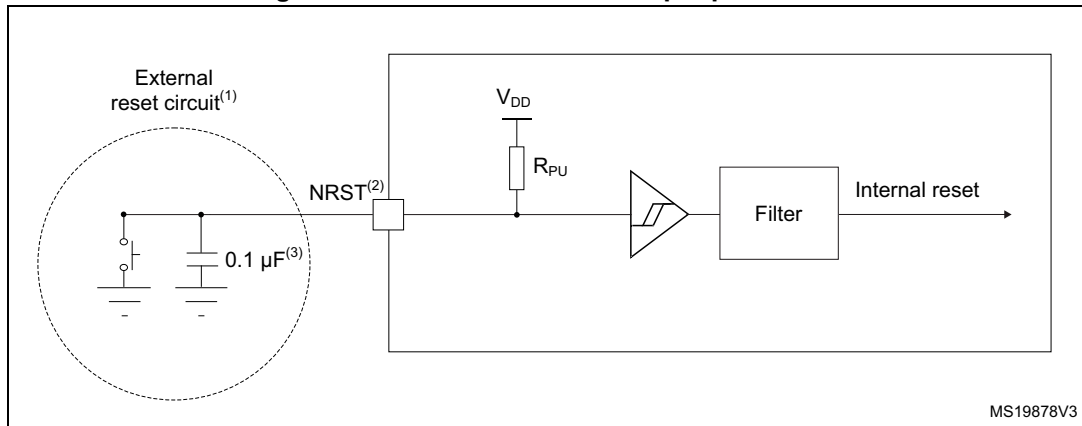
Unless otherwise specified, the parameters given in [Table 53](#) are derived from tests performed under ambient temperature and  $V_{DD}$  supply voltage conditions summarized in [Table 19](#).

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                   | -                 | $0.445V_{DD} + 0.398^{(1)}$ | -    | -                        |            |
| $V_{hys(NRST)}$      | 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 <sup>(1)</sup>       | ns         |
| $V_{NF(NRST)}^{(1)}$ | NRST Input not filtered pulse                   | -                 | 500 <sup>(1)</sup>          | -    | -                        | ns         |

- Guaranteed by design, not tested in production.
- The pull-up is designed with a true resistance in series with a switchable PMOS. This PMOS contribution to the series resistance must be minimum ( $\sim 10\%$  order).

Figure 25. Recommended NRST pin protection



MS19878V3

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 is not be taken into account by the device.
3. The external capacitor on NRST must be placed as close as possible to the device.
4. Place the external capacitor 0.1u F on NRST as close as possible to the chip.

### 6.3.16 High-resolution timer (HRTIM)

The parameters given in [Table 54](#) are derived from tests performed under ambient temperature and supply voltage conditions summarized in [Table 19](#).

Table 54. HRTIM1 characteristics

| Symbol                        | Parameter                             | Conditions                                                | Min.  | Typ. | Max.   | Unit        |
|-------------------------------|---------------------------------------|-----------------------------------------------------------|-------|------|--------|-------------|
| $T_A$                         | Timer ambient temperature range       | $f_{HRTIM}=144\text{MHz}^{(1)}$                           | -40   | -    | 105    | °C          |
|                               |                                       | $f_{HRTIM}=128\text{MHz}^{(2)}$                           | -10   | -    | 105    | °C          |
| $f_{HRTIM}$                   | HRTIM input clock for DLL calibration | As per $T_A$ conditions                                   | 128   | -    | 144    | MHz         |
| $t_{HRTIM}$                   |                                       |                                                           | 6.9   | -    | 7.8    | ns          |
| $t_{RES(HRTIM)}$              | Timer resolution time                 | $f_{HRTIM}=144\text{MHz}^{(1)}$ , $T_A$ from -40 to 105°C | -     | 217  | -      | ps          |
|                               |                                       | $f_{HRTIM}=128\text{MHz}^{(2)}$ , $T_A$ from -10 to 105°C | -     | 244  | -      | ps          |
| $Res_{HRTIM}$                 | Timer resolution                      | -                                                         | -     | -    | 16     | bit         |
| $t_{DTG}$                     | Dead time generator clock period      | -                                                         | 0.125 | -    | 16     | $t_{HRTIM}$ |
|                               |                                       | $f_{HRTIM}=144\text{MHz}^{(1)}$                           | 0.868 | -    | 111.10 | ns          |
| $ t_{DTR}  /  t_{DTF} _{max}$ | Dead time range (absolute value)      | -                                                         | -     | -    | 511    | $t_{DTG}$   |
|                               |                                       | $f_{HRTIM}=144\text{MHz}^{(1)}$                           | -     | -    | 56.77  | μs          |
| $f_{CHPFRQ}$                  | Chopper stage clock frequency         | -                                                         | 1/256 | -    | 1/16   | $f_{HRTIM}$ |
|                               |                                       | $f_{HRTIM}=144\text{MHz}^{(1)}$                           | 0.562 | -    | 9      | MHz         |
| $t_{1STPW}$                   | Chopper first pulse length            | -                                                         | 16    | -    | 256    | $t_{HRTIM}$ |
|                               |                                       | $f_{HRTIM}=144\text{MHz}^{(1)}$                           | 0.111 | -    | 1.77   | μs          |

1. Using HSE with 8MHz XTAL as clock source, configuring PLL to get PLLCLK=144MHz, and selecting PLLCLKx2 as HRTIM clock source. (Refer to Reset and clock control section in RM0364.)
2. Using HSI (internal 8MHz RC oscillator), configuring PLL to get PLLCLK=128MHz, and selecting PLLCLKx2 as HRTIM clock source. (Refer to Reset and clock control section in RM0364.)

Table 55. HRTIM output response to fault protection<sup>(1)</sup>

| Symbol        | Parameter                      | Conditions                                                                     | Min. | Typ. | Max. <sup>(2)</sup> | Unit |
|---------------|--------------------------------|--------------------------------------------------------------------------------|------|------|---------------------|------|
| $t_{LAT(DF)}$ | Digital fault response latency | Propagation delay from HRTIM1_FLTx digital input to HRTIM_CHxy output pin      | -    | 12   | 25                  | ns   |
| $t_{W(FLT)}$  | Minimum Fault pulse width      | -                                                                              | 12.5 | -    | -                   |      |
| $t_{LAT(AF)}$ | Analog fault response latency  | Propagation delay from comparator COMPx_INP input pin to HRTIM_CHxy output pin | -    | 25   | 43                  |      |

1. Refer to Fault paragraph in HRTIM section of RM0364.

2. Data based on characterization results, not tested in production.

Table 56. HRTIM output response to external events 1 to 5 (Low-Latency mode<sup>(1)</sup>)

| Symbol          | Parameter                                                     | Conditions                                                                                         | Min. | Typ. | Max. <sup>(2)</sup> | Unit              |
|-----------------|---------------------------------------------------------------|----------------------------------------------------------------------------------------------------|------|------|---------------------|-------------------|
| $t_{LAT(DEEV)}$ | Digital external event response latency                       | Propagation delay from HRTIM1_EEVx digital input to HRTIM_CHxy output pin (30pF load)              | -    | 12   | 25                  | ns                |
| $t_{W(FLT)}$    | Minimum external event pulse width                            | -                                                                                                  | 12.5 | -    | -                   | ns                |
| $t_{LAT(AEEV)}$ | Analog external event response latency                        | Propagation delay from comparator COMPx_INP input pin to HRTIM_CHxy output pin (30pF load)         | -    | 25   | 43                  | ns                |
| $T_{JIT(EEV)}$  | External event response jitter                                | Jitter of the delay from HRTIM1_EEVx digital input or COMPx_INP input pin to HRTIM_CHxy output pin | -    | -    | 0                   | $t_{HRTIM}^{(3)}$ |
| $T_{JIT(PW)}$   | Jitter on output pulse width in response to an external event | -                                                                                                  | -    | -    | 1                   | $t_{HRTIM}^{(3)}$ |

1. EEExFAST bit in HRTIM\_EECR1 register is set (Low Latency mode). This functionality is available on external events channels 1 to 5. Refer to Latency to external events paragraph in HRTIM section of RM0364.

2. Data based on characterization results, not tested in production.

3.  $T_{HRTIM} = 1 / f_{HRTIM}$  with  $f_{HRTIM} = 144$  MHz or  $f_{HRTIM} = 128$  MHz depending on the clock controller configuration. (Refer to Reset and clock control section in RM0364.)

Table 57. HRTIM output response to external events 1 to 10 (Synchronous mode<sup>(1)</sup>)

| Symbol            | Parameter                                | Conditions                                                                                           | Min. | Typ. | Max. <sup>(2)</sup> | Unit        |
|-------------------|------------------------------------------|------------------------------------------------------------------------------------------------------|------|------|---------------------|-------------|
| $T_{PROP(HRTIM)}$ | External event response latency in HRTIM | HRTIM internal propagation delay <sup>(3)</sup>                                                      | 6    | -    | 7                   | $t_{HRTIM}$ |
| $t_{LAT(DEEV)}$   | Digital external event response latency  | Propagation delay from HRTIM1_EEVx digital input to HRTIM_CHxy output pin (30pF load) <sup>(4)</sup> | -    | 61   | 72                  | ns          |

**Table 57. HRTIM output response to external events 1 to 10 (Synchronous mode <sup>(1)</sup>) (continued)**

| Symbol          | Parameter                                                     | Conditions                                                                                     | Min. | Typ. | Max. <sup>(2)</sup> | Unit                       |
|-----------------|---------------------------------------------------------------|------------------------------------------------------------------------------------------------|------|------|---------------------|----------------------------|
| $t_{LAT(AEEV)}$ | Analog external event response latency                        | Propagation delay from COMPx_INP input pin to HRTIM_CHxy output pin (30pF load) <sup>(4)</sup> | -    | 81   | 94                  | ns                         |
| $t_{W(FLT)}$    | Minimum external event pulse width                            | -                                                                                              | 12.5 | -    | -                   | ns                         |
| $T_{JIT(EEV)}$  | External event response jitter                                | Jitter of the delay from HRTIM1_EEVx digital input or COMPx_INP to HRTIM_CHxy output pin       | -    | -    | 1                   | $t_{HRTIM}$ <sup>(5)</sup> |
| $T_{JIT(PW)}$   | Jitter on output pulse width in response to an external event | -                                                                                              | -    | -    | 0                   | $t_{HRTIM}$ <sup>(5)</sup> |

1. EExFAST bit in HRTIM\_EECR1 or HRTIM\_EECR2 register is cleared (synchronous mode). External event filtering is disabled, i.e. EExF[3:0]=0000 in HRTIM\_EECR2 register. Refer to Latency to external events paragraph in HRTIM section of RM0364.
2. Data based on characterization results, not tested in production.
3. This parameter does not take into account latency introduced by GPIO or comparator. Refer to DEERL or SACRL parameter for complete latency.
4. This parameter is given for  $f_{HRTIM} = 144$  MHz.
5.  $T_{HRTIM} = 1 / f_{HRTIM}$  with  $f_{HRTIM} = 144$  MHz or  $f_{HRTIM} = 128$  MHz depending on the clock controller configuration. (Refer to Reset and clock control section in RM0364.)

**Table 58. HRTIM synchronization input / output <sup>(1)</sup>**

| Symbol          | Parameter                                                   | Conditions            | Min. | Typ.  | Max. | Unit        |
|-----------------|-------------------------------------------------------------|-----------------------|------|-------|------|-------------|
| $t_{W(SYNCIN)}$ | Minimum pulse width on SYNCIN inputs, including HRTIM1_SCIN | -                     | 2    | -     | -    | $t_{HRTIM}$ |
| $t_{LAT(DF)}$   | Response time to external synchronization request           | -                     | -    | -     | 1    | $t_{HRTIM}$ |
| $t_{LAT(AF)}$   | Pulse width on HRTIM1_SCOUT output                          | -                     | -    | 16    | -    | $t_{HRTIM}$ |
|                 |                                                             | $f_{HRTIM} = 144$ MHz | -    | 111.1 | -    | ns          |

1. Guaranteed by design, not tested in production.

### 6.3.17 Timer characteristics

The parameters given in [Table 59](#) are guaranteed by design.

Refer to [Section 6.3.14: I/O port characteristics](#) for details on the input/output alternate function characteristics (output compare, input capture, external clock, PWM output).

**Table 59. TIMx<sup>(1)(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            |
|                  |                                              | $f_{TIM1CLK} = 144\text{ MHz}$ | 6.95   | -                    | ns            |
| $f_{EXT}$        | Timer external clock frequency on CH1 to CH4 | -                              | 0      | $f_{TIMxCLK}/2$      | MHz           |
|                  |                                              | $f_{TIMxCLK} = 72\text{ MHz}$  | 0      | 36                   | 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                  | $\mu s$       |
|                  |                                              | $f_{TIM1CLK} = 144\text{ MHz}$ | 0.0069 | 455                  | $\mu s$       |
| $t_{MAX\_COUNT}$ | Maximum possible count with 32-bit counter   | -                              | -      | $65536 \times 65536$ | $t_{TIMxCLK}$ |
|                  |                                              | $f_{TIMxCLK} = 72\text{ MHz}$  | -      | 59.65                | s             |
|                  |                                              | $f_{TIM1CLK} = 144\text{ MHz}$ | -      | 29.825               | s             |

1. TIMx is used as a general term to refer to the TIM1, TIM2, TIM3, TIM15, TIM16 and TIM17 timers.
2. Guaranteed by design, not tested in production.

**Table 60. IWDG min./max. timeout period at 40 kHz (LSI) <sup>(1)</sup>**

| Prescaler divider | PR[2:0] bits | Min. timeout (ms)<br>RL[11:0] = 0x000 | Max. timeout (ms)<br>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.

**Table 61. WWDG min./max. timeout value at 72 MHz (PCLK) <sup>(1)</sup>**

| 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             |

1. Guaranteed by design, not tested in production.

### 6.3.18 Communication interfaces

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

The I<sup>2</sup>C interface meets the timings requirements of the I<sup>2</sup>C-bus specification and user manual rev. 03 for:

- Standard-mode (Sm): with a bit rate up to 100 Kbit/s
- Fast-mode (Fm): with a bit rate up to 400 Kbit/s
- Fast-mode Plus (Fm+): with a bit rate up to 1 Mbit/s.

The I<sup>2</sup>C timings requirements are guaranteed by design when the I<sup>2</sup>C peripheral is properly configured (refer to Reference manual).

The SDA and SCL I/O requirements are met with the following restrictions: the SDA and SCL I/O pins are not "true" open-drain. When configured as open-drain, the PMOS connected between the I/O pin and VDD is disabled, but is still present. Only FTf I/O pins support Fm+ low-level output current maximum requirement. Refer to [Section 6.3.14: I/O port characteristics](#) for the I<sup>2</sup>C I/O characteristics.

All I<sup>2</sup>C SDA and SCL I/Os embed an analog filter. Refer to the table below for the analog filter characteristics:

Table 62. 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, not tested in production.
2. Spikes with width below  $t_{AF}(\text{min.})$  are filtered.
3. Spikes with width above  $t_{AF}(\text{max.})$  are not filtered.

### SPI characteristics

Unless otherwise specified, the parameters given in [Table 53](#) for SPI are derived from tests performed under ambient temperature,  $f_{PCLKX}$  frequency and  $V_{DD}$  supply voltage conditions summarized in [Table 19: General operating conditions](#).

