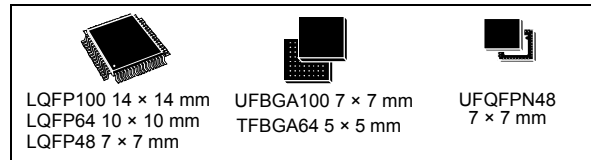


Ultra-low-power 32-bit MCU ARM[®]-based Cortex[®]-M3,
128KB Flash, 32KB SRAM, 4KB EEPROM, LCD, USB, ADC, DAC

Datasheet - production data

Features

- Ultra-low-power platform
 - 1.65 V to 3.6 V power supply
 - **-40°C to 105°C** temperature range
 - 0.28 µA Standby mode (3 wakeup pins)
 - **1.11 µA Standby mode + RTC**
 - 0.44 µA Stop mode (16 wakeup lines)
 - 1.38 µA Stop mode + RTC
 - 10.9 µA Low-power Run mode
 - 185 µA/MHz Run mode
 - 10 nA ultra-low I/O leakage
 - < 8 µs wakeup time
- Core: ARM[®] Cortex[®]-M3 32-bit CPU
 - From 32 kHz up to 32 MHz max
 - 1.25 DMIPS/MHz (Dhrystone 2.1)
 - Memory protection unit
- Reset and supply management
 - Ultra-safe, low-power BOR (brownout reset) with 5 selectable thresholds
 - Ultra-low-power POR/PDR
 - Programmable voltage detector (PVD)
- Clock sources
 - 1 to 24 MHz crystal oscillator
 - 32 kHz oscillator for RTC with calibration
 - High Speed Internal 16 MHz factory-trimmed RC (+/- 1%)
 - Internal low-power 37 kHz RC
 - Internal multispeed low-power 65 kHz to 4.2 MHz
 - PLL for CPU clock and USB (48 MHz)
- Pre-programmed bootloader
 - USART supported
- Development support
 - Serial wire debug supported
 - JTAG and trace supported
- Up to 83 fast I/Os (73 I/Os 5V tolerant), all mappable on 16 external interrupt vectors
- Memories
 - Up to 128 Kbytes Flash memory with ECC
 - Up to 32 Kbytes RAM
 - Up to 4 Kbytes of true EEPROM with ECC
 - 80-byte backup register



- LCD Driver (except STM32L151x6/8/B-A devices) for up to 8x40 segments
 - Support contrast adjustment
 - Support blinking mode
 - Step-up converter on board
- Rich analog peripherals (down to 1.8 V)
 - 12-bit ADC 1 Msps up to 24 channels
 - 12-bit DAC 2 channels with output buffers
 - 2x ultra-low-power-comparators (window mode and wake up capability)
- DMA controller 7x channels
- 8x peripheral communication interfaces
 - 1x USB 2.0 (internal 48 MHz PLL)
 - 3x USART (ISO 7816, IrDA)
 - 2x SPI 16 Mbits/s
 - 2x I2C (SMBus/PMBus)
- 10x timers: 6x 16-bit with up to 4 IC/OC/PWM channels, 2x 16-bit basic timers, 2x watchdog timers (independent and window)
- Up to 20 capacitive sensing channels supporting touchkey, linear and rotary touch sensors
- CRC calculation unit, 96-bit unique ID

Table 1. Device summary

| Reference | Part number |
|---|---|
| STM32L151CB-A, STM32L151C8-A, STM32L151C6-A, STM32L151RB-A, STM32L151R8-A, STM32L151R6-A, STM32L151VB-A, STM32L151V8-A | STM32L151CBxxA, STM32L151C8xxA, STM32L151C6xxA, STM32L151RBxxA, STM32L151R8xxA, STM32L151R6xxA, STM32L151VBxxA, STM32L151V8xxA |
| STM32L152CB-A, STM32L152C8-A, STM32L152C6-A, STM32L152RB-A, STM32L152R8-A, STM32L152R6-A, STM32L152VB-A, STM32L152V8-A | STM32L152CBxxA, STM32L152C8xxA, STM32L152C6xxA, STM32L152RBxxA, STM32L152R8xxA, STM32L152R6xxA, STM32L152VBxxA, STM32L152V8xxA |

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1 Introduction

This datasheet provides the ordering information and mechanical device characteristics of the STM32L151x6/8/B-A and STM32L152x6/8/B-A ultra-low-power ARM[®] Cortex[®]-M3 based microcontrollers product line.

The ultra-low-power STM32L151x6/8/B-A and STM32L152x6/8/B-A microcontroller family includes devices in 3 different package types: from 48 to 100 pins. Depending on the device chosen, different sets of peripherals are included, the description below gives an overview of the complete range of peripherals proposed in this family.

These features make the ultra-low-power STM32L151x6/8/B-A and STM32L152x6/8/B-A microcontroller family suitable for a wide range of applications:

- Medical and handheld equipment
- Application control and user interface
- PC peripherals, gaming, GPS and sport equipment
- Alarm systems, Wired and wireless sensors, Video intercom
- Utility metering

This STM32L151x6/8/B-A and STM32L152x6/8/B-A datasheet should be read in conjunction with the STM32L1xxxx reference manual (RM0038). The document "Getting started with STM32L1xxxx hardware development" AN3216 gives a hardware implementation overview.

Both documents are available from the STMicroelectronics website www.st.com.

For information on the ARM[®] Cortex[®]-M3 core please refer to the Cortex[®]-M3 Technical Reference Manual, available from the ARM website.

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

Caution: This datasheet does not apply to:
– STM32L15xx6/8/B
covered by a separate datasheet.

2 Description

The ultra-low-power STM32L151x6/8/B-A and STM32L152x6/8/B-A devices incorporate the connectivity power of the universal serial bus (USB) with the high-performance ARM[®] Cortex[®]-M3 32-bit RISC core operating at a frequency of 32 MHz (33.3 DMIPS), a memory protection unit (MPU), high-speed embedded memories (Flash memory up to 128 Kbytes and RAM up to 32 Kbytes) and an extensive range of enhanced I/Os and peripherals connected to two APB buses.

All the devices offer a 12-bit ADC, 2 DACs and 2 ultra-low-power comparators, six general-purpose 16-bit timers and two basic timers, which can be used as time bases.

Moreover, the STM32L151x6/8/B-A and STM32L152x6/8/B-A devices contain standard and advanced communication interfaces: up to two I²Cs and SPIs, three USARTs and a USB. The STM32L151x6/8/B-A and STM32L152x6/8/B-A devices offer up to 20 capacitive sensing channels to simply add touch sensing functionality to any application.

They also include a real-time clock with sub-second counting and a set of backup registers that remain powered in Standby mode.

Finally, the integrated LCD controller (except STM32L151x6/8/B-A devices) has a built-in LCD voltage generator that allows to drive up to 8 multiplexed LCDs with contrast independent of the supply voltage.

The ultra-low-power STM32L151x6/8/B-A and STM32L152x6/8/B-A devices operate from a 1.8 to 3.6 V power supply (down to 1.65 V at power down) with BOR and from a 1.65 to 3.6 V power supply without BOR option. They are available in the -40 to +85 °C and -40 to +105°C temperature ranges. A comprehensive set of power-saving modes allows the design of low-power applications.



2.1 Device overview

Table 2. Ultra-low-power STM32L151x6/8/B-A and STM32L152x6/8/B-A device features and peripheral counts

| Peripheral | | STM32L15xCxxxA | | | STM32L15xRxxxA | | | STM32L15xVxxxA | | |
|---|------------------|--|----|-----|--|----|-----|-------------------|-----|--|
| Flash (Kbytes) | | 32 | 64 | 128 | 32 | 64 | 128 | 64 | 128 | |
| Data EEPROM (Kbytes) | | 4 | | | | | | | | |
| RAM (Kbytes) | | 16 | 32 | 32 | 16 | 32 | 32 | 32 | 32 | |
| Timers | General-purpose | 6 | | | | | | | | |
| | Basic | 2 | | | | | | | | |
| Communication interfaces | SPI | 2 | | | | | | | | |
| | I ² C | 2 | | | | | | | | |
| | USART | 3 | | | | | | | | |
| | USB | 1 | | | | | | | | |
| GPIOs | | 37 | | | 51/50 ⁽¹⁾ | | | 83 | | |
| 12-bit synchronized ADC Number of channels | | 1 14 channels | | | 1 20/19 channels ⁽¹⁾ | | | 1 24 channels | | |
| 12-bit DAC Number of channels | | 2 2 | | | | | | | | |
| LCD (STM32L152xxxxA Only) COM x SEG | | 4x16 | | | 4x32/4x31 ⁽¹⁾ 8x28/8x27 ⁽¹⁾ | | | 4x44 8x40 | | |
| Comparator | | 2 | | | | | | | | |
| Capacitive sensing channels | | 13 | | | 20 | | | | | |
| Max. CPU frequency | | 32 MHz | | | | | | | | |
| Operating voltage | | 1.8 V to 3.6 V (down to 1.65 V at power-down) with BOR option 1.65 V to 3.6 V without BOR option | | | | | | | | |
| Operating temperatures | | Ambient operating temperatures: -40 to +85 °C / -40 to +105 °C Junction temperature: -40 to +110 °C | | | | | | | | |
| Packages | | LQFP48, UFQFPN48 | | | LQFP64, TFBGA64 | | | LQFP100, UFBGA100 | | |

1. For TFBGA64 package (instead of PC3 pin there is V_{REF+} pin).

2.2 Ultra-low-power device continuum

The ultra-low-power family offers a large choice of cores and features. From a proprietary 8-bit core up to the Cortex-M3, including the Cortex-M0+, the STM8Lx and STM32Lx series offer the best range of choices to meet your requirements in terms of ultra-low-power features. The STM32 Ultra-low-power series is an ideal fit for applications like gas/water meters, keyboard/mouse, or wearable devices for fitness and healthcare. Numerous built-in features like LCD drivers, dual-bank memory, low-power Run mode, op-amp, AES-128bit, DAC, crystal-less USB and many others, allow to build highly cost-optimized applications by reducing the BOM.

Note: STMicroelectronics as a reliable and long-term manufacturer ensures as much as possible the pin-to-pin compatibility between any STM8Lx and STM32Lx devices and between any of the STM32Lx and STM32Fx series. Thanks to this unprecedented scalability, your existing applications can be upgraded to respond to the latest market features and efficiency demand.

2.2.1 Performance

All families incorporate highly energy-efficient cores with both Harvard architecture and pipelined execution: advanced STM8 core for STM8L families and ARM Cortex-M3 core for STM32L family. In addition specific care for the design architecture has been taken to optimize the mA/DMIPS and mA/MHz ratios.

This allows the ultra-Low-power performance to range from 5 up to 33.3 DMIPs.

2.2.2 Shared peripherals

STM8L15xxx and STM32L1xxxx share identical peripherals which ensure a very easy migration from one family to another:

- Analog peripherals: ADC, DAC and comparators
- Digital peripherals: RTC and some communication interfaces

2.2.3 Common system strategy

To offer flexibility and optimize performance, the STM8L15xxx and STM32L1xxxx families use a common architecture:

- Common power supply range from 1.65 V to 3.6 V, (1.65 V at power down only for STM8L15xxx devices)
- Architecture optimized to reach ultra-low consumption both in low-power modes and Run mode
- Fast startup strategy from low-power modes
- Flexible system clock
- Ultra-safe reset: same reset strategy including power-on reset, power-down reset, brownout reset and programmable voltage detector.

2.2.4 Features

ST ultra-low-power continuum also lies in feature compatibility:

- More than 10 packages with pin count from 20 to 144 pins and size down to 3 x 3 mm
- Memory density ranging from 4 to 512 Kbytes

3.1 Low-power modes

The ultra-low-power STM32L151x6/8/B-A and STM32L152x6/8/B-A devices support dynamic voltage scaling to optimize its power consumption in run mode. The voltage from the internal low-drop regulator that supplies the logic can be adjusted according to the system's maximum operating frequency and the external voltage supply:

- In Range 1 (V_{DD} range limited to 1.71-3.6 V), the CPU runs at up to 32 MHz (refer to [Table 18](#) for consumption).
- In Range 2 (full V_{DD} range), the CPU runs at up to 16 MHz (refer to [Table 18](#) for consumption)
- In Range 3 (full V_{DD} range), the CPU runs at up to 4 MHz (generated only with the multispeed internal RC oscillator clock source). Refer to [Table 18](#) for consumption.

Seven low-power modes are provided 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.
Sleep mode power consumption: refer to [Table 20](#).
- **Low-power Run mode**
This mode is achieved with the multispeed internal (MSI) RC oscillator set to the MSI range 0 or MSI range 1 clock range (maximum 131 kHz), execution from SRAM or Flash memory, and internal regulator in low-power mode to minimize the regulator's operating current. In the low-power Run mode, the clock frequency and the number of enabled peripherals are both limited.
Low-power Run mode consumption: refer to [Table 21](#).
- **Low-power Sleep mode**
This mode is achieved by entering the Sleep mode with the internal voltage regulator in low-power mode to minimize the regulator's operating current. In the low-power Sleep mode, both the clock frequency and the number of enabled peripherals are limited; a typical example would be to have a timer running at 32 kHz.
When wakeup is triggered by an event or an interrupt, the system reverts to the run mode with the regulator on.
Low-power Sleep mode consumption: refer to [Table 22](#).
- **Stop mode with RTC**
Stop mode achieves the lowest power consumption while retaining the RAM and register contents and real time clock. All clocks in the V_{CORE} domain are stopped, the PLL, MSI RC, HSI RC and HSE crystal oscillators are disabled. The LSE or LSI is still running. The voltage regulator is in the low-power mode.
The device can be woken up from Stop mode by any of the EXTI line, in 8 μ s. The EXTI line source can be one of the 16 external lines. It can be the PVD output, the Comparator 1 event or Comparator 2 event (if internal reference voltage is on), it can be the RTC alarm(s), the USB wakeup, the RTC tamper events, the RTC timestamp event or the RTC wakeup.
- **Stop mode without RTC**
Stop mode achieves the lowest power consumption while retaining the RAM and register contents. All clocks are stopped, the PLL, MSI RC, HSI and LSI RC, LSE and HSE crystal oscillators are disabled. The voltage regulator is in the low-power mode.
The device can be woken up from Stop mode by any of the EXTI line, in 8 μ s. The EXTI

line source can be one of the 16 external lines. It can be the PVD output, the Comparator 1 event or Comparator 2 event (if internal reference voltage is on). It can also be wakened by the USB wakeup.

Stop mode consumption: refer to [Table 23](#).

- **Standby mode with RTC**

Standby mode is used to achieve the lowest power consumption and real time clock. The internal voltage regulator is switched off so that the entire V_{CORE} domain is powered off. The PLL, MSI RC, HSI RC and HSE crystal oscillators are also switched off. The LSE or LSI is still running. After entering Standby mode, the RAM and register contents are lost except for registers in the Standby circuitry (wakeup logic, IWDG, RTC, LSI, LSE Crystal 32K osc, RCC_CSR).

The device exits Standby mode in 60 μ s when an external reset (NRST pin), an IWDG reset, a rising edge on one of the three WKUP pins, RTC alarm (Alarm A or Alarm B), RTC tamper event, RTC timestamp event or RTC Wakeup event occurs.

- **Standby mode without RTC**

Standby mode is used to achieve the lowest power consumption. The internal voltage regulator is switched off so that the entire V_{CORE} domain is powered off. The PLL, MSI, RC, HSI and LSI RC, HSE and LSE crystal oscillators are also switched off. After entering Standby mode, the RAM and register contents are lost except for registers in the Standby circuitry (wakeup logic, IWDG, RTC, LSI, LSE Crystal 32K osc, RCC_CSR).

The device exits Standby mode in 60 μ s when an external reset (NRST pin) or a rising edge on one of the three WKUP pin occurs.

Standby mode consumption: refer to [Table 24](#).

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

Table 3. Functionalities depending on the operating power supply range

| Operating power supply range | Functionalities depending on the operating power supply range ⁽¹⁾ | | |
|---|--|---------------------------|-------------------------------|
| | DAC and ADC operation | USB | Dynamic voltage scaling range |
| $V_{DD} = 1.65$ to 1.71 V | Not functional | Not functional | Range 2 or Range 3 |
| $V_{DD} = 1.71$ to 1.8 V ⁽²⁾ | Not functional | Not functional | Range 1, Range 2 or Range 3 |
| $V_{DD} = 1.8$ to 2.0 V ⁽²⁾ | Conversion time up to 500 Ksps | Not functional | Range 1, Range 2 or Range 3 |
| $V_{DD} = 2.0$ to 2.4 V | Conversion time up to 500 Ksps | Functional ⁽³⁾ | Range 1, Range 2 or Range 3 |
| $V_{DD} = 2.4$ to 3.6 V | Conversion time up to 1 Msps | Functional ⁽³⁾ | Range 1, Range 2 or Range 3 |

1. The GPIO speed also depends from VDD voltage and the user has to refer to [Table 45: I/O AC characteristics](#) for more information about I/O speed.

2. CPU frequency changes from initial to final must respect " $F_{\text{CPU initial}} < 4 * F_{\text{CPU final}}$ " to limit V_{CORE} drop due to current consumption peak when frequency increases. It must also respect 5 μs delay between two changes. For example to switch from 4.2 MHz to 32 MHz, you can switch from 4.2 MHz to 16 MHz, wait 5 μs , then switch from 16 MHz to 32 MHz.
3. Should be USB-compliant from I/O voltage standpoint, the minimum V_{DD} is 3.0 V.

Table 4. CPU frequency range depending on dynamic voltage scaling

| CPU frequency range | Dynamic voltage scaling range |
|---|-------------------------------|
| 16 MHz to 32 MHz (1ws) 32 kHz to 16 MHz (0ws) | Range 1 |
| 8 MHz to 16 MHz (1ws) 32 kHz to 8 MHz (0ws) | Range 2 |
| 2.1 MHz to 4.2 MHz (1ws) 32 kHz to 2.1 MHz (0ws) | Range 3 |

Table 5. Working mode-dependent functionalities (from Run/active down to standby)

| Ips | Run/Active | Sleep | Low-power Run | Low-power Sleep | Stop | | Standby | |
|-------------------------------------|------------|-------|---------------|-----------------|-------------------|-------------------|---------|---|
| | | | | | Wakeup capability | Wakeup capability | | |
| CPU | Y | - | Y | - | - | - | - | - |
| Flash | Y | Y | Y | Y | - | - | - | - |
| RAM | Y | Y | Y | Y | Y | - | - | - |
| Backup Registers | Y | Y | Y | Y | Y | - | Y | - |
| EEPROM | Y | Y | Y | Y | Y | - | - | - |
| Brown-out reset (BOR) | Y | Y | Y | Y | Y | Y | Y | - |
| DMA | Y | Y | Y | Y | - | - | - | - |
| Programmable Voltage Detector (PVD) | Y | Y | Y | Y | Y | Y | Y | - |
| Power On Reset (POR) | Y | Y | Y | Y | Y | Y | Y | - |
| Power Down Rest (PDR) | Y | Y | Y | Y | Y | - | Y | - |
| High Speed Internal (HSI) | Y | Y | - | - | - | - | - | - |
| High Speed External (HSE) | Y | Y | - | - | - | - | - | - |
| Low Speed Internal (LSI) | Y | Y | Y | Y | Y | - | Y | - |
| Low Speed External (LSE) | Y | Y | Y | Y | Y | - | Y | - |
| Multi-Speed Internal (MSI) | Y | Y | Y | Y | - | - | - | - |
| Inter-Connect Controller | Y | Y | Y | Y | - | - | - | - |
| RTC | Y | Y | Y | Y | Y | Y | Y | - |
| RTC Tamper | Y | Y | Y | Y | Y | Y | Y | Y |
| Auto Wakeup (AWU) | Y | Y | Y | Y | Y | Y | Y | Y |
| LCD | Y | Y | Y | Y | Y | - | - | - |
| USB | Y | Y | - | - | - | Y | - | - |
| USART | Y | Y | Y | Y | Y | (1) | - | - |
| SPI | Y | Y | Y | Y | - | - | - | - |
| I2C | Y | Y | - | - | - | (1) | - | - |
| ADC | Y | Y | - | - | - | - | - | - |

Table 5. Working mode-dependent functionalities (from Run/active down to standby) (continued)

| Ips | Run/Active | Sleep | Low-power Run | Low-power Sleep | Stop | | Standby | |
|---|---------------------------------------|--|--------------------|-------------------|---|-------------------|---|--------|
| | | | | | Wakeup capability | Wakeup capability | | |
| DAC | Y | Y | Y | Y | Y | - | - | - |
| Temperature sensor | Y | Y | Y | Y | Y | - | - | - |
| Comparators | Y | Y | Y | Y | Y | Y | - | - |
| 16-bit Timers | Y | Y | Y | Y | - | - | - | - |
| IWDG | Y | Y | Y | Y | Y | Y | Y | Y |
| WWDG | Y | Y | Y | Y | - | - | - | - |
| Touch sensing | Y | - | - | - | - | - | - | - |
| Systick Timer | Y | Y | Y | Y | - | - | - | - |
| GPIOs | Y | Y | Y | Y | Y | Y | - | 3 pins |
| Wakeup time to Run mode | 0 μs | 0.4 μs | 3 μs | 46 μs | < 8 μs | | 58 μs | |
| Consumption V _{DD} =1.8V to 3.6V (Typ) | Down to 185 μA/MHz (from Flash) | Down to 36.9 μA/MHz (from Flash) | Down to 10.9 μA | Down to 5.5 μA | 0.43 μA (No RTC) V _{DD} =1.8 V | | 0.27 μA (No RTC) V _{DD} =1.8 V | |
| | | | | | 1.13 μA (with RTC) V _{DD} =1.8 V | | 0.87 μA (with RTC) V _{DD} =1.8 V | |
| | | | | | 0.44 μA (No RTC) V _{DD} =3.0 V | | 0.28 μA (No RTC) V _{DD} =3.0 V | |
| | | | | | 1.38 μA (with RTC) V _{DD} =3.0 V | | 1.11 μA (with RTC) V _{DD} =3.0 V | |

1. The startup on communication line wakes the CPU which was made possible by an EXTI, this induces a delay before entering run mode.

3.2 ARM[®] Cortex[®]-M3 core with MPU

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

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

The memory protection unit (MPU) improves system reliability by defining the memory attributes (such as read/write access permissions) for different memory regions. It provides up to eight different regions and an optional predefined background region.

Owing to its embedded ARM core, the STM32L151x6/8/B-A and STM32L152x6/8/B-A devices are compatible with all ARM tools and software.

Nested vectored interrupt controller (NVIC)

The ultra-low-power STM32L151x6/8/B-A and STM32L152x6/8/B-A devices embed a nested vectored interrupt controller able to handle up to 45 maskable interrupt channels (not including the 16 interrupt lines of Cortex-M3) and 16 priority levels.

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

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

3.3 Reset and supply management

3.3.1 Power supply schemes

- $V_{DD} = 1.65$ to 3.6 V: external power supply for I/Os and the internal regulator. Provided externally through V_{DD} pins.
- $V_{SSA}, V_{DDA} = 1.65$ to 3.6 V: external analog power supplies for ADC, reset blocks, RCs and PLL (minimum voltage to be applied to V_{DDA} is 1.8 V when the ADC is used). V_{DDA} and V_{SSA} must be connected to V_{DD} and V_{SS} , respectively.

3.3.2 Power supply supervisor

The device has an integrated ZEROPOWER power-on reset (POR)/power-down reset (PDR) that can be coupled with a brownout reset (BOR) circuitry.

The device exists in two versions:

- The version with BOR activated at power-on operates between 1.8 V and 3.6 V.
- The other version without BOR operates between 1.65 V and 3.6 V.

After the V_{DD} threshold is reached (1.65 V or 1.8 V depending on the BOR which is active or not at power-on), the option byte loading process starts, either to confirm or modify default thresholds, or to disable the BOR permanently: in this case, the V_{DD} min value becomes 1.65 V (whatever the version, BOR active or not, at power-on).

When BOR is active at power-on, it ensures proper operation starting from 1.8 V whatever the power ramp-up phase before it reaches 1.8 V. When BOR is not active at power-up, the power ramp-up should guarantee that 1.65 V is reached on V_{DD} at least 1 ms after it exits the POR area.

Five BOR thresholds are available through option bytes, starting from 1.8 V to 3 V. To reduce the power consumption in Stop mode, it is possible to automatically switch off the internal reference voltage (V_{REFINT}) in Stop mode. The device remains in reset mode when V_{DD} is below a specified threshold, $V_{POR/PDR}$ or V_{BOR} , without the need for any external reset circuit.

Note: The start-up time at power-on is typically 3.3 ms when BOR is active at power-up, the start-up time at power-on can be decreased down to 1 ms typically for devices with BOR inactive at power-up.

The device features an embedded programmable voltage detector (PVD) that monitors the V_{DD}/V_{DDA} power supply and compares it to the V_{PVD} threshold. This PVD offers 7 different levels between 1.85 V and 3.05 V, chosen by software, with a step around 200 mV. An interrupt can be generated when V_{DD}/V_{DDA} drops below the V_{PVD} threshold and/or when V_{DD}/V_{DDA} is higher than the V_{PVD} threshold. The interrupt service routine can then generate a warning message and/or put the MCU into a safe state. The PVD is enabled by software.

3.3.3 Voltage regulator

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

- MR is used in Run mode (nominal regulation)
- LPR is used in the Low-power run, Low-power sleep and Stop modes
- Power down is used in Standby mode. The regulator output is high impedance, the kernel circuitry is powered down, inducing zero consumption but the contents of the registers and RAM are lost except for the standby circuitry (wake-up logic, IWDG, RTC, LSI, LSE crystal 32K osc, RCC_CSR).

3.3.4 Boot modes

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

- Boot from Flash memory
- Boot from System Memory
- Boot from embedded RAM

The boot loader is located in System Memory. It is used to reprogram the Flash memory by using USART1 or USART2. See the application note “STM32 microcontroller system memory boot mode” (AN2606) for details.

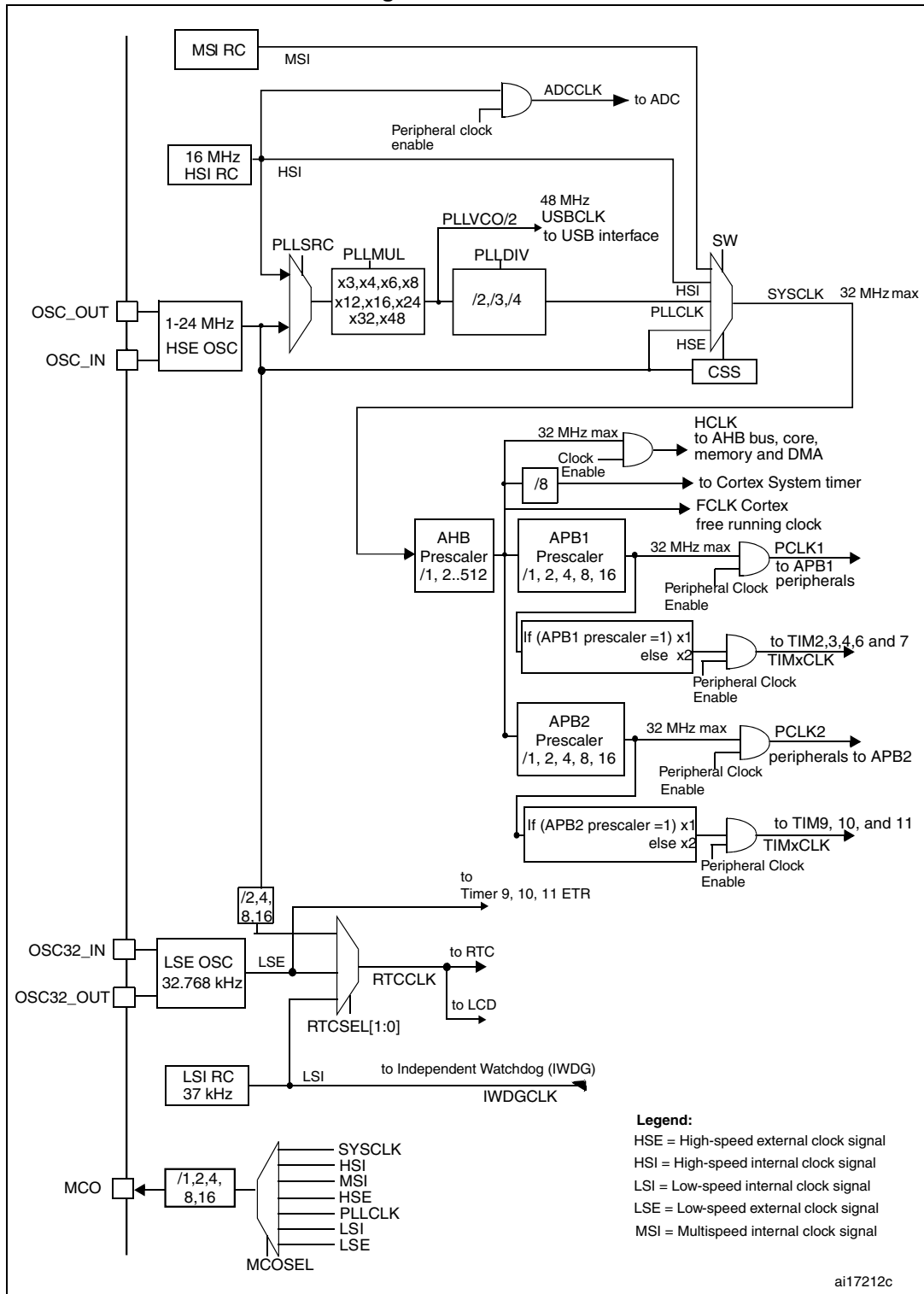
3.4 Clock management

The clock controller distributes the clocks coming from different oscillators to the core and the peripherals. It also manages clock gating for low-power modes and ensures clock robustness. It features:

- **Clock prescaler:** to get the best trade-off between speed and current consumption, the clock frequency to the CPU and peripherals can be adjusted by a programmable prescaler
- **Safe clock switching:** clock sources can be changed safely on the fly in run mode through a configuration register.
- **Clock management:** to reduce power consumption, the clock controller can stop the clock to the core, individual peripherals or memory.
- **Master clock source:** three different clock sources can be used to drive the master clock:
 - 1-24 MHz high-speed external crystal (HSE), that can supply a PLL
 - 16 MHz high-speed internal RC oscillator (HSI), trimmable by software, that can supply a PLL
 - Multispeed internal RC oscillator (MSI), trimmable by software, able to generate 7 frequencies (65.5 kHz, 131 kHz, 262 kHz, 524 kHz, 1.05 MHz, 2.1 MHz, 4.2 MHz) with a consumption proportional to speed, down to 750 nA typical. When a 32.768 kHz clock source is available in the system (LSE), the MSI frequency can be trimmed by software down to a $\pm 0.5\%$ accuracy.
- **Auxiliary clock source:** two ultra-low-power clock sources that can be used to drive the LCD controller and the real-time clock:
 - 32.768 kHz low-speed external crystal (LSE)
 - 37 kHz low-speed internal RC (LSI), also used to drive the independent watchdog. The LSI clock can be measured using the high-speed internal RC oscillator for greater precision.
- **RTC and LCD clock sources:** the LSI, LSE or HSE sources can be chosen to clock the RTC and the LCD, whatever the system clock.
- **USB clock source:** the embedded PLL has a dedicated 48 MHz clock output to supply the USB interface.
- **Startup clock:** after reset, the microcontroller restarts by default with an internal 2.1 MHz clock (MSI). The prescaler ratio and clock source can be changed by the application program as soon as the code execution starts.
- **Clock security system (CSS):** this feature can be enabled by software. If a HSE clock failure occurs, the master clock is automatically switched to HSI and a software interrupt is generated if enabled.
- **Clock-out capability (MCO: microcontroller clock output):** it outputs one of the internal clocks for external use by the application.

Several prescalers allow the configuration of the AHB frequency, the high-speed APB (APB2) and the low-speed APB (APB1) domains. The maximum frequency of the AHB and the APB domains is 32 MHz. See [Figure 2](#) for details on the clock tree.

Figure 2. Clock tree



3.5 Low-power real-time clock and backup registers

The real-time clock (RTC) is an independent BCD timer/counter. Dedicated registers contain the sub-second, second, minute, hour (12/24 hour), week day, date, month, year, in BCD (binary-coded decimal) format. Correction for 28, 29 (leap year), 30, and 31 day of the month are made automatically. The RTC provides two programmable alarms and programmable periodic interrupts with wakeup from Stop and Standby modes.

The programmable wakeup time ranges from 120 μ s to 36 hours.

The RTC can be calibrated with an external 512 Hz output, and a digital compensation circuit helps reduce drift due to crystal deviation. The RTC can also be automatically corrected with a 50/60Hz stable power line.

The RTC calendar can be updated on the fly down to sub second precision, which enables network system synchronization. A time stamp can record an external event occurrence, and generates an interrupt.

There are twenty 32-bit backup registers provided to store 80 bytes of user application data. They are cleared in case of tamper detection. Three pins can be used to detect tamper events. A change on one of these pins can reset backup register and generate an interrupt. To prevent false tamper event, like ESD event, these three tamper inputs can be digitally filtered.

3.6 GPIOs (general-purpose inputs/outputs)

Each of the GPIO pins can be configured by software as output (push-pull or open-drain), as input (with or without pull-up or pull-down) or as peripheral alternate function. Most of the GPIO pins are shared with digital or analog alternate functions, and can be individually remapped using dedicated AFIO registers. All GPIOs are high current capable. The alternate function configuration of I/Os can be locked if needed following a specific sequence in order to avoid spurious writing to the I/O registers. The I/O controller is connected to the AHB with a toggling speed of up to 16 MHz.

External interrupt/event controller (EXTI)

The external interrupt/event controller consists of 23 edge detector lines used to generate interrupt/event requests. Each line can be individually configured to select the trigger event (rising edge, falling edge, both) and can be masked independently. A pending register maintains the status of the interrupt requests. The EXTI can detect an external line with a pulse width shorter than the Internal APB2 clock period. Up to 83 GPIOs can be connected to the 16 external interrupt lines. The 7 other lines are connected to RTC, PVD, USB or Comparator events.

3.7 Memories

The STM32L151x6/8/B-A and STM32L152x6/8/B-A devices have the following features:

- Up to 32 Kbytes of embedded RAM accessed (read/write) at CPU clock speed with 0 wait states. With the enhanced bus matrix, operating the RAM does not lead to any performance penalty during accesses to the system bus (AHB and APB buses).
- The non-volatile memory is divided into three arrays:
 - 32, 64 or 128 Kbytes of embedded Flash program memory
 - 4 Kbytes of data EEPROM
 - Options bytes

The options bytes are used to write-protect or read-out-protect the memory (with 4 Kbytes granularity) and/or readout-protect the whole memory with the following options:

- Level 0: no readout protection
- Level 1: memory readout protection, the Flash memory cannot be read from or written to if either debug features are connected or boot in RAM is selected
- Level 2: chip readout protection, debug features (Cortex-M3 JTAG and serial wire) and boot in RAM selection disabled (JTAG fuse)

The whole non-volatile memory embeds the error correction code (ECC) feature.

The user area of the Flash memory can be protected against Dbus read access by the PCROP feature (see RM0038 for details).

3.8 DMA (direct memory access)

The flexible 7-channel, general-purpose DMA is able to manage memory-to-memory, peripheral-to-memory and memory-to-peripheral transfers. The DMA controller supports circular buffer management, avoiding the generation of interrupts when the controller reaches the end of the buffer.

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

The DMA can be used with the main peripherals: SPI, I²C, USART, general-purpose timers and ADC.

3.9 LCD (liquid crystal display)

The LCD drives up to 8 common terminals and 44 segment terminals to drive up to 320 pixels.