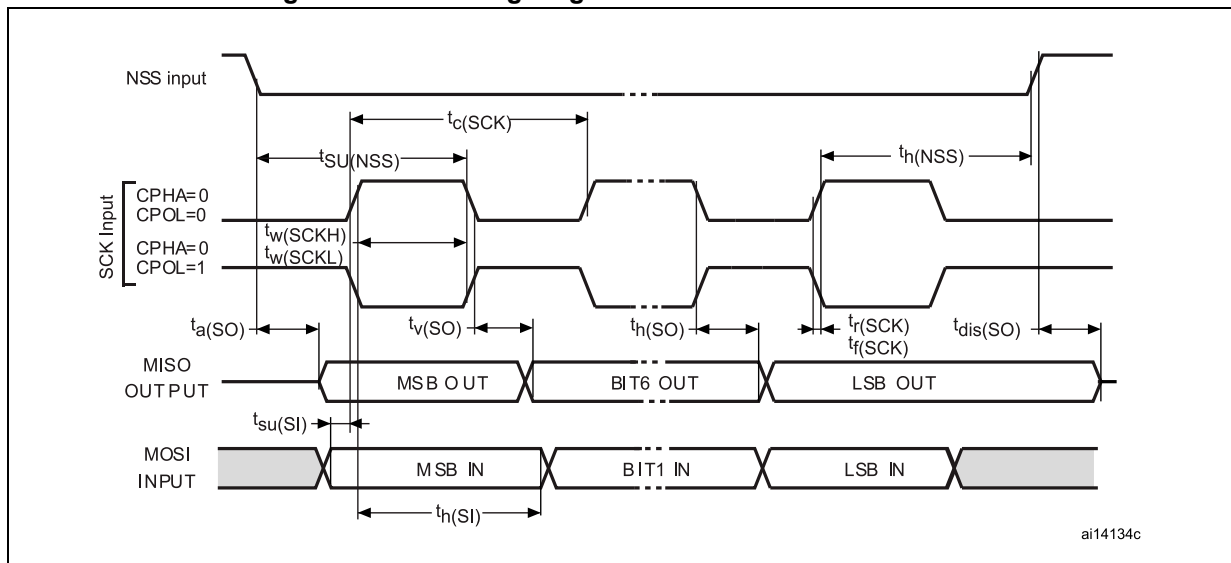
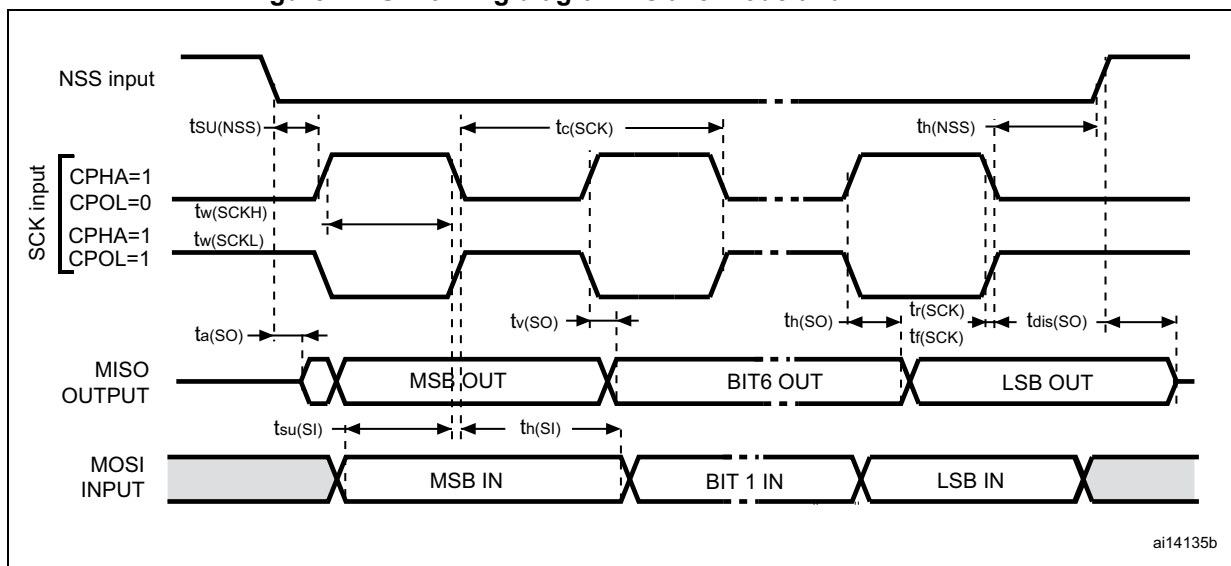
Refer to [Section 6.3.14: I/O port characteristics](#) for more details on the input/output alternate function characteristics (NSS, SCK, MOSI, MISO for SPI).

Table 63. SPI characteristics<sup>(1)</sup>

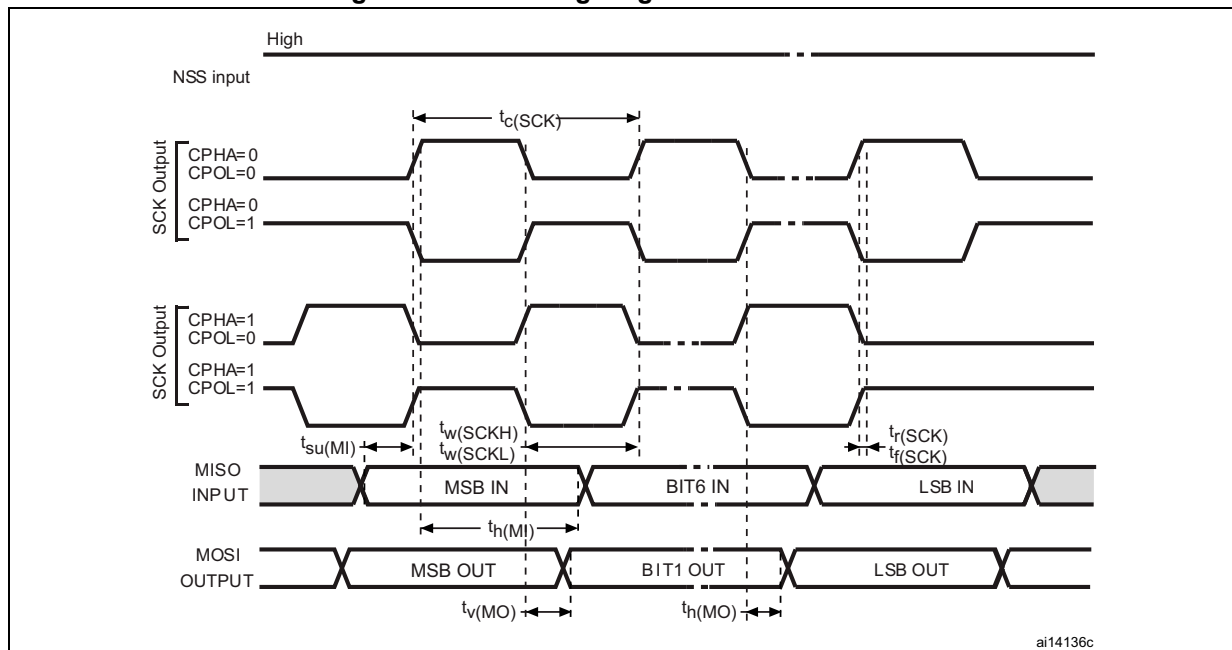
| Symbol                      | Parameter                         | Conditions                                                         | Min.               | Typ.       | Max.              | Unit |
|-----------------------------|-----------------------------------|--------------------------------------------------------------------|--------------------|------------|-------------------|------|
| $f_{SCK}$<br>$1/t_{c(SCK)}$ | SPI clock frequency               | Master mode $2.7 < V_{DD} < 3.6 \text{ V}$                         | -                  | -          | 24                | MHz  |
|                             |                                   | Master mode $2 < V_{DD} < 3.6 \text{ V}$                           |                    |            | 18                |      |
|                             |                                   | Slave mode $2 < V_{DD} < 3.6 \text{ V}$                            |                    |            | 24                |      |
|                             |                                   | Slave mode transmitter/full duplex<br>$2 < V_{DD} < 3.6 \text{ V}$ |                    |            | 18 <sup>(2)</sup> |      |
| $DuCy(SCK)$                 | Duty cycle of SPI clock frequency | Slave mode                                                         | 30                 | 50         | 70                | %    |
| $t_{su(NSS)}$               | NSS setup time                    | Slave mode, SPI presc = 2                                          | $4 \cdot T_{pclk}$ | -          | -                 | ns   |
| $t_h(NSS)$                  | NSS hold time                     | Slave mode, SPI presc = 2                                          | $2 \cdot T_{pclk}$ | -          | -                 |      |
| $t_w(SCKH)$<br>$t_w(SCKL)$  | SCK high and low time             | Master mode                                                        | $T_{pclk}-2$       | $T_{pclk}$ | $T_{pclk}+2$      |      |
| $t_{su(MI)}$                | Data input setup time             | Master mode                                                        | 0                  | -          | -                 |      |
| $t_{su(SI)}$                |                                   | Slave mode                                                         | 3                  | -          | -                 |      |
| $t_h(MI)$                   | Data input hold time              | Master mode                                                        | 5                  | -          | -                 |      |
| $t_h(SI)$                   |                                   | Slave mode                                                         | 1                  | -          | -                 |      |
| $t_a(SO)$                   | Data output access time           | Slave mode                                                         | 10                 | -          | 40                |      |
| $t_{dis(SO)}$               | Data output disable time          | Slave mode                                                         | 10                 | -          | 17                |      |
| $t_v(SO)$<br>$t_v(MO)$      | Data output valid time            | Slave mode $2.7 < V_{DD} < 3.6 \text{ V}$                          | -                  | 12         | 20                |      |
|                             |                                   | Slave mode $2 < V_{DD} < 3.6 \text{ V}$                            | -                  | 12         | 27.5              |      |
|                             |                                   | Master mode                                                        | -                  | 1.5        | 5                 |      |
| $t_h(SO)$                   | Data output hold time             | Slave mode                                                         | 7.5                | -          | -                 |      |
| $t_h(MO)$                   |                                   | Master mode                                                        | 0                  | -          | -                 |      |

1. Data based on characterization results, not tested in production.
2. Maximum frequency in Slave transmitter mode is determined by the sum of  $t_v(SO)$  and  $t_{su(MI)}$  which has to fit into SCK low or high phase preceding the SCK sampling edge. This value can be achieved when the SPI communicates with a master having  $t_{su(MI)} = 0$  while  $DuCy(SCK) = 50\%$ .

Figure 26. SPI timing diagram - slave mode and CPHA = 0

Figure 27. SPI timing diagram - slave mode and CPHA = 1<sup>(1)</sup>

1. Measurement points are done at 0.5V<sub>DD</sub> and with external C<sub>L</sub> = 30 pF.

Figure 28. SPI timing diagram - master mode<sup>(1)</sup>

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

### CAN (controller area network) interface

Refer to [Section 6.3.14: I/O port characteristics](#) for more details on the input/output alternate function characteristics (CAN\_TX and CAN\_RX).

### 6.3.19 ADC characteristics

Unless otherwise specified, the parameters showed from [Table 64](#) to [Table 67](#) are guaranteed by design, with the conditions summarized in [Table 19](#).

Table 64. ADC characteristics

| Symbol     | Parameter                                                | Conditions                  | Min. | Typ.   | Max.   | Unit    |
|------------|----------------------------------------------------------|-----------------------------|------|--------|--------|---------|
| $V_{DDA}$  | Analog supply voltage for ADC                            | -                           | 2    | -      | 3.6    | V       |
| $I_{DDA}$  | ADC current consumption<br>( <a href="#">Figure 29</a> ) | Single ended mode, 5 MSPS   | -    | 1011.3 | 1172.0 | $\mu A$ |
|            |                                                          | Single ended mode, 1 MSPS   | -    | 214.7  | 322.3  |         |
|            |                                                          | Single ended mode, 200 KSPS | -    | 54.7   | 81.1   |         |
|            |                                                          | Differential mode, 5 MSPS   | -    | 1061.5 | 1243.6 |         |
|            |                                                          | Differential mode, 1 MSPS   | -    | 246.6  | 337.6  |         |
|            |                                                          | Differential mode, 200 KSPS | -    | 56.4   | 83.0   |         |
| $V_{REF-}$ | Negative reference voltage                               | -                           | -    | 0      | -      | V       |

Table 64. ADC characteristics (continued)

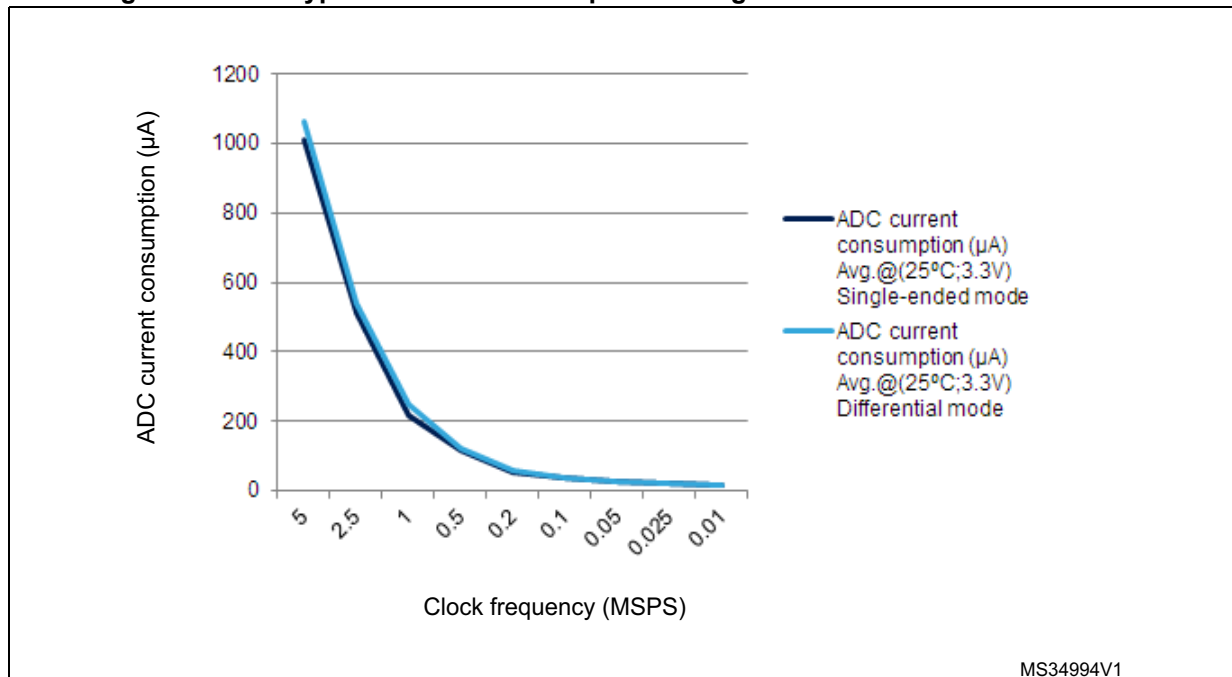
| Symbol                           | Parameter                                                                                  | Conditions                                                | Min.   | Typ. | Max.             | Unit                |
|----------------------------------|--------------------------------------------------------------------------------------------|-----------------------------------------------------------|--------|------|------------------|---------------------|
| $f_{\text{ADC}}$                 | ADC clock frequency                                                                        | -                                                         | 0.14   | -    | 72               | MHz                 |
| $f_{\text{S}}^{(1)}$             | Sampling rate                                                                              | Resolution = 12 bits,<br>Fast Channel                     | 0.01   | -    | 5.14             | MSPS                |
|                                  |                                                                                            | Resolution = 10 bits,<br>Fast Channel                     | 0.012  | -    | 6                |                     |
|                                  |                                                                                            | Resolution = 8 bits,<br>Fast Channel                      | 0.014  | -    | 7.2              |                     |
|                                  |                                                                                            | Resolution = 6 bits,<br>Fast Channel                      | 0.0175 | -    | 9                |                     |
| $f_{\text{TRIG}}^{(1)}$          | External trigger frequency                                                                 | $f_{\text{ADC}} = 72 \text{ MHz}$<br>Resolution = 12 bits | -      | -    | 5.14             | MHz                 |
|                                  |                                                                                            | Resolution = 12 bits                                      | -      | -    | 14               | $1/f_{\text{ADC}}$  |
| $V_{\text{AIN}}$                 | Conversion voltage range                                                                   | -                                                         | 0      | -    | $V_{\text{DDA}}$ | V                   |
| $R_{\text{AIN}}^{(1)}$           | External input impedance                                                                   | -                                                         | -      | -    | 100              | $\kappa\Omega$      |
| $C_{\text{ADC}}^{(1)}$           | Internal sample and hold capacitor                                                         | -                                                         | -      | 5    | -                | pF                  |
| $t_{\text{CAL}}^{(1)}$           | Calibration time                                                                           | $f_{\text{ADC}} = 72 \text{ MHz}$                         | 1.56   |      |                  | $\mu\text{s}$       |
|                                  |                                                                                            | -                                                         | 112    |      |                  | $1/f_{\text{ADC}}$  |
| $t_{\text{latr}}^{(1)}$          | Trigger conversion latency<br>Regular and injected<br>channels without<br>conversion abort | CKMODE = 00                                               | 1.5    | 2    | 2.5              | $1/f_{\text{ADC}}$  |
|                                  |                                                                                            | CKMODE = 01                                               | -      | -    | 2                | $1/f_{\text{ADC}}$  |
|                                  |                                                                                            | CKMODE = 10                                               | -      | -    | 2.25             | $1/f_{\text{ADC}}$  |
|                                  |                                                                                            | CKMODE = 11                                               | -      | -    | 2.125            | $1/f_{\text{ADC}}$  |
| $t_{\text{latrinj}}^{(1)}$       | Trigger conversion latency<br>Injected channels aborting<br>a regular conversion           | CKMODE = 00                                               | 2.5    | 3    | 3.5              | $1/f_{\text{ADC}}$  |
|                                  |                                                                                            | CKMODE = 01                                               | -      | -    | 3                | $1/f_{\text{ADC}}$  |
|                                  |                                                                                            | CKMODE = 10                                               | -      | -    | 3.25             | $1/f_{\text{ADC}}$  |
|                                  |                                                                                            | CKMODE = 11                                               | -      | -    | 3.125            | $1/f_{\text{ADC}}$  |
| $t_{\text{S}}^{(1)}$             | Sampling time                                                                              | $f_{\text{ADC}} = 72 \text{ MHz}$                         | 0.021  | -    | 8.35             | $\mu\text{s}$       |
|                                  |                                                                                            | -                                                         | 1.5    | -    | 601.5            | $1/f_{\text{ADC}}$  |
| $t_{\text{ADCVREG\_STUP}}^{(1)}$ | ADC Voltage Regulator<br>Start-up time                                                     | -                                                         | -      | -    | 10               | $\mu\text{s}$       |
| $t_{\text{STAB}}$                | Power-up time                                                                              | -                                                         | 1      |      |                  | conversion<br>cycle |

Table 64. ADC characteristics (continued)

| Symbol                  | Parameter                                       | Conditions                                                | Min.                                                                         | Typ.                                   | Max.                                          | Unit               |
|-------------------------|-------------------------------------------------|-----------------------------------------------------------|------------------------------------------------------------------------------|----------------------------------------|-----------------------------------------------|--------------------|
| $t_{\text{CONV}}^{(1)}$ | Total conversion time (including sampling time) | $f_{\text{ADC}} = 72 \text{ MHz}$<br>Resolution = 12 bits | 0.19                                                                         | -                                      | 8.52                                          | $\mu\text{s}$      |
|                         |                                                 | Resolution = 12 bits                                      | 14 to 614 ( $t_{\text{S}}$ for sampling + 12.5 for successive approximation) |                                        |                                               | $1/f_{\text{ADC}}$ |
| CMIR                    | Common Mode Input signal                        | ADC differential mode                                     | $(V_{\text{SSA}} + V_{\text{REF}}+)/2 - 0.18$                                | $(V_{\text{SSA}} + V_{\text{REF}}+)/2$ | $(V_{\text{SSA}} + V_{\text{REF}}+)/2 + 0.18$ | V                  |

1. Data guaranteed by design, not tested in production.

Figure 29. ADC typical current consumption in single-ended and differential modes

Table 65. Maximum ADC  $R_{\text{AIN}}^{(1)}$ 

| Resolution | Sampling cycle @ 72 MHz | Sampling time [ns] @ 72 MHz | $R_{\text{AIN}}$ max. ( $\text{k}\Omega$ ) |               |                               |
|------------|-------------------------|-----------------------------|--------------------------------------------|---------------|-------------------------------|
|            |                         |                             | Fast channels <sup>(2)</sup>               | Slow channels | Other channels <sup>(3)</sup> |
| 12 bits    | 1.5                     | 20.83                       | 0.018                                      | NA            | NA                            |
|            | 2.5                     | 34.72                       | 0.150                                      | NA            | 0.022                         |
|            | 4.5                     | 62.50                       | 0.470                                      | 0.220         | 0.180                         |
|            | 7.5                     | 104.17                      | 0.820                                      | 0.560         | 0.470                         |
|            | 19.5                    | 270.83                      | 2.70                                       | 1.80          | 1.50                          |
|            | 61.5                    | 854.17                      | 8.20                                       | 6.80          | 4.70                          |
|            | 181.5                   | 2520.83                     | 22.0                                       | 18.0          | 15.0                          |
|            | 601.5                   | 8354.17                     | 82.0                                       | 68.0          | 47.0                          |

Table 65. Maximum ADC  $R_{AIN}^{(1)}$  (continued)

| Resolution | Sampling cycle @ 72 MHz | Sampling time [ns] @ 72 MHz | $R_{AIN}$ max. (k $\Omega$ ) |               |                               |
|------------|-------------------------|-----------------------------|------------------------------|---------------|-------------------------------|
|            |                         |                             | Fast channels <sup>(2)</sup> | Slow channels | Other channels <sup>(3)</sup> |
| 10 bits    | 1.5                     | 20.83                       | 0.082                        | NA            | NA                            |
|            | 2.5                     | 34.72                       | 0.270                        | 0.082         | 0.100                         |
|            | 4.5                     | 62.50                       | 0.560                        | 0.390         | 0.330                         |
|            | 7.5                     | 104.17                      | 1.20                         | 0.82          | 0.68                          |
|            | 19.5                    | 270.83                      | 3.30                         | 2.70          | 2.20                          |
|            | 61.5                    | 854.17                      | 10.0                         | 8.2           | 6.8                           |
|            | 181.5                   | 2520.83                     | 33.0                         | 27.0          | 22.0                          |
|            | 601.5                   | 8354.17                     | 100.0                        | 82.0          | 68.0                          |
| 8 bits     | 1.5                     | 20.83                       | 0.150                        | NA            | 0.039                         |
|            | 2.5                     | 34.72                       | 0.390                        | 0.180         | 0.180                         |
|            | 4.5                     | 62.50                       | 0.820                        | 0.560         | 0.470                         |
|            | 7.5                     | 104.17                      | 1.50                         | 1.20          | 1.00                          |
|            | 19.5                    | 270.83                      | 3.90                         | 3.30          | 2.70                          |
|            | 61.5                    | 854.17                      | 12.00                        | 12.00         | 8.20                          |
|            | 181.5                   | 2520.83                     | 39.00                        | 33.00         | 27.00                         |
|            | 601.5                   | 8354.17                     | 100.00                       | 100.00        | 82.00                         |
| 6 bits     | 1.5                     | 20.83                       | 0.270                        | 0.100         | 0.150                         |
|            | 2.5                     | 34.72                       | 0.560                        | 0.390         | 0.330                         |
|            | 4.5                     | 62.50                       | 1.200                        | 0.820         | 0.820                         |
|            | 7.5                     | 104.17                      | 2.20                         | 1.80          | 1.50                          |
|            | 19.5                    | 270.83                      | 5.60                         | 4.7           | 3.90                          |
|            | 61.5                    | 854.17                      | 18.0                         | 15.0          | 12.0                          |
|            | 181.5                   | 2520.83                     | 56.0                         | 47.0          | 39.0                          |
|            | 601.5                   | 8354.17                     | 100.00                       | 100.0         | 100.0                         |

1. Data based on characterization results, not tested in production.

2. All fast channels, expect channel on PA6.

3. Channels available on PA6.

Table 66. ADC accuracy - limited test conditions<sup>(1)(2)</sup>

| Symbol               | Parameter                            | Conditions                                                                              |                     |                     | Min.<br>(3) | Typ. | Max. (3) | Unit |
|----------------------|--------------------------------------|-----------------------------------------------------------------------------------------|---------------------|---------------------|-------------|------|----------|------|
| ET                   | Total unadjusted error               | ADC clock freq. ≤ 72 MHz<br>Sampling freq. ≤ 5 Msps<br>V <sub>DDA</sub> = 3.3 V<br>25°C | Single ended        | Fast channel 5.1 Ms | -           | ±4   | ±4.5     | LSB  |
|                      |                                      |                                                                                         |                     | Slow channel 4.8 Ms | -           | ±5.5 | ±6       |      |
|                      |                                      |                                                                                         | Differential        | Fast channel 5.1 Ms | -           | ±3.5 | ±4       |      |
|                      |                                      |                                                                                         |                     | Slow channel 4.8 Ms | -           | ±3.5 | ±4       |      |
| EO                   | Offset error                         |                                                                                         | Single ended        | Fast channel 5.1 Ms | -           | ±2   | ±2       |      |
|                      |                                      |                                                                                         |                     | Slow channel 4.8 Ms | -           | ±1.5 | ±2       |      |
|                      |                                      |                                                                                         | Differential        | Fast channel 5.1 Ms | -           | ±1.5 | ±2       |      |
|                      |                                      |                                                                                         |                     | Slow channel 4.8 Ms | -           | ±1.5 | ±2       |      |
| EG                   | Gain error                           |                                                                                         | Single ended        | Fast channel 5.1 Ms | -           | ±3   | ±4       |      |
|                      |                                      |                                                                                         |                     | Slow channel 4.8 Ms | -           | ±5   | ±5.5     |      |
|                      |                                      |                                                                                         | Differential        | Fast channel 5.1 Ms | -           | ±3   | ±3       |      |
|                      |                                      |                                                                                         |                     | Slow channel 4.8 Ms | -           | ±3   | ±3.5     |      |
| ED                   | Differential linearity error         |                                                                                         | Single ended        | Fast channel 5.1 Ms | -           | ±1   | ±1       |      |
|                      |                                      |                                                                                         |                     | Slow channel 4.8 Ms | -           | ±1   | ±1       |      |
|                      |                                      |                                                                                         | Differential        | Fast channel 5.1 Ms | -           | ±1   | ±1       |      |
|                      |                                      |                                                                                         |                     | Slow channel 4.8 Ms | -           | ±1   | ±1       |      |
| EL                   | Integral linearity error             |                                                                                         | Single ended        | Fast channel 5.1 Ms | -           | ±1.5 | ±2       |      |
|                      |                                      |                                                                                         |                     | Slow channel 4.8 Ms | -           | ±2   | ±3       |      |
|                      |                                      |                                                                                         | Differential        | Fast channel 5.1 Ms | -           | ±1.5 | ±1.5     |      |
|                      |                                      |                                                                                         |                     | Slow channel 4.8 Ms | -           | ±1.5 | ±2       |      |
| ENOB <sup>(4)</sup>  | Effective number of bits             | Single ended                                                                            | Fast channel 5.1 Ms | 10.8                | 10.8        | -    | bit      |      |
|                      |                                      |                                                                                         | Slow channel 4.8 Ms | 10.8                | 10.8        | -    |          |      |
|                      |                                      | Differential                                                                            | Fast channel 5.1 Ms | 11.2                | 11.3        | -    |          |      |
|                      |                                      |                                                                                         | Slow channel 4.8 Ms | 11.2                | 11.3        | -    |          |      |
| SINAD <sup>(4)</sup> | Signal-to-noise and distortion ratio | Single ended                                                                            | Fast channel 5.1 Ms | 66                  | 67          | -    | dB       |      |
|                      |                                      |                                                                                         | Slow channel 4.8 Ms | 66                  | 67          | -    |          |      |
|                      |                                      | Differential                                                                            | Fast channel 5.1 Ms | 69                  | 70          | -    |          |      |
|                      |                                      |                                                                                         | Slow channel 4.8 Ms | 69                  | 70          | -    |          |      |

Table 66. ADC accuracy - limited test conditions<sup>(1)(2)</sup> (continued)

| Symbol             | Parameter                 | Conditions                                                                              |              |                     | Min.<br>(3) | Typ. | Max. (3) | Unit |
|--------------------|---------------------------|-----------------------------------------------------------------------------------------|--------------|---------------------|-------------|------|----------|------|
| SNR <sup>(4)</sup> | Signal-to-noise ratio     | ADC clock freq. ≤ 72 MHz<br>Sampling freq. ≤ 5 Msps<br>V <sub>DDA</sub> = 3.3 V<br>25°C | Single ended | Fast channel 5.1 Ms | 66          | 67   | -        | dB   |
|                    |                           |                                                                                         |              | Slow channel 4.8 Ms | 66          | 67   | -        |      |
|                    |                           |                                                                                         | Differential | Fast channel 5.1 Ms | 69          | 70   | -        |      |
|                    |                           |                                                                                         |              | Slow channel 4.8 Ms | 69          | 70   | -        |      |
| THD <sup>(4)</sup> | Total harmonic distortion |                                                                                         | Single ended | Fast channel 5.1 Ms | -           | -80  | -80      |      |
|                    |                           |                                                                                         |              | Slow channel 4.8 Ms | -           | -78  | -77      |      |
|                    |                           |                                                                                         | Differential | Fast channel 5.1 Ms | -           | -83  | -82      |      |
|                    |                           |                                                                                         |              | Slow channel 4.8 Ms | -           | -81  | -80      |      |

1. ADC DC accuracy values are measured after internal calibration.
2. ADC accuracy vs. negative Injection Current: Injecting negative current on any analog input pins must be avoided as this significantly reduces the accuracy of the conversion being performed on another analog input. It is recommended to add a Schottky diode (pin to ground) to analog pins which may potentially inject negative current. Any positive injection current within the limits specified for  $I_{INJ(PIN)}$  and  $\Sigma I_{INJ(PIN)}$  in [Section 6.3.14](#) does not affect the ADC accuracy.
3. Data based on characterization results, not tested in production.
4. Value measured with a -0.5 dB full scale 50 kHz sine wave input signal.

Table 67. ADC accuracy <sup>(1)(2)(3)</sup>

| Symbol | Parameter                    | Conditions                                                                               |              |                     | Min. <sup>(4)</sup> | Max. <sup>(4)</sup> | Unit |
|--------|------------------------------|------------------------------------------------------------------------------------------|--------------|---------------------|---------------------|---------------------|------|
| ET     | Total unadjusted error       | ADC clock freq. ≤ 72 MHz,<br>Sampling freq. ≤ 5 Msps<br>2.0 V ≤ V <sub>DDA</sub> ≤ 3.6 V | Single ended | Fast channel 5.1 Ms | -                   | ±6.5                | LSB  |
|        |                              |                                                                                          |              | Slow channel 4.8 Ms | -                   | ±6.5                |      |
|        |                              |                                                                                          | Differential | Fast channel 5.1 Ms | -                   | ±4                  |      |
|        |                              |                                                                                          |              | Slow channel 4.8 Ms | -                   | ±4.5                |      |
| EO     | Offset error                 |                                                                                          | Single ended | Fast channel 5.1 Ms | -                   | ±3                  |      |
|        |                              |                                                                                          |              | Slow channel 4.8 Ms | -                   | ±3                  |      |
|        |                              |                                                                                          | Differential | Fast channel 5.1 Ms | -                   | ±2.5                |      |
|        |                              |                                                                                          |              | Slow channel 4.8 Ms | -                   | ±2.5                |      |
| EG     | Gain error                   |                                                                                          | Single ended | Fast channel 5.1 Ms | -                   | ±6                  |      |
|        |                              |                                                                                          |              | Slow channel 4.8 Ms | -                   | ±6                  |      |
|        |                              |                                                                                          | Differential | Fast channel 5.1 Ms | -                   | ±3.5                |      |
|        |                              |                                                                                          |              | Slow channel 4.8 Ms | -                   | ±4                  |      |
| ED     | Differential linearity error |                                                                                          | Single ended | Fast channel 5.1 Ms | -                   | ±1.5                |      |
|        |                              |                                                                                          |              | Slow channel 4.8 Ms | -                   | ±1.5                |      |
|        |                              |                                                                                          | Differential | Fast channel 5.1 Ms | -                   | ±1.5                |      |
|        |                              |                                                                                          |              | Slow channel 4.8 Ms | -                   | ±1.5                |      |

Table 67. ADC accuracy <sup>(1)(2)(3)</sup> (continued)

| Symbol               | Parameter                            | Conditions                                                                               |              |                     | Min. <sup>(4)</sup> | Max. <sup>(4)</sup> | Unit |
|----------------------|--------------------------------------|------------------------------------------------------------------------------------------|--------------|---------------------|---------------------|---------------------|------|
| EL                   | Integral linearity error             | ADC clock freq. ≤ 72 MHz,<br>Sampling freq. ≤ 5 Msps<br>2.0 V ≤ V <sub>DDA</sub> ≤ 3.6 V | Single ended | Fast channel 5.1 Ms | -                   | ±3                  | LSB  |
|                      |                                      |                                                                                          |              | Slow channel 4.8 Ms | -                   | ±3.5                |      |
|                      |                                      |                                                                                          | Differential | Fast channel 5.1 Ms | -                   | ±2                  |      |
|                      |                                      |                                                                                          |              | Slow channel 4.8 Ms | -                   | ±2.5                |      |
| ENOB <sup>(5)</sup>  | Effective number of bits             |                                                                                          | Single ended | Fast channel 5.1 Ms | 10.4                | -                   | bits |
|                      |                                      |                                                                                          |              | Slow channel 4.8 Ms | 10.4                | -                   |      |
|                      |                                      |                                                                                          | Differential | Fast channel 5.1 Ms | 10.8                | -                   |      |
|                      |                                      |                                                                                          |              | Slow channel 4.8 Ms | 10.8                | -                   |      |
| SINAD <sup>(5)</sup> | Signal-to-noise and distortion ratio |                                                                                          | Single ended | Fast channel 5.1 Ms | 64                  | -                   | dB   |
|                      |                                      |                                                                                          |              | Slow channel 4.8 Ms | 63                  | -                   |      |
|                      |                                      |                                                                                          | Differential | Fast channel 5.1 Ms | 67                  | -                   |      |
|                      |                                      |                                                                                          |              | Slow channel 4.8 Ms | 67                  | -                   |      |
| SNR <sup>(5)</sup>   | Signal-to-noise ratio                | ADC clock freq. ≤ 72 MHz,<br>Sampling freq ≤ 5 Msps,<br>2.0 V ≤ V <sub>DDA</sub> ≤ 3.6 V | Single ended | Fast channel 5.1 Ms | 64                  | -                   |      |
|                      |                                      |                                                                                          |              | Slow channel 4.8 Ms | 64                  | -                   |      |
|                      |                                      |                                                                                          | Differential | Fast channel 5.1 Ms | 67                  | -                   |      |
|                      |                                      |                                                                                          |              | Slow channel 4.8 Ms | 67                  | -                   |      |
| THD <sup>(5)</sup>   | Total harmonic distortion            |                                                                                          | Single ended | Fast channel 5.1 Ms | -                   | -75                 |      |
|                      |                                      |                                                                                          |              | Slow channel 4.8 Ms | -                   | -75                 |      |
|                      |                                      |                                                                                          | Differential | Fast channel 5.1 Ms | -                   | -79                 |      |
|                      |                                      |                                                                                          |              | Slow channel 4.8 Ms | -                   | -78                 |      |

1. ADC DC accuracy values are measured after internal calibration.
2. ADC accuracy vs. negative Injection Current: Injecting negative current on any analog input pins must be avoided as this significantly reduces the accuracy of the conversion being performed on another analog input. It is recommended to add a Schottky diode (pin to ground) to analog pins which may potentially inject negative current. Any positive injection current within the limits specified for I<sub>INJ(PIN)</sub> and ΣI<sub>INJ(PIN)</sub> in [Section 6.3.14](#) does not affect the ADC accuracy.
3. Better performance may be achieved in restricted V<sub>DDA</sub>, frequency and temperature ranges.
4. Data based on characterization results, not tested in production.
5. Value measured with a -0.5 dB full scale 50 kHz sine wave input signal.