- Internal step-up converter to guarantee functionality and contrast control irrespective of V_{DD} . This converter can be deactivated, in which case the V_{LCD} pin is used to provide the voltage to the LCD
- Supports static, 1/2, 1/3, 1/4 and 1/8 duty
- Supports static, 1/2, 1/3 and 1/4 bias
- Phase inversion to reduce power consumption and EMI
- Up to 8 pixels can be programmed to blink
- Unneeded segments and common pins can be used as general I/O pins
- LCD RAM can be updated at any time owing to a double-buffer
- The LCD controller can operate in Stop mode
- V_{LCD} rail decoupling capability

Table 6. V_{LCD} rail decoupling

| | Bias | | | Pin | |
|----------------|---------------|---------------|---------------|------|------|
| | 1/2 | 1/3 | 1/4 | | |
| $V_{LCDrail1}$ | 1/2 V_{LCD} | 2/3 V_{LCD} | 1/2 V_{LCD} | PB2 | |
| $V_{LCDrail2}$ | NA | 1/3 V_{LCD} | 1/4 V_{LCD} | PB12 | PE11 |
| $V_{LCDrail3}$ | NA | NA | 3/4 V_{LCD} | PB0 | PE12 |

3.10 ADC (analog-to-digital converter)

A 12-bit analog-to-digital converters is embedded into STM32L151x6/8/B-A and STM32L152x6/8/B-A devices with up to 24 external channels, performing conversions in single-shot or scan mode. In scan mode, automatic conversion is performed on a selected group of analog inputs.

The ADC can be served by the DMA controller.

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

The events generated by the general-purpose timers (TIMx) can be internally connected to the ADC start trigger and injection trigger, to allow the application to synchronize A/D conversions and timers. An injection mode allows high priority conversions to be done by interrupting a scan mode which runs in as a background task.

The ADC includes a specific low-power mode. The converter is able to operate at maximum speed even if the CPU is operating at a very low frequency and has an auto-shutdown function. The ADC's runtime and analog front-end current consumption are thus minimized whatever the MCU operating mode.

3.10.1 Temperature sensor

The temperature sensor T_{SENSE} generates a voltage V_{SENSE} that varies linearly with temperature.

The temperature sensor is internally connected to the ADC_IN16 input channel which is used to convert the sensor output voltage into a digital value.

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

To improve the accuracy of the temperature sensor measurement, each device is individually factory-calibrated by ST. The temperature sensor factory calibration data are stored by ST in the system memory area, accessible in read-only mode, see [Table 59: Temperature sensor calibration values](#).

3.10.2 Internal voltage reference (V_{REFINT})

The internal voltage reference (V_{REFINT}) provides a stable (bandgap) voltage output for the ADC and Comparators. V_{REFINT} is internally connected to the ADC_IN17 input channel. It enables accurate monitoring of the V_{DD} value (when no external voltage, $V_{\text{REF+}}$, is available for ADC). 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 see [Table 17: Embedded internal reference voltage](#).

3.11 DAC (digital-to-analog converter)

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

This dual digital Interface supports the following features:

- two DAC converters: one for each output channel
- left or right data alignment in 12-bit mode
- synchronized update capability
- noise-wave generation
- triangular-wave generation
- dual DAC channels' independent or simultaneous conversions
- DMA capability for each channel (including the underrun interrupt)
- external triggers for conversion
- input reference voltage $V_{\text{REF+}}$

Eight DAC trigger inputs are used in the STM32L151x6/8/B-A and STM32L152x6/8/B-A devices. The DAC channels are triggered through the timer update outputs that are also connected to different DMA channels.

3.12 Ultra-low-power comparators and reference voltage

The STM32L151x6/8/B-A and STM32L152x6/8/B-A devices embed two comparators sharing the same current bias and reference voltage. The reference voltage can be internal or external (coming from an I/O).

- one comparator with fixed threshold
- one comparator with rail-to-rail inputs, fast or slow mode. The threshold can be one of the following:
 - DAC output
 - External I/O
 - Internal reference voltage (V_{REFINT}) or V_{REFINT} submultiple (1/4, 1/2, 3/4)

Both comparators can wake up from Stop mode, and be combined into a window comparator.

The internal reference voltage is available externally via a low-power / low-current output buffer (driving current capability of 1 μ A typical).

3.13 Routing interface

The highly flexible routing interface allows the application firmware to control the routing of different I/Os to the TIM2, TIM3 and TIM4 timer input captures. It also controls the routing of internal analog signals to ADC1, COMP1 and COMP2 and the internal reference voltage V_{REFINT} .

3.14 Touch sensing

The STM32L151x6/8/B-A and STM32L152x6/8/B-A devices provide a simple solution for adding capacitive sensing functionality to any application. These devices offer up to 20 capacitive sensing channels distributed over 10 analog I/O groups. Both software and timer capacitive sensing acquisition modes are supported.

Capacitive sensing technology is able to detect the presence of a finger near a sensor which is protected from direct touch by a dielectric (glass, plastic, ...). The capacitive variation introduced by the finger (or any conductive object) is measured using a proven implementation based on a surface charge transfer acquisition principle. It consists of charging the sensor 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. The capacitive sensing acquisition only requires few external components to operate. This acquisition is managed directly by the GPIOs, timers and analog I/O groups (see [Section 3.13: Routing interface](#)).

Reliable touch sensing functionality can be quickly and easily implemented using the free STM32L1xx STMTouch touch sensing firmware library.

3.15 Timers and watchdogs

The ultra-low-power STM32L151x6/8/B-A and STM32L152x6/8/B-A devices include six general-purpose timers, two basic timers and two watchdog timers.

[Table 7](#) compares the features of the general-purpose and basic timers.

Table 7. Timer feature comparison

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

3.15.1 General-purpose timers (TIM2, TIM3, TIM4, TIM9, TIM10 and TIM11)

There are six synchronizable general-purpose timers embedded in the STM32L151x6/8/B-A and STM32L152x6/8/B-A devices (see [Table 7](#) for differences).

TIM2, TIM3, TIM4

These timers are based on a 16-bit auto-reload up/down-counter and a 16-bit prescaler. They feature 4 independent channels each for input capture/output compare, PWM or one-pulse mode output. This gives up to 12 input captures/output compares/PWMs on the largest packages.

The TIM2, TIM3, TIM4 general-purpose timers can work together or with the TIM10, TIM11 and TIM9 general-purpose timers via the Timer Link feature for synchronization or event chaining. Their counter can be frozen in debug mode. Any of the general-purpose timers can be used to generate PWM outputs.

TIM2, TIM3, TIM4 all have independent DMA request generation.

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

TIM10, TIM11 and TIM9

TIM10 and TIM11 are based on a 16-bit auto-reload upcounter. TIM9 is based on a 16-bit auto-reload up/down counter. They include a 16-bit prescaler. TIM10 and TIM11 feature one independent channel, whereas TIM9 has two independent channels for input capture/output compare, PWM or one-pulse mode output. They can be synchronized with the TIM2, TIM3, TIM4 full-featured general-purpose timers.

They can also be used as simple time bases and be clocked by the LSE clock source (32.768 kHz) to provide time bases independent from the main CPU clock.

3.15.2 Basic timers (TIM6 and TIM7)

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

3.15.3 SysTick timer

This timer is dedicated to the OS, but could also be used as a standard downcounter. It is based on a 24-bit down-counter with autoreload capability and a programmable clock source. It features a maskable system interrupt generation when the counter reaches 0.

3.15.4 Independent watchdog (IWDG)

The independent watchdog is based on a 12-bit down-counter and 8-bit prescaler. It is clocked from an independent 37 kHz internal RC and, as it operates independently of 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.

3.15.5 Window watchdog (WWDG)

The window watchdog is based on a 7-bit down-counter 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.

3.16 Communication interfaces

3.16.1 I²C bus

Up to two I²C bus interfaces can operate in multimaster and slave modes. They can support standard and fast modes.

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

They can be served by DMA and they support SM Bus 2.0/PM Bus.

3.16.2 Universal synchronous/asynchronous receiver transmitter (USART)

All USART interfaces are able to communicate at speeds of up to 4 Mbit/s. They provide hardware management of the CTS and RTS signals and are ISO 7816 compliant. They support IrDA SIR ENDEC and have LIN Master/Slave capability.

All USART interfaces can be served by the DMA controller.

3.16.3 Serial peripheral interface (SPI)

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

Both SPIs can be served by the DMA controller.

3.16.4 Universal serial bus (USB)

The STM32L151x6/8/B-A and STM32L152x6/8/B-A devices embed a USB device peripheral compatible with the USB full speed 12 Mbit/s. The USB interface implements a full speed (12 Mbit/s) function interface. It has software-configurable endpoint setting and supports suspend/resume. The dedicated 48 MHz clock is generated from the internal main PLL (the clock source must use a HSE crystal oscillator).

3.17 CRC (cyclic redundancy check) calculation unit

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

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

3.18 Development support

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 JTMS and JTCK pins are shared with SWDAT and SWCLK, respectively, and a specific sequence on the JTMS pin is used to switch between JTAG-DP and SW-DP.

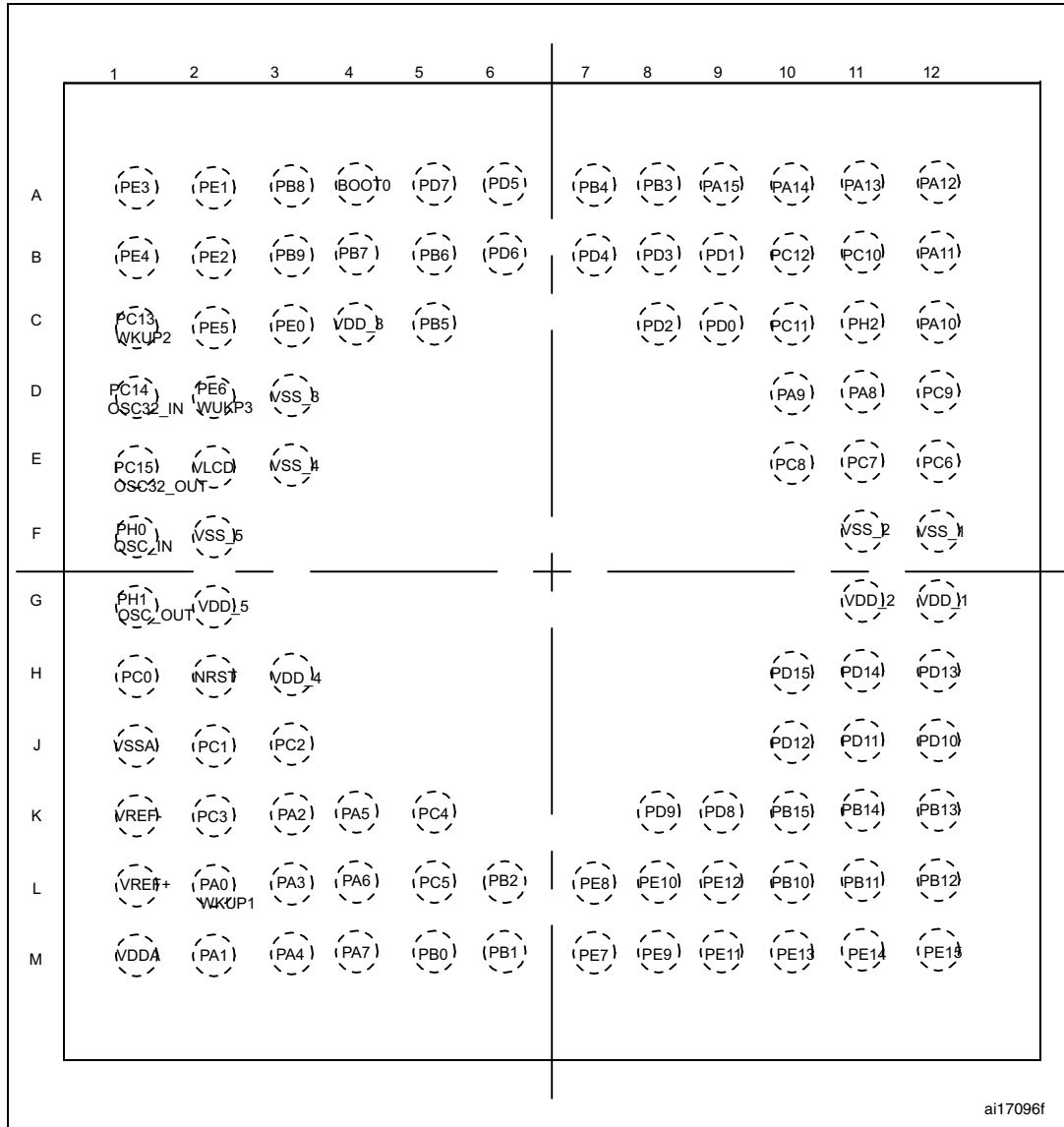
The JTAG port can be permanently disabled with a JTAG fuse.

Embedded Trace Macrocell™

The ARM Embedded Trace Macrocell provides a greater visibility of the instruction and data flow inside the CPU core by streaming compressed data at a very high rate from the STM32L151x6/8/B-A and STM32L152x6/8/B-A device through a small number of ETM pins to an external hardware trace port analyzer (TPA) device. The TPA is connected to a host computer using USB, Ethernet, or any other high-speed channel. Real-time instruction and data flow activity can be recorded and then formatted for display on the host computer running debugger software. TPA hardware is commercially available from common development tool vendors. It operates with third party debugger software tools.

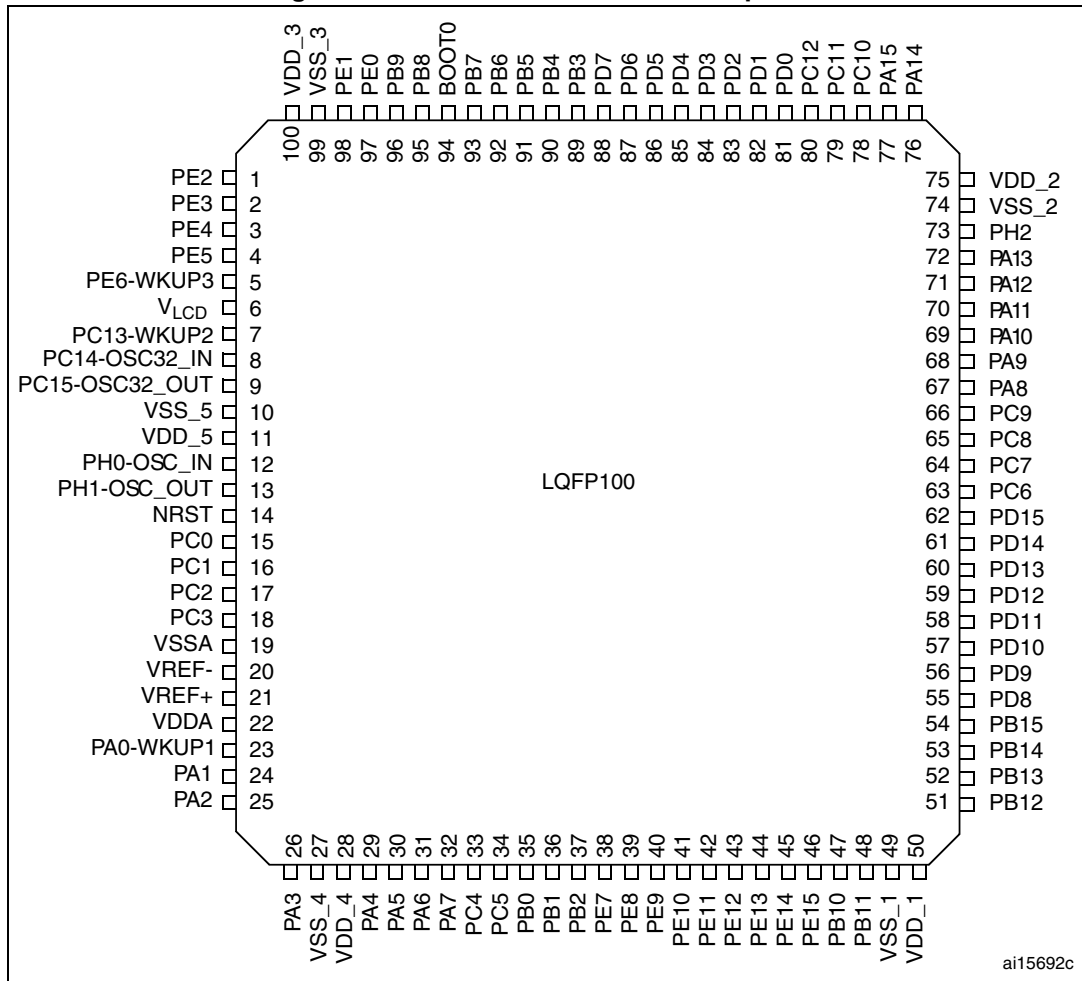
4 Pin descriptions

Figure 3. STM32L15xVxxxA UFBGA100 ballout



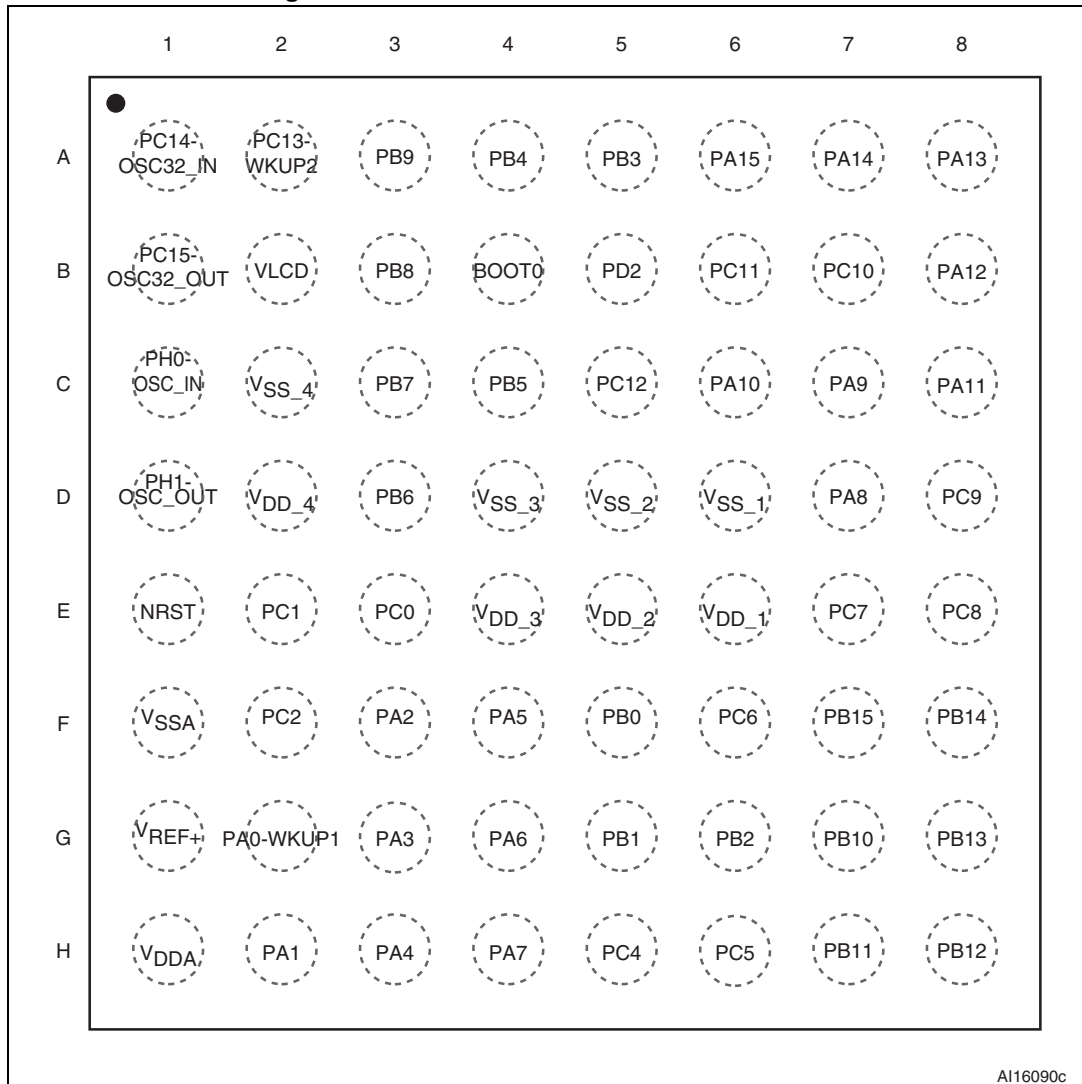
1. This figure shows the package top view.

Figure 4. STM32L15xVxxxA LQFP100 pinout



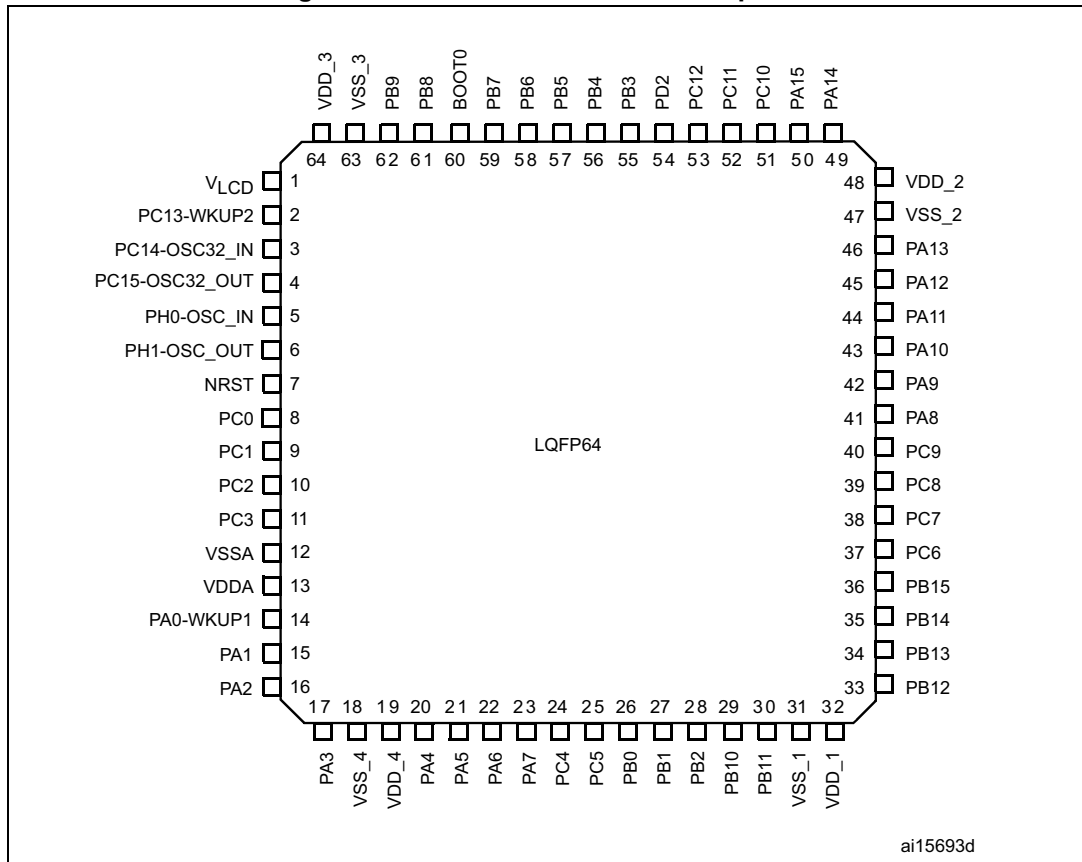
1. This figure shows the package top view.

Figure 5. STM32L15xRxxxA TFBGA64 ballout



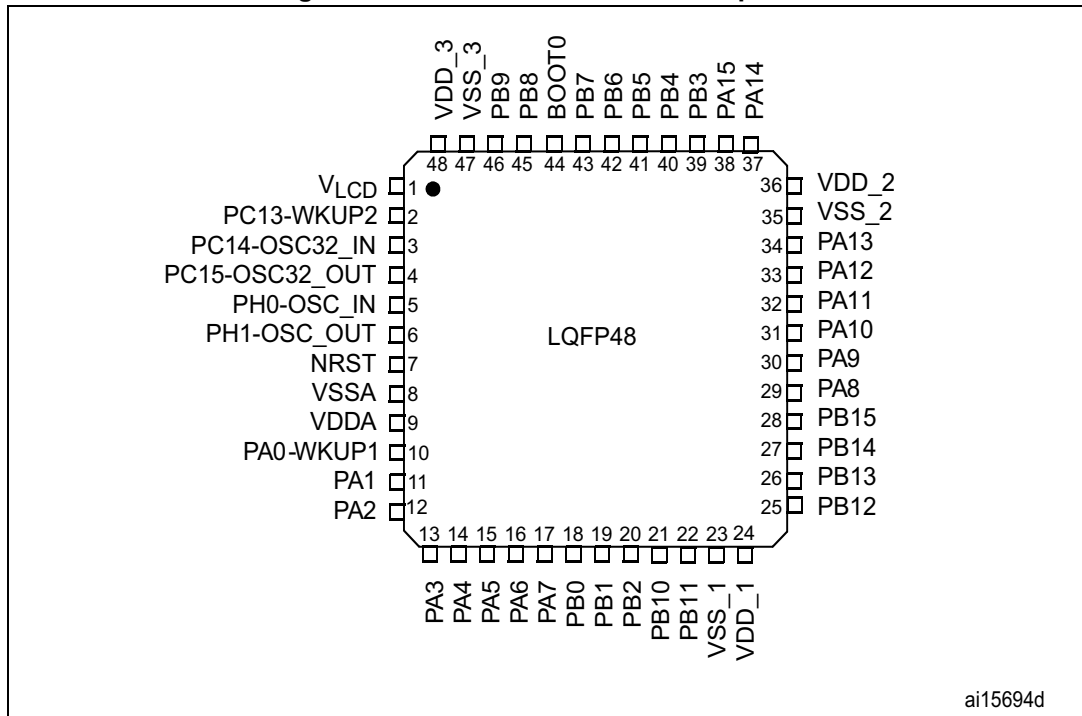
1. This figure shows the package top view.

Figure 6. STM32L15xRxxxA LQFP64 pinout



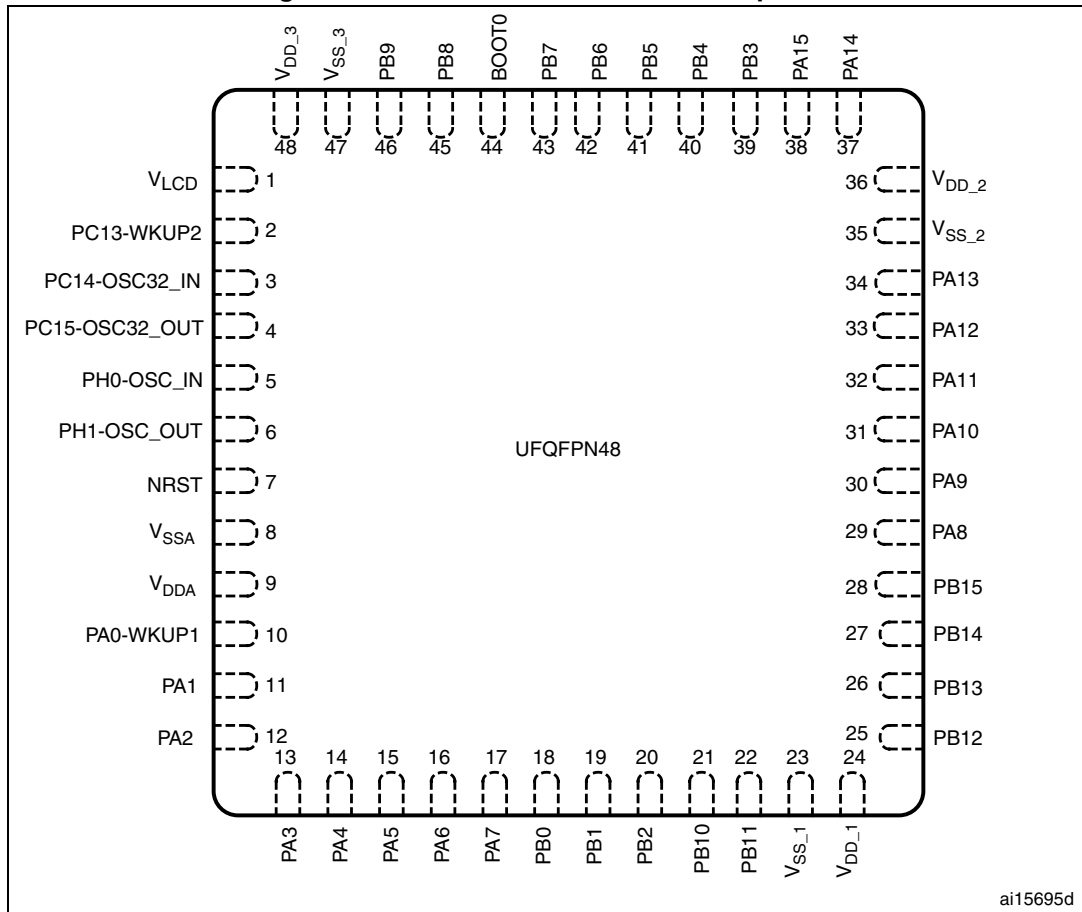
1. This figure shows the package top view.

Figure 7. STM32L15xCxxxA LQFP48 pinout



1. This figure shows the package top view.

Figure 8. STM32L15xCxxxA UFQFPN48 pinout



ai15695d

1. This figure shows the package top view.

Table 8. 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 |
| | | TC | Standard 3.3 V I/O |
| | | B | Dedicated BOOT0 pin |
| | | RST | Bidirectional reset pin with embedded weak pull-up resistor |
| Notes | | Unless otherwise specified by a note, all I/Os are set as floating inputs during and after reset | |
| Pin functions | Alternate functions | Functions selected through GPIOx_AFR registers | |
| | Additional functions | Functions directly selected/enabled through peripheral registers | |

Table 9. STM32L151x6/8/B-A and STM32L152x6/8/B-A pin definitions

| Pins | | | | | Pin name | Pin type ⁽¹⁾ | I/O structure | Main function ⁽²⁾ (after reset) | Pins functions | |
|---------|--------|------------------|----------|--------------------|-----------------------------------|-------------------------|---------------|---|---------------------------------|--|
| LQFP100 | LQFP64 | TFBGA64 | UFBGA100 | LQFP48 or UFQFPN48 | | | | | Alternate functions | Additional functions |
| 1 | - | - | B2 | - | PE2 | I/O | FT | PE2 | TRACECLK/ LCD_SEG38/TIM3_ETR | - |
| 2 | - | - | A1 | - | PE3 | I/O | FT | PE3 | TRACED0/ LCD_SEG39/TIM3_CH1 | - |
| 3 | - | - | B1 | - | PE4 | I/O | FT | PE4 | TRACED1/TIM3_CH2 | - |
| 4 | - | - | C2 | - | PE5 | I/O | FT | PE5 | TRACED2/TIM9_CH1 | - |
| 5 | - | - | D2 | - | PE6-WKUP3 | I/O | FT | PE6 | TRACED3/TIM9_CH2 | WKUP3 /RTC_TAMP3 |
| 6 | 1 | B2 | E2 | 1 | V _{LCD} ⁽³⁾ | S | - | V _{LCD} | - | - |
| 7 | 2 | A2 | C1 | 2 | PC13-WKUP2 | I/O | FT | PC13 | - | RTC_TAMP1/ RTC_TS/ RTC_OUT/ WKUP2 |
| 8 | 3 | A1 | D1 | 3 | PC14- OSC32_IN ⁽⁴⁾ | I/O | TC | PC14 | - | OSC32_IN |
| 9 | 4 | B1 | E1 | 4 | PC15- OSC32_OUT ⁽⁴⁾ | I/O | TC | PC15 | - | OSC32_OUT |
| 10 | - | - | F2 | - | V _{SS_5} | S | - | V _{SS_5} | - | - |
| 11 | - | - | G2 | - | V _{DD_5} | S | - | V _{DD_5} | - | - |
| 12 | 5 | C1 | F1 | 5 | PH0-OSC_IN ⁽⁵⁾ | I/O | TC | PH0 | - | OSC_IN |
| 13 | 6 | D1 | G1 | 6 | PH1-OSC_OUT | I/O | TC | PH1 | - | OSC_OUT |
| 14 | 7 | E1 | H2 | 7 | NRST | I/O | RST | NRST | - | - |
| 15 | 8 | E3 | H1 | - | PC0 | I/O | FT | PC0 | LCD_SEG18 | ADC_IN10/ COMP1_INP |
| 16 | 9 | E2 | J2 | - | PC1 | I/O | FT | PC1 | LCD_SEG19 | ADC_IN11/ COMP1_INP |
| 17 | 10 | F2 | J3 | - | PC2 | I/O | FT | PC2 | LCD_SEG20 | ADC_IN12/ COMP1_INP |
| 18 | 11 | - ⁽⁶⁾ | K2 | - | PC3 | I/O | TC | PC3 | LCD_SEG21 | ADC_IN13/ COMP1_INP |
| 19 | 12 | F1 | J1 | 8 | V _{SSA} | S | - | V _{SSA} | - | - |

Table 9. STM32L151x6/8/B-A and STM32L152x6/8/B-A pin definitions (continued)

| Pins | | | | | Pin name | Pin type ⁽¹⁾ | I/O structure | Main function ⁽²⁾ (after reset) | Pins functions | |
|---------|--------|-----------|----------|--------------------|-------------------|-------------------------|---------------|---|--|---|
| LQFP100 | LQFP64 | TFBGA64 | UFBGA100 | LQFP48 or UFQFPN48 | | | | | Alternate functions | Additional functions |
| 20 | - | - | K1 | - | V _{REF-} | S | - | V _{REF-} | - | - |
| 21 | - | G1 (6) | L1 | - | V _{REF+} | S | - | V _{REF+} | - | - |
| 22 | 13 | H1 | M1 | 9 | V _{DDA} | S | - | V _{DDA} | - | - |
| 23 | 14 | G2 | L2 | 10 | PA0-WKUP1 | I/O | FT | PA0 | USART2_CTS/ TIM2_CH1_ETR | WKUP1/ ADC_IN0/ COMP1_INP /RTC_TAMP2 |
| 24 | 15 | H2 | M2 | 11 | PA1 | I/O | FT | PA1 | USART2_RTS/ TIM2_CH2/LCD_SEG0 | ADC_IN1/ COMP1_INP |
| 25 | 16 | F3 | K3 | 12 | PA2 | I/O | FT | PA2 | USART2_TX/ TIM2_CH3/ TIM9_CH1/ LCD_SEG1 | ADC_IN2/ COMP1_INP |
| 26 | 17 | G3 | L3 | 13 | PA3 | I/O | TC | PA3 | USART2_RX/ TIM2_CH4/ TIM9_CH2/ LCD_SEG2 | ADC_IN3/ COMP1_INP |
| 27 | 18 | C2 | E3 | - | V _{SS_4} | S | - | V _{SS_4} | - | - |
| 28 | 19 | D2 | H3 | - | V _{DD_4} | S | - | V _{DD_4} | - | - |
| 29 | 20 | H3 | M3 | 14 | PA4 | I/O | TC | PA4 | SPI1_NSS/ USART2_CK | ADC_IN4/ DAC_OUT1/ COMP1_INP |
| 30 | 21 | F4 | K4 | 15 | PA5 | I/O | TC | PA5 | SPI1_SCK/ TIM2_CH1_ETR | ADC_IN5/ DAC_OUT2/ COMP1_INP |
| 31 | 22 | G4 | L4 | 16 | PA6 | I/O | FT | PA6 | SPI1_MISO/TIM3_CH1/ LCD_SEG3/TIM10_CH1 | ADC_IN6/ COMP1_INP |
| 32 | 23 | H4 | M4 | 17 | PA7 | I/O | FT | PA7 | SPI1_MOSI/TIM3_CH2/ LCD_SEG4/TIM11_CH1 | ADC_IN7/ COMP1_INP |
| 33 | 24 | H5 | K5 | - | PC4 | I/O | FT | PC4 | LCD_SEG22 | ADC_IN14/ COMP1_INP |
| 34 | 25 | H6 | L5 | - | PC5 | I/O | FT | PC5 | LCD_SEG23 | ADC_IN15/ COMP1_INP |

Table 9. STM32L151x6/8/B-A and STM32L152x6/8/B-A pin definitions (continued)

| Pins | | | | | Pin name | Pin type ⁽¹⁾ | I/O structure | Main function ⁽²⁾ (after reset) | Pins functions | |
|---------|--------|---------|----------|--------------------|-------------------|-------------------------|---------------|---|---|--|
| LQFP100 | LQFP64 | TFBGA64 | UFBGA100 | LQFP48 or UFQFPN48 | | | | | Alternate functions | Additional functions |
| 35 | 26 | F5 | M5 | 18 | PB0 | I/O | TC | PB0 | TIM3_CH3/ LCD_SEG5 | ADC_IN8/ COMP1_INP/ VREF_OUT /VLCDRAIL3 |
| 36 | 27 | G5 | M6 | 19 | PB1 | I/O | FT | PB1 | TIM3_CH4/ LCD_SEG6 | ADC_IN9/ COMP1_INP/ VREF_OUT |
| 37 | 28 | G6 | L6 | 20 | PB2 | I/O | FT | PB2/ BOOT1 | BOOT1 | VLCDRAIL1 |
| 38 | - | - | M7 | - | PE7 | I/O | TC | PE7 | - | ADC_IN22/ COMP1_INP |
| 39 | - | - | L7 | - | PE8 | I/O | TC | PE8 | - | ADC_IN23/ COMP1_INP |
| 40 | - | - | M8 | - | PE9 | I/O | TC | PE9 | TIM2_CH1_ETR | ADC_IN24/ COMP1_INP |
| 41 | - | - | L8 | - | PE10 | I/O | TC | PE10 | TIM2_CH2 | ADC_IN25/ COMP1_INP |
| 42 | - | - | M9 | - | PE11 | I/O | FT | PE11 | TIM2_CH3 | VLCDRAIL2 |
| 43 | - | - | L9 | - | PE12 | I/O | FT | PE12 | TIM2_CH4/ SPI1_NSS | VLCDRAIL3 |
| 44 | - | - | M10 | - | PE13 | I/O | FT | PE13 | SPI1_SCK | - |
| 45 | - | - | M11 | - | PE14 | I/O | FT | PE14 | SPI1_MISO | - |
| 46 | - | - | M12 | - | PE15 | I/O | FT | PE15 | SPI1_MOSI | - |
| 47 | 29 | G7 | L10 | 21 | PB10 | I/O | FT | PB10 | I2C2_SCL/USART3_TX /TIM2_CH3/ LCD_SEG10 | - |
| 48 | 30 | H7 | L11 | 22 | PB11 | I/O | FT | PB11 | I2C2_SDA/USART3_RX /TIM2_CH4/ LCD_SEG11 | - |
| 49 | 31 | D6 | F12 | 23 | V _{SS_1} | S | - | V _{SS_1} | - | - |
| 50 | 32 | E6 | G12 | 24 | V _{DD_1} | S | - | V _{DD_1} | - | - |

Table 9. STM32L151x6/8/B-A and STM32L152x6/8/B-A pin definitions (continued)

| Pins | | | | | Pin name | Pin type ⁽¹⁾ | I/O structure | Main function ⁽²⁾ (after reset) | Pins functions | |
|---------|--------|---------|----------|--------------------|----------|-------------------------|---------------|---|--|--------------------------------------|
| LQFP100 | LQFP64 | TFBGA64 | UFBGA100 | LQFP48 or UFQFPN48 | | | | | Alternate functions | Additional functions |
| 51 | 33 | H8 | L12 | 25 | PB12 | I/O | FT | PB12 | SPI2_NSS/I2C2_SMBA/ USART3_CK/ LCD_SEG12/ TIM10_CH1 | ADC_IN18/ COMP1_INP /LCDRAIL2 |
| 52 | 34 | G8 | K12 | 26 | PB13 | I/O | FT | PB13 | SPI2_SCK/ USART3_CTS/ LCD_SEG13/TIM9_CH1 | ADC_IN19/ COMP1_INP |
| 53 | 35 | F8 | K11 | 27 | PB14 | I/O | FT | PB14 | SPI2_MISO/ USART3_RTS/ LCD_SEG14/TIM9_CH2 | ADC_IN20/ COMP1_INP |
| 54 | 36 | F7 | K10 | 28 | PB15 | I/O | FT | PB15 | SPI2_MOSI/ LCD_SEG15/ TIM11_CH1 | ADC_IN21/ COMP1_INP/ RTC_REFIN |
| 55 | - | - | K9 | - | PD8 | I/O | FT | PD8 | USART3_TX/ LCD_SEG28 | - |
| 56 | - | - | K8 | - | PD9 | I/O | FT | PD9 | USART3_RX/ LCD_SEG29 | - |
| 57 | - | - | J12 | - | PD10 | I/O | FT | PD10 | USART3_CK/ LCD_SEG30 | - |
| 58 | - | - | J11 | - | PD11 | I/O | FT | PD11 | USART3_CTS/ LCD_SEG31 | - |
| 59 | - | - | J10 | - | PD12 | I/O | FT | PD12 | TIM4_CH1/ USART3_RTS/ LCD_SEG32 | - |
| 60 | - | - | H12 | - | PD13 | I/O | FT | PD13 | TIM4_CH2/LCD_SEG33 | - |
| 61 | - | - | H11 | - | PD14 | I/O | FT | PD14 | TIM4_CH3/LCD_SEG34 | - |
| 62 | - | - | H10 | - | PD15 | I/O | FT | PD15 | TIM4_CH4/LCD_SEG35 | - |
| 63 | 37 | F6 | E12 | - | PC6 | I/O | FT | PC6 | TIM3_CH1/LCD_SEG24 | - |
| 64 | 38 | E7 | E11 | - | PC7 | I/O | FT | PC7 | TIM3_CH2/LCD_SEG25 | - |
| 65 | 39 | E8 | E10 | - | PC8 | I/O | FT | PC8 | TIM3_CH3/LCD_SEG26 | - |
| 66 | 40 | D8 | D12 | - | PC9 | I/O | FT | PC9 | TIM3_CH4/LCD_SEG27 | - |

Table 9. STM32L151x6/8/B-A and STM32L152x6/8/B-A pin definitions (continued)

| Pins | | | | | Pin name | Pin type ⁽¹⁾ | I/O structure | Main function ⁽²⁾ (after reset) | Pins functions | |
|---------|--------|---------|----------|--------------------|-------------------|-------------------------|---------------|---|--|----------------------|
| LQFP100 | LQFP64 | TFBGA64 | UFBGA100 | LQFP48 or UFQFPN48 | | | | | Alternate functions | Additional functions |
| 67 | 41 | D7 | D11 | 29 | PA8 | I/O | FT | PA8 | USART1_CK/MCO/ LCD_COM0 | - |
| 68 | 42 | C7 | D10 | 30 | PA9 | I/O | FT | PA9 | USART1_TX/ LCD_COM1 | - |
| 69 | 43 | C6 | C12 | 31 | PA10 | I/O | FT | PA10 | USART1_RX/ LCD_COM2 | - |
| 70 | 44 | C8 | B12 | 32 | PA11 | I/O | FT | PA11 | USART1_CTS/ SPI1_MISO | USB_DM |
| 71 | 45 | B8 | A12 | 33 | PA12 | I/O | FT | PA12 | USART1_RTS/ SPI1_MOSI | USB_DP |
| 72 | 46 | A8 | A11 | 34 | PA13 | I/O | FT | JTMS- SWDIO | JTMS-SWDIO | - |
| 73 | - | - | C11 | - | PH2 | I/O | FT | PH2 | - | - |
| 74 | 47 | D5 | F11 | 35 | V _{SS_2} | S | - | V _{SS_2} | - | - |
| 75 | 48 | E5 | G11 | 36 | V _{DD_2} | S | - | V _{DD_2} | - | - |
| 76 | 49 | A7 | A10 | 37 | PA14 | I/O | FT | JTKK- SWCLK | JCTK-SWCLK | - |
| 77 | 50 | A6 | A9 | 38 | PA15 | I/O | FT | JTDI | TIM2_CH1_ETR/PA15/ SPI1_NSS/ LCD_SEG17 | - |
| 78 | 51 | B7 | B11 | - | PC10 | I/O | FT | PC10 | USART3_TX/ LCD_SEG28/ LCD_SEG40/ LCD_COM4 | - |
| 79 | 52 | B6 | C10 | - | PC11 | I/O | FT | PC11 | USART3_RX/ LCD_SEG29/ LCD_SEG41/ LCD_COM5 | - |
| 80 | 53 | C5 | B10 | - | PC12 | I/O | FT | PC12 | USART3_CK/ LCD_SEG30/ LCD_SEG42/ LCD_COM6 | - |
| 81 | - | - | C9 | - | PD0 | I/O | FT | PD0 | SPI2_NSS/TIM9_CH1 | - |

Table 9. STM32L151x6/8/B-A and STM32L152x6/8/B-A pin definitions (continued)

| Pins | | | | | Pin name | Pin type ⁽¹⁾ | I/O structure | Main function ⁽²⁾ (after reset) | Pins functions | |
|---------|--------|---------|----------|--------------------|----------|-------------------------|---------------|---|--|----------------------|
| LQFP100 | LQFP64 | TFBGA64 | UFBGA100 | LQFP48 or UFQFPN48 | | | | | Alternate functions | Additional functions |
| 82 | - | - | B9 | - | PD1 | I/O | FT | PD1 | SPI2_SCK | - |
| 83 | 54 | B5 | C8 | - | PD2 | I/O | FT | PD2 | TIM3_ETR/LCD_SEG31 /LCD_SEG43/ LCD_COM7 | - |
| 84 | - | - | B8 | - | PD3 | I/O | FT | PD3 | USART2_CTS/ SPI2_MISO | - |
| 85 | - | - | B7 | - | PD4 | I/O | FT | PD4 | USART2_RTS/ SPI2_MOSI | - |
| 86 | - | - | A6 | - | PD5 | I/O | FT | PD5 | USART2_TX | - |
| 87 | - | - | B6 | - | PD6 | I/O | FT | PD6 | USART2_RX | - |
| 88 | - | - | A5 | - | PD7 | I/O | FT | PD7 | USART2_CK/ TIM9_CH2 | - |
| 89 | 55 | A5 | A8 | 39 | PB3 | I/O | FT | JTDO | TIM2_CH2/PB3/ SPI1_SCK/ LCD_SEG7/JTDO | COMP2_INM |
| 90 | 56 | A4 | A7 | 40 | PB4 | I/O | FT | NJTRST | TIM3_CH1/PB4/ SPI1_MISO/LCD_SEG8 /NJTRST | COMP2_INP |
| 91 | 57 | C4 | C5 | 41 | PB5 | I/O | FT | PB5 | I2C1_SMBA/TIM3_CH2/ SPI1_MOSI/LCD_SEG9 | COMP2_INP |
| 92 | 58 | D3 | B5 | 42 | PB6 | I/O | FT | PB6 | I2C1_SCL/TIM4_CH1/ USART1_TX | - |
| 93 | 59 | C3 | B4 | 43 | PB7 | I/O | FT | PB7 | I2C1_SDA/TIM4_CH2/ USART1_RX | PVD_IN |
| 94 | 60 | B4 | A4 | 44 | BOOT0 | I | B | BOOT0 | - | - |
| 95 | 61 | B3 | A3 | 45 | PB8 | I/O | FT | PB8 | TIM4_CH3/I2C1_SCL/ LCD_SEG16/ TIM10_CH1 | - |
| 96 | 62 | A3 | B3 | 46 | PB9 | I/O | FT | PB9 | TIM4_CH4/I2C1_SDA/ LCD_COM3/ TIM11_CH1 | - |
| 97 | - | - | C3 | - | PE0 | I/O | FT | PE0 | TIM4_ETR/LCD_SEG36 /TIM10_CH1 | - |

Table 9. STM32L151x6/8/B-A and STM32L152x6/8/B-A pin definitions (continued)

| Pins | | | | | Pin name | Pin type ⁽¹⁾ | I/O structure | Main function ⁽²⁾ (after reset) | Pins functions | |
|---------|--------|---------|----------|--------------------|-------------------|-------------------------|---------------|---|-------------------------|----------------------|
| LQFP100 | LQFP64 | TFBGA64 | UFBGA100 | LQFP48 or UFQFPN48 | | | | | Alternate functions | Additional functions |
| 98 | - | - | A2 | - | PE1 | I/O | FT | PE1 | LCD_SEG37/ TIM11_CH1 | - |
| 99 | 63 | D4 | D3 | 47 | V _{SS_3} | S | - | V _{SS_3} | - | - |
| 100 | 64 | E4 | C4 | 48 | V _{DD_3} | S | - | V _{DD_3} | - | - |

1. I = input, O = output, S = supply.
2. Function availability depends on the chosen device. For devices having reduced peripheral counts, it is always the lower number of peripheral that is included. For example, if a device has only one SPI and two USARTs, they will be called SPI1 and USART1 & USART2, respectively. Refer to [Table 2 on page 11](#).
3. Applicable to STM32L152xxxxA devices only. In STM32L151xxxxA devices, this pin should be connected to V_{DD}.
4. The PC14 and PC15 I/Os are only configured as OSC32_IN/OSC32_OUT when the LSE oscillator is on (by setting the LSEON bit in the RCC_CSR register). The LSE oscillator pins OSC32_IN/OSC32_OUT can be used as general-purpose PC14/PC15 I/Os, respectively, when the LSE oscillator is off (after reset, the LSE oscillator is off). The LSE has priority over the GPIO function. For more details, refer to Using the OSC32_IN/OSC32_OUT pins as GPIO PC14/PC15 port pins section in the STM32L1xxxx reference manual (RM0038).
5. The PH0 and PH1 I/Os are only configured as OSC_IN/OSC_OUT when the HSE oscillator is on (by setting the HSEON bit in the RCC_CR register). The HSE oscillator pins OSC_IN/OSC_OUT can be used as general-purpose PH0/PH1 I/Os, respectively, when the HSE oscillator is off (after reset, the HSE oscillator is off). The HSE has priority over the GPIO function.
6. Unlike in the LQFP64 package, there is no PC3 in the TFBGA64 package. The V_{REF+} functionality is provided instead.



Table 10. Alternate function input/output

| Port name | Digital alternate function number | | | | | | | | | | | | | | |
|-----------|-----------------------------------|--------------|----------|------------|--------|-----------|-------|------------|-------|-------|--------|--------|--------|----------|----------|
| | AFIO0 | AFIO1 | AFIO2 | AFIO3 | AFIO4 | AFIO5 | AFOI6 | AFIO7 | AFI08 | AFI09 | AFIO11 | AFIO12 | AFIO13 | AFIO14 | AFIO15 |
| | Alternate function | | | | | | | | | | | | | | |
| | SYSTEM | TIM2 | TIM3/4 | TIM9/10/11 | I2C1/2 | SPI1/2 | N/A | USART1/2/3 | N/A | N/A | LCD | N/A | N/A | RI | SYSTEM |
| BOOT0 | BOOT0 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| NRST | NRST | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| PA0-WKUP1 | - | TIM2_CH1_ETR | - | - | - | - | - | USART2_CTS | - | - | - | - | - | TIMx_IC1 | EVENTOUT |
| PA1 | - | TIM2_CH2 | - | - | - | - | - | USART2_RTS | - | - | [SEG0] | - | - | TIMx_IC2 | EVENTOUT |
| PA2 | - | TIM2_CH3 | - | TIM9_CH1 | - | - | - | USART2_TX | - | - | [SEG1] | - | - | TIMx_IC3 | EVENTOUT |
| PA3 | - | TIM2_CH4 | - | TIM9_CH2 | - | - | - | USART2_RX | - | - | [SEG2] | - | - | TIMx_IC4 | EVENTOUT |
| PA4 | - | - | - | - | - | SPI1_NSS | - | USART2_CK | - | - | - | - | - | TIMx_IC1 | EVENTOUT |
| PA5 | - | TIM2_CH1_ETR | - | - | - | SPI1_SCK | - | - | - | - | - | - | - | TIMx_IC2 | EVENTOUT |
| PA6 | - | - | TIM3_CH1 | TIM10_CH1 | - | SPI1_MISO | - | - | - | - | [SEG3] | - | - | TIMx_IC3 | EVENTOUT |
| PA7 | - | - | TIM3_CH2 | TIM11_CH1 | - | SPI1_MOSI | - | - | - | - | [SEG4] | - | - | TIMx_IC4 | EVENTOUT |
| PA8 | MCO | - | - | - | - | - | - | USART1_CK | - | - | [COM0] | - | - | TIMx_IC1 | EVENTOUT |
| PA9 | - | - | - | - | - | - | - | USART1_TX | - | - | [COM1] | - | - | TIMx_IC2 | EVENTOUT |
| PA10 | - | - | - | - | - | - | - | USART1_RX | - | - | [COM2] | - | - | TIMx_IC3 | EVENTOUT |
| PA11 | - | - | - | - | - | SPI1_MISO | - | USART1_CTS | - | - | - | - | - | TIMx_IC4 | EVENTOUT |
| PA12 | - | - | - | - | - | SPI1_MOSI | - | USART1_RTS | - | - | - | - | - | TIMx_IC1 | EVENTOUT |
| PA13 | JTMS-SWDIO | - | - | - | - | - | - | - | - | - | - | - | - | TIMx_IC2 | EVENTOUT |
| PA14 | JTCK-SWCLK | - | - | - | - | - | - | - | - | - | - | - | - | TIMx_IC3 | EVENTOUT |
| PA15 | JTDI | TIM2_CH1_ETR | - | - | - | SPI1_NSS | - | - | - | - | SEG17 | - | - | TIMx_IC4 | EVENTOUT |
| PB0 | - | - | TIM3_CH3 | - | - | - | - | - | - | - | [SEG5] | - | - | - | EVENTOUT |
| PB1 | - | - | TIM3_CH4 | - | - | - | - | - | - | - | [SEG6] | - | - | - | EVENTOUT |
| PB2 | BOOT1 | - | - | - | - | - | - | - | - | - | - | - | - | - | EVENTOUT |
| PB3 | JTDO | TIM2_CH2 | - | - | - | SPI1_SCK | - | - | - | - | [SEG7] | - | - | - | EVENTOUT |



Table 10. Alternate function input/output (continued)

| Port name | Digital alternate function number | | | | | | | | | | | | | | |
|-----------|-----------------------------------|----------|----------|------------|-----------|-----------|-------|------------|-------|-------|--------|--------|--------|----------|----------|
| | AFIO0 | AFIO1 | AFIO2 | AFIO3 | AFIO4 | AFIO5 | AFIO6 | AFIO7 | AFIO8 | AFIO9 | AFIO11 | AFIO12 | AFIO13 | AFIO14 | AFIO15 |
| | Alternate function | | | | | | | | | | | | | | |
| | SYSTEM | TIM2 | TIM3/4 | TIM9/10/11 | I2C1/2 | SPI1/2 | N/A | USART1/2/3 | N/A | N/A | LCD | N/A | N/A | RI | SYSTEM |
| PB4 | NJTRST | - | TIM3_CH1 | - | - | SPI1_MISO | - | - | - | - | [SEG8] | - | - | - | EVENTOUT |
| PB5 | - | - | TIM3_CH2 | - | I2C1_SMBA | SPI1_MOSI | - | - | - | - | [SEG9] | - | - | - | EVENTOUT |
| PB6 | - | - | TIM4_CH1 | - | I2C1_SCL | - | - | USART1_TX | - | - | - | - | - | - | EVENTOUT |
| PB7 | - | - | TIM4_CH2 | - | I2C1_SDA | - | - | USART1_RX | - | - | - | - | - | - | EVENTOUT |
| PB8 | - | - | TIM4_CH3 | TIM10_CH1* | I2C1_SCL | - | - | - | - | - | SEG16 | - | - | - | EVENTOUT |
| PB9 | - | - | TIM4_CH4 | TIM11_CH1* | I2C1_SDA | - | - | - | - | - | [COM3] | - | - | - | EVENTOUT |
| PB10 | - | TIM2_CH3 | - | - | I2C2_SCL | - | - | USART3_TX | - | - | SEG10 | - | - | - | EVENTOUT |
| PB11 | - | TIM2_CH4 | - | - | I2C2_SDA | - | - | USART3_RX | - | - | SEG11 | - | - | - | EVENTOUT |
| PB12 | - | - | - | TIM10_CH1 | I2C2_SMBA | SPI2_NSS | - | USART3_CK | - | - | SEG12 | - | - | - | EVENTOUT |
| PB13 | - | - | - | TIM9_CH1 | - | SPI2_SCK | - | USART3_CTS | - | - | SEG13 | - | - | - | EVENTOUT |
| PB14 | - | - | - | TIM9_CH2 | - | SPI2_MISO | - | USART3_RTS | - | - | SEG14 | - | - | - | EVENTOUT |
| PB15 | - | - | - | TIM11_CH1 | - | SPI2_MOSI | - | - | - | - | SEG15 | - | - | - | EVENTOUT |
| PC0 | - | - | - | - | - | - | - | - | - | - | SEG18 | - | - | TIMx_IC1 | EVENTOUT |
| PC1 | - | - | - | - | - | - | - | - | - | - | SEG19 | - | - | TIMx_IC2 | EVENTOUT |
| PC2 | - | - | - | - | - | - | - | - | - | - | SEG20 | - | - | TIMx_IC3 | EVENTOUT |
| PC3 | - | - | - | - | - | - | - | - | - | - | SEG21 | - | - | TIMx_IC4 | EVENTOUT |
| PC4 | - | - | - | - | - | - | - | - | - | - | SEG22 | - | - | TIMx_IC1 | EVENTOUT |
| PC5 | - | - | - | - | - | - | - | - | - | - | SEG23 | - | - | TIMx_IC2 | EVENTOUT |
| PC6 | - | - | TIM3_CH1 | - | - | - | - | - | - | - | SEG24 | - | - | TIMx_IC3 | EVENTOUT |
| PC7 | - | - | TIM3_CH2 | - | - | - | - | - | - | - | SEG25 | - | - | TIMx_IC4 | EVENTOUT |
| PC8 | - | - | TIM3_CH3 | - | - | - | - | - | - | - | SEG26 | - | - | TIMx_IC1 | EVENTOUT |
| PC9 | - | - | TIM3_CH4 | - | - | - | - | - | - | - | SEG27 | - | - | TIMx_IC2 | EVENTOUT |



Table 10. Alternate function input/output (continued)

| Port name | Digital alternate function number | | | | | | | | | | | | | | |
|--------------------|-----------------------------------|-------|----------|------------|--------|-----------|-------|-------------|--------|--------|----------------------|---------|---------|----------|----------|
| | AFIO0 | AFIO1 | AFIO2 | AFIO3 | AFIO4 | AFIO5 | AFOI6 | AFIO7 | AFI 08 | AFI 09 | AFIO11 | AFIO 12 | AFIO 13 | AFIO14 | AFIO15 |
| | Alternate function | | | | | | | | | | | | | | |
| | SYSTEM | TIM2 | TIM3/4 | TIM9/10/11 | I2C1/2 | SPI1/2 | N/A | USART 1/2/3 | N/A | N/A | LCD | N/A | N/A | RI | SYSTEM |
| PC10 | - | - | - | - | - | - | - | USART3_TX | - | - | COM4 / SEG28 / SEG40 | - | - | TIMx_IC3 | EVENTOUT |
| PC11 | - | - | - | - | - | - | - | USART3_RX | - | - | COM5 / SEG29 / SEG41 | - | - | TIMx_IC4 | EVENTOUT |
| PC12 | - | - | - | - | - | - | - | USART3_CK | - | - | COM6 / SEG30 / SEG42 | - | - | TIMx_IC1 | EVENTOUT |
| PC13- WKUP2 | - | - | - | - | - | - | - | - | - | - | - | - | - | TIMx_IC2 | EVENTOUT |
| PC14- OSC32_IN | - | - | - | - | - | - | - | - | - | - | - | - | - | TIMx_IC3 | EVENTOUT |
| PC15- OSC32_OUT | - | - | - | - | - | - | - | - | - | - | - | - | - | TIMx_IC4 | EVENTOUT |
| PD0 | - | - | - | TIM9_CH1 | - | SPI2_NSS | - | - | - | - | - | - | - | TIMx_IC1 | EVENTOUT |
| PD1 | - | - | - | - | - | SPI2_SCK | - | - | - | - | - | - | - | TIMx_IC2 | EVENTOUT |
| PD2 | - | - | TIM3_ETR | - | - | - | - | - | - | - | COM7 / SEG31 / SEG43 | - | - | TIMx_IC3 | EVENTOUT |
| PD3 | - | - | - | - | - | SPI2_MISO | - | USART2_CTS | - | - | - | - | - | TIMx_IC4 | EVENTOUT |
| PD4 | - | - | - | - | - | SPI2_MOSI | - | USART2_RTS | - | - | - | - | - | TIMx_IC1 | EVENTOUT |
| PD5 | - | - | - | - | - | - | - | USART2_TX | - | - | - | - | - | TIMx_IC2 | EVENTOUT |
| PD6 | - | - | - | - | - | - | - | USART2_RX | - | - | - | - | - | TIMx_IC3 | EVENTOUT |
| PD7 | - | - | - | TIM9_CH2 | - | - | - | USART2_CK | - | - | - | - | - | TIMx_IC4 | EVENTOUT |
| PD8 | - | - | - | - | - | - | - | USART3_TX | - | - | - | - | - | TIMx_IC1 | EVENTOUT |
| PD9 | - | - | - | - | - | - | - | USART3_RX | - | - | - | - | - | TIMx_IC2 | EVENTOUT |



Table 10. Alternate function input/output (continued)

| Port name | Digital alternate function number | | | | | | | | | | | | | | |
|------------|-----------------------------------|--------------|----------|------------|--------|--------|-----------|------------|-------|-------|--------|--------|--------|----------|----------|
| | AFIO0 | AFIO1 | AFIO2 | AFIO3 | AFIO4 | AFIO5 | AFO16 | AFIO7 | AFI08 | AFI09 | AFIO11 | AFIO12 | AFIO13 | AFIO14 | AFIO15 |
| | Alternate function | | | | | | | | | | | | | | |
| | SYSTEM | TIM2 | TIM3/4 | TIM9/10/11 | I2C1/2 | SPI1/2 | N/A | USART1/2/3 | N/A | N/A | LCD | N/A | N/A | RI | SYSTEM |
| PD10 | - | - | - | - | - | - | - | USART3_CK | - | - | - | - | - | TIMx_IC3 | EVENTOUT |
| PD11 | - | - | - | - | - | - | - | USART3_CTS | - | - | - | - | - | TIMx_IC4 | EVENTOUT |
| PD12 | - | - | TIM4_CH1 | - | - | - | - | USART3_RTS | - | - | - | - | - | TIMx_IC1 | EVENTOUT |
| PD13 | - | - | TIM4_CH2 | - | - | - | - | - | - | - | - | - | - | TIMx_IC2 | EVENTOUT |
| PD14 | - | - | TIM4_CH3 | - | - | - | - | - | - | - | - | - | - | TIMx_IC3 | EVENTOUT |
| PD15 | - | - | TIM4_CH4 | - | - | - | - | - | - | - | - | - | - | TIMx_IC4 | EVENTOUT |
| PE0 | - | - | TIM4_ETR | TIM10_CH1 | - | - | - | - | - | - | - | - | - | TIMx_IC1 | EVENTOUT |
| PE1 | - | - | - | TIM11_CH1 | - | - | - | - | - | - | - | - | - | TIMx_IC2 | EVENTOUT |
| PE2 | TRACECK | - | TIM3_ETR | - | - | - | - | - | - | - | - | - | - | TIMx_IC3 | EVENTOUT |
| PE3 | TRACED0 | - | TIM3_CH1 | - | - | - | - | - | - | - | - | - | - | TIMx_IC4 | EVENTOUT |
| PE4 | TRACED1 | - | TIM3_CH2 | - | - | - | - | - | - | - | - | - | - | TIMx_IC1 | EVENTOUT |
| PE5 | TRACED2 | - | - | TIM9_CH1* | - | - | - | - | - | - | - | - | - | TIMx_IC2 | EVENTOUT |
| PE6 | TRACED3 | - | - | TIM9_CH2* | - | - | - | - | - | - | - | - | - | TIMx_IC3 | EVENTOUT |
| PE7 | - | - | - | - | - | - | - | - | - | - | - | - | - | TIMx_IC4 | EVENTOUT |
| PE8 | - | - | - | - | - | - | - | - | - | - | - | - | - | TIMx_IC1 | EVENTOUT |
| PE9 | - | TIM2_CH1_ETR | - | - | - | - | - | - | - | - | - | - | - | TIMx_IC2 | EVENTOUT |
| PE10 | - | TIM2_CH2 | - | - | - | - | - | - | - | - | - | - | - | TIMx_IC3 | EVENTOUT |
| PE11 | - | TIM2_CH3 | - | - | - | - | - | - | - | - | - | - | - | TIMx_IC4 | EVENTOUT |
| PE12 | - | TIM2_CH4 | - | - | - | - | SPI1_NSS | - | - | - | - | - | - | TIMx_IC1 | EVENTOUT |
| PE13 | - | - | - | - | - | - | SPI1_SCK | - | - | - | - | - | - | TIMx_IC2 | EVENTOUT |
| PE14 | - | - | - | - | - | - | SPI1_MISO | - | - | - | - | - | - | TIMx_IC3 | EVENTOUT |
| PE15 | - | - | - | - | - | - | SPI1_MOSI | - | - | - | - | - | - | TIMx_IC4 | EVENTOUT |
| PH0-OSC_IN | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |



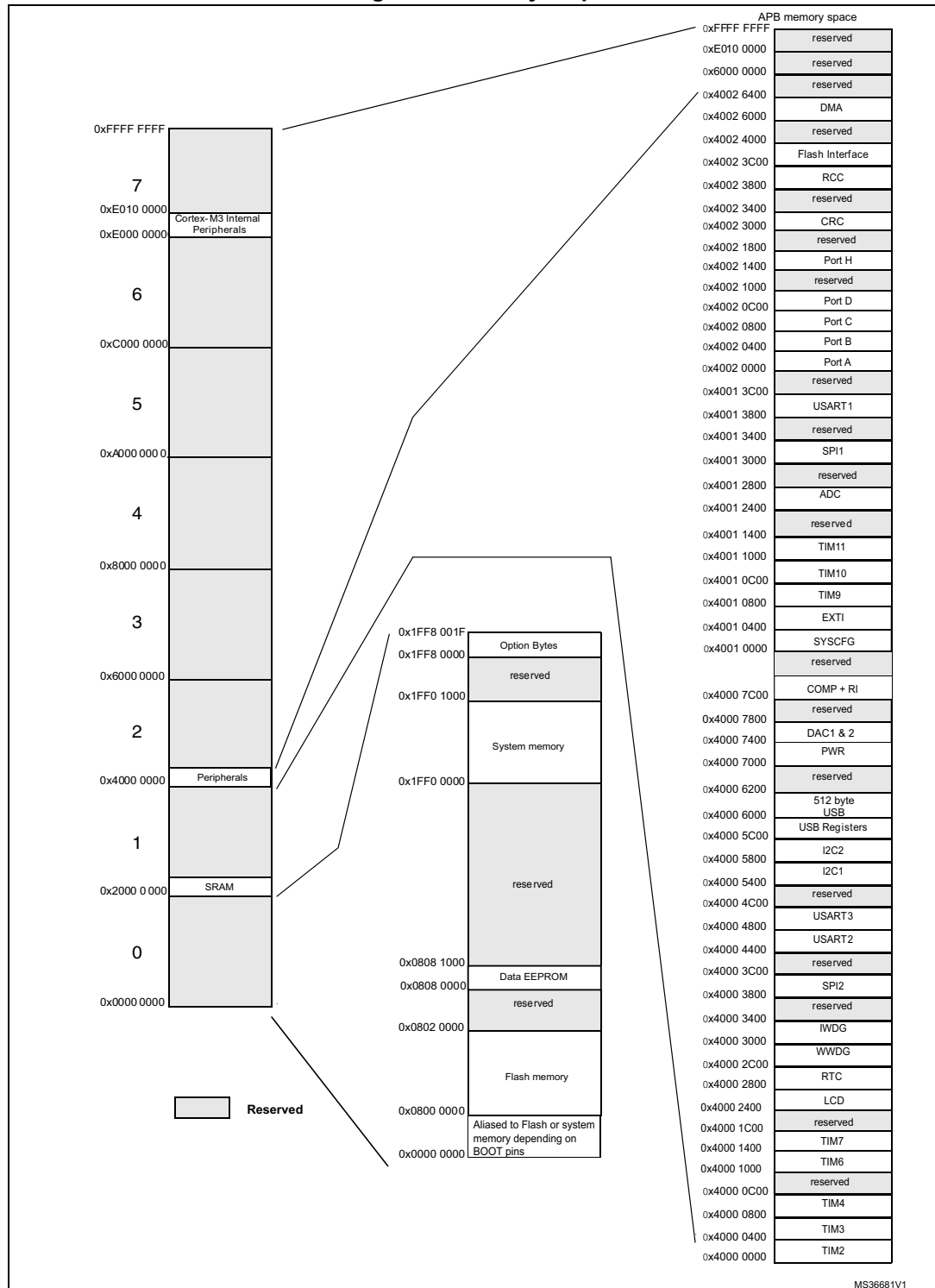
Table 10. Alternate function input/output (continued)

| Port name | Digital alternate function number | | | | | | | | | | | | | | |
|-----------------|-----------------------------------|-------|--------|------------|--------|--------|-------|----------------|-------|-------|--------|--------|--------|--------|--------|
| | AFIO0 | AFIO1 | AFIO2 | AFIO3 | AFIO4 | AFIO5 | AFIO6 | AFIO7 | AFIO8 | AFIO9 | AFIO11 | AFIO12 | AFIO13 | AFIO14 | AFIO15 |
| | Alternate function | | | | | | | | | | | | | | |
| | SYSTEM | TIM2 | TIM3/4 | TIM9/10/11 | I2C1/2 | SPI1/2 | N/A | USART 1/2/3 | N/A | N/A | LCD | N/A | N/A | RI | SYSTEM |
| PH1- OSC_OUT | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| PH2 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

5 Memory mapping

The memory map is shown in the following figure.

Figure 9. Memory map



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 $T_A = 25\text{ °C}$ and $T_A = T_{Amax}$ (given by the selected temperature range).

Data based on characterization results, design simulation and/or technology characteristics are indicated in the table footnotes. Based on characterization, the minimum and maximum values refer to sample tests and represent the mean value plus or minus three times the standard deviation ($\text{mean} \pm 3\sigma$).

Please refer to device ErrataSheet for possible latest changes of electrical characteristics.

6.1.2 Typical values

Unless otherwise specified, typical data are based on $T_A = 25\text{ °C}$, $V_{DD} = 3.0\text{ V}$ (for the $1.65\text{ V} \leq V_{DD} \leq 3.6\text{ V}$ voltage range). They are given only as design guidelines and are not tested.

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

6.1.3 Typical curves

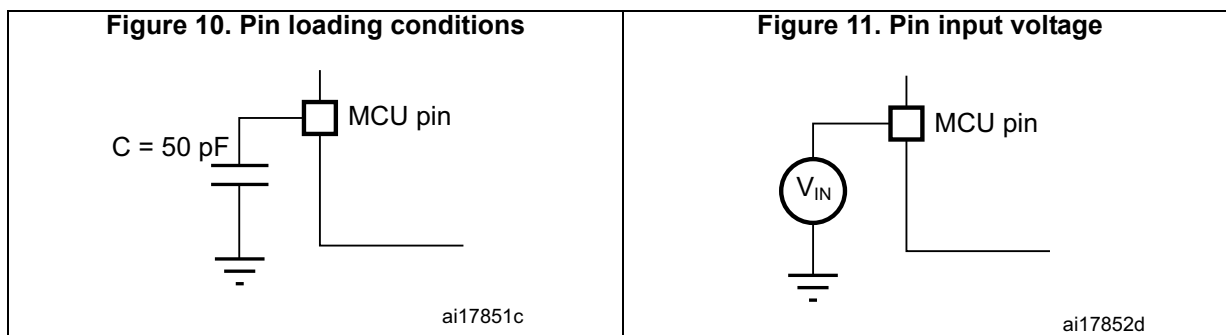
Unless otherwise specified, all typical curves are given only as design guidelines and are not tested.