Table 68. ADC accuracy<sup>(1)(2)</sup> at 1MSPS

| Symbol | Parameter                    | Test conditions                                                                                                           |              | Typ. | Max <sup>(3)</sup> | Unit |
|--------|------------------------------|---------------------------------------------------------------------------------------------------------------------------|--------------|------|--------------------|------|
| ET     | Total unadjusted error       | ADC Freq. ≤ 72 MHz<br>Sampling Freq. ≤ 1MSPS<br>2.4 V ≤ V <sub>DDA</sub> = V <sub>REF+</sub> ≤ 3.6 V<br>Single-ended mode | Fast channel | ±2.5 | ±5                 | LSB  |
|        |                              |                                                                                                                           | Slow channel | ±3.5 | ±5                 |      |
| EO     | Offset error                 |                                                                                                                           | Fast channel | ±1   | ±2.5               |      |
|        |                              |                                                                                                                           | Slow channel | ±1.5 | ±2.5               |      |
| EG     | Gain error                   |                                                                                                                           | Fast channel | ±2   | ±3                 |      |
|        |                              |                                                                                                                           | Slow channel | ±3   | ±4                 |      |
| ED     | Differential linearity error |                                                                                                                           | Fast channel | ±0.7 | ± 2                |      |
|        |                              |                                                                                                                           | Slow channel | ±0.7 | ±2                 |      |
| EL     | Integral linearity error     |                                                                                                                           | Fast channel | ±1   | ±3                 |      |
|        |                              |                                                                                                                           | Slow channel | ±1.2 | ±3                 |      |

1. ADC DC accuracy values are measured after internal calibration.
2. ADC accuracy vs. negative Injection Current: Injecting negative current on any analog input pins must be avoided as this significantly reduces the accuracy of the conversion being performed on another analog input. It is recommended to add a Schottky diode (pin to ground) to analog pins which may potentially inject negative current. Any positive injection current within the limits specified for IINJ(PIN) and ΣIINJ(PIN) in [Section 6.3.14: I/O port characteristics](#) does not affect the ADC accuracy.
3. Data based on characterization results, not tested in production.

Figure 30. ADC accuracy characteristics

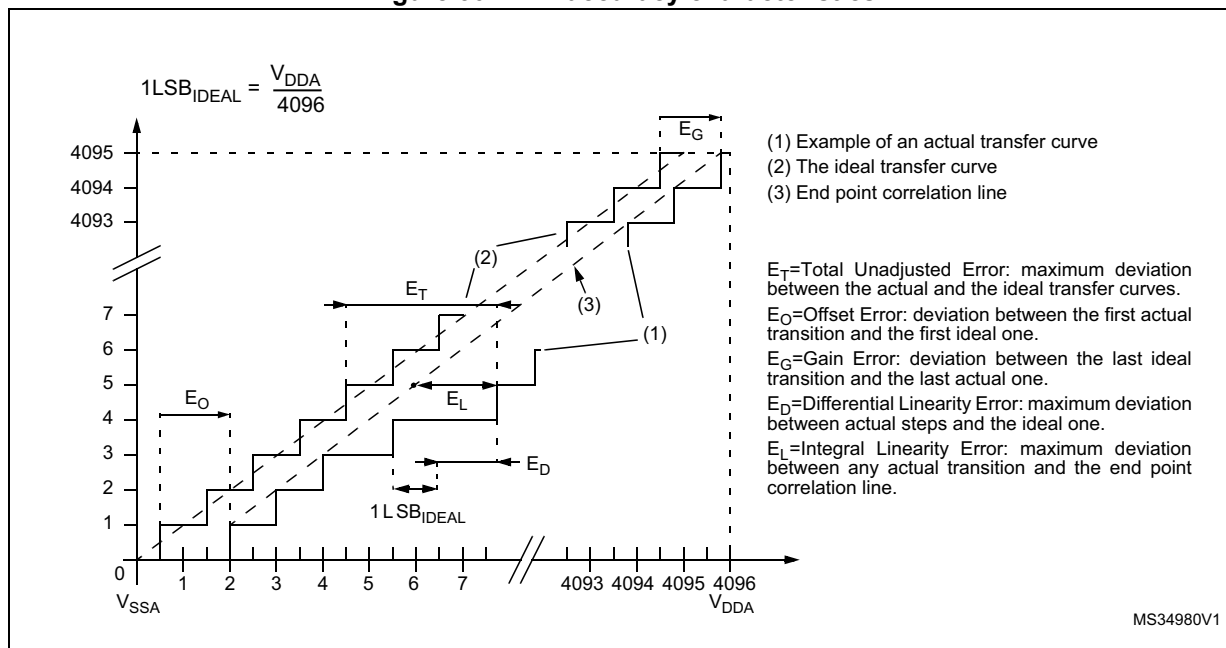
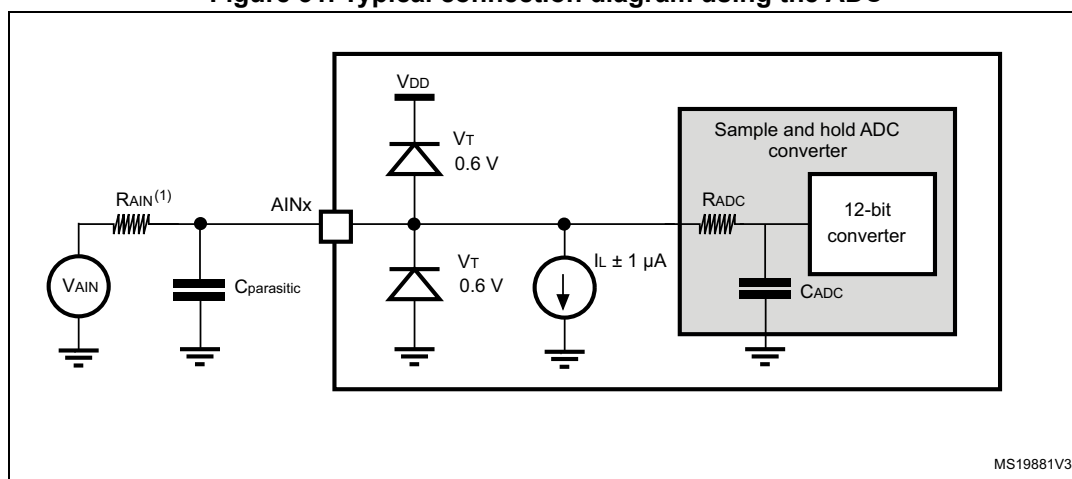


Figure 31. Typical connection diagram using the ADC



1. Refer to [Table 64](#) for the values of  $R_{AIN}$ .
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 downgrades conversion accuracy. To remedy this,  $f_{ADC}$  must be reduced.

### General PCB design guidelines

Power supply decoupling must be performed as shown in [Figure 12: Power-supply scheme](#). The 10 nF capacitor must be ceramic (good quality) and it must be placed as close as possible to the chip.

## 6.3.20 DAC electrical specifications

Table 69. DAC characteristics

| Symbol               | Parameter                                                   | Conditions                                                                                                            | Min. | Typ. | Max.             | Unit       |
|----------------------|-------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------|------|------|------------------|------------|
| $V_{DDA}$            | Analog supply voltage                                       | -                                                                                                                     | 2.4  | -    | 3.6              | V          |
| $R_{LOAD}^{(1)}$     | Resistive load                                              | DAC output buffer ON (to $V_{SSA}$ )                                                                                  | 5    | -    |                  | k $\Omega$ |
|                      |                                                             | DAC output buffer ON (to $V_{DDA}$ )                                                                                  | 25   |      |                  |            |
| $R_O^{(1)}$          | Output impedance                                            | DAC output buffer OFF                                                                                                 | -    | -    | 15               | k $\Omega$ |
| $C_{LOAD}^{(1)}$     | Capacitive load                                             | DAC output buffer ON                                                                                                  | -    | -    | 50               | pF         |
| $V_{DAC\_OUT}^{(1)}$ | Voltage on DAC_OUT output                                   | Corresponds to 12-bit input code (0x0E0) to (0xF1C) at $V_{DDA} = 3.6$ V and (0x155) and (0xEAB) at $V_{DDA} = 2.4$ V | 0.2  | -    | $V_{DDA} - 0.2$  | V          |
|                      |                                                             | DAC output buffer OFF                                                                                                 | -    | 0.5  | -                | mV         |
|                      |                                                             |                                                                                                                       | -    | -    | $V_{DDA} - 1LSB$ | V          |
| $I_{DDA}^{(3)}$      | DAC DC current consumption in quiescent mode <sup>(2)</sup> | With no load, middle code (0x800) on the input                                                                        | -    | -    | 380              | $\mu$ A    |
|                      |                                                             | With no load, worst code (0xF1C) on the input.                                                                        | -    | -    | 480              | $\mu$ A    |

Table 69. DAC characteristics (continued)

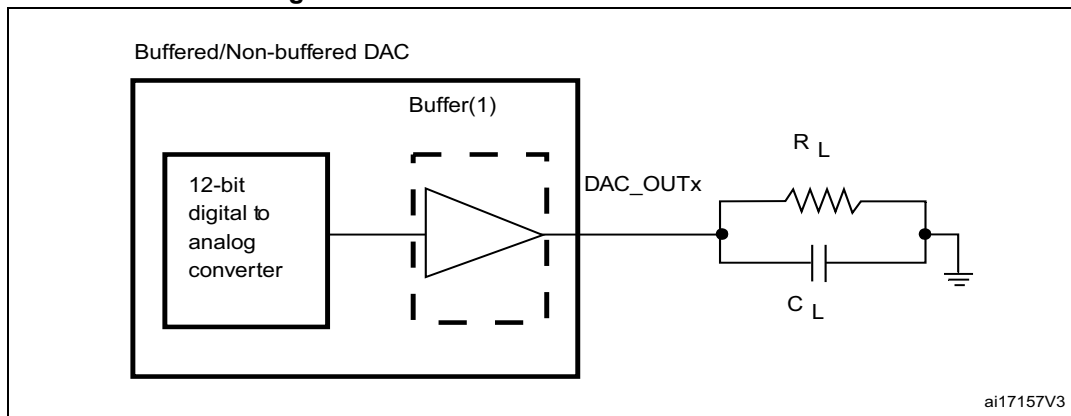
| Symbol                           | Parameter                                                                                                                                                           | Conditions                                                                    | Min. | Typ. | Max.        | Unit |
|----------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------|------|------|-------------|------|
| DNL <sup>(3)</sup>               | Differential non linearity<br>Difference between two consecutive code-1LSB)                                                                                         | Given for a 10-bit input code<br>DAC1 channel 1                               | -    | -    | ±0.5        | LSB  |
|                                  |                                                                                                                                                                     | Given for a 12-bit input code<br>DAC1 channel 1                               | -    | -    | ±2          | LSB  |
|                                  |                                                                                                                                                                     | Given for a 10-bit input code<br>DAC1 channel 2 & DAC2 channel 1              | -    | -    | -0.75/+0.25 | LSB  |
|                                  |                                                                                                                                                                     | Given for a 12-bit input code<br>DAC1 channel 2 & DAC2 channel 1              | -    | -    | -3/+1       | LSB  |
| INL <sup>(3)</sup>               | Integral non linearity<br>(difference between<br>measured value at Code i<br>and the value at Code i on a<br>line drawn between Code 0<br>and last Code 4095)       | Given for a 10-bit input code                                                 | -    | -    | ±1          | LSB  |
|                                  |                                                                                                                                                                     | Given for a 12-bit input code                                                 | -    | -    | ±4          | LSB  |
| Offset <sup>(3)</sup>            | Offset error<br>(difference between<br>measured value at Code<br>(0x800) and the ideal value<br>= $V_{DDA}/2$ )                                                     | -                                                                             | -    | -    | ±10         | mV   |
|                                  |                                                                                                                                                                     | Given for a 10-bit input code at<br>$V_{DDA} = 3.6\text{ V}$                  | -    | -    | ±3          | LSB  |
|                                  |                                                                                                                                                                     | Given for a 12-bit input code                                                 | -    | -    | ±12         | LSB  |
| Gain error <sup>(3)</sup>        | Gain error                                                                                                                                                          | Given for a 12-bit input code                                                 | -    | -    | ±0.5        | %    |
| $t_{\text{SETTLING}}^{(3)}$      | Settling time (full scale: for<br>a 12-bit input code<br>transition between the<br>lowest and the highest input<br>codes when DAC_OUT<br>reaches final value ±1LSB) | $C_{\text{LOAD}} \leq 50\text{ pF}$ , $R_{\text{LOAD}} \geq 5\text{ k}\Omega$ | -    | 3    | 4           | µs   |
| Update rate <sup>(3)</sup>       | Max frequency for a correct<br>DAC_OUT change when<br>small variation in the input<br>code (from code i to<br>i+1LSB)                                               | $C_{\text{LOAD}} \leq 50\text{ pF}$ , $R_{\text{LOAD}} \geq 5\text{ k}\Omega$ | -    | -    | 1           | MS/s |
| $I_{\text{skink}}$               | Output sink current                                                                                                                                                 | DAC buffer ON<br>Output level higher than 0.2 V                               | 100  | -    | -           | µA   |
| $t_{\text{WAKEUP}}^{(3)}$        | Wakeup time from off state<br>(Setting the ENx bit in the<br>DAC Control register)                                                                                  | $C_{\text{LOAD}} \leq 50\text{ pF}$ , $R_{\text{LOAD}} \geq 5\text{ k}\Omega$ | -    | 6.5  | 10          | µs   |
| PSRR <sup>+</sup> <sup>(1)</sup> | Power supply rejection ratio<br>(to $V_{DDA}$ ) (static DC<br>measurement)                                                                                          | No $R_{\text{LOAD}}$ , $C_{\text{LOAD}} = 50\text{ pF}$                       | -    | -67  | -40         | dB   |

1. Guaranteed by design, not tested in production.

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

3. Data based on characterization results, not tested in production.

Figure 32. 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.

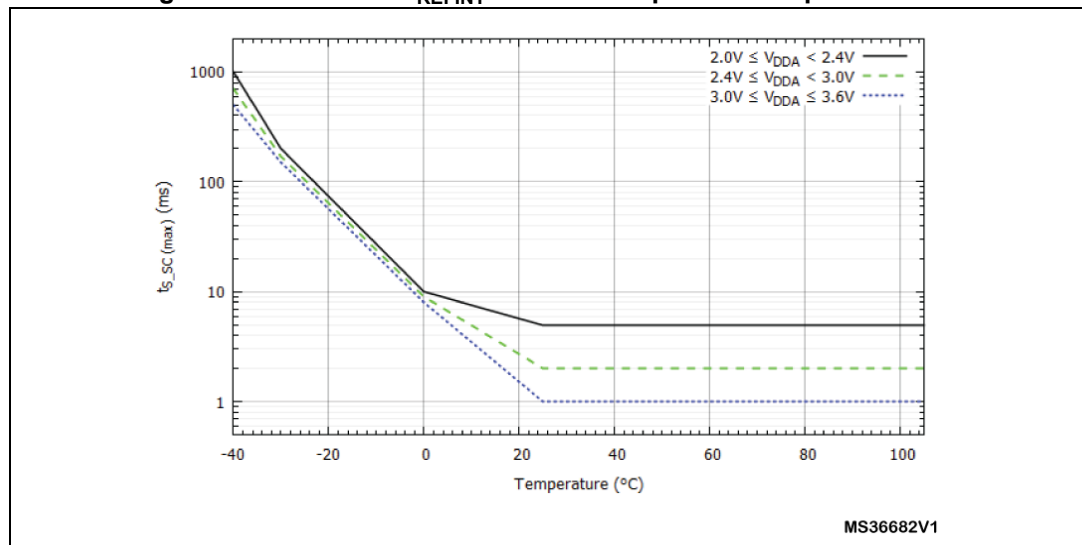
### 6.3.21 Comparator characteristics

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

| Symbol         | Parameter                                                   | Conditions                                                  | Min. | Typ.          | Max.             | Unit          |
|----------------|-------------------------------------------------------------|-------------------------------------------------------------|------|---------------|------------------|---------------|
| $V_{DDA}$      | Analog supply voltage                                       | -                                                           | 2    | -             | 3.6              | V             |
| $V_{IN}$       | Comparator input voltage range                              | -                                                           | 0    | -             | $V_{DDA}$        | -             |
| $V_{BG}$       | Scaler input voltage                                        | -                                                           | -    | $V_{REFINIT}$ | -                | -             |
| $V_{SC}$       | Scaler offset voltage                                       | -                                                           | -    | $\pm 5$       | $\pm 10$         | mV            |
| $t_{S\_SC}$    | $V_{REFINIT}$ scaler startup time from power down           | First $V_{REFINIT}$ scaler activation after device power on | -    | -             | 1 <sup>(2)</sup> | s             |
|                |                                                             | Next activations                                            | -    | -             | 0.2              | ms            |
| $t_{START}$    | Comparator startup time                                     | $V_{DDA} < 2.7\text{ V}$                                    | -    | -             | 4                | $\mu\text{s}$ |
|                |                                                             | $V_{DDA} < 2.7\text{ V}$                                    | -    | -             | 10               |               |
| $t_D$          | Propagation delay for 200 mV step with 100 mV overdrive     | $V_{DDA} \geq 2.7\text{ V}$                                 | -    | 25            | 28               | ns            |
|                |                                                             | $V_{DDA} < 2.7\text{ V}$                                    | -    | 28            | 30               |               |
|                | Propagation delay for full range step with 100 mV overdrive | $V_{DDA} \geq 2.7\text{ V}$                                 | -    | 32            | 35               |               |
|                |                                                             | $V_{DDA} < 2.7\text{ V}$                                    | -    | 35            | 40               |               |
| $V_{OFFSET}$   | Comparator offset error                                     | $V_{DDA} \geq 2.7\text{ V}$                                 | -    | $\pm 5$       | $\pm 10$         | mV            |
|                |                                                             | $V_{DDA} < 2.7\text{ V}$                                    | -    | -             | $\pm 25$         |               |
| $TV_{OFFSET}$  | Total offset variation                                      | Full temperature range                                      | -    | -             | 3                | mV            |
| $I_{DD(Comp)}$ | COMP current consumption                                    | -                                                           | -    | 400           | 600              | $\mu\text{A}$ |

1. Guaranteed by design, not tested in production.

2. For more details and conditions see [Figure 33: Maximum  \$V\_{REFINIT}\$  scaler startup time from power-down.](#)

Figure 33. Maximum  $V_{REFINT}$  scaler startup time from power-down

### 6.3.22 Operational amplifier characteristics

Table 71. Operational amplifier characteristics<sup>(1)</sup>

| Symbol                 | Parameter                    |                           | Condition                | Min. | Typ. | Max.             | Unit  |
|------------------------|------------------------------|---------------------------|--------------------------|------|------|------------------|-------|
| V <sub>DDA</sub>       | Analog supply voltage        |                           | -                        | 2.4  | -    | 3.6              | V     |
| CMIR                   | Common mode input range      |                           | -                        | 0    | -    | V <sub>DDA</sub> | V     |
| V <sub>I</sub> OFFSET  | Input offset voltage         | Maximum calibration range | 25°C, No Load on output. | -    | -    | 4                | mV    |
|                        |                              |                           | All voltage/Temp.        | -    | -    | 6                |       |
|                        |                              | After offset calibration  | 25°C, No Load on output. | -    | -    | 1.6              |       |
|                        |                              |                           | All voltage/Temp.        | -    | -    | 3                |       |
| ΔV <sub>I</sub> OFFSET | Input offset voltage drift   |                           | -                        | -    | 5    | -                | μV/°C |
| I <sub>LOAD</sub>      | Drive current                |                           | -                        | -    | -    | 500              | μA    |
| IDDOPAMP               | Consumption                  |                           | No load, quiescent mode  | -    | 690  | 1450             | μA    |
| CMRR                   | Common mode rejection ratio  |                           | -                        | -    | 90   | -                | dB    |
| PSRR                   | Power supply rejection ratio |                           | DC                       | 73   | 117  | -                | dB    |
| GBW                    | Bandwidth                    |                           | -                        | -    | 8.2  | -                | MHz   |
| SR                     | Slew rate                    |                           | -                        | -    | 4.7  | -                | V/μs  |
| R <sub>LOAD</sub>      | Resistive load               |                           | -                        | 4    | -    | -                | kΩ    |
| C <sub>LOAD</sub>      | Capacitive load              |                           | -                        | -    | -    | 50               | pF    |

Table 71. Operational amplifier characteristics<sup>(1)</sup> (continued)

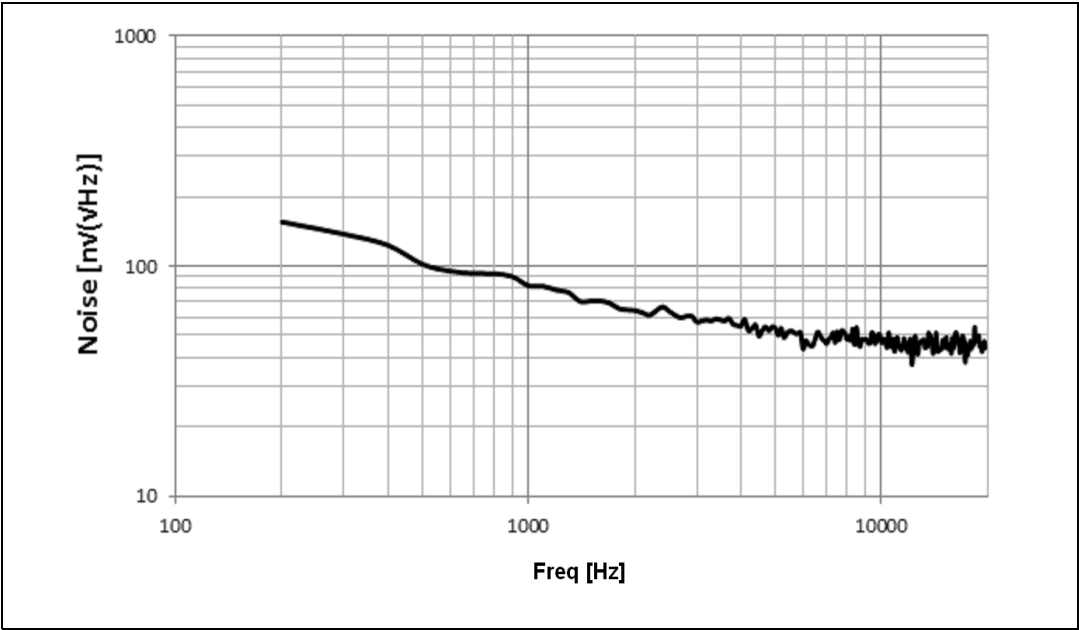
| Symbol                   | Parameter                                                                                               | Condition                                                                            | Min.                  | Typ.     | Max.                | Unit |
|--------------------------|---------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|-----------------------|----------|---------------------|------|
| VOH <sub>SAT</sub>       | High saturation voltage <sup>(2)</sup>                                                                  | R <sub>load</sub> = min,<br>Input at V <sub>DDA</sub> .                              | V <sub>DDA</sub> -100 | -        |                     | mV   |
|                          |                                                                                                         | R <sub>load</sub> = 20K,<br>Input at V <sub>DDA</sub> .                              | V <sub>DDA</sub> -20  | -        |                     |      |
| VOL <sub>SAT</sub>       | Low saturation voltage                                                                                  | R <sub>load</sub> = min,<br>input at 0 V                                             | -                     | -        | 100                 |      |
|                          |                                                                                                         | R <sub>load</sub> = 20K,<br>input at 0 V.                                            | -                     | -        | 20                  |      |
| φ <sub>m</sub>           | Phase margin                                                                                            | -                                                                                    | -                     | 62       | -                   | °    |
| t <sub>OFFTRIM</sub>     | Offset trim time: during calibration,<br>minimum time needed between two<br>steps to have 1 mV accuracy | -                                                                                    | -                     | -        | 2                   | ms   |
| t <sub>WAKEUP</sub>      | Wakeup time from OFF state.                                                                             | C <sub>LOAD</sub> ≤ 50 pF,<br>R <sub>LOAD</sub> ≥ 4 kΩ,<br>Follower<br>configuration | -                     | 2.8      | 5                   | μs   |
| t <sub>S_OPAM_VOUT</sub> | ADC sampling time when reading the OPAMP output                                                         |                                                                                      | 400                   | -        | -                   | ns   |
| PGA gain                 | Non inverting gain value                                                                                | -                                                                                    | -                     | 2        | -                   | -    |
|                          |                                                                                                         |                                                                                      | -                     | 4        | -                   | -    |
|                          |                                                                                                         |                                                                                      | -                     | 8        | -                   | -    |
|                          |                                                                                                         |                                                                                      | -                     | 16       | -                   | -    |
| R <sub>network</sub>     | R2/R1 internal resistance values in<br>PGA mode <sup>(3)</sup>                                          | Gain=2                                                                               | -                     | 5.4/5.4  | -                   | kΩ   |
|                          |                                                                                                         | Gain=4                                                                               | -                     | 16.2/5.4 | -                   |      |
|                          |                                                                                                         | Gain=8                                                                               | -                     | 37.8/5.4 | -                   |      |
|                          |                                                                                                         | Gain=16                                                                              | -                     | 40.5/2.7 | -                   |      |
| PGA gain error           | PGA gain error                                                                                          | -                                                                                    | -1%                   | -        | 1%                  | -    |
| I <sub>bias</sub>        | OPAMP input bias current                                                                                | -                                                                                    | -                     | -        | ±0.2 <sup>(4)</sup> | μA   |
| PGA BW                   | PGA bandwidth for different non<br>inverting gain                                                       | PGA Gain = 2,<br>C <sub>load</sub> = 50pF,<br>R <sub>load</sub> = 4 KΩ               | -                     | 4        | -                   | MHz  |
|                          |                                                                                                         | PGA Gain = 4,<br>C <sub>load</sub> = 50pF,<br>R <sub>load</sub> = 4 KΩ               | -                     | 2        | -                   |      |
|                          |                                                                                                         | PGA Gain = 8,<br>C <sub>load</sub> = 50pF,<br>R <sub>load</sub> = 4 KΩ               | -                     | 1        | -                   |      |
|                          |                                                                                                         | PGA Gain = 16,<br>C <sub>load</sub> = 50pF,<br>R <sub>load</sub> = 4 KΩ              | -                     | 0.5      | -                   |      |

Table 71. Operational amplifier characteristics<sup>(1)</sup> (continued)

| Symbol | Parameter             | Condition                        | Min. | Typ. | Max. | Unit                   |
|--------|-----------------------|----------------------------------|------|------|------|------------------------|
| en     | Voltage noise density | @ 1KHz, Output loaded with 4 KΩ  | -    | 109  | -    | $\frac{nV}{\sqrt{Hz}}$ |
|        |                       | @ 10KHz, Output loaded with 4 KΩ | -    | 43   | -    |                        |

- 1. Guaranteed by design, not tested in production.
- 2. The saturation voltage can also be limited by the I<sub>load</sub>.
- 3. R2 is the internal resistance between OPAMP output and OPAMP inverting input.  
R1 is the internal resistance between OPAMP inverting input and ground.  
The PGA gain = 1+R2/R1
- 4. Mostly TTA I/O leakage, when used in analog mode.

Figure 34. OPAMP voltage noise versus frequency



### 6.3.23 Temperature sensor (TS) characteristics

**Table 72. Temperature sensor (TS) characteristics**

| Symbol                   | Parameter                                      | Min. | Typ.    | Max.    | Unit  |
|--------------------------|------------------------------------------------|------|---------|---------|-------|
| $T_L^{(1)}$              | $V_{SENSE}$ linearity with temperature         | -    | $\pm 1$ | $\pm 2$ | °C    |
| Avg_Slope <sup>(1)</sup> | Average slope                                  | 4.0  | 4.3     | 4.6     | mV/°C |
| $V_{25}$                 | Voltage at 25 °C                               | 1.34 | 1.43    | 1.52    | V     |
| $t_{START}^{(1)}$        | Startup time                                   | 4    | -       | 10      | µs    |
| $T_{S\_temp}^{(1)(2)}$   | ADC sampling time when reading the temperature | 2.2  | -       | -       | µs    |

1. Guaranteed by design, not tested in production.

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

**Table 73. Temperature sensor (TS) calibration values**

| Calibration value name | Description                                                         | Memory address            |
|------------------------|---------------------------------------------------------------------|---------------------------|
| TS_CAL1                | TS ADC raw data acquired at temperature of 30 °C, $V_{DDA} = 3.3$ V | 0x1FFF F7B8 - 0x1FFF F7B9 |
| TS_CAL2                | TS ADC raw data acquired at temperature of 110 °C $V_{DDA} = 3.3$ V | 0x1FFF F7C2 - 0x1FFF F7C3 |

### 6.3.24 $V_{BAT}$ monitoring characteristics

**Table 74.  $V_{BAT}$  monitoring characteristics**

| Symbol                 | Parameter                                                    | Min. | Typ. | Max. | Unit |
|------------------------|--------------------------------------------------------------|------|------|------|------|
| R                      | Resistor bridge for $V_{BAT}$                                | -    | 50   | -    | KΩ   |
| Q                      | Ratio on $V_{BAT}$ measurement                               | -    | 2    | -    | -    |
| $Er^{(1)}$             | Error on Q                                                   | -1   | -    | +1   | %    |
| $T_{S\_vbat}^{(1)(2)}$ | ADC sampling time when reading the $V_{BAT}$<br>1mV accuracy | 2.2  | -    | -    | µs   |

1. Guaranteed by design, not tested in production.

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

## 7 Package information

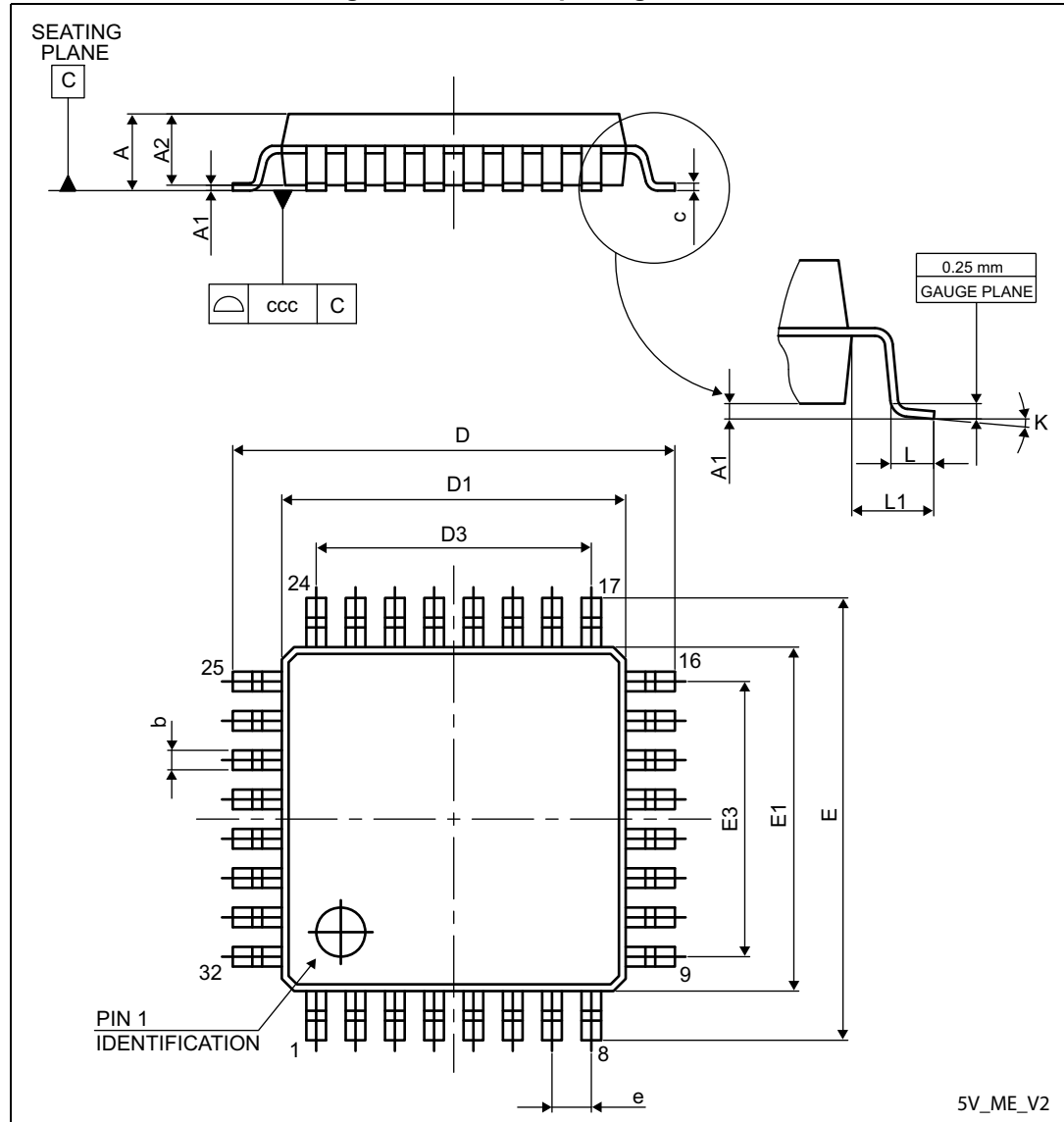
### 7.1 Package mechanical data

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

## 7.2 LQFP32 package information

LQFP32 is a 32-pin, 7 x 7mm low-profile quad flat package.