6.1.4 Loading capacitor

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

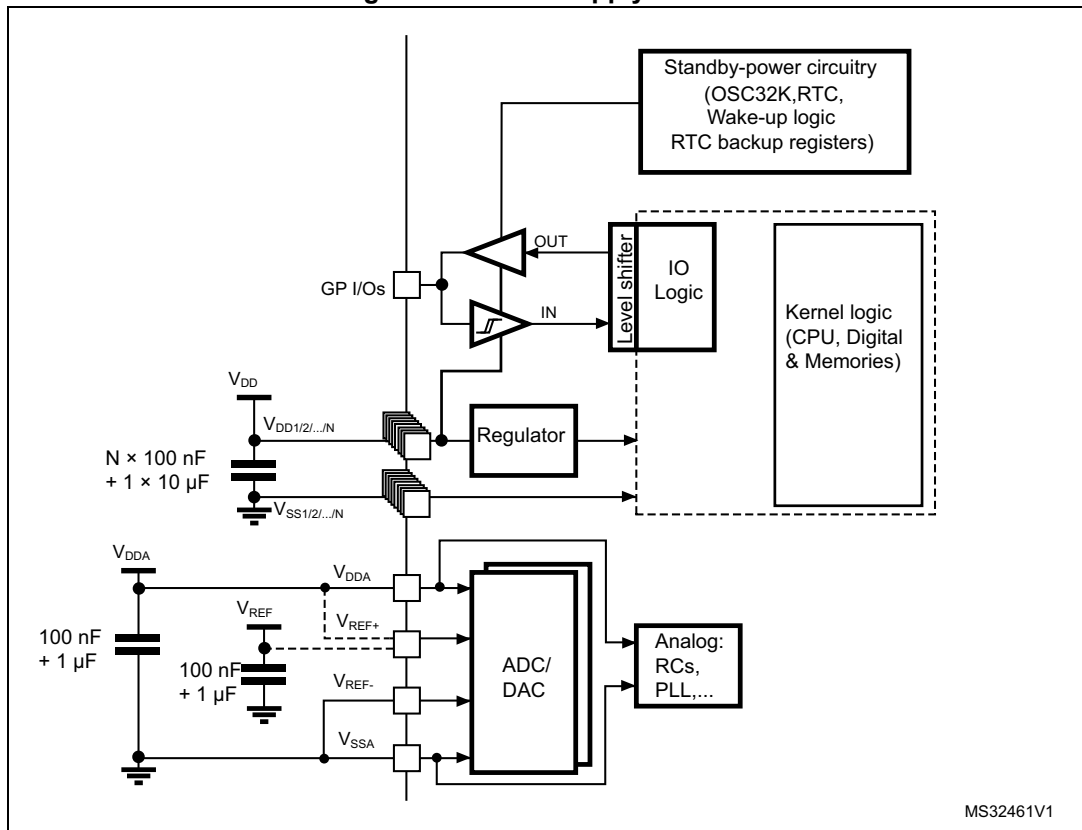
6.1.5 Pin input voltage

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



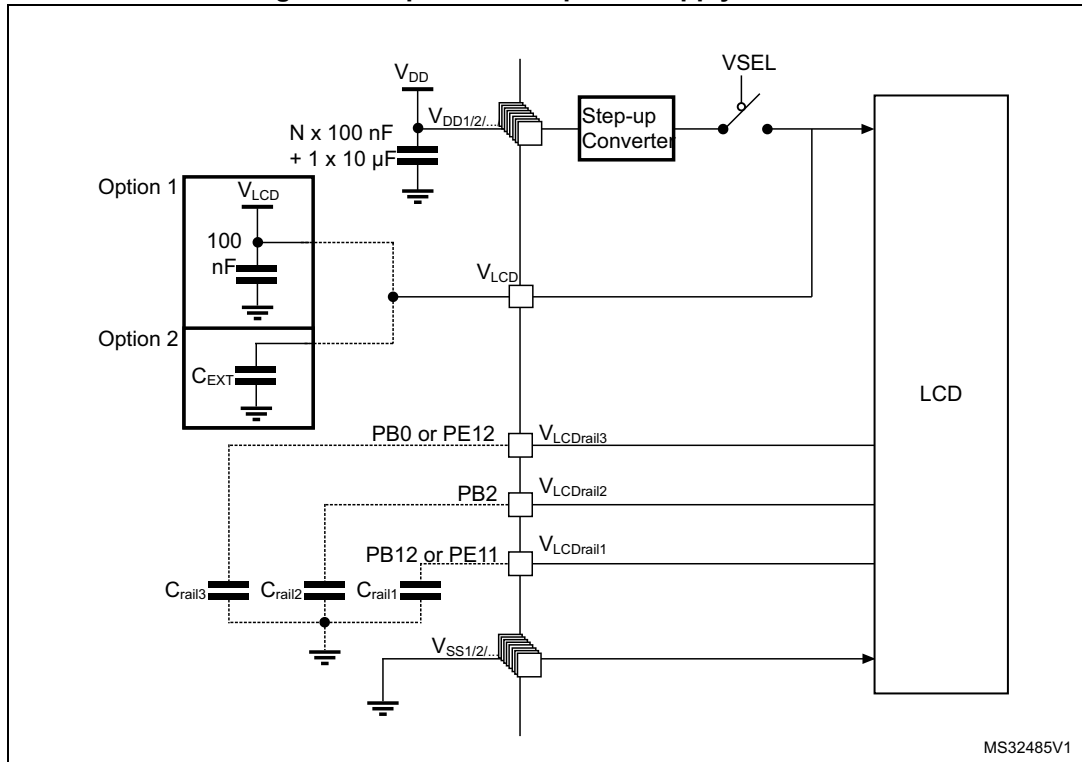
6.1.6 Power supply scheme

Figure 12. Power supply scheme



6.1.7 Optional LCD power supply scheme

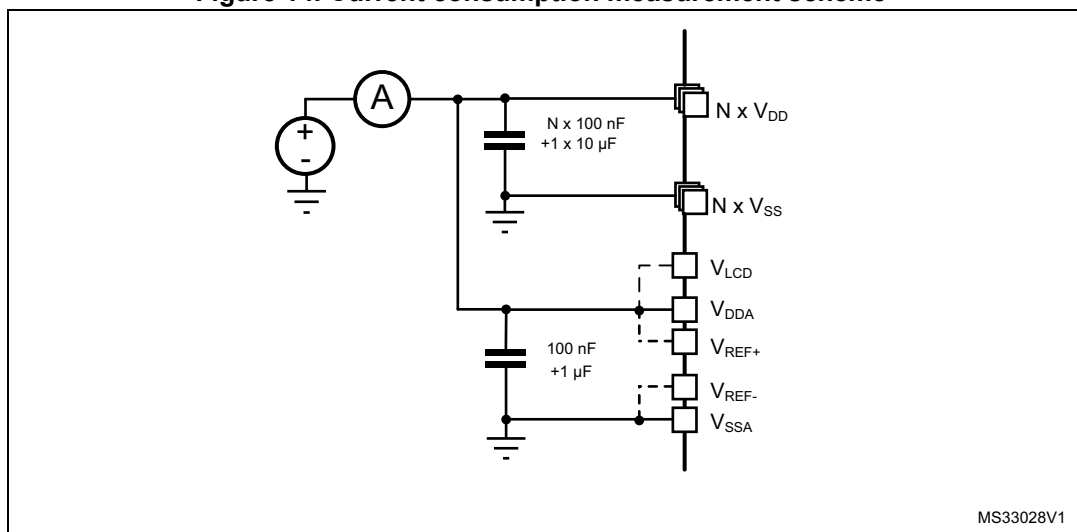
Figure 13. Optional LCD power supply scheme



- Option 1: LCD power supply is provided by a dedicated VLCD supply source, VSEL switch is open.
- Option 2: LCD power supply is provided by the internal step-up converter, VSEL switch is closed, an external capacitance is needed for correct behavior of this converter.

6.1.8 Current consumption measurement

Figure 14. Current consumption measurement scheme



6.2 Absolute maximum ratings

Stresses above the absolute maximum ratings listed in [Table 11: Voltage characteristics](#), [Table 12: Current characteristics](#), and [Table 13: Thermal characteristics](#) may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these conditions is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.

Table 11. Voltage characteristics

| Symbol | Ratings | Min | Max | Unit |
|-------------------------|---|------------------------------------|--------------|------|
| $V_{DD}-V_{SS}$ | External main supply voltage (including V_{DDA} and V_{DD}) ⁽¹⁾ | -0.3 | 4.0 | V |
| V_{IN} ⁽²⁾ | Input voltage on five-volt tolerant pin | $V_{SS}-0.3$ | $V_{DD}+4.0$ | |
| | Input voltage on any other pin | $V_{SS}-0.3$ | 4.0 | |
| $ \Delta V_{DDx} $ | Variations between different V_{DD} power pins | - | 50 | mV |
| $ V_{SSx}-V_{SS} $ | Variations between all different ground pins ⁽³⁾ | - | 50 | |
| $V_{REF+}-V_{DDA}$ | Allowed voltage difference for $V_{REF+} > V_{DDA}$ | - | 0.4 | V |
| $V_{ESD(HBM)}$ | Electrostatic discharge voltage (human body model) | see Section 6.3.11 | | - |

1. All main power (V_{DD} , V_{DDA}) and ground (V_{SS} , V_{SSA}) pins must always be connected to the external power supply, in the permitted range.
2. V_{IN} maximum must always be respected. Refer to [Table 12](#) for maximum allowed injected current values.
3. Include V_{REF-} pin.

Table 12. Current characteristics

| Symbol | Ratings | Max. | Unit |
|---------------------------------|--|----------|------|
| ΣI_{VDD} | Total current into sum of all V_{DD_x} power lines (source) ⁽¹⁾ | 100 | mA |
| ΣI_{VSS} ⁽²⁾ | Total current out of sum of all V_{SS_x} ground lines (sink) ⁽¹⁾ | 100 | |
| $I_{VDD(PIN)}$ | Maximum current into each V_{DD_x} power pin (source) ⁽¹⁾ | 70 | |
| $I_{VSS(PIN)}$ | Maximum current out of each V_{SS_x} ground pin (sink) ⁽¹⁾ | -70 | |
| I_{IO} | Output current sunk by any I/O and control pin | 25 | |
| | Output current sourced by any I/O and control pin | -25 | |
| $\Sigma I_{IO(PIN)}$ | Total output current sunk by sum of all IOs and control pins ⁽²⁾ | 60 | |
| | Total output current sourced by sum of all IOs and control pins ⁽²⁾ | -60 | |
| $I_{INJ(PIN)}$ ⁽³⁾ | Injected current on five-volt tolerant I/O ⁽⁴⁾ RST and B pins | -5/+0 | |
| | Injected current on any other pin ⁽⁵⁾ | ± 5 | |
| $\Sigma I_{INJ(PIN)}$ | Total injected current (sum of all I/O and control pins) ⁽⁶⁾ | ± 25 | |

1. All main power (V_{DD} , V_{DDA}) and ground (V_{SS} , V_{SSA}) pins must always be connected to the external power supply, in the permitted range.
2. 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. Negative injection disturbs the analog performance of the device. See note in [Section 6.3.17](#).
4. Positive current injection is not possible on these I/Os. A negative injection is induced by $V_{IN} < V_{SS}$. $I_{INJ(PIN)}$ must never be exceeded. Refer to [Table 11](#) for maximum allowed input voltage values.
5. 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 11: Voltage characteristics](#) for the maximum allowed input voltage values.
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 13. Thermal characteristics

| Symbol | Ratings | Value | Unit |
|------------|---|-------------------------|------|
| T_{STG} | Storage temperature range | -65 to +150 | °C |
| T_J | Maximum junction temperature | 150 | °C |
| T_{LEAD} | Maximum lead temperature during soldering | see note ⁽¹⁾ | °C |

1. Compliant with JEDEC Std J-STD-020D (for small body, Sn-Pb or Pb assembly), the ST ECOPACK[®] 7191395 specification, and the European directive on Restrictions on Hazardous Substances (ROHS directive 2011/65/EU, July 2011).

6.3 Operating conditions

6.3.1 General operating conditions

Table 14. General operating conditions

| Symbol | Parameter | Conditions | Min | Max | Unit |
|-----------------|---|--|------|--------------|------|
| f_{HCLK} | Internal AHB clock frequency | - | 0 | 32 | MHz |
| f_{PCLK1} | Internal APB1 clock frequency | - | 0 | 32 | |
| f_{PCLK2} | Internal APB2 clock frequency | - | 0 | 32 | |
| V_{DD} | Standard operating voltage | BOR detector disabled | 1.65 | 3.6 | V |
| | | BOR detector enabled, at power on | 1.8 | 3.6 | |
| | | BOR detector disabled, after power on | 1.65 | 3.6 | |
| $V_{DDA}^{(1)}$ | Analog operating voltage (ADC and DAC not used) | Must be the same voltage as $V_{DD}^{(2)}$ | 1.65 | 3.6 | V |
| | Analog operating voltage (ADC or DAC used) | | 1.8 | 3.6 | |
| V_{IN} | I/O input voltage | FT pins: $2.0\text{ V} \leq V_{DD}$ | -0.3 | $5.5^{(3)}$ | V |
| | | FT pins: $V_{DD} < 2.0\text{ V}$ | -0.3 | $5.25^{(3)}$ | |
| | | BOOT0 | 0 | 5.5 | |
| | | Any other pin | -0.3 | $V_{DD}+0.3$ | |

Table 14. General operating conditions (continued)

| Symbol | Parameter | Conditions | Min | Max | Unit |
|----------------|---|--|-----|-----|------|
| P _D | Power dissipation at TA = 85 °C for suffix 6 or TA = 105 °C for suffix 7 ⁽⁴⁾ | UFBGA100 package | - | 339 | mW |
| | | LQFP100 package | - | 435 | |
| | | TFBGA64 package | - | 308 | |
| | | LQFP64 package | - | 444 | |
| | | LQFP48 package | - | 364 | |
| | | UFQFPN48 package | - | 606 | |
| T _A | Ambient temperature for 6 suffix version | Maximum power dissipation ⁽⁵⁾ | -40 | 85 | °C |
| | Ambient temperature for 7 suffix version | Maximum power dissipation | -40 | 105 | |
| T _J | Junction temperature range | 6 suffix version | -40 | 105 | °C |
| | Junction temperature range | 7 suffix version | -40 | 110 | |

1. When the ADC is used, refer to [Table 55: ADC characteristics](#).
2. It is recommended to power V_{DD} and V_{DDA} from the same source. A maximum difference of 300 mV between V_{DD} and V_{DDA} can be tolerated during power-up and operation.
3. To sustain a voltage higher than V_{DD}+0.3 V, the internal pull-up/pull-down resistors must be disabled.
4. If T_A is lower, higher P_D values are allowed as long as T_J does not exceed T_J max (see [Table 13: Thermal characteristics on page 56](#)).
5. In low-power dissipation state, T_A can be extended to -40°C to 105°C temperature range as long as T_J does not exceed T_J max (see [Table 13: Thermal characteristics on page 56](#)).

6.3.2 Embedded reset and power control block characteristics

The parameters given in the following table are derived from the tests performed under the ambient temperature condition summarized in the following table.

Table 15. Embedded reset and power control block characteristics

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|--------------------------------------|-------------------------------------|---|-----|-----|------|------|
| t _{VDD} ⁽¹⁾ | V _{DD} rise time rate | BOR detector enabled | 0 | - | ∞ | μs/V |
| | | BOR detector disabled | 0 | - | 1000 | |
| | V _{DD} fall time rate | BOR detector enabled | 20 | - | ∞ | |
| | | BOR detector disabled | 0 | - | 1000 | |
| T _{RSTTEMPO} ⁽¹⁾ | Reset temporization | V _{DD} rising, BOR enabled | - | 2 | 3.3 | ms |
| | | V _{DD} rising, BOR disabled ⁽²⁾ | 0.4 | 0.7 | 1.6 | |
| V _{POR/PDR} | Power on/power down reset threshold | Falling edge | 1 | 1.5 | 1.65 | V |
| | | Rising edge | 1.3 | 1.5 | 1.65 | |

Table 15. Embedded reset and power control block characteristics (continued)

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit | |
|-------------------|---|---|------|------|------|------|---|
| V _{BOR0} | Brown-out reset threshold 0 | Falling edge | 1.67 | 1.7 | 1.74 | V | |
| | | Rising edge | 1.69 | 1.76 | 1.8 | | |
| V _{BOR1} | Brown-out reset threshold 1 | Falling edge | 1.87 | 1.93 | 1.97 | | |
| | | Rising edge | 1.96 | 2.03 | 2.07 | | |
| V _{BOR2} | Brown-out reset threshold 2 | Falling edge | 2.22 | 2.30 | 2.35 | | |
| | | Rising edge | 2.31 | 2.41 | 2.44 | | |
| V _{BOR3} | Brown-out reset threshold 3 | Falling edge | 2.45 | 2.55 | 2.60 | | |
| | | Rising edge | 2.54 | 2.66 | 2.7 | | |
| V _{BOR4} | Brown-out reset threshold 4 | Falling edge | 2.68 | 2.8 | 2.85 | | |
| | | Rising edge | 2.78 | 2.9 | 2.95 | | |
| V _{PVD0} | Programmable voltage detector threshold 0 | Falling edge | 1.8 | 1.85 | 1.88 | | V |
| | | Rising edge | 1.88 | 1.94 | 1.99 | | |
| V _{PVD1} | PVD threshold 1 | Falling edge | 1.98 | 2.04 | 2.09 | | |
| | | Rising edge | 2.08 | 2.14 | 2.18 | | |
| V _{PVD2} | PVD threshold 2 | Falling edge | 2.20 | 2.24 | 2.28 | | |
| | | Rising edge | 2.28 | 2.34 | 2.38 | | |
| V _{PVD3} | PVD threshold 3 | Falling edge | 2.39 | 2.44 | 2.48 | | |
| | | Rising edge | 2.47 | 2.54 | 2.58 | | |
| V _{PVD4} | PVD threshold 4 | Falling edge | 2.57 | 2.64 | 2.69 | | |
| | | Rising edge | 2.68 | 2.74 | 2.79 | | |
| V _{PVD5} | PVD threshold 5 | Falling edge | 2.77 | 2.83 | 2.88 | | |
| | | Rising edge | 2.87 | 2.94 | 2.99 | | |
| V _{PVD6} | PVD threshold 6 | Falling edge | 2.97 | 3.05 | 3.09 | | |
| | | Rising edge | 3.08 | 3.15 | 3.20 | | |
| V _{hyst} | Hysteresis voltage | BOR0 threshold | - | 40 | - | mV | |
| | | All BOR and PVD thresholds excepting BOR0 | - | 100 | - | | |

1. Guaranteed by characterization.

2. Valid for device version without BOR at power up. Please see option "D" in Ordering information scheme for more details.

6.3.3 Embedded internal reference voltage

The parameters given in the following table are based on characterization results, unless otherwise specified.

Table 16. Embedded internal reference voltage calibration values

| Calibration value name | Description | Memory address |
|------------------------|--|-------------------------|
| VREFINT_CAL | Raw data acquired at temperature of 30 °C ±5 °C, V _{DDA} = 3 V ±10 mV | 0x1FF8 0078-0x1FF8 0079 |

Table 17. Embedded internal reference voltage

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|---|-------|-------|-------|-----------------------|
| V _{REFINT_out} ⁽¹⁾ | Internal reference voltage | -40 °C < T _J < +110 °C | 1.202 | 1.224 | 1.242 | V |
| I _{REFINT} | Internal reference current consumption | - | - | 1.4 | 2.3 | µA |
| T _{VREFINT} | Internal reference startup time | - | - | 2 | 3 | ms |
| V _{VREF_MEAS} | V _{DDA} and V _{REF+} voltage during V _{REFINT} factory measure | - | 2.99 | 3 | 3.01 | V |
| A _{VREF_MEAS} | Accuracy of factory-measured V _{REF} value ⁽²⁾ | Including uncertainties due to ADC and V _{DDA} /V _{REF+} values | - | - | ±5 | mV |
| T _{Coeff} ⁽³⁾ | Temperature coefficient | -40 °C < T _J < +110 °C | - | 25 | 100 | ppm/°C |
| A _{Coeff} ⁽³⁾ | Long-term stability | 1000 hours, T = 25 °C | - | - | 1000 | ppm |
| V _{DDCcoeff} ⁽³⁾⁽⁴⁾ | Voltage coefficient | 3.0 V < V _{DDA} < 3.6 V | - | - | 2000 | ppm/V |
| T _{S_vrefint} ⁽³⁾ | ADC sampling time when reading the internal reference voltage | - | 4 | - | - | µs |
| T _{ADC_BUF} ⁽³⁾ | Startup time of reference voltage buffer for ADC | - | - | - | 10 | µs |
| I _{BUF_ADC} ⁽³⁾ | Consumption of reference voltage buffer for ADC | - | - | 13.5 | 25 | µA |
| I _{VREF_OUT} ⁽³⁾ | VREF_OUT output current ⁽⁵⁾ | - | - | - | 1 | µA |
| C _{VREF_OUT} ⁽³⁾ | VREF_OUT output load | - | - | - | 50 | pF |
| I _{LPBUF} ⁽³⁾ | Consumption of reference voltage buffer for VREF_OUT and COMP | - | - | 730 | 1200 | nA |
| V _{REFINT_DIV1} ⁽³⁾ | 1/4 reference voltage | - | 24 | 25 | 26 | % V _{REFINT} |
| V _{REFINT_DIV2} ⁽³⁾ | 1/2 reference voltage | - | 49 | 50 | 51 | |
| V _{REFINT_DIV3} ⁽³⁾ | 3/4 reference voltage | - | 74 | 75 | 76 | |

1. Guaranteed by test in production.

2. The internal V_{REF} value is individually measured in production and stored in dedicated EEPROM bytes.

3. Guaranteed by characterization results.

4. Shortest sampling time can be determined in the application by multiple interactions.

5. To guarantee less than 1% VREF_OUT deviation.

6.3.4 Supply current characteristics

The current consumption is a function of several parameters and factors such as the operating voltage, ambient temperature, I/O pin loading, device software configuration, operating frequencies, I/O pin switching rate, program location in memory and executed binary code. The current consumption is measured as described in [Figure 14: Current consumption measurement scheme](#).

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

The current consumption values are derived from the tests performed under ambient temperature $T_A=25^\circ\text{C}$ and V_{DD} supply voltage conditions summarized in [Table 14: General operating conditions](#), unless otherwise specified.

The MCU is placed under the following conditions:

- All I/O pins are configured in analog input mode.
- All peripherals are disabled except when explicitly mentioned.
- The Flash memory access time, 64-bit access and prefetch is adjusted depending on f_{HCLK} frequency and voltage range to provide the best CPU performance.
- When the peripherals are enabled $f_{APB1} = f_{APB2} = f_{AHB}$.
- When PLL is ON, the PLL inputs are equal to HSI = 16 MHz (if internal clock is used) or HSE = 16 MHz (if HSE bypass mode is used).
- The HSE user clock applied to OSC_IN input follows the characteristics specified in [Table 27: High-speed external user clock characteristics](#).
- For maximum current consumption $V_{DD} = V_{DDA} = 3.6\text{ V}$ is applied to all supply pins.
- For typical current consumption $V_{DD} = V_{DDA} = 3.0\text{ V}$ is applied to all supply pins if not specified otherwise.

Table 18. Current consumption in Run mode, code with data processing running from Flash

| Symbol | Parameter | Conditions | f _{HCLK} | Typ | Max ⁽¹⁾ | Unit | |
|----------------------------------|--|---|--|--|--------------------|-------|----|
| I _{DD} (Run from Flash) | Supply current in Run mode, code executed from Flash | f _{HSE} = f _{HCLK} up to 16 MHz, included f _{HSE} = f _{HCLK} /2 above 16 MHz (PLL ON) ⁽²⁾ | Range 3, V _{CORE} =1.2 V VOS[1:0] = 11 | 1 MHz | 215 | 285 | µA |
| | | | | 2 MHz | 400 | 490 | |
| | | | | 4 MHz | 725 | 1000 | |
| | | | Range 2, V _{CORE} =1.5 V VOS[1:0] = 10 | 4 MHz | 0.915 | 1.3 | mA |
| | | | | 8 MHz | 1.75 | 2.15 | |
| | | | | 16 MHz | 3.4 | 4 | |
| | | | Range 1, V _{CORE} =1.8 V VOS[1:0] = 01 | 8 MHz | 2.1 | 2.9 | |
| | | | | 16 MHz | 4.2 | 5.2 | |
| | | | | 32 MHz | 8.25 | 9.6 | |
| | | HSI clock source (16 MHz) | Range 2, V _{CORE} =1.5 V VOS[1:0] = 10 | 16 MHz | 3.5 | 4.4 | |
| | | | | Range 1, V _{CORE} =1.8 V VOS[1:0] = 01 | 32 MHz | 8.2 | |
| | | MSI clock, 65 kHz | Range 3, V _{CORE} =1.2 V VOS[1:0] = 11 | 65 kHz | 0.041 | 0.085 | |
| | | MSI clock, 524 kHz | | 524 kHz | 0.125 | 0.180 | |
| | | MSI clock, 4.2 MHz | | 4.2 MHz | 0.775 | 0.935 | |

1. Guaranteed by characterization results, unless otherwise specified.
2. Oscillator bypassed (HSEBYP = 1 in RCC_CR register).

Table 19. Current consumption in Run mode, code with data processing running from RAM

| Symbol | Parameter | Conditions | | f _{HCLK} | Typ | Max ⁽¹⁾ | Unit |
|--------------------------------|--|---|---|---|--------|--------------------|------|
| I _{DD} (Run from RAM) | Supply current in Run mode, code executed from RAM, Flash switched off | f _{HSE} = f _{HCLK} up to 16 MHz, included f _{HSE} = f _{HCLK} /2 above 16 MHz (PLL ON) ⁽²⁾ | Range 3, V _{CORE} =1.2 V VOS[1:0] = 11 | 1 MHz | 185 | 255 | μA |
| | | | | 2 MHz | 345 | 435 | |
| | | | | 4 MHz | 645 | 930 | |
| | | | Range 2, V _{CORE} =1.5 V VOS[1:0] = 10 | 4 MHz | 0.755 | 1.5 | mA |
| | | | | 8 MHz | 1.5 | 2.2 | |
| | | | | 16 MHz | 3.0 | 3.6 | |
| | | Range 1, V _{CORE} =1.8 V VOS[1:0] = 01 | 8 MHz | 1.8 | 2.9 | | |
| | | | 16 MHz | 3.6 | 4.3 | | |
| | | | 32 MHz | 7.15 | 8.5 | | |
| | | HSI clock source (16 MHz) | Range 2, V _{CORE} =1.5 V VOS[1:0] = 10 | 16 MHz | 2.95 | 3.7 | |
| | | | | Range 1, V _{CORE} =1.8 V VOS[1:0] = 01 | 32 MHz | 7.15 | 8.7 |
| | | MSI clock, 65 kHz | Range 3, V _{CORE} =1.2 V VOS[1:0] = 11 | 65 kHz | 39 | 115 | μA |
| | | MSI clock, 524 kHz | | 524 kHz | 110 | 205 | |
| MSI clock, 4.2 MHz | 4.2 MHz | 690 | | 870 | | | |

1. Guaranteed by characterization results, unless otherwise specified.
2. Oscillator bypassed (HSEBYP = 1 in RCC_CR register).

Table 20. Current consumption in Sleep mode

| Symbol | Parameter | Conditions | f _{HCLK} | Typ | Max ⁽¹⁾ | Unit | |
|---|---|--|--|---|--------------------|--------------------|----|
| I _{DD} (Sleep) | Supply current in Sleep mode, Flash OFF | f _{HSE} = f _{HCLK} up to 16 MHz included, f _{HSE} = f _{HCLK} /2 above 16 MHz (PLL ON) ⁽²⁾ | Range 3, V _{CORE} =1.2 V VOS[1:0] = 11 | 1 MHz | 50 | 155 | μA |
| | | | | 2 MHz | 78.5 | 235 | |
| | | | | 4 MHz | 140 | 370 ⁽³⁾ | |
| | | | Range 2, V _{CORE} =1.5 V VOS[1:0] = 10 | 4 MHz | 165 | 375 | |
| | | | | 8 MHz | 310 | 530 | |
| | | | | 16 MHz | 590 | 1000 | |
| | | | Range 1, V _{CORE} =1.8 V VOS[1:0] = 01 | 8 MHz | 350 | 615 | |
| | | | | 16 MHz | 680 | 1200 | |
| | | | | 32 MHz | 1600 | 2350 | |
| | | HSI clock source (16 MHz) | Range 2, V _{CORE} =1.5 V VOS[1:0] = 10 | 16 MHz | 640 | 970 | |
| | | | Range 1, V _{CORE} =1.8 V VOS[1:0] = 01 | 32 MHz | 1600 | 2350 | |
| | | | MSI clock, 65 kHz | 65 kHz | 19 | 60 | |
| | | MSI clock, 524 kHz | Range 3, V _{CORE} =1.2 V VOS[1:0] = 11 | 524 kHz | 33 | 90 | |
| | | MSI clock, 4.2 MHz | | 4.2 MHz | 145 | 210 | |
| | | Supply current in Sleep mode, Flash ON | f _{HSE} = f _{HCLK} up to 16 MHz included, f _{HSE} = f _{HCLK} /2 above 16 MHz (PLL ON) ⁽²⁾ | Range 3, V _{CORE} =1.2 V VOS[1:0] = 11 | 1 MHz | 60.5 | |
| | | | | 2 MHz | 89.5 | 225 | |
| | | | | 4 MHz | 150 | 360 | |
| | Range 2, V _{CORE} =1.5 V VOS[1:0] = 10 | | | 4 MHz | 180 | 370 | |
| | | | | 8 MHz | 320 | 490 | |
| | | | | 16 MHz | 605 | 895 | |
| | Range 1, V _{CORE} =1.8 V VOS[1:0] = 01 | | | 8 MHz | 380 | 565 | |
| | | | | 16 MHz | 695 | 1070 | |
| | | | | 32 MHz | 1600 | 2200 | |
| | HSI clock source (16 MHz) | | Range 2, V _{CORE} =1.5 V VOS[1:0] = 10 | 16 MHz | 650 | 970 | |
| Range 1, V _{CORE} =1.8 V VOS[1:0] = 01 | | | 32 MHz | 1600 | 2320 | | |
| MSI clock, 65 kHz | | | 65 kHz | 29.5 | 65 | | |
| MSI clock, 524 kHz | Range 3, V _{CORE} =1.2V VOS[1:0] = 11 | | 524 kHz | 44 | 80 | | |
| MSI clock, 4.2 MHz | | | 4.2 MHz | 155 | 220 | | |

1. Guaranteed by characterization results, unless otherwise specified.
2. Oscillator bypassed (HSEBYP = 1 in RCC_CR register)
3. Guaranteed by test in production.

Table 21. Current consumption in Low-power run mode

| Symbol | Parameter | Conditions | | | Typ | Max ⁽¹⁾ | Unit |
|---|---|---|---|----------------------------------|------|--------------------|------|
| I _{DD} (LP Run) | Supply current in Low-power run mode | All peripherals OFF, code executed from RAM, Flash switched OFF, V _{DD} from 1.65 V to 3.6 V | MSI clock, 65 kHz f _{HCLK} = 32 kHz | T _A = -40 °C to 25 °C | 10.9 | 12 | μA |
| | | | | T _A = 85 °C | 16.5 | 23 | |
| | | | | T _A = 105 °C | 26 | 47 | |
| | | | MSI clock, 65 kHz f _{HCLK} = 65 kHz | T _A = -40 °C to 25 °C | 15 | 16 | |
| | | | | T _A = 85 °C | 22 | 29 | |
| | | | | T _A = 105 °C | 32 | 51 | |
| | | | MSI clock, 131 kHz f _{HCLK} = 131 kHz | T _A = -40 °C to 25 °C | 29 | 37 | |
| | | | | T _A = 55 °C | 32.5 | 40 | |
| | | | | T _A = 85 °C | 35.5 | 54 | |
| | | All peripherals OFF, code executed from Flash, V _{DD} from 1.65 V to 3.6 V | MSI clock, 65 kHz f _{HCLK} = 32 kHz | T _A = -40 °C to 25 °C | 23 | 24 | |
| | | | | T _A = 85 °C | 31 | 34 | |
| | | | | T _A = 105 °C | 42.5 | 56 | |
| | | | MSI clock, 65 kHz f _{HCLK} = 65 kHz | T _A = -40 °C to 25 °C | 29 | 31 | |
| | | | | T _A = 85 °C | 38 | 41 | |
| | | | | T _A = 105 °C | 49 | 63 | |
| | | | MSI clock, 131 kHz f _{HCLK} = 131 kHz | T _A = -40 °C to 25 °C | 46 | 55 | |
| | | | | T _A = 55 °C | 48 | 59 | |
| | | | | T _A = 85 °C | 53.5 | 72 | |
| | T _A = 105 °C | 64.8 | 84 | | | | |
| I _{DD} Max (LP Run) ⁽²⁾ | Max allowed current in Low-power run mode | V _{DD} from 1.65 V to 3.6 V | - | - | - | 200 | |

1. Guaranteed by characterization results, unless otherwise specified.
2. This limitation is related to the consumption of the CPU core and the peripherals that are powered by the regulator. Consumption of the I/Os is not included in this limitation.