**Figure 35. LQFP32 package outline**



1. Drawing is not to scale.

**Table 75. LQFP32 mechanical data**

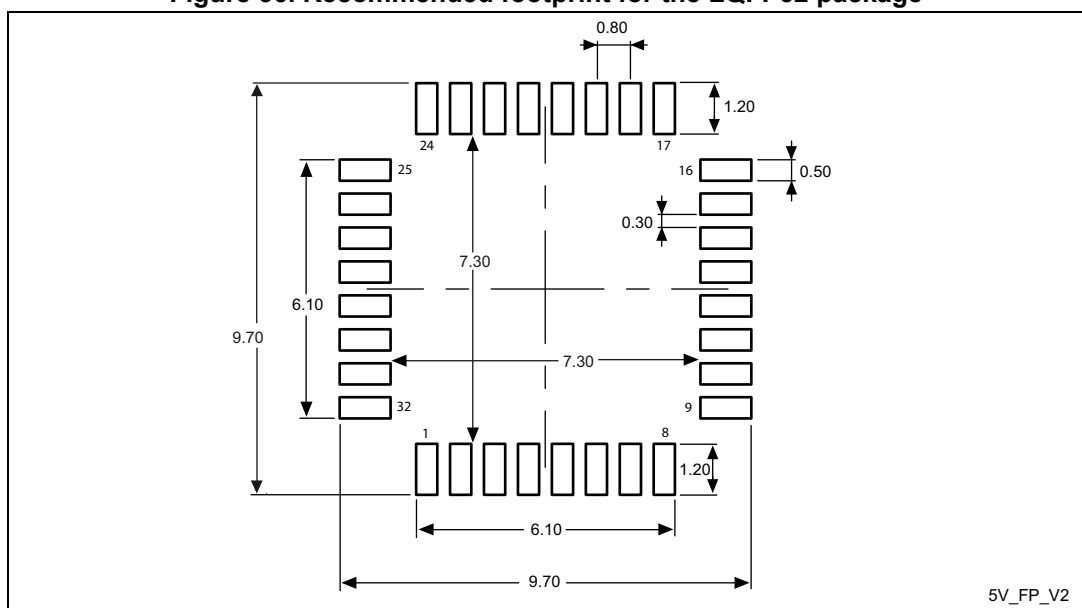
| Symbol | Millimeters |       |       | Inches <sup>(1)</sup> |        |        |
|--------|-------------|-------|-------|-----------------------|--------|--------|
|        | Min.        | Typ.  | Max.  | Min.                  | Typ.   | Max.   |
| A      | -           | -     | 1.600 | -                     | -      | 0.0630 |
| A1     | 0.050       | -     | 0.150 | 0.0020                | -      | 0.0059 |
| A2     | 1.350       | 1.400 | 1.450 | 0.0531                | 0.0551 | 0.0571 |

Table 75. LQFP32 mechanical data (continued)

| Symbol | Millimeters |       |       | Inches <sup>(1)</sup> |        |        |
|--------|-------------|-------|-------|-----------------------|--------|--------|
|        | Min.        | Typ.  | Max.  | Min.                  | Typ.   | Max.   |
| b      | 0.300       | 0.370 | 0.450 | 0.0118                | 0.0146 | 0.0177 |
| 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     | -           | 5.600 | -     | -                     | 0.2205 | -      |
| 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     | -           | 5.600 | -     | -                     | 0.2205 | -      |
| e      | -           | 0.800 | -     | -                     | 0.0315 | -      |
| 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    | -           | -     | 0.100 | -                     | -      | 0.0039 |

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

Figure 36. Recommended footprint for the LQFP32 package



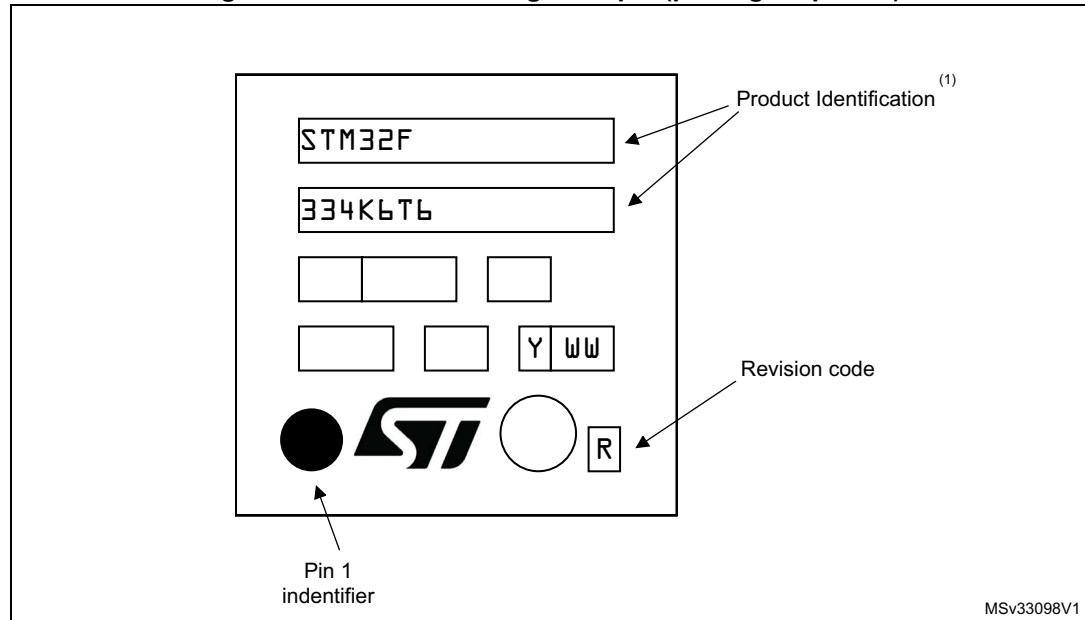
1. Drawing is not to scale.
2. Dimensions are expressed in millimeters.

### Device marking for LQFP32

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

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

**Figure 37. LQFP32 marking example (package top view)**

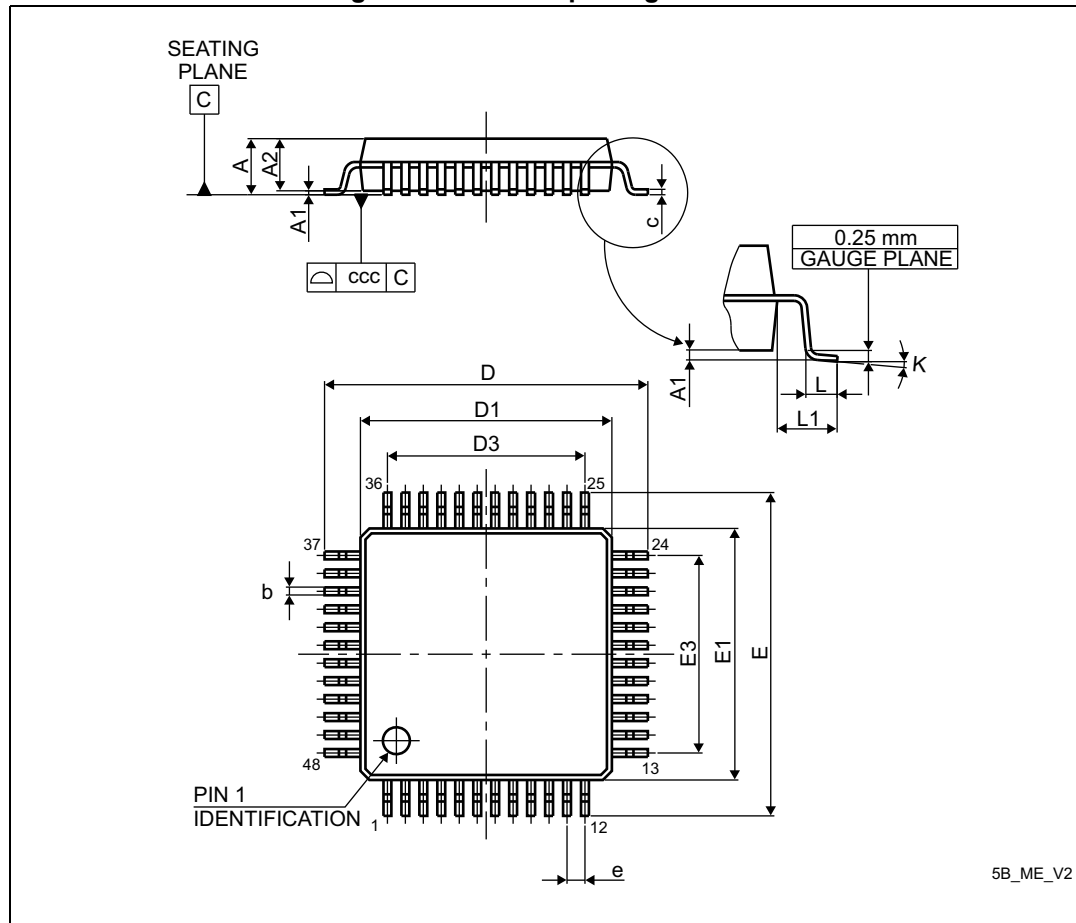


1. Parts marked as ES or E or accompanied by an Engineering Sample notification letter are not yet qualified and therefore not approved for use in production. ST is not responsible for any consequences resulting from such use. In no event will ST be liable for the customer using any of these engineering samples in production. ST's Quality department must be contacted prior to any decision to use these engineering samples to run a qualification activity.

### 7.3 LQFP48 package information

LQFP48 is a 48-pin, 7 x 7mm low-profile quad flat package.

**Figure 38. LQFP48 package outline**



1. Drawing is not to scale.

**Table 76. LQFP48 package mechanical data**

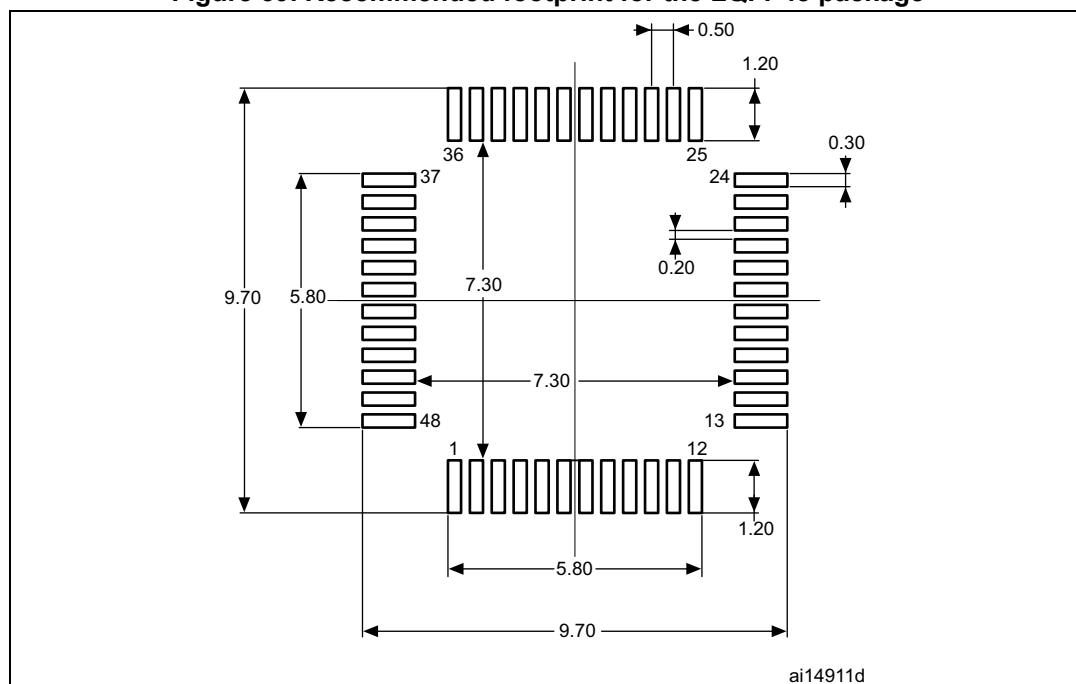
| Symbol | millimeters |       |       | inches <sup>(1)</sup> |        |        |
|--------|-------------|-------|-------|-----------------------|--------|--------|
|        | Min         | Typ   | Max   | Min                   | Typ    | Max    |
| A      | -           | -     | 1.600 | -                     | -      | 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 | -      |

Table 76. LQFP48 package mechanical data (continued)

| Symbol | millimeters |       |       | inches <sup>(1)</sup> |        |        |
|--------|-------------|-------|-------|-----------------------|--------|--------|
|        | Min         | Typ   | Max   | Min                   | Typ    | Max    |
| 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 39. Recommended footprint for the LQFP48 package



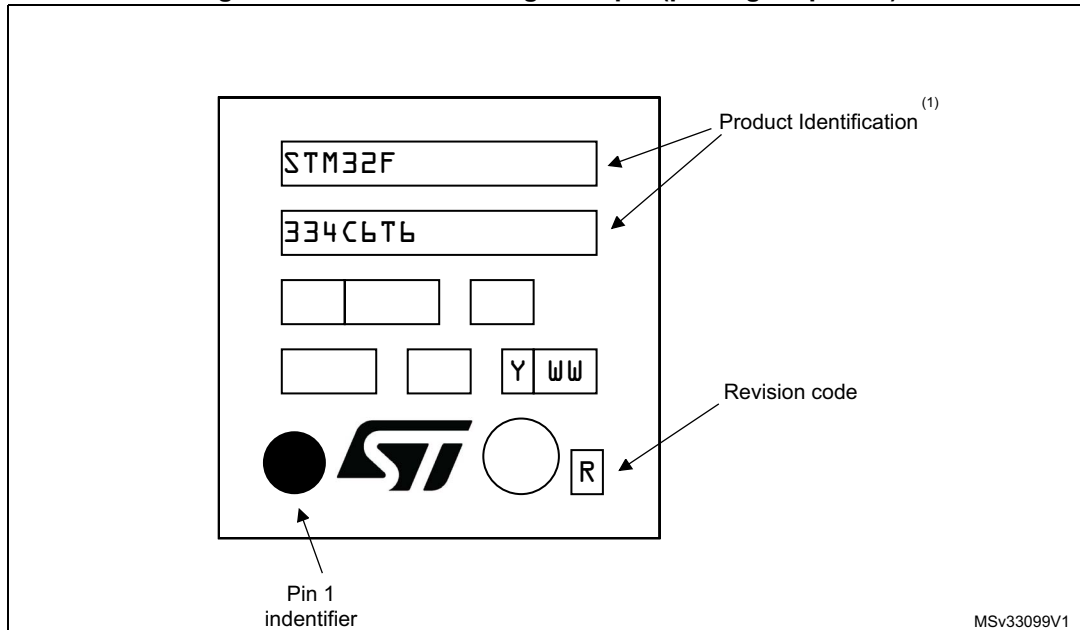
1. Drawing is not to scale.
2. Dimensions are in millimeters.

### Device marking for LQFP48

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

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

**Figure 40. LQFP48 marking example (package top view)**

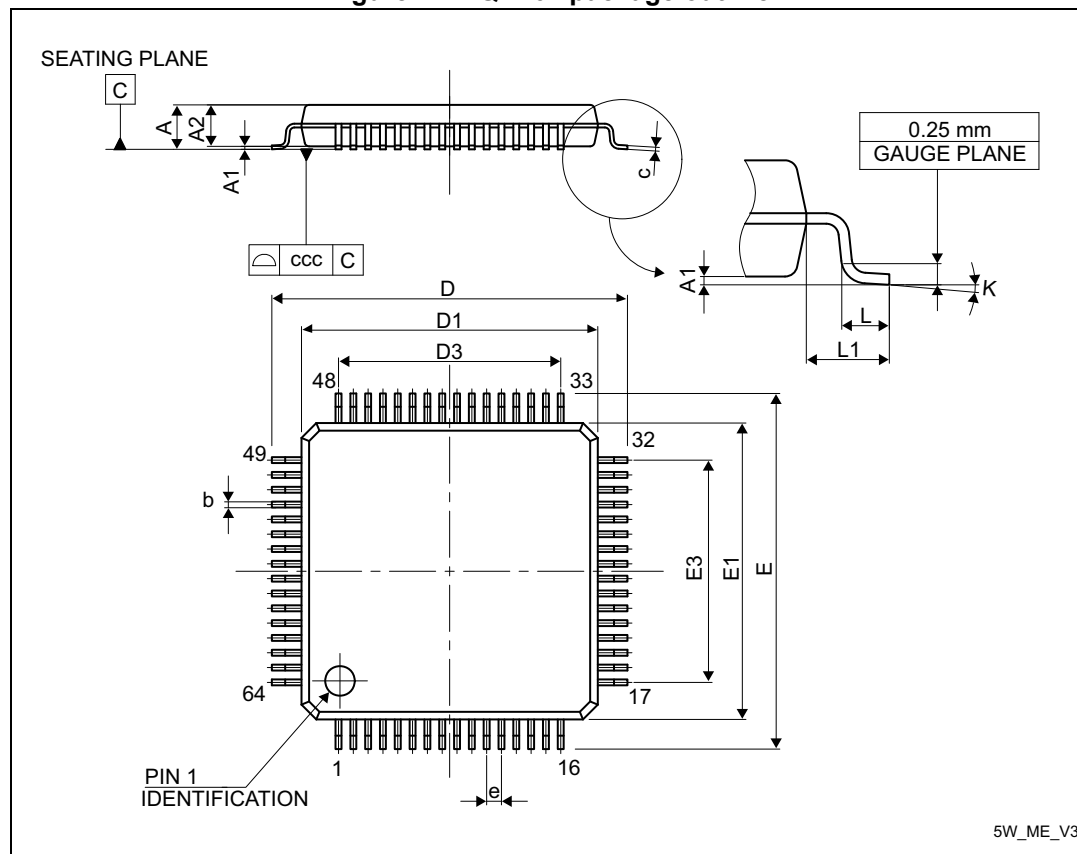


1. Parts marked as ES or E or accompanied by an Engineering Sample notification letter are not yet qualified and therefore not approved for use in production. ST is not responsible for any consequences resulting from such use. In no event will ST be liable for the customer using any of these engineering samples in production. ST's Quality department must be contacted prior to any decision to use these engineering samples to run a qualification activity.

## 7.4 LQFP64 package information

LQFP64 is a 64-pin, 10 x 10 mm low-profile quad flat package.

Figure 41. LQFP64 package outline



1. Drawing is not to scale.

Table 77. LQFP64 package mechanical data

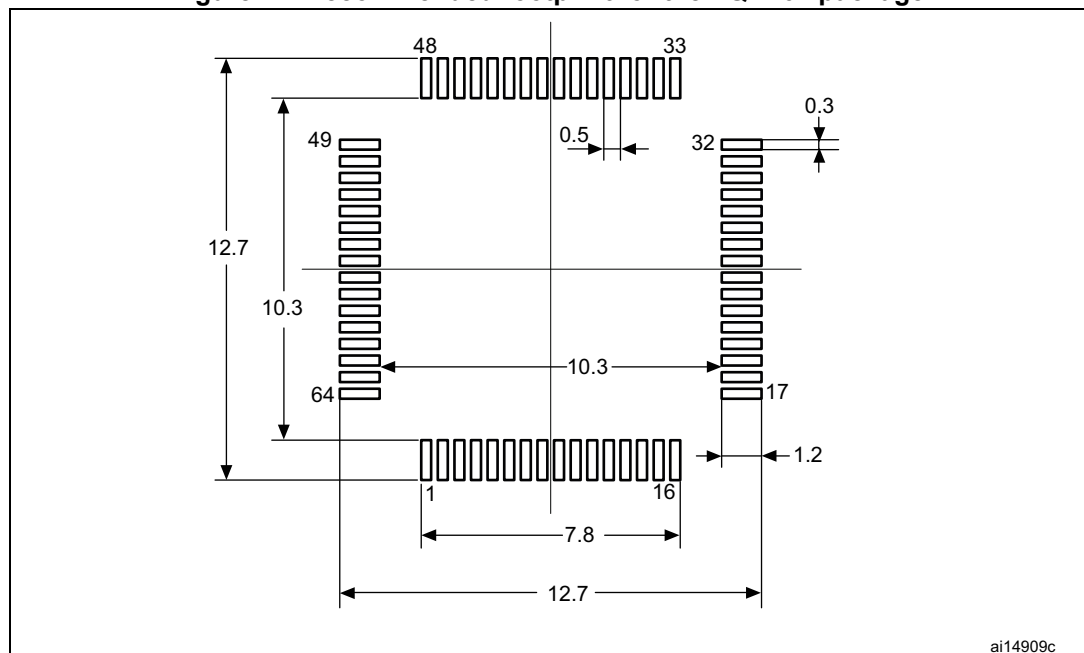
| Symbol | millimeters |        |       | inches <sup>(1)</sup> |        |        |
|--------|-------------|--------|-------|-----------------------|--------|--------|
|        | Min         | Typ    | Max   | Min                   | Typ    | Max    |
| A      | -           | -      | 1.600 | -                     | -      | 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      | 11.800      | 12.000 | -     | -                     | 0.4724 | -      |
| D1     | 9.800       | 10.000 | -     | -                     | 0.3937 | -      |
| E      | -           | 12.000 | -     | -                     | 0.4724 | -      |
| E1     | -           | 10.000 | -     | -                     | 0.3937 | -      |
| e      | -           | 0.500  | -     | -                     | 0.0197 | -      |

**Table 77. LQFP64 package mechanical data (continued)**

| Symbol | millimeters    |       |       | inches <sup>(1)</sup> |        |        |
|--------|----------------|-------|-------|-----------------------|--------|--------|
|        | Min            | Typ   | Max   | Min                   | Typ    | Max    |
| θ      | 0°             | 3.5°  | 7°    | 0°                    | 3.5°   | 7°     |
| L      | 0.450          | 0.600 | 0.750 | 0.0177                | 0.0236 | 0.0295 |
| L1     | -              | 1.000 | -     | -                     | 0.0394 | -      |
| N      | Number of pins |       |       |                       |        |        |
|        | 64             |       |       |                       |        |        |

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

**Figure 42. Recommended footprint for the LQFP64 package**



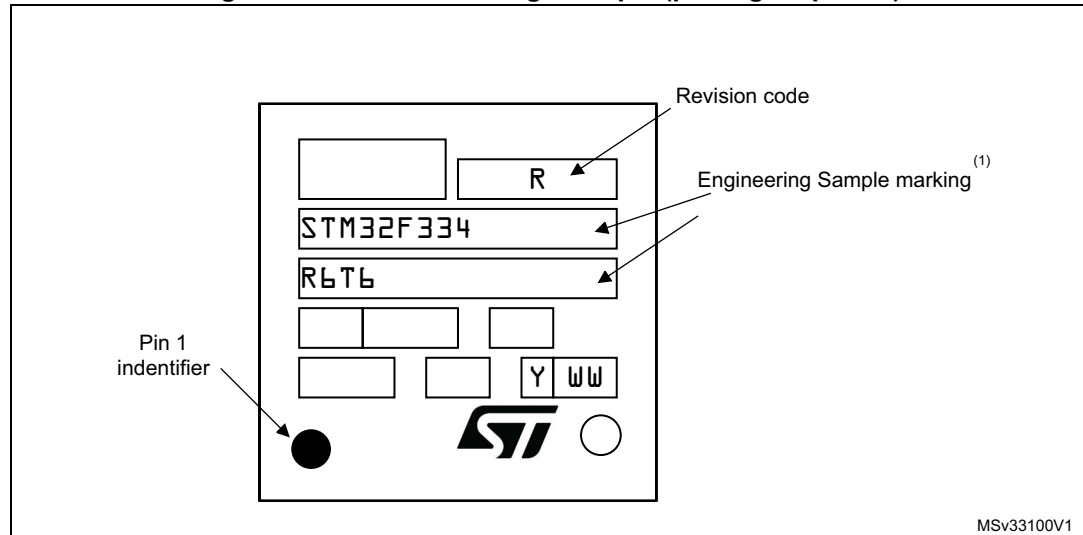
1. Drawing is not to scale.
2. Dimensions are in millimeters.

### Device marking for LQFP64

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

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

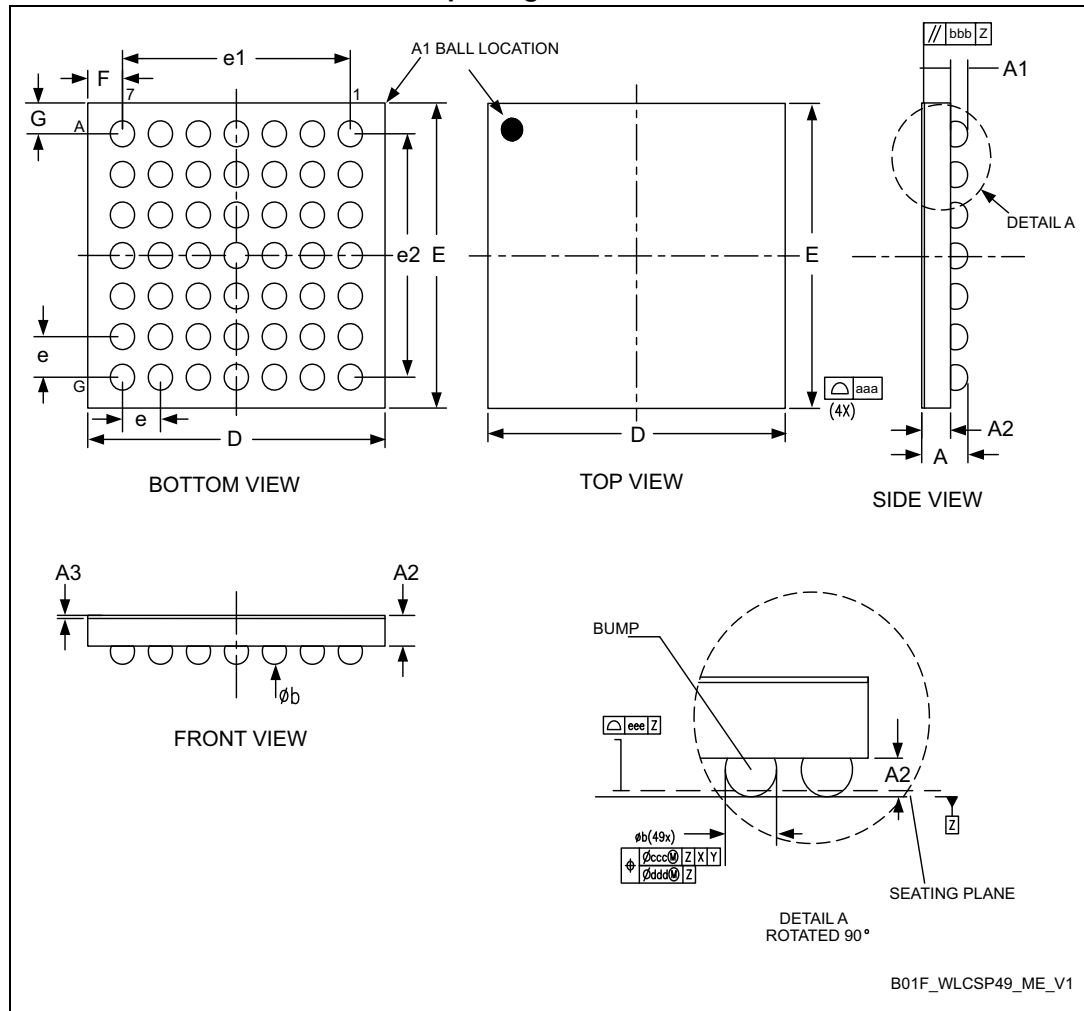
**Figure 43. LQFP64 marking example (package top view)**



1. Parts marked as ES or E or accompanied by an Engineering Sample notification letter are not yet qualified and therefore not approved for use in production. ST is not responsible for any consequences resulting from such use. In no event will ST be liable for the customer using any of these engineering samples in production. ST's Quality department must be contacted prior to any decision to use these engineering samples to run a qualification activity.

## 7.5 WLCSP49 package information

Figure 44. WLCSP - 49 ball, 3.89x3.74 mm, 0.5 mm pitch, wafer level chip scale, package outline

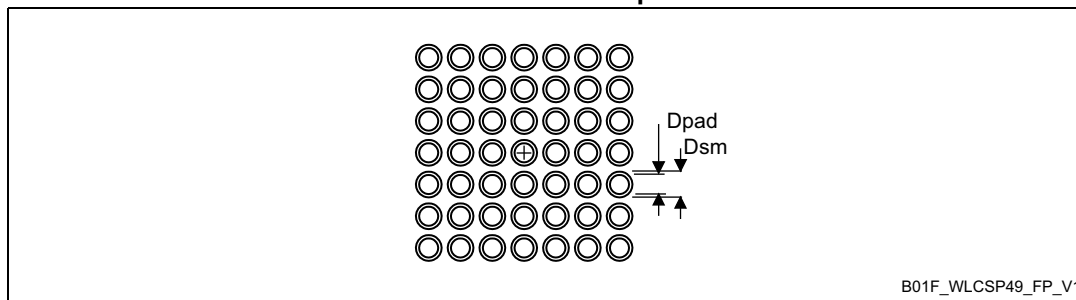


1. Dimension is measured at the maximum bump diameter parallel to primary datum Z.
2. Primary datum Z and seating plane are defined by the spherical crowns of the bump.
3. Bump position designation per JESD 95-1, SPP-010.

**Table 78. WLCSP - 49 ball, 3.89x3.74 mm, 0.5 mm pitch, wafer level chip scale, mechanical data**

| Symbol | millimeters |                      |      | inches <sup>(1)</sup> |       |        |
|--------|-------------|----------------------|------|-----------------------|-------|--------|
|        | Min         | Typ                  | Max  | Min                   | Typ   | Max    |
| A      | -           | -                    | 0.62 | -                     | -     | 0.0244 |
| A1     | -           | 0.23                 | -    | -                     | 0.009 | -      |
| A2     | -           | 0.36                 | -    | -                     | 0.014 | -      |
| A3     | -           | 0.025 <sup>(2)</sup> | -    | -                     | 0.001 | -      |
| b      | 0.30        | 0.33                 | 0.36 | 0.012                 | 0.013 | 0.014  |
| D      | 3.87        | 3.89                 | 3.91 | 0.152                 | 0.153 | 0.154  |
| E      | 3.72        | 3.74                 | 3.76 | 0.146                 | 0.147 | 0.148  |
| e      | -           | 0.50                 | -    | -                     | 0.020 | -      |
| e1     | -           | 3.00                 | -    | -                     | 0.118 | -      |
| e2     | -           | 3.00                 | -    | -                     | 0.118 | -      |
| F      | -           | 0.445 <sup>(3)</sup> | -    | -                     | 0.017 | -      |
| G      | -           | 0.370 <sup>(4)</sup> | -    | -                     | 0.015 | -      |
| aaa    | -           | -                    | 0.10 | -                     | -     | 0.004  |
| bbb    | -           | -                    | 0.10 | -                     | -     | 0.004  |
| ccc    | -           | -                    | 0.10 | -                     | -     | 0.004  |
| ddd    | -           | -                    | 0.05 | -                     | -     | 0.002  |
| eee    | -           | -                    | 0.05 | -                     | -     | 0.002  |

1. Values in inches are converted from mm and rounded to 4 decimal digits.
2. A3 value is guaranteed by technology design value.
3. This value is calculated from over value D and e1.
4. This value is calculated from over value E and e2.

**Figure 45. WLCSP - 49 ball, 3.89x3.74 mm, 0.5 mm pitch, wafer level chip scale, recommended footprint**

1. Dimensions are expressed in millimeters.

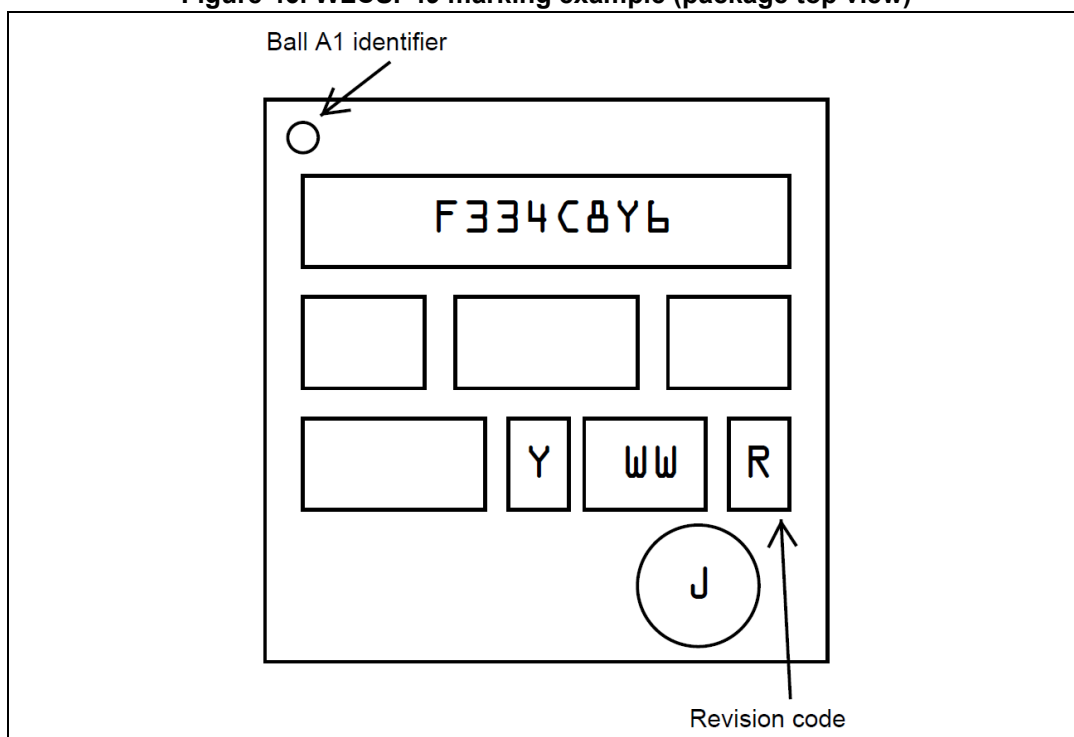
**Table 79. WLCSP - 49 ball, 3.89x3.74 mm, 0.5 mm pitch, wafer level chip scale, recommended PCB design rules**

| Dimension         | Recommended values                                               |
|-------------------|------------------------------------------------------------------|
| Pitch             | 0.5 mm                                                           |
| Dpad              | 0.290 mm                                                         |
| Dsm               | 0.350 mm typ. (depends on the soldermask registration tolerance) |
| Stencil opening   | 0.310 mm                                                         |
| Stencil thickness | 0.100 mm                                                         |

**Device marking**

The following figure gives an example of topside marking orientation versus ball A1 identifier location.