Table 22. Current consumption in Low-power sleep mode

| Symbol | Parameter | Conditions | | | Typ | Max (1) | Unit |
|---------------------|--|--|---|---------------------------|----------------|------------|---------|
| I_{DD} (LP Sleep) | Supply current in Low-power sleep mode | All peripherals OFF, V_{DD} from 1.65 V to 3.6 V | MSI clock, 65 kHz $f_{HCLK} = 32$ kHz Flash OFF | $T_A = -40$ °C to 25 °C | 5.5 | - | μA |
| | | | | $T_A = -40$ °C to 25 °C | 15 | 16 | |
| | | | | | $T_A = 85$ °C | 20 | |
| | | | MSI clock, 65 kHz $f_{HCLK} = 32$ kHz Flash ON | $T_A = 105$ °C | 24 | 26 | |
| | | | | $T_A = -40$ °C to 25 °C | 15 | 16 | |
| | | | | | $T_A = 85$ °C | 20.5 | |
| | | | MSI clock, 65 kHz $f_{HCLK} = 65$ kHz, Flash ON | $T_A = 105$ °C | 25.4 | 27 | |
| | | | | $T_A = -40$ °C to 25 °C | 18 | 20 | |
| | | | | | $T_A = 55$ °C | 21 | |
| | | MSI clock, 131 kHz $f_{HCLK} = 131$ kHz, Flash ON | $T_A = 85$ °C | 23 | 27 | | |
| | | | $T_A = 105$ °C | 28 | 31 | | |
| | | | MSI clock, 65 kHz $f_{HCLK} = 32$ kHz | $T_A = -40$ °C to 25 °C | 15 | 16 | |
| | | $T_A = 85$ °C | | 20 | 22 | | |
| | | | | $T_A = 105$ °C | 24 | 26 | |
| | | TIM9 and USART1 enabled, Flash ON, V_{DD} from 1.65 V to 3.6 V | MSI clock, 65 kHz $f_{HCLK} = 65$ kHz | $T_A = -40$ °C to 25 °C | 15 | 16 | |
| | | | | $T_A = 85$ °C | 20.5 | 23 | |
| | | | | | $T_A = 105$ °C | 25.4 | |
| | | | MSI clock, 131 kHz $f_{HCLK} = 131$ kHz | $T_A = -40$ °C to 25 °C | 18 | 20 | |
| $T_A = 55$ °C | 21 | | | 22 | | | |
| | $T_A = 85$ °C | | | 23 | 27 | | |
| | $T_A = 105$ °C | | 28 | 30 | | | |
| | - | | - | - | 200 | | |
| | | | | - | - | | |
| - | | - | | | | | |

1. Guaranteed by characterization results, unless otherwise specified.

Table 23. Typical and maximum current consumptions in Stop mode

| Symbol | Parameter | Conditions | | Typ ⁽¹⁾ | Max ⁽¹⁾⁽²⁾ | Unit | | | |
|--|---|---|--|---|-----------------------|---|---------------|------|---|
| I_{DD} (Stop with RTC) | Supply current in Stop mode with RTC enabled | RTC clocked by LSI, regulator in LP mode, HSI and HSE OFF (no independent watchdog) | LCD OFF | $T_A = -40^{\circ}\text{C}$ to 25°C $V_{DD} = 1.8\text{ V}$ | 1.13 | - | μA | | |
| | | | | $T_A = -40^{\circ}\text{C}$ to 25°C | 1.38 | 4 | | | |
| | | | | $T_A = 55^{\circ}\text{C}$ | 1.70 | 6 | | | |
| | | | | $T_A = 85^{\circ}\text{C}$ | 3.30 | 10 | | | |
| | | | | $T_A = 105^{\circ}\text{C}$ | 7.80 | 23 | | | |
| | | | LCD ON (static duty) ⁽³⁾ | $T_A = -40^{\circ}\text{C}$ to 25°C | 1.50 | 6 | | | |
| | | | | $T_A = 55^{\circ}\text{C}$ | 1.80 | 7 | | | |
| | | | | $T_A = 85^{\circ}\text{C}$ | 3.45 | 12 | | | |
| | | | | $T_A = 105^{\circ}\text{C}$ | 8.02 | 27 | | | |
| | | | LCD ON (1/8 duty) ⁽⁴⁾ | $T_A = -40^{\circ}\text{C}$ to 25°C | 3.80 | 10 | | | |
| | | | | $T_A = 55^{\circ}\text{C}$ | 4.30 | 11 | | | |
| | | | | $T_A = 85^{\circ}\text{C}$ | 6.10 | 16 | | | |
| | | | | $T_A = 105^{\circ}\text{C}$ | 10.8 | 44 | | | |
| | | | Supply current in Stop mode with RTC enabled | RTC clocked by LSE external clock (32.768 kHz), regulator in LP mode, HSI and HSE OFF (no independent watchdog) | LCD OFF | $T_A = -40^{\circ}\text{C}$ to 25°C | | 1.50 | - |
| | | | | | | $T_A = 55^{\circ}\text{C}$ | | 1.90 | - |
| | $T_A = 85^{\circ}\text{C}$ | 3.65 | | | | - | | | |
| | $T_A = 105^{\circ}\text{C}$ | 8.25 | | | | - | | | |
| | LCD ON (static duty) ⁽³⁾ | $T_A = -40^{\circ}\text{C}$ to 25°C | | | 1.60 | - | | | |
| | | $T_A = 55^{\circ}\text{C}$ | | | 2.05 | - | | | |
| | | $T_A = 85^{\circ}\text{C}$ | | | 3.75 | - | | | |
| | | $T_A = 105^{\circ}\text{C}$ | | | 8.40 | - | | | |
| LCD ON (1/8 duty) ⁽⁴⁾ | $T_A = -40^{\circ}\text{C}$ to 25°C | 3.90 | | | - | | | | |
| | $T_A = 55^{\circ}\text{C}$ | 4.55 | | | - | | | | |
| | $T_A = 85^{\circ}\text{C}$ | 6.35 | | | - | | | | |
| | $T_A = 105^{\circ}\text{C}$ | 11.10 | | | - | | | | |
| Supply current in Stop mode with RTC enabled | RTC clocked by LSE (no independent watchdog) ⁽⁵⁾ | LCD OFF | $T_A = -40^{\circ}\text{C}$ to 25°C $V_{DD} = 1.8\text{ V}$ | 1.23 | - | | | | |
| | | | $T_A = -40^{\circ}\text{C}$ to 25°C $V_{DD} = 3.0\text{ V}$ | 1.50 | - | | | | |
| | | | $T_A = -40^{\circ}\text{C}$ to 25°C $V_{DD} = 3.6\text{ V}$ | 1.75 | - | | | | |

Table 23. Typical and maximum current consumptions in Stop mode (continued)

| Symbol | Parameter | Conditions | | Typ ⁽¹⁾ | Max ⁽¹⁾⁽²⁾ | Unit |
|--------------------------------|--|---|---|--------------------|-----------------------|------|
| I _{DD (Stop)} | Supply current in Stop mode (RTC disabled) | Regulator in LP mode, HSI and HSE OFF, independent watchdog and LSI enabled | T _A = -40°C to 25°C | 1.80 | 2.2 | µA |
| | | Regulator in LP mode, LSI, HSI and HSE OFF (no independent watchdog) | T _A = -40°C to 25°C | 0.434 | 1 | |
| | | | T _A = 55°C | 0.735 | 3 | |
| | | | T _A = 85°C | 2.350 | 9 | |
| | | | T _A = 105°C | 6.84 | 22 ⁽⁶⁾ | |
| I _{DD (WU from Stop)} | RMS (root mean square) supply current during wakeup time when exiting from Stop mode | MSI = 4.2 MHz | V _{DD} = 3.0 V T _A = -40°C to 25°C | 2 | - | mA |
| | | MSI = 1.05 MHz | | 1.45 | - | |
| | | MSI = 65 kHz ⁽⁷⁾ | | 1.45 | - | |

1. The typical values are given for V_{DD} = 3.0 V and max values are given for V_{DD} = 3.6 V, unless otherwise specified.
2. Guaranteed by characterization results, unless otherwise specified.
3. LCD enabled with external VLCD, static duty, division ratio = 256, all pixels active, no LCD connected.
4. LCD enabled with external VLCD, 1/8 duty, 1/3 bias, division ratio = 64, all pixels active, no LCD connected.
5. Based on characterization done with a 32.768 kHz crystal (MC306-G-06Q-32.768, manufacturer JFVNY) with two 6.8pF loading capacitors.
6. Guaranteed by test in production.
7. When MSI = 64 kHz, the RMS current is measured over the first 15 µs following the wakeup event. For the remaining time of the wakeup period, the current is similar to the Run mode current.

Table 24. Typical and maximum current consumptions in Standby mode

| Symbol | Parameter | Conditions | Typ ⁽¹⁾ | Max ⁽¹⁾⁽²⁾ | Unit | |
|---------------------------------------|--|---|---|-----------------------|--------------------|----|
| I _{DD} (Standby with RTC) | Supply current in Standby mode with RTC enabled | RTC clocked by LSI (no independent watchdog) | T _A = -40 °C to 25 °C V _{DD} = 1.8 V | 0.865 | - | μA |
| | | | T _A = -40 °C to 25 °C | 1.11 | 1.9 | |
| | | | T _A = 55 °C | 1.15 | 2.2 | |
| | | | T _A = 85 °C | 1.35 | 4 | |
| | | | T _A = 105 °C | 1.93 | 8.3 ⁽³⁾ | |
| | | RTC clocked by LSE (no independent watchdog) ⁽⁴⁾ | T _A = -40 °C to 25 °C V _{DD} = 1.8 V | 0.97 | - | |
| | | | T _A = -40 °C to 25 °C | 1.28 | - | |
| | | | T _A = 55 °C | 1.4 | - | |
| | | | T _A = 85 °C | 1.7 | - | |
| | | | T _A = 105 °C | 2.34 | - | |
| I _{DD} (Standby) | Supply current in Standby mode with RTC disabled | Independent watchdog and LSI enabled | T _A = -40 °C to 25 °C | 1.0 | 1.7 | |
| | | Independent watchdog and LSI OFF | T _A = -40 °C to 25 °C | 0.277 | 0.6 | |
| | | | T _A = 55 °C | 0.31 | 0.9 | |
| | | | T _A = 85 °C | 0.52 | 2.75 | |
| | | | T _A = 105 °C | 1.09 | 7 ⁽³⁾ | |
| I _{DD} (WU from Standby) | RMS supply current during wakeup time when exiting from Standby mode | - | V _{DD} = 3.0 V T _A = -40 °C to 25 °C | 1 | - | mA |

1. The typical values are given for V_{DD} = 3.0 V and max values are given for V_{DD} = 3.6 V, unless otherwise specified.
2. Guaranteed by characterization results, unless otherwise specified.
3. Guaranteed by test in production.
4. Based on characterization done with a 32.768 kHz crystal (MC306-G-06Q-32.768, manufacturer JFVNY) with two 6.8pF loading capacitors.

On-chip peripheral current consumption

The current consumption of the on-chip peripherals is given in the following table. The MCU is placed under the following conditions:

- all I/O pins are in input mode with a static value at V_{DD} or V_{SS} (no load)
- all peripherals are disabled unless otherwise mentioned
- the given value is calculated by measuring the current consumption
 - with all peripherals clocked off
 - with only one peripheral clocked on



Table 25. Peripheral current consumption⁽¹⁾

| Peripheral | | Typical consumption, V _{DD} = 3.0 V, T _A = 25 °C | | | | Unit |
|-------------|--------------------|--|---|---|----------------------------|--------------------------------|
| | | Range 1, V _{CORE} = 1.8 V VOS[1:0] = 01 | Range 2, V _{CORE} = 1.5 V VOS[1:0] = 10 | Range 3, V _{CORE} = 1.2 V VOS[1:0] = 11 | Low-power sleep and run | |
| APB1 | TIM2 | 11.3 | 9.0 | 7.3 | 9.0 | μA/MHz (f _{HCLK}) |
| | TIM3 | 11.4 | 9.1 | 7.1 | 9.1 | |
| | TIM4 | 11.3 | 9.0 | 7.3 | 9.0 | |
| | TIM6 | 3.9 | 3.1 | 2.5 | 3.1 | |
| | TIM7 | 4.2 | 3.3 | 2.6 | 3.3 | |
| | LCD | 4.7 | 3.6 | 2.9 | 3.6 | |
| | WWDG | 3.7 | 2.9 | 2.4 | 2.9 | |
| | SPI2 | 5.9 | 4.8 | 3.9 | 4.8 | |
| | USART2 | 8.1 | 6.6 | 5.1 | 6.6 | |
| | USART3 | 7.9 | 6.4 | 5.0 | 6.4 | |
| | I2C1 | 7.8 | 6.1 | 4.9 | 6.1 | |
| | I2C2 | 7.2 | 5.7 | 4.6 | 5.7 | |
| | USB | 12.7 | 10.3 | 8.1 | 10.3 | |
| | PWR | 3.1 | 2.4 | 2.0 | 2.4 | |
| | DAC | 6.6 | 5.3 | 4.3 | 5.3 | |
| COMP | 5.3 | 4.3 | 3.4 | 4.3 | | |
| APB2 | SYSCFG & RI | 2.2 | 1.9 | 1.6 | 1.9 | μA/MHz (f _{HCLK}) |
| | TIM9 | 9.1 | 7.3 | 5.9 | 7.3 | |
| | TIM10 | 6.0 | 4.9 | 3.9 | 4.9 | |
| | TIM11 | 5.8 | 4.6 | 3.8 | 4.6 | |
| | ADC ⁽²⁾ | 8.7 | 7.0 | 5.6 | 7.0 | |
| | SPI1 | 4.4 | 3.4 | 2.8 | 3.4 | |
| | USART1 | 8.1 | 6.5 | 5.2 | 6.5 | |
| AHB | GPIOA | 4.4 | 3.5 | 2.9 | 3.5 | μA/MHz (f _{HCLK}) |
| | GPIOB | 4.4 | 3.5 | 2.9 | 3.5 | |
| | GPIOC | 3.7 | 3.0 | 2.5 | 3.0 | |
| | GPIOD | 3.6 | 2.8 | 2.4 | 2.8 | |
| | GPIOE | 4.7 | 3.8 | 3.1 | 3.8 | |
| | GPIOH | 3.7 | 2.9 | 2.4 | 2.9 | |
| | CRC | 0.6 | 0.4 | 0.4 | 0.4 | |
| | FLASH | 12.2 | 10.2 | 7.8 | _(3) | |
| | DMA1 | 12.4 | 10.1 | 8.2 | 10.1 | |
| All enabled | | 160 | 135 | 103 | 124.8 | |

Table 25. Peripheral current consumption⁽¹⁾ (continued)

| Peripheral | Typical consumption, V _{DD} = 3.0 V, T _A = 25 °C | | | | Unit |
|--|--|---|---|----------------------------|------|
| | Range 1, V _{CORE} = 1.8 V VOS[1:0] = 01 | Range 2, V _{CORE} = 1.5 V VOS[1:0] = 10 | Range 3, V _{CORE} = 1.2 V VOS[1:0] = 11 | Low-power sleep and run | |
| I _{DD} (RTC) | 0.4 | | | | μA |
| I _{DD} (LCD) | 3.1 | | | | |
| I _{DD} (ADC) ⁽⁴⁾ | 1450 | | | | |
| I _{DD} (DAC) ⁽⁵⁾ | 340 | | | | |
| I _{DD} (COMP1) | 0.16 | | | | |
| I _{DD} (COMP2) | Slow mode | 2 | | | |
| | Fast mode | 5 | | | |
| I _{DD} (PVD / BOR) ⁽⁶⁾ | 2.6 | | | | |
| I _{DD} (IWDG) | 0.25 | | | | |

1. Data based on differential I_{DD} measurement between all peripherals OFF and one peripheral with clock enabled, in the following conditions: f_{HCLK} = 32 MHz (Range 1), f_{HCLK} = 16 MHz (Range 2), f_{HCLK} = 4 MHz (Range 3), f_{HCLK} = 64kHz (Low-power run/sleep), f_{APB1} = f_{HCLK}, f_{APB2} = f_{HCLK}, default prescaler value for each peripheral. The CPU is in Sleep mode in both cases. No I/O pins toggling.
2. HSI oscillator is OFF for this measure.
3. In low-power sleep and run mode, the Flash memory must always be in power-down mode.
4. Data based on a differential I_{DD} measurement between ADC in reset configuration and continuous ADC conversion (HSI consumption not included).
5. Data based on a differential I_{DD} measurement between DAC in reset configuration and continuous DAC conversion of V_{DD}/2. DAC is in buffered mode, output is left floating.
6. Including supply current of internal reference voltage.

6.3.5 Wakeup time from Low-power mode

The wakeup times given in the following table are measured with the MSI RC oscillator. The clock source used to wake up the device depends on the current operating mode:

- Sleep mode: the clock source is the clock that was set before entering Sleep mode
- Stop mode: the clock source is the MSI oscillator in the range configured before entering Stop mode
- Standby mode: the clock source is the MSI oscillator running at 2.1 MHz

All timings are derived from tests performed under ambient temperature and V_{DD} supply voltage conditions summarized in [Table 14](#).

Table 26. Low-power mode wakeup timings

| Symbol | Parameter | Conditions | Typ | Max ⁽¹⁾ | Unit |
|-------------------|--|---|------|--------------------|------|
| $t_{WUSLEEP}$ | Wakeup from Sleep mode | $f_{HCLK} = 32 \text{ MHz}$ | 0.4 | - | μs |
| $t_{WUSLEEP_LP}$ | Wakeup from Low-power sleep mode $f_{HCLK} = 262 \text{ kHz}$ | $f_{HCLK} = 262 \text{ kHz}$ Flash enabled | 46 | - | |
| | | $f_{HCLK} = 262 \text{ kHz}$ Flash switched OFF | 46 | - | |
| t_{WUSTOP} | Wakeup from Stop mode, regulator in Run mode | $f_{HCLK} = f_{MSI} = 4.2 \text{ MHz}$ | 8.2 | - | |
| | | $f_{HCLK} = f_{MSI} = 4.2 \text{ MHz}$ Voltage Range 1 and 2 | 7.7 | 8.9 | |
| | Wakeup from Stop mode, regulator in low-power mode | $f_{HCLK} = f_{MSI} = 4.2 \text{ MHz}$ Voltage Range 3 | 8.2 | 13.1 | |
| | | $f_{HCLK} = f_{MSI} = 2.1 \text{ MHz}$ | 10.2 | 13.4 | |
| | | $f_{HCLK} = f_{MSI} = 1.05 \text{ MHz}$ | 16 | 20 | |
| | | $f_{HCLK} = f_{MSI} = 524 \text{ kHz}$ | 31 | 37 | |
| | | $f_{HCLK} = f_{MSI} = 262 \text{ kHz}$ | 57 | 66 | |
| | | $f_{HCLK} = f_{MSI} = 131 \text{ kHz}$ | 112 | 123 | |
| $t_{WUSTDBY}$ | Wakeup from Standby mode FWU bit = 1 | $f_{HCLK} = MSI = 2.1 \text{ MHz}$ | 58 | 104 | |
| | Wakeup from Standby mode FWU bit = 0 | $f_{HCLK} = MSI = 2.1 \text{ MHz}$ | 2.6 | 3.25 | ms |

1. Guaranteed by characterization results, unless otherwise specified

6.3.6 External clock source characteristics

High-speed external user clock generated from an external source

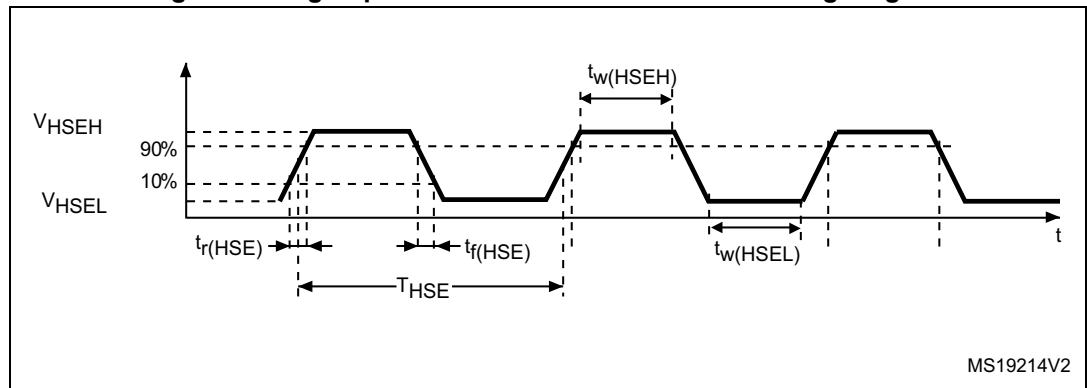
In bypass mode the HSE oscillator is switched off and the input pin is a standard GPIO. The external clock signal has to respect the I/O characteristics in [Section 6.3.13](#). However, the recommended clock input waveform is shown in [Figure 15](#).

Table 27. High-speed external user clock characteristics⁽¹⁾

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|--------------------------------|--------------------------------------|--------------------------|-------------|-----|-------------|------|
| f_{HSE_ext} | User external clock source frequency | CSS is on or PLL is used | 1 | 8 | 32 | MHz |
| | | CSS is off, PLL not used | 0 | | | |
| V_{HSEH} | OSC_IN input pin high level voltage | - | $0.7V_{DD}$ | - | V_{DD} | |
| V_{HSEL} | OSC_IN input pin low level voltage | | V_{SS} | - | $0.3V_{DD}$ | |
| $t_{w(HSEH)}$ $t_{w(HSEL)}$ | OSC_IN high or low time | | 12 | - | - | ns |
| $t_r(HSE)$ $t_f(HSE)$ | OSC_IN rise or fall time | | - | - | 20 | |
| $C_{in(HSE)}$ | OSC_IN input capacitance | - | - | 2.6 | - | pF |

1. Guaranteed by design.

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



MS19214V2

Low-speed external user clock generated from an external source

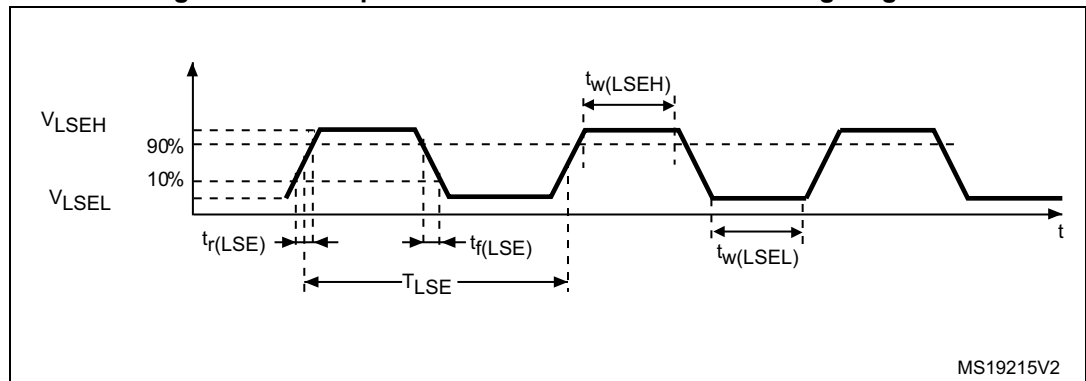
The characteristics given in the following table result from tests performed using a low-speed external clock source, and under ambient temperature and supply voltage conditions summarized in [Table 14](#).

Table 28. Low-speed external user clock characteristics⁽¹⁾

| Symbol | Parameter | Min | Typ | Max | Unit |
|--------------------------------|---------------------------------------|-------------|--------|-------------|------|
| f_{LSE_ext} | User external clock source frequency | 1 | 32.768 | 1000 | kHz |
| V_{LSEH} | OSC32_IN input pin high level voltage | $0.7V_{DD}$ | - | V_{DD} | - |
| V_{LSEL} | OSC32_IN input pin low level voltage | V_{SS} | - | $0.3V_{DD}$ | - |
| $t_{w(LSEH)}$ $t_{w(LSEL)}$ | OSC32_IN high or low time | 465 | - | - | ns |
| $t_{r(LSE)}$ $t_{f(LSE)}$ | OSC32_IN rise or fall time | - | - | 10 | |
| $C_{IN(LSE)}$ | OSC32_IN input capacitance | - | 0.6 | - | pF |

1. Guaranteed by design.

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



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

The high-speed external (HSE) clock can be supplied with a 1 to 24 MHz crystal/ceramic resonator oscillator. All the information given in this paragraph are based on characterization results obtained with typical external components specified in [Table 29](#). In the application, the resonator and the load capacitors have to be placed as close as possible to the oscillator pins in order to minimize output distortion and startup stabilization time. Refer to the crystal resonator manufacturer for more details on the resonator characteristics (frequency, package, accuracy).

Table 29. HSE oscillator characteristics⁽¹⁾⁽²⁾

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|---------------|----------------------|------------|-----|-----|-----|------|
| f_{OSC_IN} | Oscillator frequency | - | 1 | | 24 | MHz |
| R_F | Feedback resistor | - | | 200 | - | kΩ |

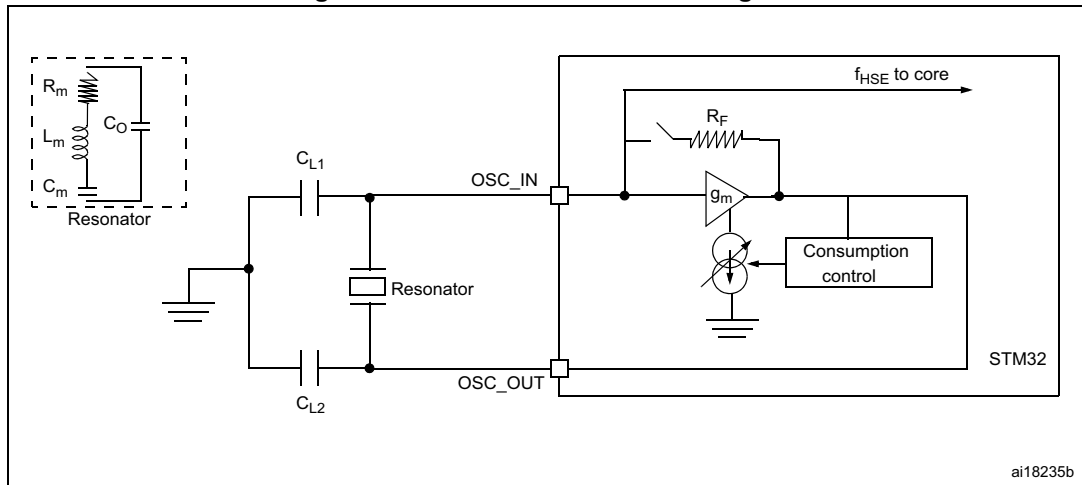
Table 29. HSE oscillator characteristics⁽¹⁾⁽²⁾ (continued)

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|------------------------------|--|---|-----|-----|------------------------------------|----------|
| C | Recommended load capacitance versus equivalent serial resistance of the crystal (R_S) ⁽³⁾ | $R_S = 30 \Omega$ | - | 20 | - | pF |
| I_{HSE} | HSE driving current | $V_{DD} = 3.3 V$, $V_{IN} = V_{SS}$ with 30 pF load | - | - | 3 | mA |
| $I_{DD(HSE)}$ | HSE oscillator power consumption | C = 20 pF $f_{OSC} = 16 MHz$ | - | - | 2.5 (startup) 0.7 (stabilized) | mA |
| | | C = 10 pF $f_{OSC} = 16 MHz$ | - | - | 2.5 (startup) 0.46 (stabilized) | |
| g_m | Oscillator transconductance | Startup | 3.5 | - | - | mA /V |
| $t_{SU(HSE)}$ ⁽⁴⁾ | Startup time | V_{DD} is stabilized | - | 1 | - | ms |

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

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

Figure 17. HSE oscillator circuit diagram



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

The low-speed external (LSE) clock can be supplied with a 32.768 kHz crystal/ceramic resonator oscillator. All the information given in this paragraph are based on characterization results obtained with typical external components specified in [Table 14](#). In the application, the resonator and the load capacitors have to be placed as close as possible to the oscillator pins in order to minimize output distortion and startup stabilization time. Refer to the crystal resonator manufacturer for more details on the resonator characteristics (frequency, package, accuracy).

Table 30. LSE oscillator characteristics ($f_{LSE} = 32.768 \text{ kHz}$)⁽¹⁾

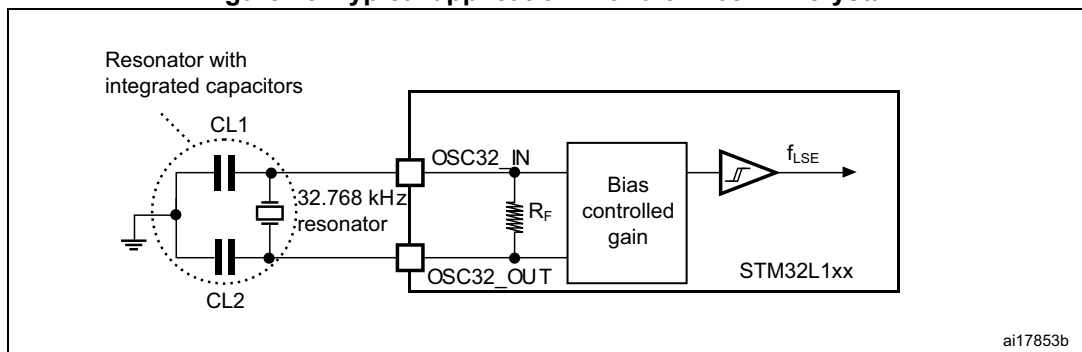
| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|---------------------|--|---|-----|--------|-----|------|
| f_{LSE} | Low speed external oscillator frequency | - | - | 32.768 | - | kHz |
| R_F | Feedback resistor | - | - | 1.2 | - | MΩ |
| $C^{(2)}$ | Recommended load capacitance versus equivalent serial resistance of the crystal (R_S) ⁽³⁾ | $R_S = 30 \text{ k}\Omega$ | - | 8 | - | pF |
| I_{LSE} | LSE driving current | $V_{DD} = 3.3 \text{ V}, V_{IN} = V_{SS}$ | - | - | 1.1 | μA |
| $I_{DD} (LSE)$ | LSE oscillator current consumption | $V_{DD} = 1.8 \text{ V}$ | - | 450 | - | nA |
| | | $V_{DD} = 3.0 \text{ V}$ | - | 600 | - | |
| | | $V_{DD} = 3.6 \text{ V}$ | - | 750 | - | |
| g_m | Oscillator transconductance | - | 3 | - | - | μA/V |
| $t_{SU(LSE)}^{(4)}$ | Startup time | V_{DD} is stabilized | - | 1 | - | s |

1. Guaranteed by characterization results.
2. Refer to the note and caution paragraphs below the table, and to the application note AN2867 "Oscillator design guide for ST microcontrollers".
3. The oscillator selection can be optimized in terms of supply current using a high quality resonator with small R_S value for example MSIV-TIN32.768kHz. Refer to crystal manufacturer for more details.
4. $t_{SU(LSE)}$ 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 resonator and it can vary significantly with the crystal manufacturer.

Note: For CL1 and CL2, it is recommended to use high-quality ceramic capacitors in the 5 pF to 15 pF range selected to match the requirements of the crystal or resonator (see [Figure 18](#)). CL1 and CL2, are usually the same size. The crystal manufacturer typically specifies a load capacitance which is the series combination of CL1 and CL2.
 Load capacitance CL has the following formula: $CL = CL1 \times CL2 / (CL1 + CL2) + C_{stray}$ where Cstray is the pin capacitance and board or trace PCB-related capacitance. Typically, it is between 2 pF and 7 pF.

Caution: To avoid exceeding the maximum value of CL1 and CL2 (15 pF) it is strongly recommended to use a resonator with a load capacitance $CL \leq 7$ pF. Never use a resonator with a load capacitance of 12.5 pF.
 Example: if the user chooses a resonator with a load capacitance of $CL = 6$ pF and $C_{stray} = 2$ pF, then $CL1 = CL2 = 8$ pF.

Figure 18. Typical application with a 32.768 kHz crystal



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6.3.7 Internal clock source characteristics

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

High-speed internal (HSI) RC oscillator

Table 31. HSI oscillator characteristics

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|---------------------|---|--|-------------------|-----------|------------------|---------------|
| f_{HSI} | Frequency | $V_{DD} = 3.0\text{ V}$ | - | 16 | - | MHz |
| $TRIM^{(1)(2)}$ | HSI user-trimmed resolution | Trimming code is not a multiple of 16 | - | ± 0.4 | 0.7 | % |
| | | Trimming code is a multiple of 16 | - | - | ± 1.5 | % |
| $ACC_{HSI}^{(2)}$ | Accuracy of the factory-calibrated HSI oscillator | $V_{DDA} = 3.0\text{ V}, T_A = 25\text{ }^\circ\text{C}$ | -1 ⁽³⁾ | - | 1 ⁽³⁾ | % |
| | | $V_{DDA} = 3.0\text{ V}, T_A = 0\text{ to }55\text{ }^\circ\text{C}$ | -1.5 | - | 1.5 | % |
| | | $V_{DDA} = 3.0\text{ V}, T_A = -10\text{ to }70\text{ }^\circ\text{C}$ | -2 | - | 2 | % |
| | | $V_{DDA} = 3.0\text{ V}, T_A = -10\text{ to }85\text{ }^\circ\text{C}$ | -2.5 | - | 2 | % |
| | | $V_{DDA} = 3.0\text{ V}, T_A = -10\text{ to }105\text{ }^\circ\text{C}$ | -4 | - | 2 | % |
| | | $V_{DDA} = 1.65\text{ V to }3.6\text{ V}$ $T_A = -40\text{ to }105\text{ }^\circ\text{C}$ | -4 | - | 3 | % |
| $t_{SU(HSI)}^{(2)}$ | HSI oscillator startup time | - | - | 3.7 | 6 | μs |
| $I_{DD(HSI)}^{(2)}$ | HSI oscillator power consumption | - | - | 100 | 140 | μA |

1. The trimming step differs depending on the trimming code. It is usually negative on the codes which are multiples of 16 (0x00, 0x10, 0x20, 0x30...0xE0).
2. Guaranteed by characterization results.
3. Guaranteed by test in production.

Low-speed internal (LSI) RC oscillator

Table 32. LSI oscillator characteristics

| Symbol | Parameter | Min | Typ | Max | Unit |
|---------------------|--|-----|-----|-----|---------------|
| $f_{LSI}^{(1)}$ | LSI frequency | 26 | 38 | 56 | kHz |
| $D_{LSI}^{(2)}$ | LSI oscillator frequency drift $0^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$ | -10 | - | 4 | % |
| $t_{su(LSI)}^{(3)}$ | LSI oscillator startup time | - | - | 200 | μs |
| $I_{DD(LSI)}^{(3)}$ | LSI oscillator power consumption | - | 400 | 510 | nA |

1. Guaranteed by test in production.
2. This is a deviation for an individual part, once the initial frequency has been measured.
3. Guaranteed by design.

Multi-speed internal (MSI) RC oscillator

Table 33. MSI oscillator characteristics

| Symbol | Parameter | Condition | Typ | Max | Unit | | |
|-----------------------|--|--|-----------|-------------|---------------|---|-----|
| f_{MSI} | Frequency after factory calibration, done at $V_{DD}= 3.3\text{ V}$ and $T_A = 25\text{ }^\circ\text{C}$ | MSI range 0 | 65.5 | - | kHz | | |
| | | MSI range 1 | 131 | - | | | |
| | | MSI range 2 | 262 | - | | | |
| | | | | MSI range 3 | 524 | - | MHz |
| | | | | MSI range 4 | 1.05 | - | |
| | | | | MSI range 5 | 2.1 | - | |
| | | | | MSI range 6 | 4.2 | - | |
| ACC_{MSI} | Frequency error after factory calibration | - | ± 0.5 | - | % | | |
| $D_{TEMP(MSI)}^{(1)}$ | MSI oscillator frequency drift $0\text{ }^\circ\text{C} \leq T_A \leq 105\text{ }^\circ\text{C}$ | - | ± 3 | - | % | | |
| $D_{VOLT(MSI)}^{(1)}$ | MSI oscillator frequency drift $1.65\text{ V} \leq V_{DD} \leq 3.6\text{ V}$, $T_A = 25\text{ }^\circ\text{C}$ | - | - | 2.5 | %/V | | |
| $I_{DD(MSI)}^{(2)}$ | MSI oscillator power consumption | MSI range 0 | 0.75 | - | μA | | |
| | | MSI range 1 | 1 | - | | | |
| | | MSI range 2 | 1.5 | - | | | |
| | | MSI range 3 | 2.5 | - | | | |
| | | MSI range 4 | 4.5 | - | | | |
| | | MSI range 5 | 8 | - | | | |
| | | MSI range 6 | 15 | - | | | |
| $t_{SU(MSI)}$ | MSI oscillator startup time | MSI range 0 | 30 | - | μs | | |
| | | MSI range 1 | 20 | - | | | |
| | | MSI range 2 | 15 | - | | | |
| | | MSI range 3 | 10 | - | | | |
| | | MSI range 4 | 6 | - | | | |
| | | MSI range 5 | 5 | - | | | |
| | | MSI range 6, Voltage range 1 and 2 | 3.5 | - | | | |
| | | MSI range 6, Voltage range 3 | 5 | - | | | |

Table 33. MSI oscillator characteristics (continued)

| Symbol | Parameter | Condition | Typ | Max | Unit |
|------------------------------|------------------------------------|------------------------------------|-----|-----|---------------|
| $t_{\text{STAB(MSI)}}^{(2)}$ | MSI oscillator stabilization time | MSI range 0 | - | 40 | μs |
| | | MSI range 1 | - | 20 | |
| | | MSI range 2 | - | 10 | |
| | | MSI range 3 | - | 4 | |
| | | MSI range 4 | - | 2.5 | |
| | | MSI range 5 | - | 2 | |
| | | MSI range 6, Voltage range 1 and 2 | - | 2 | |
| | | MSI range 3, Voltage Range 3 | - | 3 | |
| $f_{\text{OVER(MSI)}}$ | MSI oscillator frequency overshoot | Any range to range 5 | - | 4 | MHz |
| | | Any range to range 6 | - | 6 | |

1. This is a deviation for an individual part, once the initial frequency has been measured.
2. Guaranteed by characterization results.

6.3.8 PLL characteristics

The parameters given in [Table 34](#) are derived from tests performed under ambient temperature and V_{DD} supply voltage conditions summarized in [Table 14](#).

Table 34. PLL characteristics

| Symbol | Parameter | Value | | | Unit |
|-----------------------|---|-------|-----|--------------------|---------------|
| | | Min | Typ | Max ⁽¹⁾ | |
| $f_{\text{PLL_IN}}$ | PLL input clock ⁽²⁾ | 2 | - | 24 | MHz |
| | PLL input clock duty cycle | 45 | - | 55 | % |
| $f_{\text{PLL_OUT}}$ | PLL output clock | 2 | - | 32 | MHz |
| t_{LOCK} | PLL lock time PLL input = 16 MHz PLL VCO = 96 MHz | - | 115 | 160 | μs |
| Jitter | Cycle-to-cycle jitter | - | - | ± 600 | ps |
| $I_{\text{DDA(PLL)}}$ | Current consumption on V_{DDA} | - | 220 | 450 | μA |
| $I_{\text{DD(PLL)}}$ | Current consumption on V_{DD} | - | 120 | 150 | |

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

6.3.9 Memory characteristics

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

RAM memory

Table 35. RAM and hardware registers

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|--------|------------------------------------|----------------------|------|-----|-----|------|
| VRM | Data retention mode ⁽¹⁾ | STOP mode (or RESET) | 1.65 | - | - | V |

1. Minimum supply voltage without losing data stored in RAM (in Stop mode or under Reset) or in hardware registers (only in Stop mode).

Flash memory and data EEPROM

Table 36. Flash memory and data EEPROM characteristics

| Symbol | Parameter | Conditions | Min | Typ | Max ⁽¹⁾ | Unit |
|------------|---|---------------------------------|------|------|--------------------|---------|
| V_{DD} | Operating voltage Read / Write / Erase | - | 1.65 | - | 3.6 | V |
| t_{prog} | Programming / erasing time for byte / word / double word / half- page | Erasing | - | 3.28 | 3.94 | ms |
| | | Programming | - | 3.28 | 3.94 | |
| I_{DD} | Average current during whole program/erase operation | $T_A = 25$ °C, $V_{DD} = 3.6$ V | - | 300 | - | μ A |
| | Maximum current (peak) during program/erase operation | | - | 1.5 | 2.5 | mA |

1. Guaranteed by design.

Table 37. Flash memory, data EEPROM endurance and data retention

| Symbol | Parameter | Conditions | Value | | | Unit |
|--------------------------|--|-------------------------------|--------------------|-----|-----|---------|
| | | | Min ⁽¹⁾ | Typ | Max | |
| NCYC ⁽²⁾ | Cycling (erase / write) Program memory | $T_A = -40$ °C to 105 °C | 10 | - | - | kcycles |
| | Cycling (erase / write) EEPROM data memory | | 300 | - | - | |
| t_{RET} ⁽²⁾ | Data retention (program memory) after 10 kcycles at $T_A = 85$ °C | TRET = +85 °C | 30 | - | - | years |
| | Data retention (EEPROM data memory) after 300 kcycles at $T_A = 85$ °C | | 30 | - | - | |
| | Data retention (program memory) after 10 kcycles at $T_A = 105$ °C | TRET = +105 °C | 10 | - | - | |
| | Data retention (EEPROM data memory) after 300 kcycles at $T_A = 105$ °C | | 10 | - | - | |

1. Guaranteed by characterization results.
2. Characterization is done according to JEDEC JESD22-A117.

6.3.10 EMC characteristics

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

Functional EMS (electromagnetic susceptibility)

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

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

A device reset allows normal operations to be resumed.

The test results are given in [Table 38](#). They are based on the EMS levels and classes defined in application note AN1709.

Table 38. EMS characteristics

| Symbol | Parameter | Conditions | Level/Class |
|------------|---|---|-------------|
| V_{FESD} | Voltage limits to be applied on any I/O pin to induce a functional disturbance | $V_{DD} = 3.3\text{ V}$, LQFP100, $T_A = +25\text{ }^\circ\text{C}$, $f_{HCLK} = 32\text{ MHz}$ conforms to IEC 61000-4-2 | 3B |
| 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 | $V_{DD} = 3.3\text{ V}$, LQFP100, $T_A = +25\text{ }^\circ\text{C}$, $f_{HCLK} = 32\text{ MHz}$ conforms to IEC 61000-4-4 | 4A |

Designing hardened software to avoid noise problems

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

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

Software recommendations

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

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

Prequalification trials

Most of the common failures (unexpected reset and program counter corruption) can be reproduced by manually forcing a low state on the NRST pin or the oscillator pins for 1 second.

To complete these trials, ESD stress can be applied directly on the device, over the range of specification values. When unexpected behavior is detected, the software can be hardened to prevent unrecoverable errors occurring (see application note AN1015).

Electromagnetic Interference (EMI)

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

Table 39. EMI characteristics

| Symbol | Parameter | Conditions | Monitored frequency band | Max vs. frequency range | | | Unit |
|------------------|------------|---|--------------------------|-------------------------|------------------------|------------------------|------|
| | | | | 4 MHz voltage Range 3 | 16 MHz voltage Range 2 | 32 MHz voltage Range 1 | |
| S _{EMI} | Peak level | V _{DD} = 3.3 V, T _A = 25 °C, LQFP100 package compliant with IEC 61967-2 | 0.1 to 30 MHz | -16 | -7 | -3 | dBμV |
| | | | 30 to 130 MHz | -12 | 2 | 12 | |
| | | | 130 MHz to 1GHz | -11 | 0 | 8 | |
| | | | SAE EMI Level | 1 | 1.5 | 2 | - |

6.3.11 Electrical sensitivity characteristics

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

Electrostatic discharge (ESD)

Electrostatic discharges (a positive then a negative pulse separated by 1 second) are applied to the pins of each sample according to each pin combination. The sample size depends on the number of supply pins in the device (3 parts × (n+1) supply pins). This test conforms to the JESD22-A114, ANSI/ESD STM5.3.1 standard.

Table 40. ESD absolute maximum ratings

| Symbol | Ratings | Conditions | Packages | Class | Maximum value ⁽¹⁾ | Unit |
|-----------------------|---|--|----------|-------|------------------------------|------|
| V _{ESD(HBM)} | Electrostatic discharge voltage (human body model) | T _A = +25 °C, conforming to JESD22-A114 | All | 2 | 2000 | V |
| V _{ESD(CDM)} | Electrostatic discharge voltage (charge device model) | T _A = +25 °C, conforming to ANSI/ESD STM5.3.1 | All | C4 | 500 | V |

1. Guaranteed by characterization results.



Static latch-up

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

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

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

Table 41. Electrical sensitivities

| Symbol | Parameter | Conditions | Class |
|--------|-----------------------|--|------------|
| LU | Static latch-up class | T _A = +105 °C conforming to JESD78A | II level A |

6.3.12 I/O current injection characteristics

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

Functional susceptibility to I/O current injection

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

The failure is indicated by an out of range parameter: ADC error above a certain limit (higher than 5 LSB TUE), out of conventional limits of induced leakage current on adjacent pins (out of -5 µA/+0 µA range), or other functional failure (for example reset occurrence, oscillator frequency deviation, LCD levels).

The test results are given in [Table 42](#).

Table 42. I/O current injection susceptibility

| Symbol | Description | Functional susceptibility | | Unit |
|------------------|--|---------------------------|--------------------|------|
| | | Negative injection | Positive injection | |
| I _{INJ} | Injected current on all 5 V tolerant (FT) pins | -5 | NA ⁽¹⁾ | mA |
| | Injected current on BOOT0 | -0 | NA ⁽¹⁾ | |
| | Injected current on any other pin | -5 | +5 | |

1. Injection is not possible.

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

6.3.13 I/O port characteristics

General input/output characteristics

Unless otherwise specified, the parameters given in [Table 43](#) are derived from tests performed under conditions summarized in [Table 14](#). All I/Os are CMOS and TTL compliant.

Table 43. I/O static characteristics

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|------------------|---|--|---|------------------------------------|---------------------------------------|------|
| V _{IL} | Input low level voltage | TC and FT I/O | - | - | 0.3 V _{DD} ⁽¹⁾⁽²⁾ | V |
| | | BOOT0 | - | - | 0.14 V _{DD} ⁽²⁾ | |
| V _{IH} | Input high level voltage | TC I/O | 0.45 V _{DD} +0.38 ⁽²⁾ | - | - | |
| | | FT I/O | 0.39 V _{DD} +0.59 ⁽²⁾ | - | - | |
| | | BOOT0 | 0.15 V _{DD} +0.56 ⁽²⁾ | - | - | |
| V _{hys} | I/O Schmitt trigger voltage hysteresis ⁽²⁾ | TC and FT I/O | - | 10% V _{DD} ⁽³⁾ | - | |
| | | BOOT0 | - | 0.01 | - | |
| I _{lkg} | Input leakage current ⁽⁴⁾ | V _{SS} ≤ V _{IN} ≤ V _{DD} I/Os with LCD | - | - | ±50 | nA |
| | | V _{SS} ≤ V _{IN} ≤ V _{DD} I/Os with analog switches | - | - | ±50 | |
| | | V _{SS} ≤ V _{IN} ≤ V _{DD} I/Os with analog switches and LCD | - | - | ±50 | |
| | | V _{SS} ≤ V _{IN} ≤ V _{DD} I/Os with USB | - | - | ±250 | |
| | | V _{SS} ≤ V _{IN} ≤ V _{DD} TC and FT I/O | - | - | ±50 | |
| | | FT I/O V _{DD} ≤ V _{IN} ≤ 5V | - | - | ±10 | uA |
| R _{PU} | Weak pull-up equivalent resistor ⁽⁵⁾⁽¹⁾ | V _{IN} = V _{SS} | 25 | 45 | 65 | kΩ |
| R _{PD} | Weak pull-down equivalent resistor ⁽⁵⁾ | V _{IN} = V _{DD} | 25 | 45 | 65 | kΩ |
| C _{IO} | I/O pin capacitance | - | - | 5 | - | pF |

1. Guaranteed by test in production.

2. Guaranteed by design.

3. With a minimum of 200 mV.

4. The max. value may be exceeded if negative current is injected on adjacent pins.

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

Output driving current

The GPIOs (general purpose input/outputs) can sink or source up to ±8 mA, and sink or source up to ±20 mA (with the non-standard V_{OL}/V_{OH} specifications given in [Table 44](#)).

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 ΣI_{VDD} (see [Table 12](#)).
- 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 ΣI_{VSS} (see [Table 12](#)).

Output voltage levels

Unless otherwise specified, the parameters given in [Table 44](#) are derived from tests performed under ambient temperature and V_{DD} supply voltage conditions summarized in [Table 14](#). All I/Os are CMOS and TTL compliant.

Table 44. Output voltage characteristics

| Symbol | Parameter | Conditions | Min | Max | Unit |
|-------------------|--|---|---------------|------|------|
| $V_{OL}^{(1)(2)}$ | Output low level voltage for an I/O pin | $I_{IO} = 8 \text{ mA}$ | - | 0.4 | V |
| $V_{OH}^{(3)(2)}$ | Output high level voltage for an I/O pin | $2.7 \text{ V} < V_{DD} < 3.6 \text{ V}$ | $V_{DD}-0.4$ | - | |
| $V_{OL}^{(1)(4)}$ | Output low level voltage for an I/O pin | $I_{IO} = 4 \text{ mA}$ | - | 0.45 | |
| $V_{OH}^{(3)(4)}$ | Output high level voltage for an I/O pin | $1.65 \text{ V} < V_{DD} < 2.7 \text{ V}$ | $V_{DD}-0.45$ | - | |
| $V_{OL}^{(1)(4)}$ | Output low level voltage for an I/O pin | $I_{IO} = 15 \text{ mA}$ | - | 1.3 | |
| $V_{OH}^{(3)(4)}$ | Output high level voltage for an I/O pin | $2.7 \text{ V} < V_{DD} < 3.6 \text{ V}$ | $V_{DD}-1.3$ | - | |

1. The I_{IO} current sunk by the device must always respect the absolute maximum rating specified in [Table 12](#) and the sum of I_{IO} (I/O ports and control pins) must not exceed I_{VSS} .
2. Guaranteed by test in production.
3. The I_{IO} current sourced by the device must always respect the absolute maximum rating specified in [Table 12](#) and the sum of I_{IO} (I/O ports and control pins) must not exceed I_{VDD} .
4. Guaranteed by characterization results.

Input/output AC characteristics

The definition and values of input/output AC characteristics are given in [Figure 19](#) and [Table 45](#), respectively.

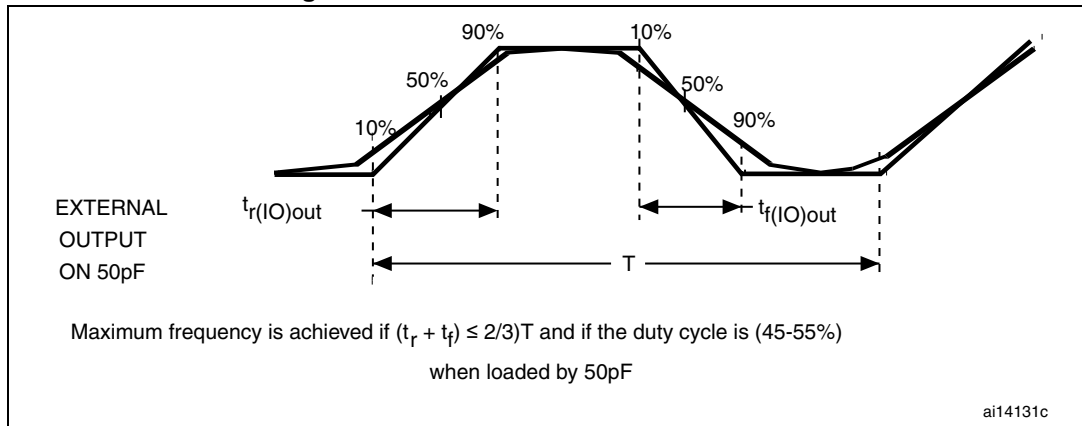
Unless otherwise specified, the parameters given in [Table 45](#) are derived from tests performed under ambient temperature and V_{DD} supply voltage conditions summarized in [Table 14](#).

Table 45. I/O AC characteristics⁽¹⁾

| OSPEEDRx [1:0] bit value ⁽¹⁾ | Symbol | Parameter | Conditions | Min | Max ⁽²⁾ | Unit |
|---|--|---|--|-----|--------------------|------|
| 00 | $f_{\max(\text{IO})\text{out}}$ | Maximum frequency ⁽³⁾ | $C_L = 50 \text{ pF}, V_{DD} = 2.7 \text{ V to } 3.6 \text{ V}$ | - | 400 | kHz |
| | | | $C_L = 50 \text{ pF}, V_{DD} = 1.65 \text{ V to } 2.7 \text{ V}$ | - | 400 | |
| | $t_{f(\text{IO})\text{out}}$ $t_{r(\text{IO})\text{out}}$ | Output rise and fall time | $C_L = 50 \text{ pF}, V_{DD} = 2.7 \text{ V to } 3.6 \text{ V}$ | - | 625 | ns |
| | | | $C_L = 50 \text{ pF}, V_{DD} = 1.65 \text{ V to } 2.7 \text{ V}$ | - | 625 | |
| 01 | $f_{\max(\text{IO})\text{out}}$ | Maximum frequency ⁽³⁾ | $C_L = 50 \text{ pF}, V_{DD} = 2.7 \text{ V to } 3.6 \text{ V}$ | - | 2 | MHz |
| | | | $C_L = 50 \text{ pF}, V_{DD} = 1.65 \text{ V to } 2.7 \text{ V}$ | - | 1 | |
| | $t_{f(\text{IO})\text{out}}$ $t_{r(\text{IO})\text{out}}$ | Output rise and fall time | $C_L = 50 \text{ pF}, V_{DD} = 2.7 \text{ V to } 3.6 \text{ V}$ | - | 125 | ns |
| | | | $C_L = 50 \text{ pF}, V_{DD} = 1.65 \text{ V to } 2.7 \text{ V}$ | - | 250 | |
| 10 | $F_{\max(\text{IO})\text{out}}$ | Maximum frequency ⁽³⁾ | $C_L = 50 \text{ pF}, V_{DD} = 2.7 \text{ V to } 3.6 \text{ V}$ | - | 10 | MHz |
| | | | $C_L = 50 \text{ pF}, V_{DD} = 1.65 \text{ V to } 2.7 \text{ V}$ | - | 2 | |
| | $t_{f(\text{IO})\text{out}}$ $t_{r(\text{IO})\text{out}}$ | Output rise and fall time | $C_L = 50 \text{ pF}, V_{DD} = 2.7 \text{ V to } 3.6 \text{ V}$ | - | 25 | ns |
| | | | $C_L = 50 \text{ pF}, V_{DD} = 1.65 \text{ V to } 2.7 \text{ V}$ | - | 125 | |
| 11 | $F_{\max(\text{IO})\text{out}}$ | Maximum frequency ⁽³⁾ | $C_L = 50 \text{ pF}, V_{DD} = 2.7 \text{ V to } 3.6 \text{ V}$ | - | 50 | MHz |
| | | | $C_L = 50 \text{ pF}, V_{DD} = 1.65 \text{ V to } 2.7 \text{ V}$ | - | 8 | |
| | $t_{f(\text{IO})\text{out}}$ $t_{r(\text{IO})\text{out}}$ | Output rise and fall time | $C_L = 30 \text{ pF}, V_{DD} = 2.7 \text{ V to } 3.6 \text{ V}$ | - | 5 | ns |
| | | | $C_L = 50 \text{ pF}, V_{DD} = 1.65 \text{ V to } 2.7 \text{ V}$ | - | 30 | |
| - | $t_{\text{EXTI}pw}$ | Pulse width of external signals detected by the EXTI controller | - | 8 | - | ns |

1. The I/O speed is configured using the OSPEEDRx[1:0] bits. Refer to the reference manual for a description of GPIO Port configuration register.
2. Guaranteed by design.
3. The maximum frequency is defined in [Figure 19](#).

Figure 19. I/O AC characteristics definition



6.3.14 NRST pin characteristics

The NRST pin input driver uses CMOS technology. It is connected to a permanent pull-up resistor, RPU (see [Table 46](#)).

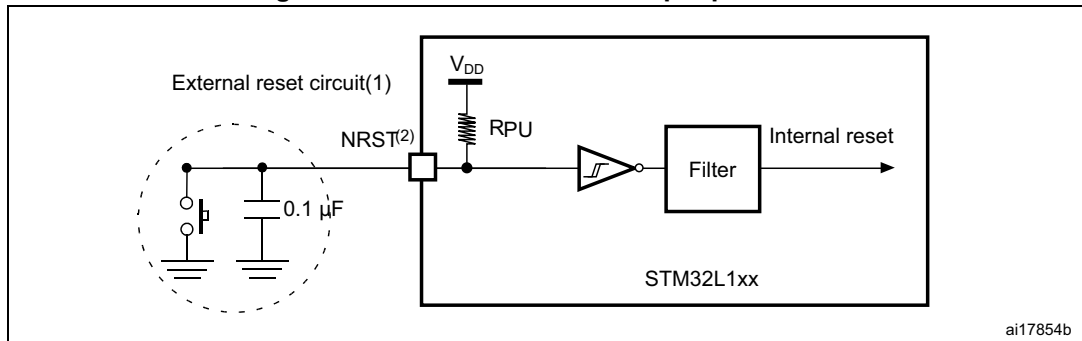
Unless otherwise specified, the parameters given in [Table 46](#) are derived from tests performed under ambient temperature and V_{DD} supply voltage conditions summarized in [Table 14](#).

Table 46. NRST pin characteristics

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|-----------------------|---|--|----------------------|---------------------|--------------|------------|
| $V_{IL(NRST)}^{(1)}$ | NRST input low level voltage | - | - | - | $0.3 V_{DD}$ | V |
| $V_{IH(NRST)}^{(1)}$ | NRST input high level voltage | - | $0.39 V_{DD} + 0.59$ | - | | |
| $V_{OL(NRST)}^{(1)}$ | NRST output low level voltage | $I_{OL} = 2 \text{ mA}$ $2.7 \text{ V} < V_{DD} < 3.6 \text{ V}$ | - | - | 0.4 | |
| | | $I_{OL} = 1.5 \text{ mA}$ $1.65 \text{ V} < V_{DD} < 2.7 \text{ V}$ | - | - | | |
| $V_{hys(NRST)}^{(1)}$ | NRST Schmitt trigger voltage hysteresis | - | - | $10\% V_{DD}^{(2)}$ | | mV |
| R_{PU} | Weak pull-up equivalent resistor ⁽³⁾ | $V_{IN} = V_{SS}$ | 25 | 45 | 65 | k Ω |
| $V_{F(NRST)}^{(1)}$ | NRST input filtered pulse | - | - | - | 50 | ns |
| $V_{NF(NRST)}^{(1)}$ | NRST input not filtered pulse | - | 350 | - | - | ns |

1. Guaranteed by design.
2. 200 mV minimum value.
3. The pull-up is designed with a true resistance in series with a switchable PMOS. This PMOS contribution to the series resistance is around 10%.

Figure 20. Recommended NRST pin protection



1. The reset network protects the device against parasitic resets. 0.1 uF capacitor must be placed as close as possible to the chip.
2. The user must ensure that the level on the NRST pin can go below the $V_{IL(NRST)}$ max level specified in [Table 46](#). Otherwise the reset will not be taken into account by the device.

6.3.15 TIM timer characteristics

The parameters given in [Table 47](#) are guaranteed by design.

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

Table 47. TIMx⁽¹⁾ characteristics

| Symbol | Parameter | Conditions | Min | Max | Unit |
|------------------|--|--------------------------------|--------|----------------------|---------------|
| $t_{res(TIM)}$ | Timer resolution time | - | 1 | - | $t_{TIMxCLK}$ |
| | | $f_{TIMxCLK} = 32 \text{ MHz}$ | 31.25 | - | ns |
| f_{EXT} | Timer external clock frequency on CH1 to CH4 | - | 0 | $f_{TIMxCLK}/2$ | MHz |
| | | $f_{TIMxCLK} = 32 \text{ MHz}$ | 0 | 16 | MHz |
| Res_{TIM} | Timer resolution | - | - | 16 | bit |
| $t_{COUNTER}$ | 16-bit counter clock period when internal clock is selected (timer's prescaler disabled) | - | 1 | 65536 | $t_{TIMxCLK}$ |
| | | $f_{TIMxCLK} = 32 \text{ MHz}$ | 0.0312 | 2048 | μs |
| t_{MAX_COUNT} | Maximum possible count | - | - | 65536×65536 | $t_{TIMxCLK}$ |
| | | $f_{TIMxCLK} = 32 \text{ MHz}$ | - | 134.2 | s |

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

6.3.16 Communication interfaces

I²C interface characteristics

The STM32L151x6/8/B-A and STM32L152x6/8/B-A product line I²C interface meets the requirements of the standard I²C communication protocol with the following restrictions: SDA and SCL are not “true” open-drain I/O pins. When configured as open-drain, the PMOS connected between the I/O pin and V_{DD} is disabled, but is still present.

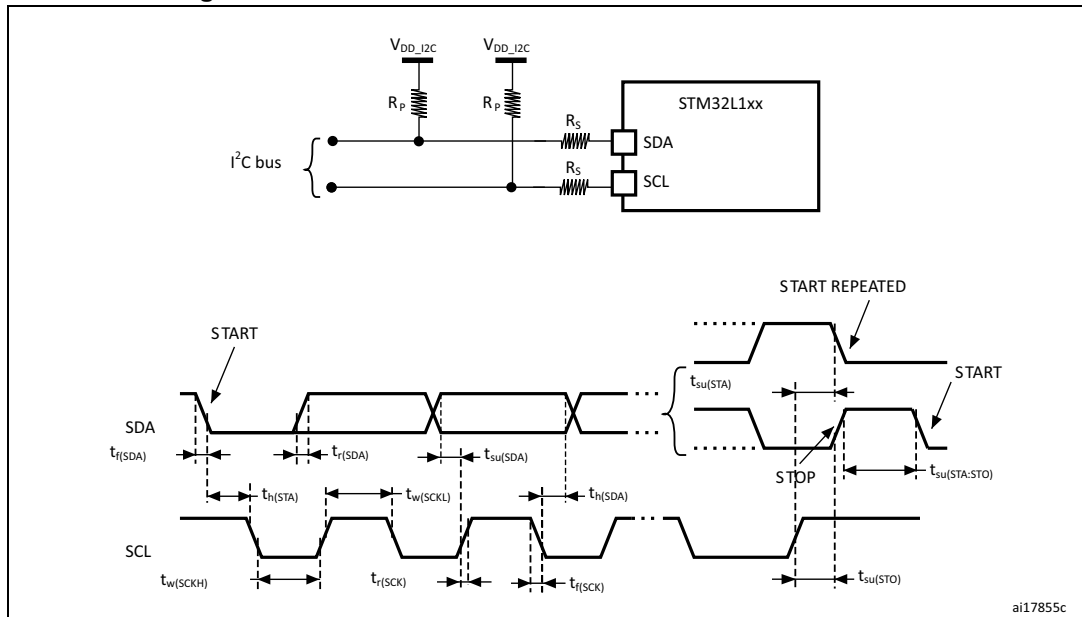
The I²C characteristics are described in [Table 48](#). Refer also to [Section 6.3.12: I/O current injection characteristics](#) for more details on the input/output alternate function characteristics (SDA and SCL).

Table 48. I²C characteristics

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

1. Guaranteed by design.
2. f_{CLKI} must be at least 2 MHz to achieve standard mode I²C frequencies. It must be at least 4 MHz to achieve fast mode I²C frequencies. It must be a multiple of 10 MHz to reach the 400 kHz maximum I²C fast mode clock.
3. The maximum Data hold time has only to be met if the interface does not stretch the low period of SCL signal.
4. The minimum width of the spikes filtered by the analog filter is above t_{SP(max)}.

Figure 21. I²C bus AC waveforms and measurement circuit



1. R_S = series protection resistors
2. R_P = pull-up resistors
3. V_{DD_I2C} = I2C bus supply
4. Measurement points are done at CMOS levels: $0.3V_{DD}$ and $0.7V_{DD}$.

Table 49. SCL frequency ($f_{PCLK1} = 32\text{ MHz}$, $V_{DD} = V_{DD_I2C} = 3.3\text{ V}$)⁽¹⁾⁽²⁾

| f_{SCL} (kHz) | I2C_CCR value |
|-----------------|----------------------------|
| | $R_P = 4.7\text{ k}\Omega$ |
| 400 | 0x801B |
| 300 | 0x8024 |
| 200 | 0x8035 |
| 100 | 0x00A0 |
| 50 | 0x0140 |
| 20 | 0x0320 |

1. R_P = External pull-up resistance, f_{SCL} = I²C speed.
2. For speeds around 200 kHz, the tolerance on the achieved speed is of $\pm 5\%$. For other speed ranges, the tolerance on the achieved speed is $\pm 2\%$. These variations depend on the accuracy of the external components used to design the application.

SPI characteristics

Unless otherwise specified, the parameters given in the following table are derived from tests performed under ambient temperature, f_{PCLKx} frequency and V_{DD} supply voltage conditions summarized in [Table 14](#).

Refer to [Section 6.3.12: I/O current injection characteristics](#) for more details on the input/output alternate function characteristics (NSS, SCK, MOSI, MISO).

Table 50. SPI characteristics⁽¹⁾

| Symbol | Parameter | Conditions | Min | Max ⁽²⁾ | Unit |
|--|----------------------------------|----------------------------|---------------|--------------------|------|
| f_{SCK} $1/t_{c(SCK)}$ | SPI clock frequency | Master mode | - | 16 | MHz |
| | | Slave mode | - | 16 | |
| | | Slave transmitter | - | 12 ⁽³⁾ | |
| $t_{r(SCK)}^{(2)}$ $t_{f(SCK)}^{(2)}$ | SPI clock rise and fall time | Capacitive load: C = 30 pF | - | 6 | ns |
| DuCy(SCK) | SPI slave input clock duty cycle | Slave mode | 30 | 70 | % |
| $t_{su(NSS)}$ | NSS setup time | Slave mode | $4t_{HCLK}$ | - | ns |
| $t_{h(NSS)}$ | NSS hold time | Slave mode | $2t_{HCLK}$ | - | |
| $t_{w(SCKH)}^{(2)}$ $t_{w(SCKL)}^{(2)}$ | SCK high and low time | Master mode | $t_{SCK}/2-5$ | $t_{SCK}/2+3$ | |
| $t_{su(MI)}^{(2)}$ | Data input setup time | Master mode | 5 | - | |
| $t_{su(SI)}^{(2)}$ | | Slave mode | 6 | - | |
| $t_{h(MI)}^{(2)}$ | Data input hold time | Master mode | 5 | - | |
| $t_{h(SI)}^{(2)}$ | | Slave mode | 5 | - | |
| $t_{a(SO)}^{(4)}$ | Data output access time | Slave mode | 0 | $3t_{HCLK}$ | |
| $t_{v(SO)}^{(2)}$ | Data output valid time | Slave mode | - | 33 | |
| $t_{v(MO)}^{(2)}$ | Data output valid time | Master mode | - | 6.5 | |
| $t_{h(SO)}^{(2)}$ | Data output hold time | Slave mode | 17 | - | |
| $t_{h(MO)}^{(2)}$ | | Master mode | 0.5 | - | |

1. The characteristics above are given for voltage Range 1.
2. Guaranteed by characterization results.
3. The maximum SPI clock frequency in slave transmitter mode is given for an SPI slave input clock duty cycle (DuCy(SCK)) ranging between 40 to 60%.
4. Min time is for the minimum time to drive the output and max time is for the maximum time to validate the data.

Figure 22. SPI timing diagram - slave mode and CPHA = 0

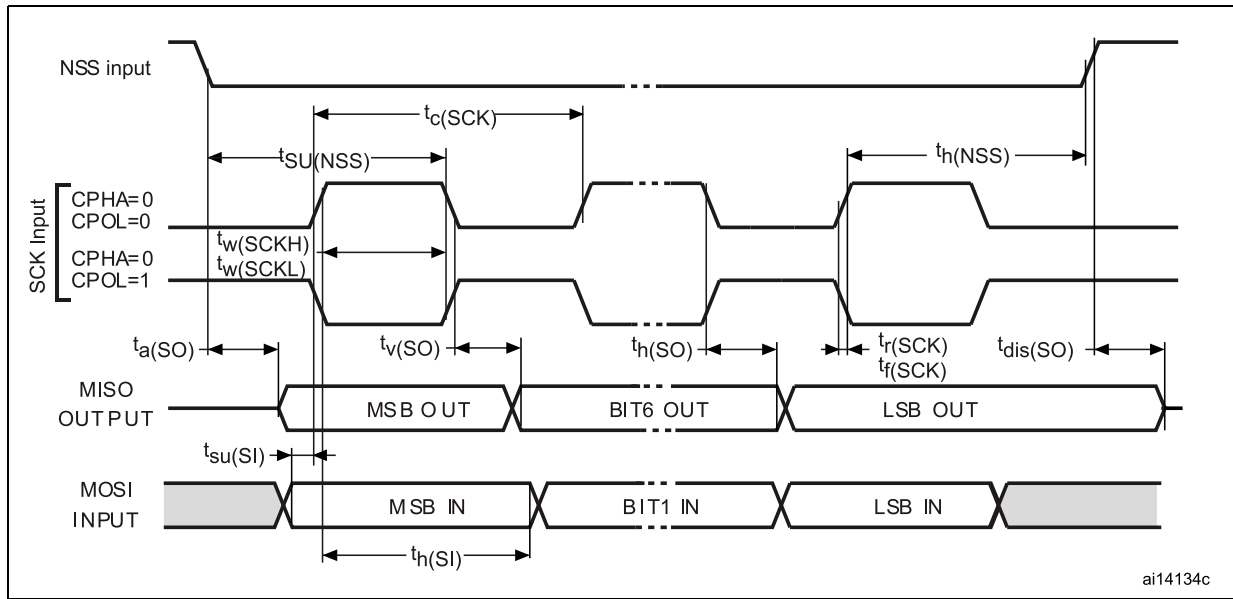
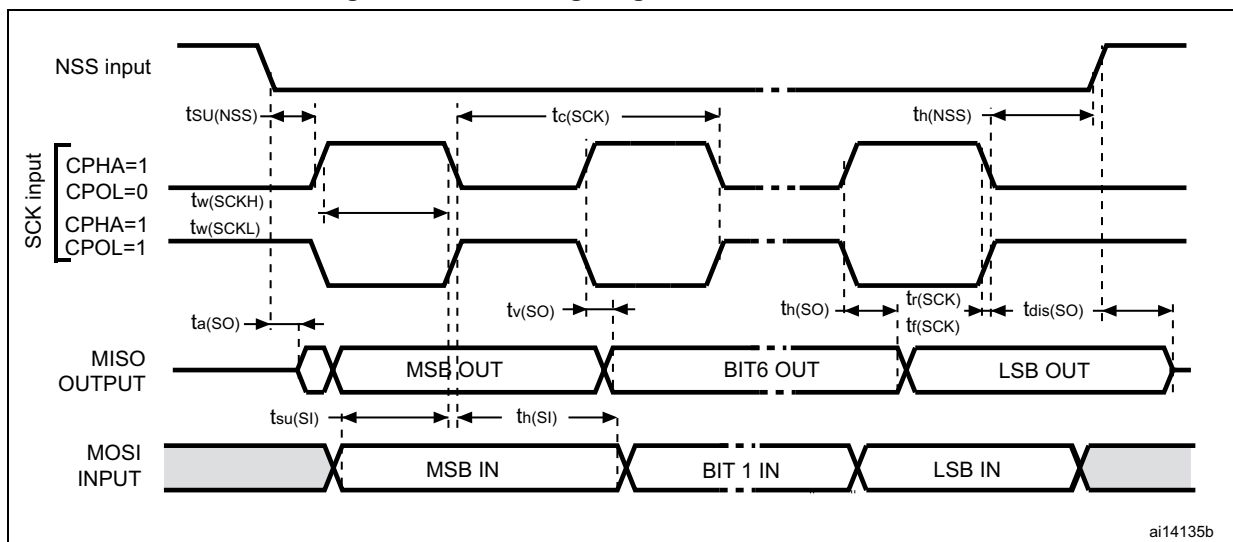
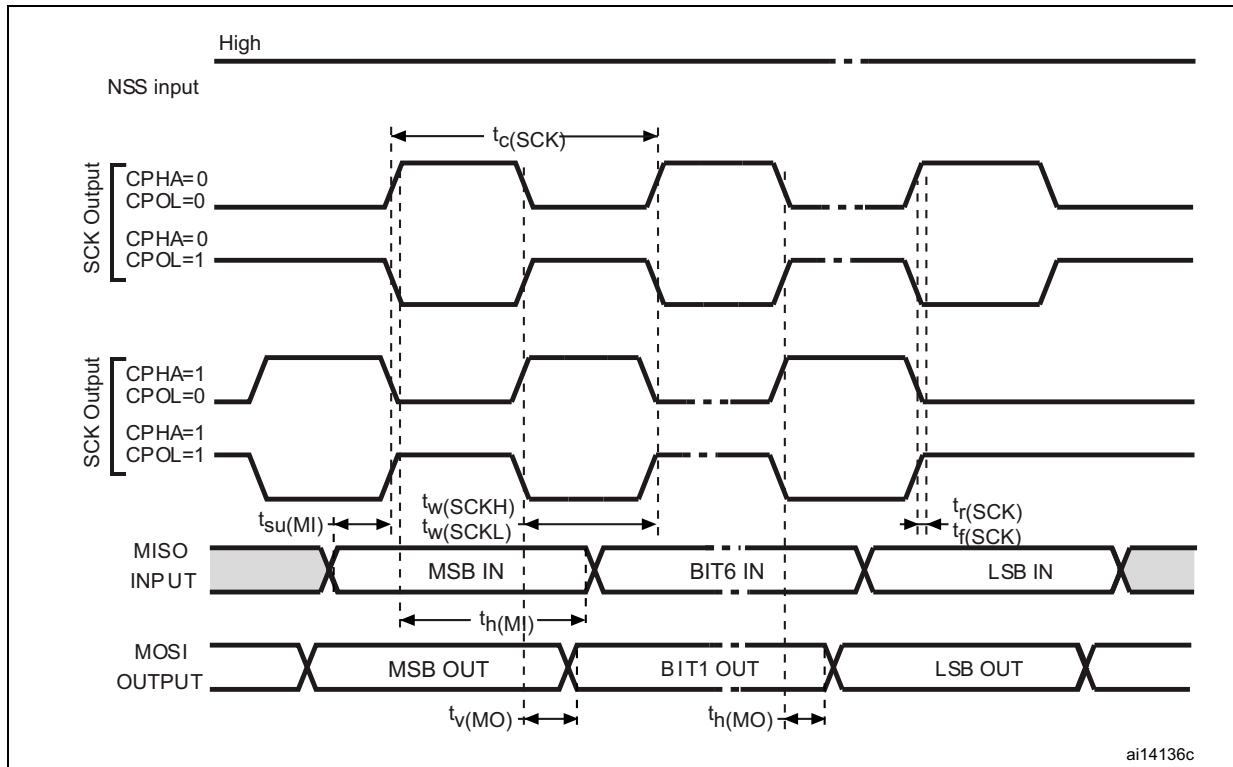


Figure 23. SPI timing diagram - slave mode and CPHA = 1⁽¹⁾



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

Figure 24. SPI timing diagram - master mode⁽¹⁾



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

USB characteristics

The USB interface is USB-IF certified (full speed).