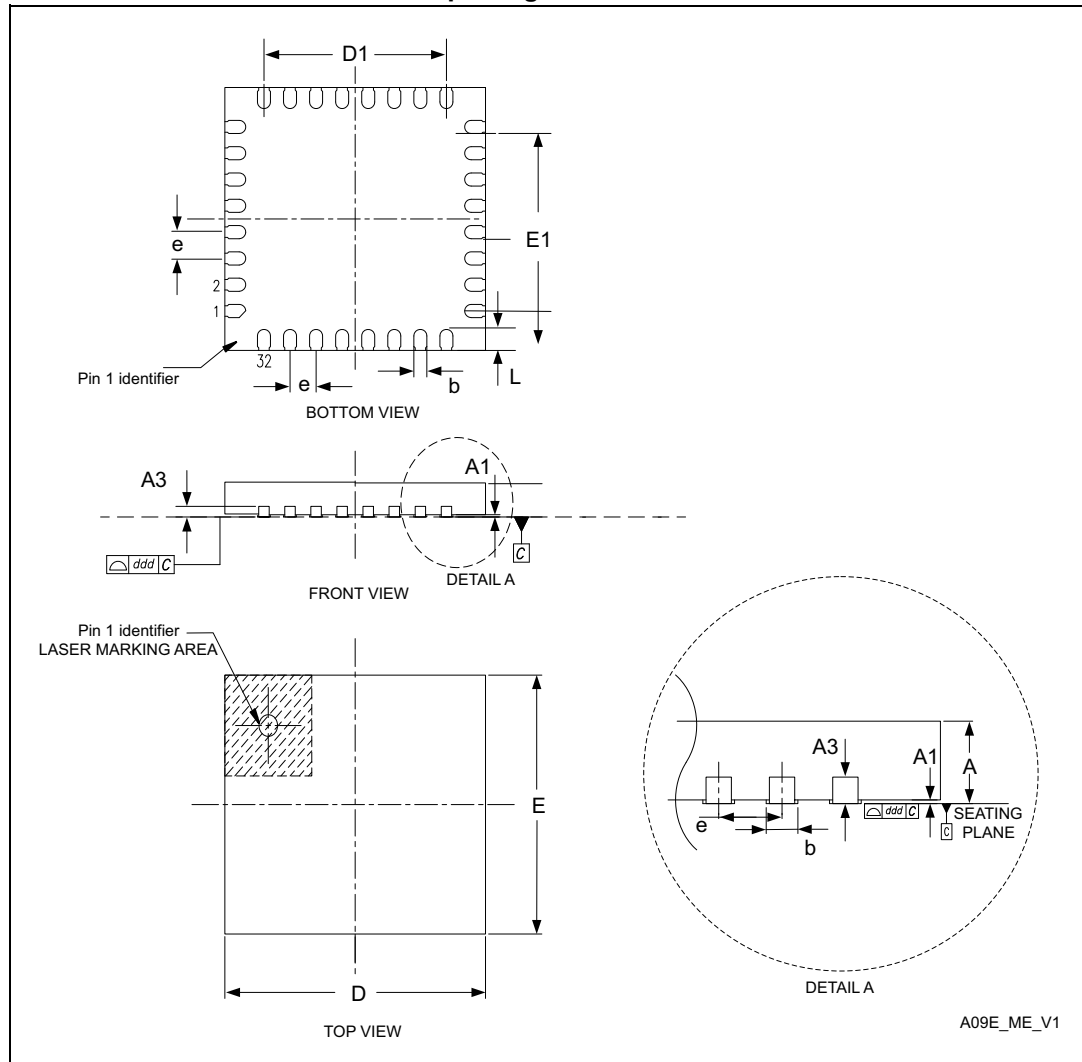
Other optional marking or inset/upset marks, which identify the parts throughout supply chain operations, are not indicated below.

**Figure 46. WLCSP49 marking example (package top view)**

1. Parts marked as ES or E or accompanied by an Engineering Sample notification letter are not yet qualified and therefore not approved for use in production. ST is not responsible for any consequences resulting from such use. In no event will ST be liable for the customer using any of these engineering samples in production. ST's Quality department must be contacted prior to any decision to use these engineering samples to run a qualification activity.

## 7.6 UFQFPN32 package information

Figure 47. UFQFPN - 32 pin, 5 x 5 mm 0.5 mm pitch ultra thin fine pitch quad flat package outline



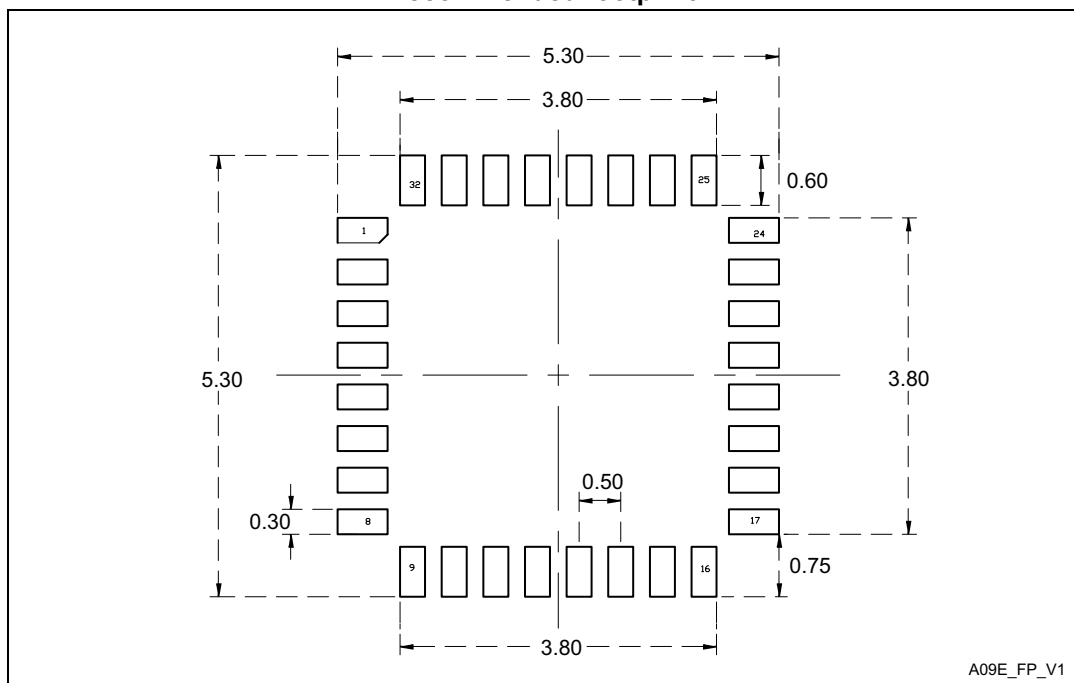
1. Drawing is not in scale.

**Table 80. UFQFPN - 32 pin, 5 x 5 mm 0.5 mm pitch ultra thin fine pitch quad flat mechanical data**

| Symbol           | millimeters |       |       | inches <sup>(1)</sup> |        |        |
|------------------|-------------|-------|-------|-----------------------|--------|--------|
|                  | Min         | Typ   | Max   | Min                   | Typ    | Max    |
| A <sup>(2)</sup> | 0.500       | 0.550 | 0.600 | 0.0197                | 0.0217 | 0.0236 |
| A1               | 0           | 0.020 | 0.050 | 0                     | 0.0008 | 0.0020 |
| A3               | -           | 0.152 | -     | -                     | 0.0060 | -      |
| b                | 0.180       | 0.250 | 0.280 | 0.0071                | 0.0098 | 0.0110 |
| D <sup>(3)</sup> | 4.900       | 5.000 | 5.100 | 0.1929                | 0.1969 | 0.2008 |
| D1               | 3.400       | 3.500 | 3.600 | 0.1339                | 0.1378 | 0.1417 |
| E <sup>(3)</sup> | 4.900       | 5.000 | 5.100 | 0.1929                | 0.1969 | 0.2008 |
| E1               | 3.400       | 3.500 | 3.600 | 0.1339                | 0.1378 | 0.1417 |
| e                | -           | 0.500 | -     | -                     | 0.0197 | -      |
| L                | 0.300       | 0.400 | 0.500 | 0.0118                | 0.0157 | 0.0197 |
| ddd              | -           | -     | 0.080 | -                     | -      | 0.0031 |

1. Values in inches are converted from mm and rounded to 4 decimal digits.
2. UFQFPN stands for Thermally Enhanced Ultrathin Fine pitch Quad Flat Package No lead.
3. Dimensions D and E do not include mold protrusion, not to exceed 0,15mm.

**Figure 48. UFQFPN - 32 pin, 5 x 5 mm 0.5 mm pitch ultra thin fine pitch quad flat recommended footprint**



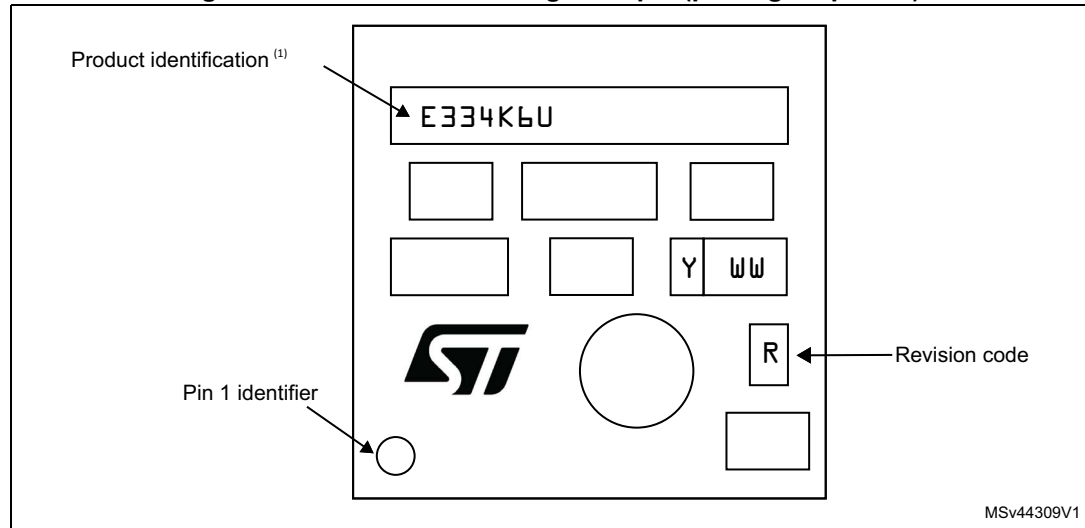
1. Dimensions are expressed in millimeters.

## Device marking

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

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

**Figure 49. UFQFPN32 marking example (package top view)**



1. Parts marked as ES or E or accompanied by an Engineering Sample notification letter are not yet qualified and therefore not approved for use in production. ST is not responsible for any consequences resulting from such use. In no event will ST be liable for the customer using any of these engineering samples in production. ST's Quality department must be contacted prior to any decision to use these engineering samples to run a qualification activity.

## 7.7 Thermal characteristics

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

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

Where:

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

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

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

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

**Table 81. 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 / 0.5 mm pitch        | 55    |      |
|               | <b>Thermal resistance junction-ambient</b><br>LQFP32 - 7 × 7 mm / 0.8 mm pitch        | 60    |      |
|               | <b>Thermal resistance junction-ambient</b><br>UFQFN32 - 5 × 5 mm                      | 37    |      |
|               | <b>Thermal resistance junction-ambient</b><br>WLCSP49 - 3.89 × 3.74 mm / 0.5 mm pitch | 48.3  |      |

### 7.7.1 Reference document

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

### 7.7.2 Selecting the product temperature range

When ordering the microcontroller, the temperature range is specified in the ordering information scheme shown in [Table 82: Ordering information scheme](#).

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 STM32F334x4/6/8 microcontroller at maximum dissipation, it is useful to calculate the exact power consumption and junction temperature to determine which temperature range is best suited to the application.

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

### Example: high-performance application

Assuming the following application conditions:

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

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

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

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

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

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

Using the values obtained in [Table 81: Package thermal characteristics](#),  $T_{Jmax}$  is calculated as follows:

– For LQFP64,  $45\text{ }^{\circ}\text{C/W}$

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

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

In this case, parts must be ordered at least with the temperature range suffix 6 (see [Table 82: Ordering information scheme](#)).

# 8      Ordering information

Table 82. Ordering information scheme

|                                                   |       |   |     |   |   |   |   |     |
|---------------------------------------------------|-------|---|-----|---|---|---|---|-----|
| Example:                                          | STM32 | F | 334 | C | 8 | T | 6 | xxx |
| <b>Device family</b>                              |       |   |     |   |   |   |   |     |
| STM32 = Arm®-based 32-bit microcontroller         |       |   |     |   |   |   |   |     |
| <b>Product type</b>                               |       |   |     |   |   |   |   |     |
| F = general-purpose                               |       |   |     |   |   |   |   |     |
| <b>Device subfamily</b>                           |       |   |     |   |   |   |   |     |
| 334 = STM32F334xx, 2.0 to 3.6 V operating voltage |       |   |     |   |   |   |   |     |
| <b>Pin count</b>                                  |       |   |     |   |   |   |   |     |
| K = 32 pins                                       |       |   |     |   |   |   |   |     |
| C = 48 or 49 pins                                 |       |   |     |   |   |   |   |     |
| R = 64 pins                                       |       |   |     |   |   |   |   |     |
| <b>Flash memory size</b>                          |       |   |     |   |   |   |   |     |
| 4 = 16 Kbytes of Flash memory                     |       |   |     |   |   |   |   |     |
| 6 = 32 Kbytes of Flash memory                     |       |   |     |   |   |   |   |     |
| 8 = 64 Kbytes of Flash memory                     |       |   |     |   |   |   |   |     |
| <b>Package</b>                                    |       |   |     |   |   |   |   |     |
| T = LQFP                                          |       |   |     |   |   |   |   |     |
| Y = WLCSP                                         |       |   |     |   |   |   |   |     |
| U = UFQFPN                                        |       |   |     |   |   |   |   |     |
| <b>Temperature range</b>                          |       |   |     |   |   |   |   |     |
| 6 = Industrial temperature range, –40 to 85 °C    |       |   |     |   |   |   |   |     |
| 7 = Industrial temperature range, –40 to 105 °C   |       |   |     |   |   |   |   |     |
| <b>Options</b>                                    |       |   |     |   |   |   |   |     |
| xxx = programmed parts                            |       |   |     |   |   |   |   |     |
| TR = tape and reel                                |       |   |     |   |   |   |   |     |

## 9 Revision history

**Table 83. Document revision history**

| Date        | Revision | Changes                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|-------------|----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 19-Jun-2014 | 1        | Initial release.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| 09-Dec-2014 | 2        | Updated:<br><ul style="list-style-type: none"> <li>– Table 54: TIMx characteristics</li> <li>– Table 14: STM32F334x6/8 pin definitions</li> <li>– Table 59: ADC characteristics</li> <li>– Table 34: Peripheral current consumption</li> <li>– Table 40: HSI oscillator characteristics</li> <li>– Table 17: HSI oscillator accuracy characterization results for soldered parts</li> <li>– Table 2: STM32F334x4/6/8 family device features and peripheral counts</li> </ul>                                                                    |
| 2-Feb-2015  | 3        | Updated:<br><ul style="list-style-type: none"> <li>– <i>Figure 1: STM32F334x4/6/8 block diagram</i></li> <li>– <i>Table 38: HSE oscillator characteristics</i></li> <li>– <i>Table 43: Flash memory characteristics</i></li> </ul> Added <i>Figure 15: High-speed external clock source AC timing diagram</i>                                                                                                                                                                                                                                   |
| 09-Jun-2015 | 4        | Updated:<br><ul style="list-style-type: none"> <li>– Title</li> <li>– <i>Section 3.14.1: 217 ps high-resolution timer (HRTIM1)</i></li> <li>– <i>Section 6.1.6: Power-supply scheme</i></li> <li>– <i>Table 19: General operating conditions</i></li> </ul>                                                                                                                                                                                                                                                                                     |
| 27-Sep-2016 | 5        | Updated:<br><i>Section Table 69.: DAC characteristics, Section Table 64.: ADC characteristics, Table 53: NRST pin characteristics, Figure 2: Clock tree, Table 13: STM32F334x4/6/8 pin definitions, Table 71: Operational amplifier characteristics, Figure 22: 5V- tolerant (FT and FTf) I/O input characteristics - CMOS port, Table 23: Embedded internal reference voltage, Table 39: LSE oscillator characteristics (<math>f_{LSE} = 32.768</math> kHz)</i><br>Added <i>Table 35: Wakeup time using USART.</i>                             |
| 15-May-2017 | 6        | Updated:<br><ul style="list-style-type: none"> <li>– <i>Table 2: STM32F334x4/6/8 family device features and peripheral counts</i></li> <li>– <i>Table 13: STM32F334x4/6/8 pin definitions</i></li> <li>– <i>Table 19: General operating conditions</i></li> <li>– <i>Table 81: Package thermal characteristics</i></li> <li>– <i>Table 82: Ordering information scheme</i></li> </ul> Added:<br><ul style="list-style-type: none"> <li>– <i>Figure 7: WLCSP49 ballout</i></li> <li>– <i>Section 7.5: WLCSP49 package information</i></li> </ul> |

Table 83. Document revision history (continued)

| Date         | Revision | Changes                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|--------------|----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 23-Nov--2017 | 7        | Updated:<br><ul style="list-style-type: none"> <li>– Footnotes of Table 25: Typical and maximum current consumption from <math>V_{DD}</math> supply at <math>V_{DD} = 3.6V</math></li> <li>– Footnotes of Table 26: Typical and maximum current consumption from the <math>V_{DDA}</math> supply</li> </ul>                                                                                                                                                                                     |
| 19-Dec-2017  | 8        | Updated Table 1: Device summary: STM32F334R4 product not covered by this datasheet                                                                                                                                                                                                                                                                                                                                                                                                              |
| 16-Jul-2018  | 9        | Updated:<br><ul style="list-style-type: none"> <li>– Table 2: STM32F334x4/6/8 family device features and peripheral counts</li> <li>– Table 13: STM32F334x4/6/8 pin definitions</li> <li>– Table 19: General operating conditions</li> <li>– Table 81: Package thermal characteristics</li> <li>– Table 82: Ordering information scheme</li> </ul> Added:<br><ul style="list-style-type: none"> <li>– Figure 8: UFQFPN32 pinout</li> <li>– Section 7.6: UFQFPN32 package information</li> </ul> |

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