Table 51. USB startup time

| Symbol | Parameter | Max | Unit |
|---------------------|------------------------------|-----|---------|
| $t_{STARTUP}^{(1)}$ | USB transceiver startup time | 1 | μs |

1. Guaranteed by design.

Table 52. USB DC electrical characteristics

| Symbol | Parameter | Conditions | Min. ⁽¹⁾ | Max. ⁽¹⁾ | Unit |
|--------------------------------|--------------------------------------|---|---------------------|---------------------|------|
| Input levels | | | | | |
| V _{DD} | USB operating voltage ⁽²⁾ | - | 3.0 | 3.6 | V |
| V _{DI} ⁽³⁾ | Differential input sensitivity | I(USB_DP, USB_DM) | 0.2 | - | V |
| V _{CM} ⁽³⁾ | Differential common mode range | Includes V _{DI} range | 0.8 | 2.5 | |
| V _{SE} ⁽³⁾ | Single ended receiver threshold | - | 1.3 | 2.0 | |
| Output levels | | | | | |
| V _{OL} ⁽⁴⁾ | Static output level low | R _L of 1.5 kΩ to 3.6 V ⁽⁵⁾ | - | 0.3 | V |
| V _{OH} ⁽⁴⁾ | Static output level high | R _L of 15 kΩ to V _{SS} ⁽⁵⁾ | 2.8 | 3.6 | |

1. All the voltages are measured from the local ground potential.
2. To be compliant with the USB 2.0 full speed electrical specification, the USB_DP (D+) pin should be pulled up with a 1.5 kΩ resistor to a 3.0-to-3.6 V voltage range.
3. Guaranteed by characterization results.
4. Guaranteed by test in production.
5. R_L is the load connected on the USB drivers.

Figure 25. USB timings: definition of data signal rise and fall time

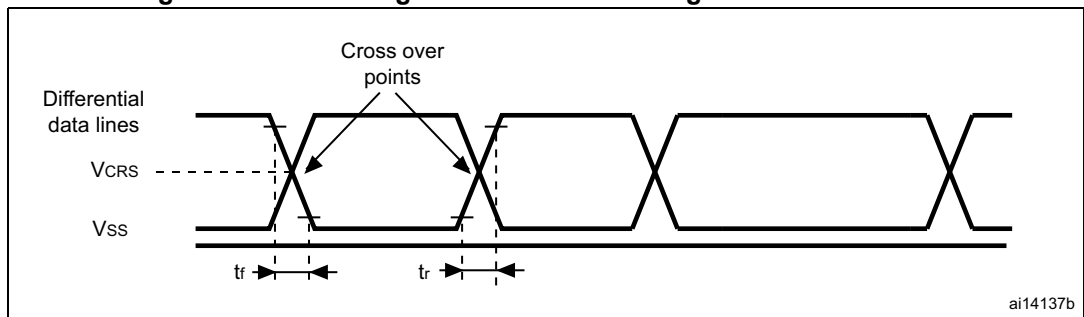


Table 53. USB: full speed electrical characteristics

| Driver characteristics ⁽¹⁾ | | | | | |
|---------------------------------------|---------------------------------|--------------------------------|-----|-----|------|
| Symbol | Parameter | Conditions | Min | Max | Unit |
| t _r | Rise time ⁽²⁾ | C _L = 50 pF | 4 | 20 | ns |
| t _f | Fall Time ⁽²⁾ | C _L = 50 pF | 4 | 20 | ns |
| t _{rfm} | Rise/ fall time matching | t _r /t _f | 90 | 110 | % |
| V _{CRS} | Output signal crossover voltage | - | 1.3 | 2.0 | V |

1. Guaranteed by design.
2. Measured from 10% to 90% of the data signal. For more detailed informations, please refer to USB Specification section 7 (version 2.0).

6.3.17 12-bit ADC characteristics

Unless otherwise specified, the parameters given in [Table 55](#) are guaranteed by design.

Table 54. ADC clock frequency

| Symbol | Parameter | Conditions | | Min | Max | Unit | |
|------------------|---------------------|---------------------|--------------------------------------|---|-------|------|-----|
| f _{ADC} | ADC clock frequency | Voltage Range 1 & 2 | 2.4 V ≤ V _{DDA} ≤ 3.6 V | V _{REF+} = V _{DDA} | 0.480 | 16 | MHz |
| | | | | V _{REF+} < V _{DDA} V _{REF+} > 2.4 V | | 8 | |
| | | | 1.8 V ≤ V _{DDA} ≤ 2.4 V | V _{REF+} < V _{DDA} V _{REF+} ≥ 2.4 V | | 4 | |
| | | | | V _{REF+} = V _{DDA} | | 8 | |
| | | Voltage Range 3 | V _{REF+} < V _{DDA} | 4 | | | |
| | | | | 4 | | | |

Table 55. ADC characteristics

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|----------------------------------|---|--|--------------------|------------------|-------------------|------|
| V _{DDA} | Power supply | - | 1.8 | - | 3.6 | V |
| V _{REF+} | Positive reference voltage | 2.4 V ≤ V _{DDA} ≤ 3.6 V V _{REF+} must be below or equal to V _{DDA} | 1.8 ⁽¹⁾ | - | V _{DDA} | V |
| V _{REF-} | Negative reference voltage | - | - | V _{SSA} | - | V |
| I _{VDDA} | Current on the V _{DDA} input pin | - | - | 1000 | 1450 | μA |
| I _{VREF} ⁽²⁾ | Current on the V _{REF} input pin | Peak | - | 400 | 700 | μA |
| | | Average | - | - | 450 | μA |
| V _{AIN} | Conversion voltage range ⁽³⁾ | - | 0 ⁽⁴⁾ | - | V _{REF+} | V |
| f _S | 12-bit sampling rate | Direct channels | - | - | 1 | Msps |
| | | Multiplexed channels | - | - | 0.76 | |
| | 10-bit sampling rate | Direct channels | - | - | 1.07 | Msps |
| | | Multiplexed channels | - | - | 0.8 | |
| | 8-bit sampling rate | Direct channels | - | - | 1.23 | Msps |
| | | Multiplexed channels | - | - | 0.89 | |
| | 6-bit sampling rate | Direct channels | - | - | 1.45 | Msps |
| | | Multiplexed channels | - | - | 1 | |

Table 55. ADC characteristics (continued)

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|------------|--|---|---|-----|--------------|----------------|
| t_S | Sampling time ⁽⁵⁾ | Direct channels $2.4\text{ V} \leq V_{DDA} \leq 3.6\text{ V}$ | 0.25 | - | - | μs |
| | | Multiplexed channels $2.4\text{ V} \leq V_{DDA} \leq 3.6\text{ V}$ | 0.56 | - | - | |
| | | Direct channels $1.8\text{ V} \leq V_{DDA} \leq 2.4\text{ V}$ | 0.56 | - | - | |
| | | Multiplexed channels $1.8\text{ V} \leq V_{DDA} \leq 2.4\text{ V}$ | 1 | - | - | |
| | | - | 4 | - | 384 | $1/f_{ADC}$ |
| t_{CONV} | Total conversion time (including sampling time) | $f_{ADC} = 16\text{ MHz}$ | 1 | - | 24.75 | μs |
| | | - | 4 to 384 (sampling phase) + 12 (successive approximation) | | | $1/f_{ADC}$ |
| C_{ADC} | Internal sample and hold capacitor | Direct channels | - | 16 | - | pF |
| | | Multiplexed channels | - | | - | |
| f_{TRIG} | External trigger frequency Regular sequencer | 12-bit conversions | - | - | $T_{conv}+1$ | $1/f_{ADC}$ |
| | | 6/8/10-bit conversions | - | - | T_{conv} | $1/f_{ADC}$ |
| f_{TRIG} | External trigger frequency Injected sequencer | 12-bit conversions | - | - | $T_{conv}+2$ | $1/f_{ADC}$ |
| | | 6/8/10-bit conversions | - | - | $T_{conv}+1$ | $1/f_{ADC}$ |
| R_{AIN} | Signal source impedance ⁽⁵⁾ | - | - | - | 50 | $\kappa\Omega$ |
| t_{lat} | Injection trigger conversion latency | $f_{ADC} = 16\text{ MHz}$ | 219 | - | 281 | ns |
| | | - | 3.5 | - | 4.5 | $1/f_{ADC}$ |
| t_{latr} | Regular trigger conversion latency | $f_{ADC} = 16\text{ MHz}$ | 156 | - | 219 | ns |
| | | - | 2.5 | - | 3.5 | $1/f_{ADC}$ |
| t_{STAB} | Power-up time | - | - | - | 3.5 | μs |

- The V_{REF+} input can be grounded if neither the ADC nor the DAC are used (this allows to shut down an external voltage reference).
- The current consumption through V_{REF} is composed of two parameters:
 - one constant (max 300 μA)
 - one variable (max 400 μA), only during sampling time + 2 first conversion pulses.

So, peak consumption is $300+400 = 700\text{ }\mu\text{A}$ and average consumption is $300 + [(4\text{ sampling} + 2)/16] \times 400 = 450\text{ }\mu\text{A}$ at 1Msps
- V_{REF+} can be internally connected to V_{DDA} and V_{REF-} can be internally connected to V_{SSA} , depending on the package. Refer to [Section 4: Pin descriptions](#) for further details.
- V_{SSA} or V_{REF-} must be tied to ground.
- See [Table 57: Maximum source impedance \$R_{AIN\text{ max}}\$](#) for R_{AIN} limitations

Table 56. ADC accuracy⁽¹⁾⁽²⁾

| Symbol | Parameter | Test conditions | Min ⁽³⁾ | Typ | Max ⁽³⁾ | Unit |
|--------|--------------------------------------|---|--------------------|-----|--------------------|------|
| ET | Total unadjusted error | $2.4\text{ V} \leq V_{DDA} \leq 3.6\text{ V}$ $2.4\text{ V} \leq V_{REF+} \leq 3.6\text{ V}$ $f_{ADC} = 8\text{ MHz}$, $R_{AIN} = 50\ \Omega$ $T_A = -40\text{ to }105\text{ }^\circ\text{C}$ | - | 2.5 | 4 | LSB |
| EO | Offset error | | - | 1 | 2 | |
| EG | Gain error | | - | 1.5 | 3.5 | |
| ED | Differential linearity error | | - | 1 | 2 | |
| EL | Integral linearity error | | - | 2 | 3 | |
| ENOB | Effective number of bits | $2.4\text{ V} \leq V_{DDA} \leq 3.6\text{ V}$ | 9.5 | 10 | - | bits |
| SINAD | Signal-to-noise and distortion ratio | $V_{DDA} = V_{REF+}$ $f_{ADC} = 16\text{ MHz}$, $R_{AIN} = 50\ \Omega$ | 59 | 62 | - | dB |
| SNR | Signal-to-noise ratio | $T_A = -40\text{ to }105\text{ }^\circ\text{C}$ | 60 | 62 | - | |
| THD | Total harmonic distortion | $F_{input} = 10\text{ kHz}$ | - | -72 | -69 | |
| ENOB | Effective number of bits | $1.8\text{ V} \leq V_{DDA} \leq 2.4\text{ V}$ | 9.5 | 10 | - | bits |
| SINAD | Signal-to-noise and distortion ratio | $V_{DDA} = V_{REF+}$ $f_{ADC} = 8\text{ MHz}$ or 4 MHz , $R_{AIN} = 50\ \Omega$ | 59 | 62 | - | dB |
| SNR | Signal-to-noise ratio | $T_A = -40\text{ to }105\text{ }^\circ\text{C}$ | 60 | 62 | - | |
| THD | Total harmonic distortion | $F_{input} = 10\text{ kHz}$ | - | -72 | -69 | |
| ET | Total unadjusted error | $2.4\text{ V} \leq V_{DDA} \leq 3.6\text{ V}$ $1.8\text{ V} \leq V_{REF+} \leq 2.4\text{ V}$ $f_{ADC} = 4\text{ MHz}$, $R_{AIN} = 50\ \Omega$ $T_A = -40\text{ to }105\text{ }^\circ\text{C}$ | - | 4 | 6.5 | LSB |
| EO | Offset error | | - | 1.5 | 3.5 | |
| EG | Gain error | | - | 3.5 | 6 | |
| ED | Differential linearity error | | - | 1 | 2 | |
| EL | Integral linearity error | | - | 2.5 | 3.5 | |
| ET | Total unadjusted error | $1.8\text{ V} \leq V_{DDA} \leq 2.4\text{ V}$ $1.8\text{ V} \leq V_{REF+} \leq 2.4\text{ V}$ $f_{ADC} = 4\text{ MHz}$, $R_{AIN} = 50\ \Omega$ $T_A = -40\text{ to }105\text{ }^\circ\text{C}$ | - | 2 | 3 | LSB |
| EO | Offset error | | - | 1 | 1.5 | |
| EG | Gain error | | - | 1.5 | 2.5 | |
| ED | Differential linearity error | | - | 1 | 2 | |
| EL | Integral linearity error | | - | 2 | 3 | |

1. ADC DC accuracy values are measured after internal calibration.
2. ADC accuracy vs. negative injection current: Injecting a negative current on any analog input pins should be avoided as this significantly reduces the accuracy of the conversion being performed on another analog input. It is recommended to add a Schottky diode (pin to ground) to analog pins which may potentially inject negative currents. Any positive injection current within the limits specified for $I_{INJ(PIN)}$ and $\Sigma I_{INJ(PIN)}$ in [Section 6.3.12](#) does not affect the ADC accuracy.
3. Guaranteed by characterization results.

Figure 26. ADC accuracy characteristics

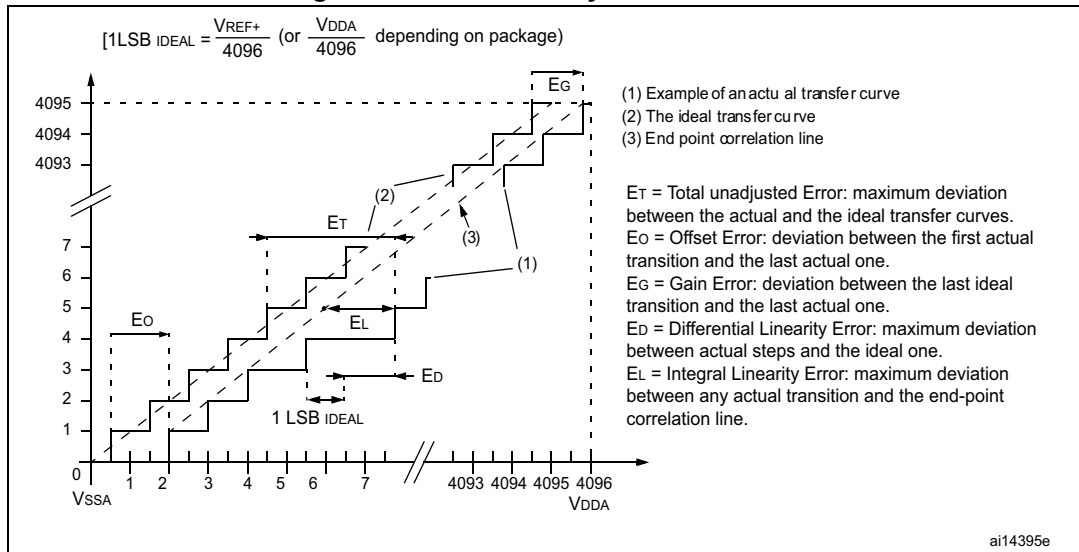
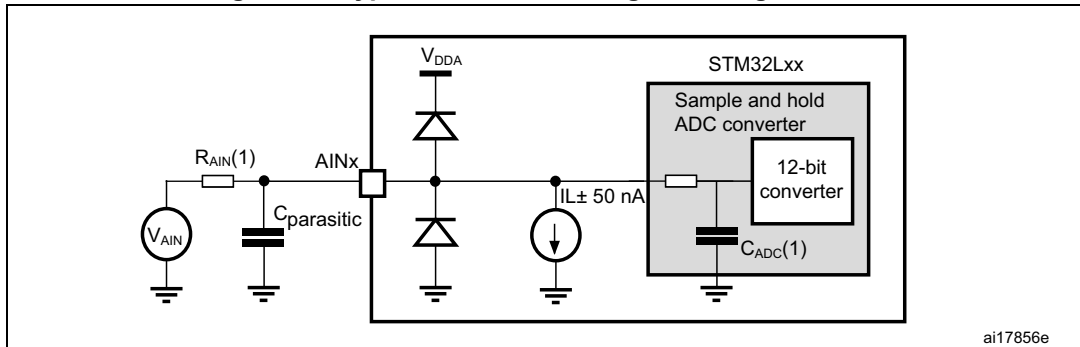


Figure 27. Typical connection diagram using the ADC



1. Refer to [Table 57: Maximum source impedance RAIN max](#) for the value of R_{AIN} and [Table 55: ADC characteristics](#) for the value of C_{ADC}
2. $C_{\text{parasitic}}$ represents the capacitance of the PCB (dependent on soldering and PCB layout quality) plus the pad capacitance (roughly 7 pF). A high $C_{\text{parasitic}}$ value will downgrade conversion accuracy. To remedy this, f_{ADC} should be reduced.

Figure 28. Maximum dynamic current consumption on V_{REF+} supply pin during ADC conversion

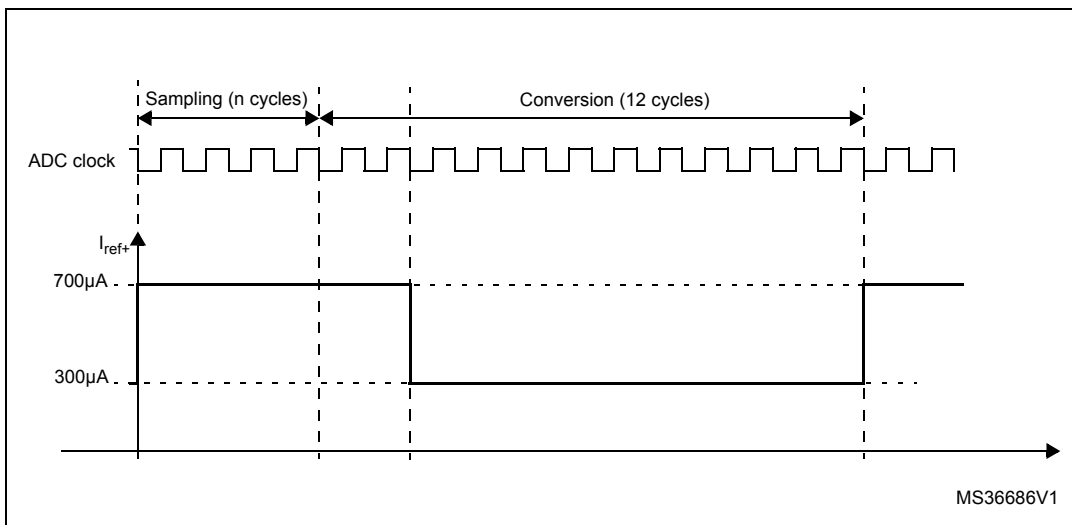


Table 57. Maximum source impedance R_{AIN} max⁽¹⁾

| Ts (µs) | R _{AIN} max (kOhm) | | | | Ts (cycles) f _{ADC} = 16 MHz ⁽²⁾ |
|---------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|---|
| | Multiplexed channels | | Direct channels | | |
| | 2.4 V < V _{DDA} < 3.6 V | 1.8 V < V _{DDA} < 2.4 V | 2.4 V < V _{DDA} < 3.3 V | 1.8 V < V _{DDA} < 2.4 V | |
| 0.25 | Not allowed | Not allowed | 0.7 | Not allowed | 4 |
| 0.5625 | 0.8 | Not allowed | 2.0 | 1.0 | 9 |
| 1 | 2.0 | 0.8 | 4.0 | 3.0 | 16 |
| 1.5 | 3.0 | 1.8 | 6.0 | 4.5 | 24 |
| 3 | 6.8 | 4.0 | 15.0 | 10.0 | 48 |
| 6 | 15.0 | 10.0 | 30.0 | 20.0 | 96 |
| 12 | 32.0 | 25.0 | 50.0 | 40.0 | 192 |
| 24 | 50.0 | 50.0 | 50.0 | 50.0 | 384 |

1. Guaranteed by design.
2. Number of samples calculated for f_{ADC} = 16 MHz. For f_{ADC} = 8 and 4 MHz the number of sampling cycles can be reduced with respect to the minimum sampling time Ts (µs).

General PCB design guidelines

Power supply decoupling should be performed as shown in [Figure 12](#), depending on whether V_{REF+} is connected to V_{DDA} or not. The 100 nF capacitors should be ceramic (good quality). They should be placed as close as possible to the chip.

6.3.18 DAC electrical specifications

Data guaranteed by design, unless otherwise specified.

Table 58. DAC characteristics

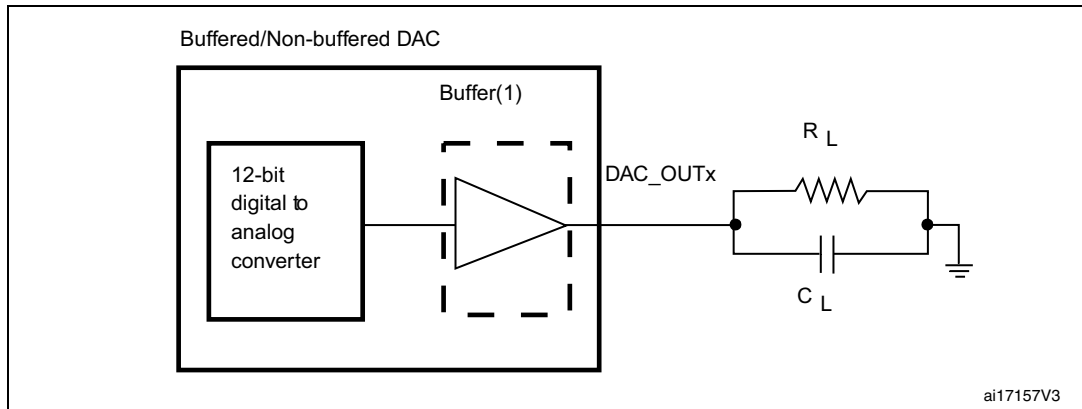
| Symbol | Parameter | Conditions | Min | Typ | Max | Unit | |
|------------------------|--|---|------------------------|-----------|--------------------------|------------|------------|
| V_{DDA} | Analog supply voltage | - | 1.8 | - | 3.6 | V | |
| V_{REF+} | Reference supply voltage | V_{REF+} must always be below V_{DDA} | 1.8 | - | 3.6 | V | |
| V_{REF-} | Lower reference voltage | - | V_{SSA} | | | V | |
| $I_{DDVREF+}^{(1)}$ | Current consumption on V_{REF+} supply $V_{REF+} = 3.3$ V | No load, middle code (0x800) | - | 130 | 220 | μ A | |
| | | No load, worst code (0x000) | - | 220 | 350 | μ A | |
| $I_{DDA}^{(1)}$ | Current consumption on V_{DDA} supply $V_{DDA} = 3.3$ V | No load, middle code (0x800) | - | 210 | 320 | μ A | |
| | | No load, worst code (0xF1C) | - | 320 | 520 | μ A | |
| R_L | Resistive load | DAC output buffer ON | Connected to V_{SSA} | 5 | - | - | k Ω |
| | | DAC output buffer ON | Connected to V_{DDA} | 25 | - | - | |
| C_L | Capacitive load | DAC output buffer ON | - | - | 50 | pF | |
| R_O | Output impedance | DAC output buffer OFF | 12 | 16 | 20 | k Ω | |
| V_{DAC_OUT} | Voltage on DAC_OUT output | DAC output buffer ON | 0.2 | - | $V_{DDA} - 0.2$ | V | |
| | | DAC output buffer OFF | 0.5 | - | $V_{REF+} - 1\text{LSB}$ | mV | |
| $DNL^{(1)}$ | Differential non linearity ⁽²⁾ | $C_L \leq 50$ pF, $R_L \geq 5$ k Ω DAC output buffer ON | - | 1.5 | 3 | LSB | |
| | | No R_L , $C_L \leq 50$ pF DAC output buffer OFF | - | 1.5 | 3 | | |
| $INL^{(1)}$ | Integral non linearity ⁽³⁾ | $C_L \leq 50$ pF, $R_L \geq 5$ k Ω DAC output buffer ON | - | 2 | 4 | | |
| | | No R_L , $C_L \leq 50$ pF DAC output buffer OFF | - | 2 | 4 | | |
| Offset ⁽¹⁾ | Offset error at code 0x800 ⁽⁴⁾ | $C_L \leq 50$ pF, $R_L \geq 5$ k Ω DAC output buffer ON | - | ± 10 | ± 25 | | |
| | | No R_L , $C_L \leq 50$ pF DAC output buffer OFF | - | ± 5 | ± 8 | | |
| Offset1 ⁽¹⁾ | Offset error at code 0x001 ⁽⁵⁾ | No R_L , $C_L \leq 50$ pF DAC output buffer OFF | - | ± 1.5 | ± 5 | | |

Table 58. DAC characteristics (continued)

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|---------------------------|--|---|-----|-----------------|------------------|-------|
| dOffset/dT ⁽¹⁾ | Offset error temperature coefficient (code 0x800) | V _{DDA} = 3.3V, V _{REF+} = 3.0V T _A = 0 to 50 °C DAC output buffer OFF | -20 | -10 | 0 | μV/°C |
| | | V _{DDA} = 3.3V, V _{REF+} = 3.0V T _A = 0 to 50 °C DAC output buffer ON | 0 | 20 | 50 | |
| Gain ⁽¹⁾ | Gain error ⁽⁶⁾ | C _L ≤ 50 pF, R _L ≥ 5 kΩ DAC output buffer ON | - | +0.1 / -0.2% | +0.2 / - 0.5% | % |
| | | No R _L , C _L ≤ 50 pF DAC output buffer OFF | - | +0 / - 0.2% | +0 / - 0.4% | |
| dGain/dT ⁽¹⁾ | Gain error temperature coefficient | V _{DDA} = 3.3V, V _{REF+} = 3.0V T _A = 0 to 50 °C DAC output buffer OFF | -10 | -2 | 0 | μV/°C |
| | | V _{DDA} = 3.3V, V _{REF+} = 3.0V T _A = 0 to 50 °C DAC output buffer ON | -40 | -8 | 0 | |
| TUE ⁽¹⁾ | Total unadjusted error | C _L ≤ 50 pF, R _L ≥ 5 kΩ DAC output buffer ON | - | 12 | 30 | LSB |
| | | No R _L , C _L ≤ 50 pF DAC output buffer OFF | - | 8 | 12 | |
| t _{SETTLING} | Settling time (full scale: for a 12-bit code transition between the lowest and the highest input codes till DAC_OUT reaches final value ±1LSB) | C _L ≤ 50 pF, R _L ≥ 5 kΩ | - | 7 | 12 | μs |
| Update rate | Max frequency for a correct DAC_OUT change (95% of final value) with 1 LSB variation in the input code | C _L ≤ 50 pF, R _L ≥ 5 kΩ | - | - | 1 | MSPS |
| t _{WAKEUP} | Wakeup time from off state (setting the ENx bit in the DAC Control register) ⁽⁷⁾ | C _L ≤ 50 pF, R _L ≥ 5 kΩ | - | 9 | 15 | μs |
| PSRR+ | V _{DDA} supply rejection ratio (static DC measurement) | C _L ≤ 50 pF, R _L ≥ 5 kΩ | - | -60 | -35 | dB |

1. Guaranteed by characterization results.
2. Difference between two consecutive codes - 1 LSB.
3. Difference between measured value at Code i and the value at Code i on a line drawn between Code 0 and last Code 4095.
4. Difference between the value measured at Code (0x800) and the ideal value = V_{REF+}/2.
5. Difference between the value measured at Code (0x001) and the ideal value.
6. Difference between ideal slope of the transfer function and measured slope computed from code 0x000 and 0xFFFF when buffer is OFF, and from code giving 0.2 V and (V_{DDA} - 0.2) V when buffer is ON.
7. In buffered mode, the output can overshoot above the final value for low input code (starting from min value).

Figure 29. 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.

6.3.19 Temperature sensor characteristics

Table 59. Temperature sensor calibration values

| Calibration value name | Description | Memory address |
|------------------------|--|-------------------------|
| TS_CAL1 | TS ADC raw data acquired at temperature of 30 °C±5, V _{DDA} = 3 V ±10mV | 0x1FF8 007A-0x1FF8 007B |
| TS_CAL2 | TS ADC raw data acquired at temperature of 110 ±5°C V _{DDA} = 3 V ±10mV | 0x1FF8 007E-0x1FF8 007F |

Table 60. Temperature sensor characteristics

| Symbol | Parameter | Min | Typ | Max | Unit |
|---------------------------------------|--|------|-------|-------|-------|
| T _L ⁽¹⁾ | V _{SENSE} linearity with temperature | - | ±1 | ±2 | °C |
| Avg_Slope ⁽¹⁾ | Average slope | 1.48 | 1.61 | 1.75 | mV/°C |
| V ₁₁₀ | Voltage at 110°C ±5°C ⁽²⁾ | 612 | 626.8 | 641.5 | mV |
| I _{DDA(TEMP)} ⁽³⁾ | Current consumption | - | 3.4 | 6 | µA |
| t _{START} ⁽³⁾ | Startup time | - | - | 10 | µs |
| T _{S_temp} ⁽³⁾ | ADC sampling time when reading the temperature | 4 | - | - | |

1. Guaranteed by characterization results.
2. Measured at V_{DD} = 3 V ±10 mV. V110 ADC conversion result is stored in the byte.
3. Guaranteed by design.

6.3.20 Comparator

Table 61. Comparator 1 characteristics

| Symbol | Parameter | Conditions | Min ⁽¹⁾ | Typ | Max ⁽¹⁾ | Unit |
|--------------------------|--|--|--------------------|-----|--------------------|-----------|
| V _{DDA} | Analog supply voltage | - | 1.65 | | 3.6 | V |
| R _{400K} | R _{400K} value | - | - | 400 | - | kΩ |
| R _{10K} | R _{10K} value | - | - | 10 | - | |
| V _{IN} | Comparator 1 input voltage range | - | 0.6 | - | V _{DDA} | V |
| t _{START} | Comparator startup time | - | - | 7 | 10 | μs |
| t _d | Propagation delay ⁽²⁾ | - | - | 3 | 10 | |
| V _{offset} | Comparator offset | - | - | ±3 | ±10 | mV |
| d _{Voffset} /dt | Comparator offset variation in worst voltage stress conditions | V _{DDA} = 3.6 V V _{IN+} = 0 V V _{IN-} = V _{REFINT} T _A = 25 °C | 0 | 1.5 | 10 | mV/1000 h |
| I _{COMP1} | Current consumption ⁽³⁾ | - | - | 160 | 260 | nA |

1. Guaranteed by characterization results.
2. The delay is characterized for 100 mV input step with 10 mV overdrive on the inverting input, the non-inverting input set to the reference.
3. Comparator consumption only. Internal reference voltage not included.

Table 62. Comparator 2 characteristics

| Symbol | Parameter | Conditions | Min | Typ | Max ⁽¹⁾ | Unit |
|------------------------|---|---|------|---------|--------------------|--------------------------|
| V_{DDA} | Analog supply voltage | - | 1.65 | - | 3.6 | V |
| V_{IN} | Comparator 2 input voltage range | - | 0 | - | V_{DDA} | V |
| t_{START} | Comparator startup time | Fast mode | - | 15 | 20 | μ s |
| | | Slow mode | - | 20 | 25 | |
| $t_{d\ slow}$ | Propagation delay ⁽²⁾ in slow mode | $1.65\text{ V} \leq V_{DDA} \leq 2.7\text{ V}$ | - | 1.8 | 3.5 | |
| | | $2.7\text{ V} \leq V_{DDA} \leq 3.6\text{ V}$ | - | 2.5 | 6 | |
| $t_{d\ fast}$ | Propagation delay ⁽²⁾ in fast mode | $1.65\text{ V} \leq V_{DDA} \leq 2.7\text{ V}$ | - | 0.8 | 2 | |
| | | $2.7\text{ V} \leq V_{DDA} \leq 3.6\text{ V}$ | - | 1.2 | 4 | |
| V_{offset} | Comparator offset error | - | - | ± 4 | ± 20 | mV |
| $d\text{Threshold}/dt$ | Threshold voltage temperature coefficient | $V_{DDA} = 3.3\text{ V}$ $T_A = 0\text{ to }50\text{ }^\circ\text{C}$ $V_- = V_{REFINT},$ $3/4 V_{REFINT},$ $1/2 V_{REFINT},$ $1/4 V_{REFINT}$ | - | 15 | 100 | ppm/ $^\circ\text{C}$ |
| I_{COMP2} | Current consumption ⁽³⁾ | Fast mode | - | 3.5 | 5 | μ A |
| | | Slow mode | - | 0.5 | 2 | |

1. Guaranteed by characterization results.
2. The delay is characterized for 100 mV input step with 10 mV overdrive on the inverting input, the non-inverting input set to the reference.
3. Comparator consumption only. Internal reference voltage (necessary for comparator operation) is not included.

6.3.21 LCD controller (STM32L152x6/8/B-A devices only)

The STM32L152xx-A devices embed a built-in step-up converter to provide a constant LCD reference voltage independently from the V_{DD} voltage. An external capacitor C_{ext} must be connected to the V_{LCD} pin to decouple this converter.

Table 63. LCD controller characteristics

| Symbol | Parameter | Min | Typ | Max | Unit |
|-----------------------|--|------|---------------|-----------|-----------|
| V_{LCD} | LCD external voltage | - | - | 3.6 | V |
| V_{LCD0} | LCD internal reference voltage 0 | - | 2.6 | - | |
| V_{LCD1} | LCD internal reference voltage 1 | - | 2.73 | - | |
| V_{LCD2} | LCD internal reference voltage 2 | - | 2.86 | - | |
| V_{LCD3} | LCD internal reference voltage 3 | - | 2.98 | - | |
| V_{LCD4} | LCD internal reference voltage 4 | - | 3.12 | - | |
| V_{LCD5} | LCD internal reference voltage 5 | - | 3.26 | - | |
| V_{LCD6} | LCD internal reference voltage 6 | - | 3.4 | - | |
| V_{LCD7} | LCD internal reference voltage 7 | - | 3.55 | - | |
| C_{ext} | V_{LCD} external capacitance | 0.1 | - | 2 | μF |
| $I_{LCD}^{(1)}$ | Supply current at $V_{DD} = 2.2 V$ | - | 3.3 | - | μA |
| | Supply current at $V_{DD} = 3.0 V$ | - | 3.1 | - | |
| $R_{Htot}^{(2)}$ | Low drive resistive network overall value | 5.28 | 6.6 | 7.92 | $M\Omega$ |
| $R_L^{(2)}$ | High drive resistive network total value | 192 | 240 | 288 | $k\Omega$ |
| V_{44} | Segment/Common highest level voltage | - | - | V_{LCD} | V |
| V_{34} | Segment/Common 3/4 level voltage | - | $3/4 V_{LCD}$ | - | V |
| V_{23} | Segment/Common 2/3 level voltage | - | $2/3 V_{LCD}$ | - | |
| V_{12} | Segment/Common 1/2 level voltage | - | $1/2 V_{LCD}$ | - | |
| V_{13} | Segment/Common 1/3 level voltage | - | $1/3 V_{LCD}$ | - | |
| V_{14} | Segment/Common 1/4 level voltage | - | $1/4 V_{LCD}$ | - | |
| V_0 | Segment/Common lowest level voltage | 0 | - | - | |
| $\Delta V_{xx}^{(2)}$ | Segment/Common level voltage error $T_A = -40$ to $105^\circ C$ | - | - | ± 50 | mV |

1. LCD enabled with 3 V internal step-up active, 1/8 duty, 1/4 bias, division ratio= 64, all pixels active, no LCD connected

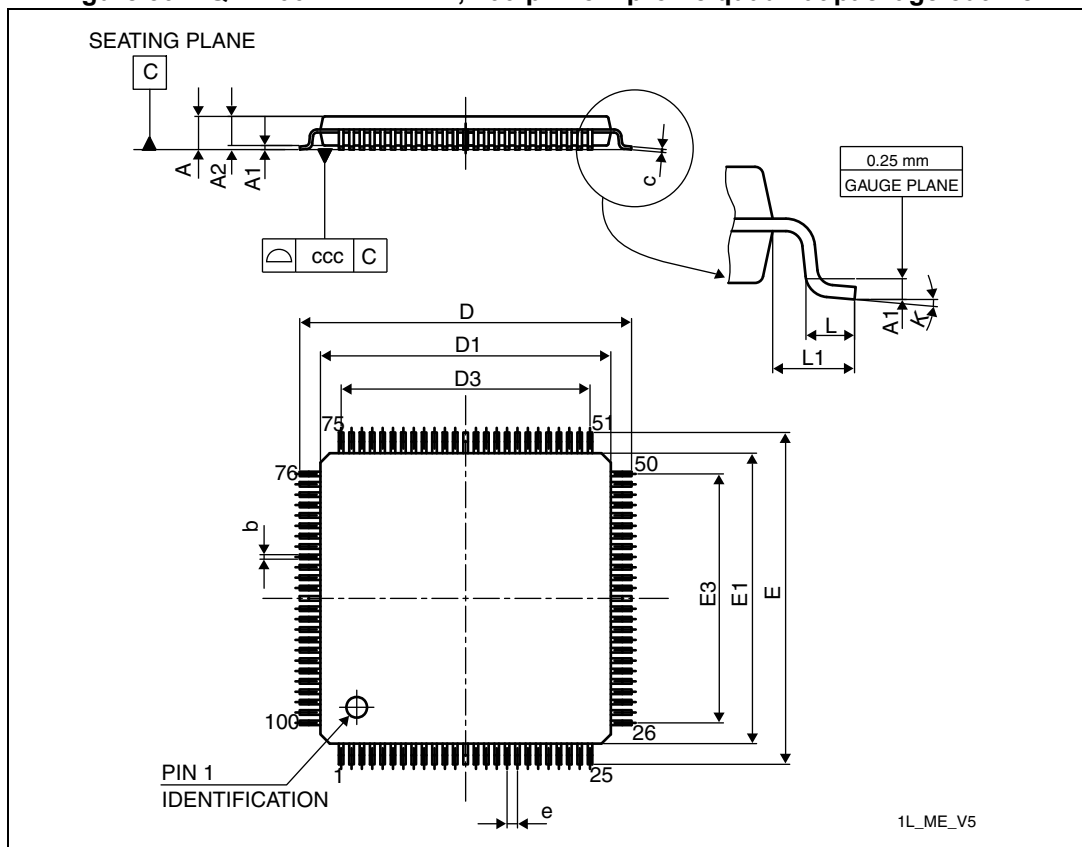
2. Guaranteed by characterization results.

7 Package information

In order to meet 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. ECOPACK® is an ST trademark.

7.1 LQFP100 14 x 14 mm, 100-pin low-profile quad flat package information

Figure 30. LQFP100 14 x 14 mm, 100-pin low-profile quad flat package outline



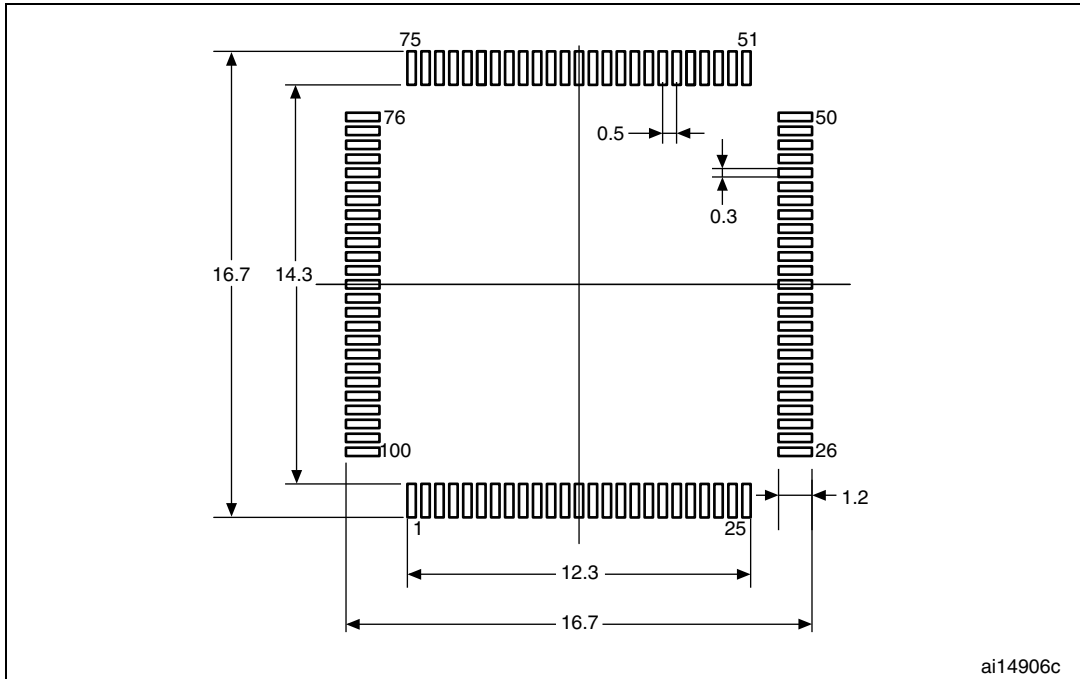
1. Drawing is not to scale.

Table 64. LQPF100 14 x 14 mm, 100-pin low-profile quad flat package mechanical data

| Symbol | millimeters | | | inches ⁽¹⁾ | | |
|--------|-------------|--------|--------|-----------------------|--------|--------|
| | Min | Typ | Max | Min | Typ | Max |
| A | - | - | 1.600 | - | - | 0.0630 |
| A1 | 0.050 | - | 0.150 | 0.0020 | - | 0.0059 |
| A2 | 1.350 | 1.400 | 1.450 | 0.0531 | 0.0551 | 0.0571 |
| b | 0.170 | 0.220 | 0.270 | 0.0067 | 0.0087 | 0.0106 |
| c | 0.090 | - | 0.200 | 0.0035 | - | 0.0079 |
| D | 15.800 | 16.000 | 16.200 | 0.6220 | 0.6299 | 0.6378 |
| D1 | 13.800 | 14.000 | 14.200 | 0.5433 | 0.5512 | 0.5591 |
| D3 | - | 12.000 | - | - | 0.4724 | - |
| E | 15.800 | 16.000 | 16.200 | 0.6220 | 0.6299 | 0.6378 |
| E1 | 13.800 | 14.000 | 14.200 | 0.5433 | 0.5512 | 0.5591 |
| E3 | - | 12.000 | - | - | 0.4724 | - |
| e | - | 0.500 | - | - | 0.0197 | - |
| L | 0.450 | 0.600 | 0.750 | 0.0177 | 0.0236 | 0.0295 |
| L1 | - | 1.000 | - | - | 0.0394 | - |
| k | 0.0° | 3.5° | 7.0° | 0.0° | 3.5° | 7.0° |
| ccc | - | - | 0.080 | - | - | 0.0031 |

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

Figure 31. LQFP100 14 x 14 mm, 100-pin low-profile quad flat package recommended footprint



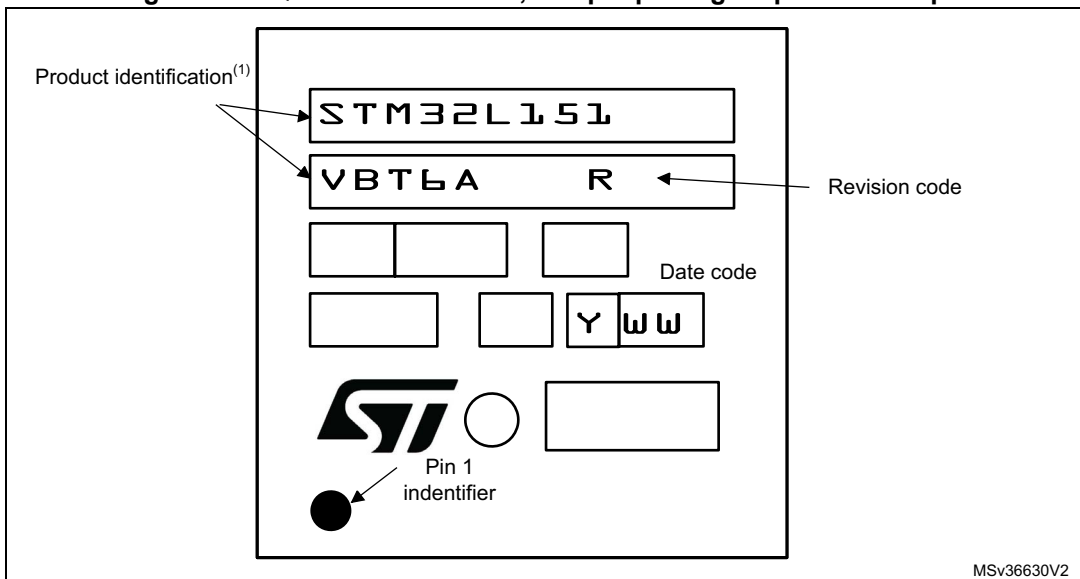
1. Dimensions are in millimeters.

LQFP100 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 32. LQFP100 14 x 14 mm, 100-pin package top view example

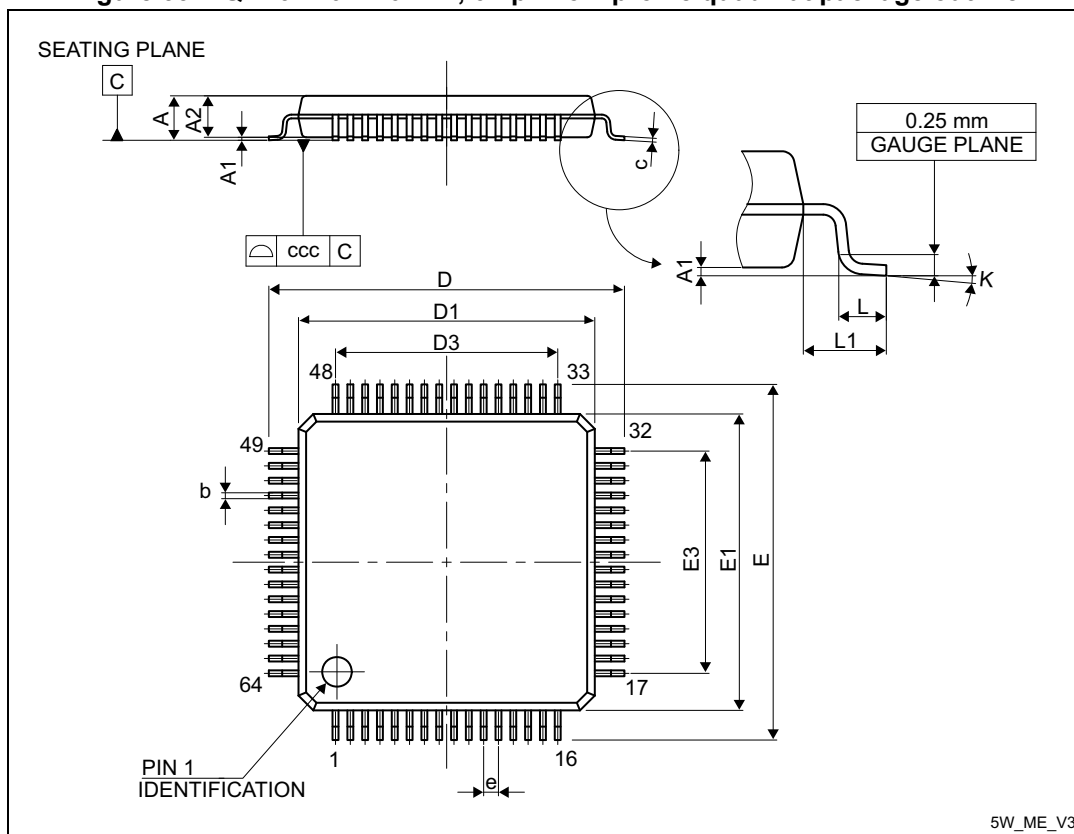


1. Parts marked as ES or E or accompanied by an engineering sample notification letter are not yet qualified

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.

7.2 LQFP64 10 x 10 mm, 64-pin low-profile quad flat package information

Figure 33. LQFP64 10 x 10 mm, 64-pin low-profile quad flat package outline



1. Drawing is not to scale.

Table 65. LQFP64 10 x 10 mm, 64-pin low-profile quad flat package mechanical data

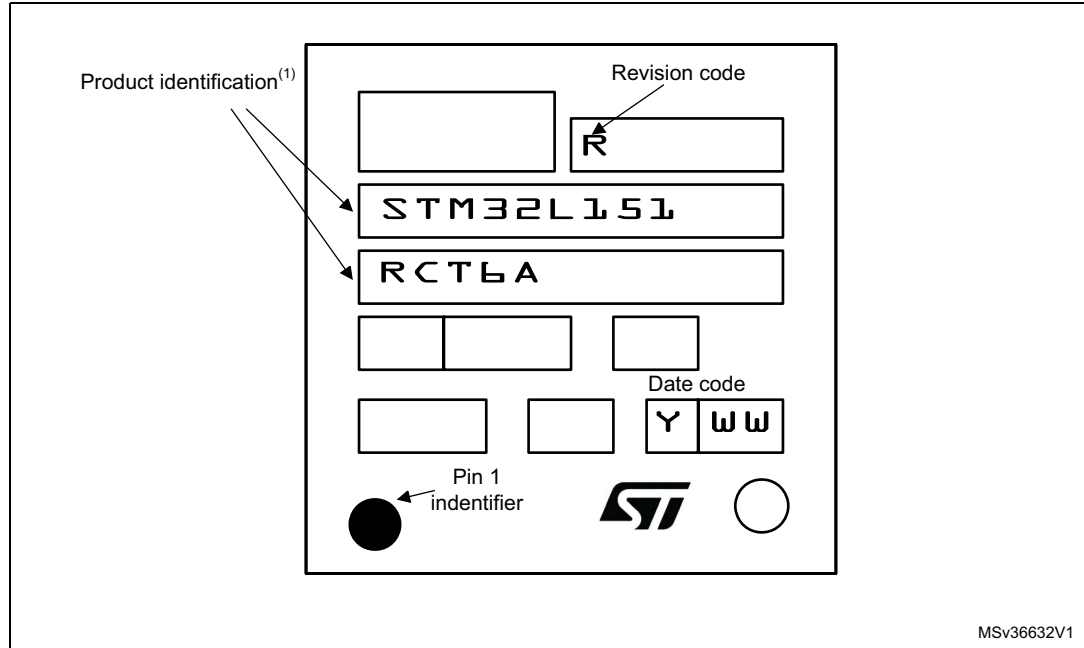
| Symbol | millimeters | | | inches ⁽¹⁾ | | |
|--------|-------------|--------|-------|-----------------------|--------|--------|
| | Min | Typ | Max | Typ | Min | Max |
| A | - | - | 1.600 | - | - | 0.0630 |
| A1 | 0.050 | - | 0.150 | 0.0020 | - | 0.0059 |
| A2 | 1.350 | 1.400 | 1.450 | 0.0531 | 0.0551 | 0.0571 |
| b | 0.170 | 0.220 | 0.270 | 0.0067 | 0.0087 | 0.0106 |
| c | 0.090 | - | 0.200 | 0.0035 | - | 0.0079 |
| D | - | 12.000 | - | - | 0.4724 | - |

LQFP64 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.

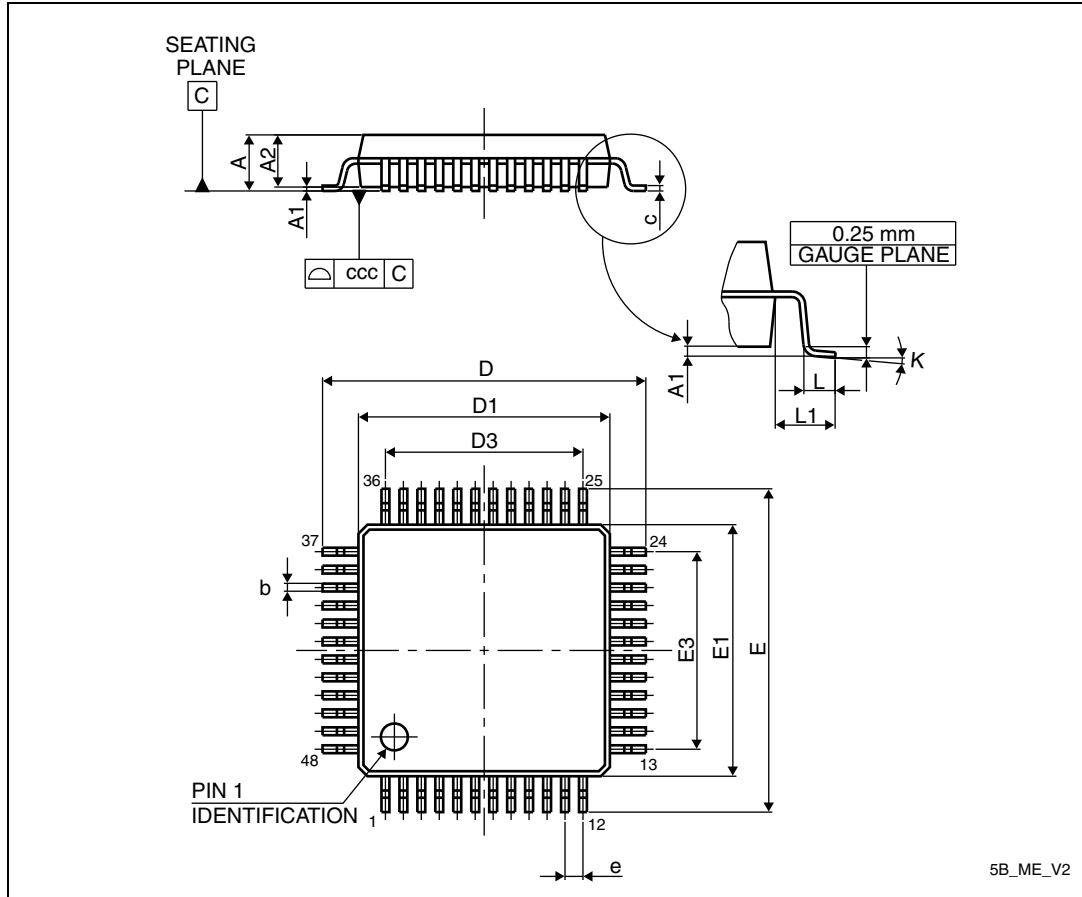
Figure 35. LQFP64 10 x 10 mm, 64-pin low-profile quad flat package top view example



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 7 x 7 mm, 48-pin low-profile quad flat package information

Figure 36. LQFP48 7 x 7 mm, 48-pin low-profile quad flat package outline



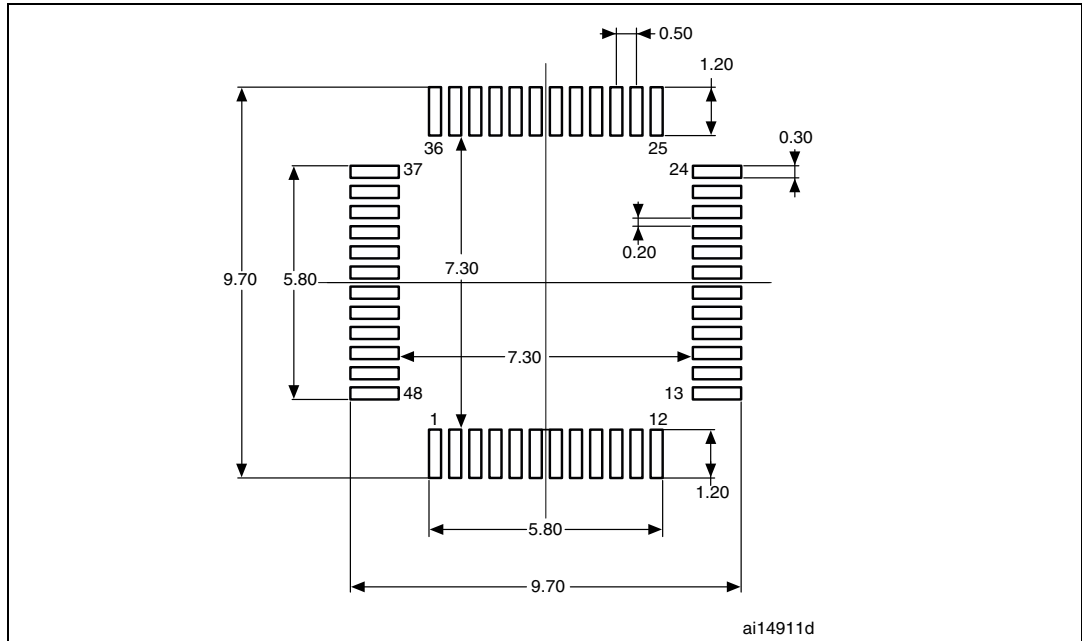
1. Drawing is not to scale.

Table 66. LQFP48 7 x 7 mm, 48-pin low-profile quad flat package mechanical data

| Symbol | millimeters | | | inches ⁽¹⁾ | | |
|--------|-------------|-------|-------|-----------------------|--------|--------|
| | Min | Typ | Max | Min | Typ | Max |
| A | - | - | 1.600 | - | - | 0.0630 |
| A1 | 0.050 | - | 0.150 | 0.0020 | - | 0.0059 |
| A2 | 1.350 | 1.400 | 1.450 | 0.0531 | 0.0551 | 0.0571 |
| b | 0.170 | 0.220 | 0.270 | 0.0067 | 0.0087 | 0.0106 |
| c | 0.090 | - | 0.200 | 0.0035 | - | 0.0079 |
| D | 8.800 | 9.000 | 9.200 | 0.3465 | 0.3543 | 0.3622 |
| D1 | 6.800 | 7.000 | 7.200 | 0.2677 | 0.2756 | 0.2835 |
| D3 | - | 5.500 | - | - | 0.2165 | - |
| E | 8.800 | 9.000 | 9.200 | 0.3465 | 0.3543 | 0.3622 |
| E1 | 6.800 | 7.000 | 7.200 | 0.2677 | 0.2756 | 0.2835 |
| E3 | - | 5.500 | - | - | 0.2165 | - |
| e | - | 0.500 | - | - | 0.0197 | - |
| L | 0.450 | 0.600 | 0.750 | 0.0177 | 0.0236 | 0.0295 |
| L1 | - | 1.000 | - | - | 0.0394 | - |
| k | 0° | 3.5° | 7° | 0° | 3.5° | 7° |
| ccc | - | - | 0.080 | - | - | 0.0031 |

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

Figure 37. LQFP48 7 x 7 mm, 48-pin low-profile quad flat package recommended footprint



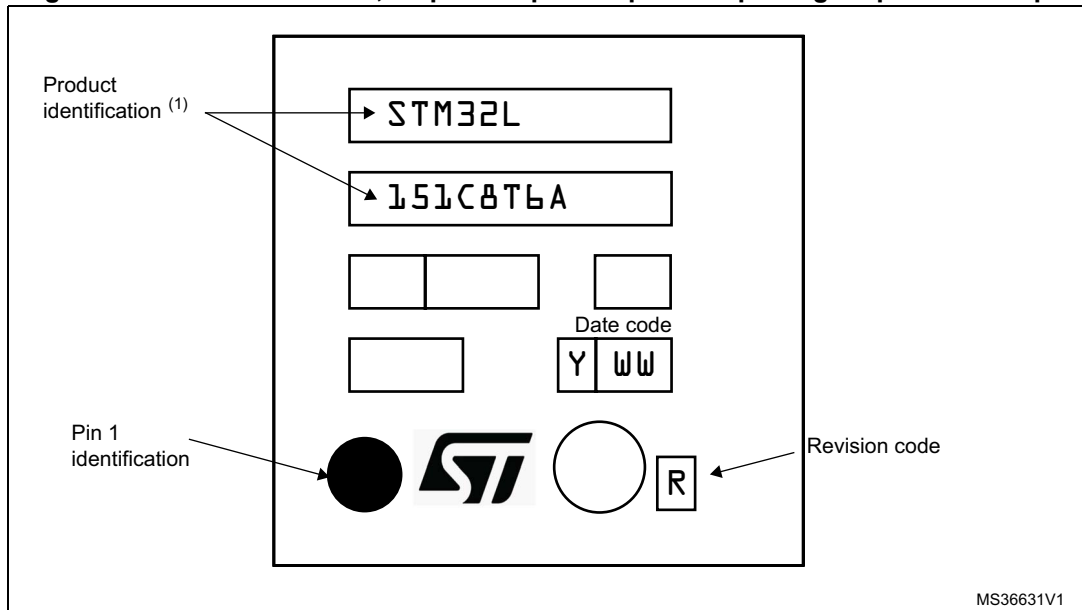
1. Dimensions are in millimeters.

LQFP48 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 38. LQFP48 7 x 7 mm, 48-pin low-profile quad flat package top view example

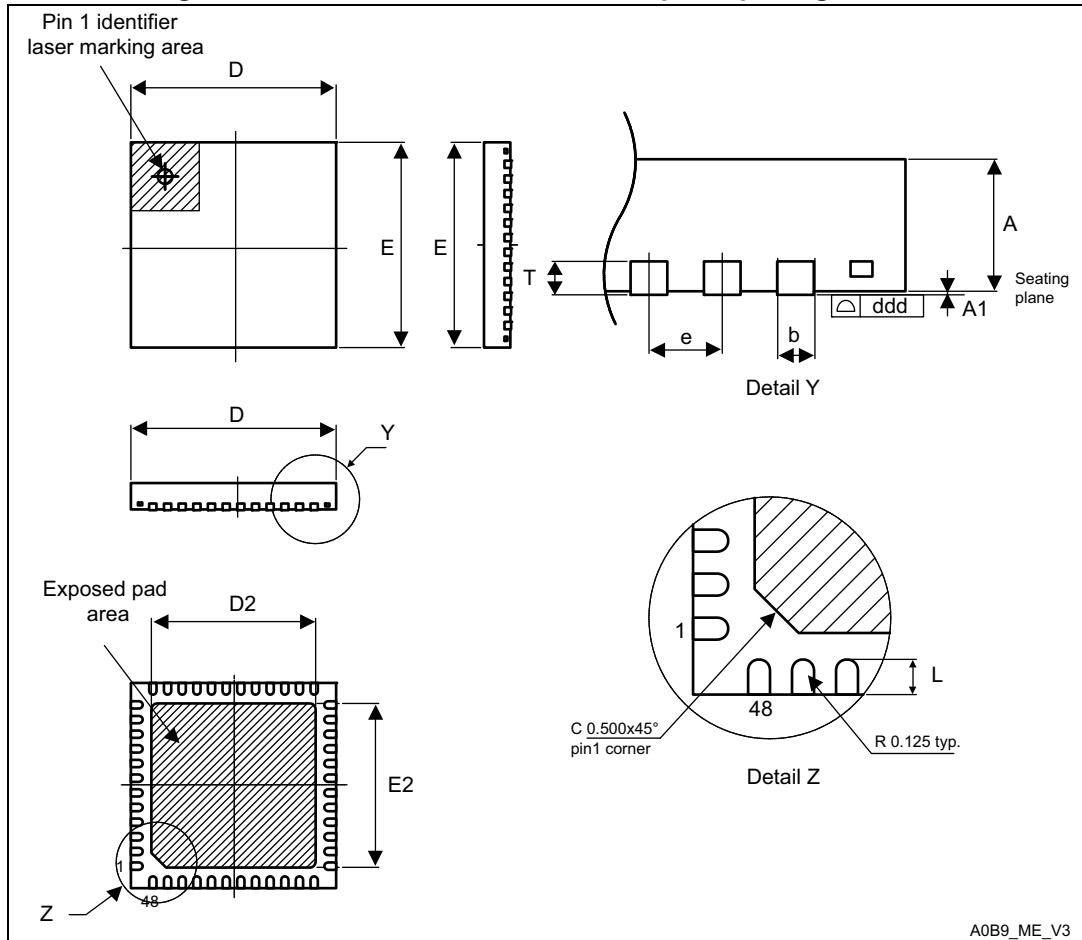


1. Parts marked as ES or E or accompanied by an engineering sample notification letter are not yet qualified

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 UFQFPN48 7 x 7 mm, 0.5 mm pitch, package information

Figure 39. UFQFPN48 7 x 7 mm, 0.5 mm pitch, package outline



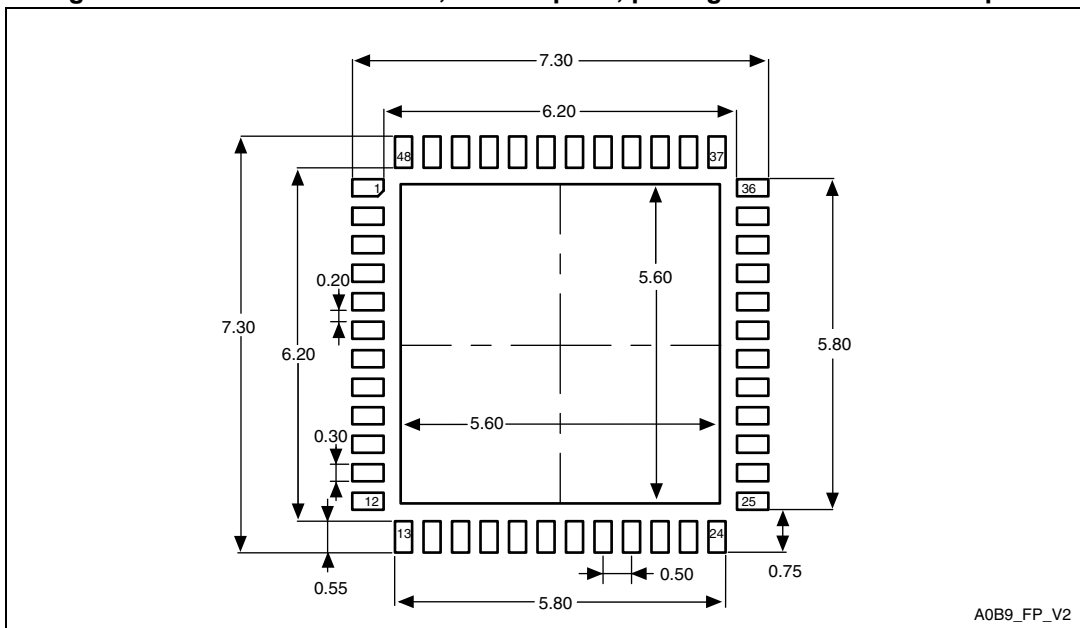
1. Drawing is not to scale.
2. All leads/pads should also be soldered to the PCB to improve the lead/pad solder joint life.
3. There is an exposed die pad on the underside of the UFQFPN package. It is recommended to connect and solder this back-side pad to PCB ground.

Table 67. UFQFPN48 7 x 7 mm, 0.5 mm pitch, package mechanical data

| Symbol | millimeters | | | inches ⁽¹⁾ | | |
|--------|-------------|-------|-------|-----------------------|--------|--------|
| | Min | Typ | Max | Min | Typ | Max |
| A | 0.500 | 0.550 | 0.600 | 0.0197 | 0.0217 | 0.0236 |
| A1 | 0.000 | 0.020 | 0.050 | 0.0000 | 0.0008 | 0.0020 |
| D | 6.900 | 7.000 | 7.100 | 0.2717 | 0.2756 | 0.2795 |
| E | 6.900 | 7.000 | 7.100 | 0.2717 | 0.2756 | 0.2795 |
| D2 | 5.500 | 5.600 | 5.700 | 0.2165 | 0.2205 | 0.2244 |
| E2 | 5.500 | 5.600 | 5.700 | 0.2165 | 0.2205 | 0.2244 |
| L | 0.300 | 0.400 | 0.500 | 0.0118 | 0.0157 | 0.0197 |
| T | - | 0.152 | - | - | 0.0060 | - |
| b | 0.200 | 0.250 | 0.300 | 0.0079 | 0.0098 | 0.0118 |
| e | - | 0.500 | - | - | 0.0197 | - |
| ddd | - | - | 0.080 | - | - | 0.0031 |

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

Figure 40. UFQFPN48 7 x 7 mm, 0.5 mm pitch, package recommended footprint



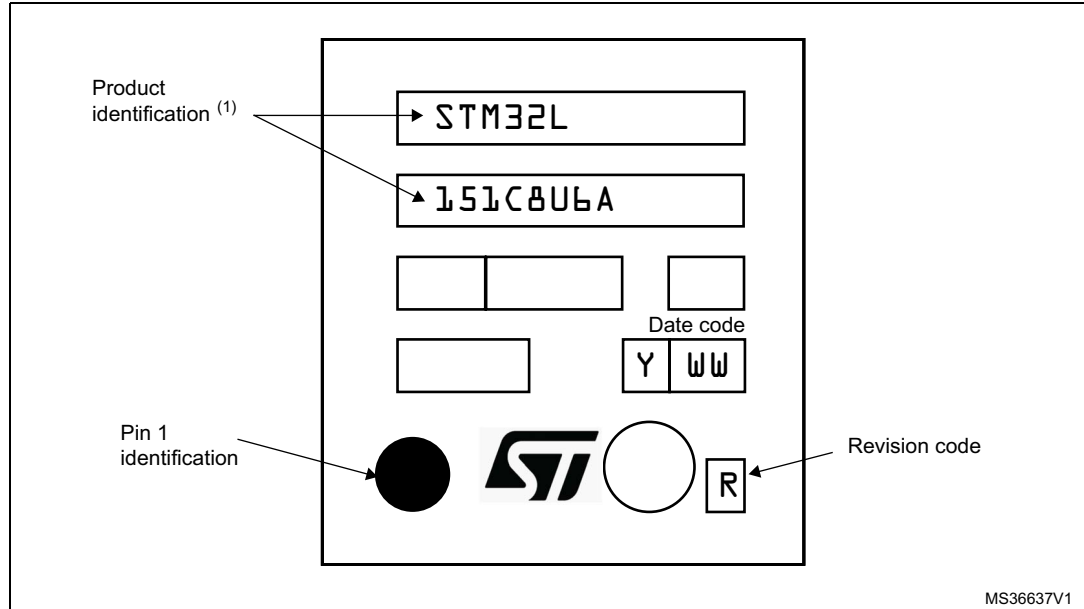
1. Dimensions are in millimeters.

UFQFPN48 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.

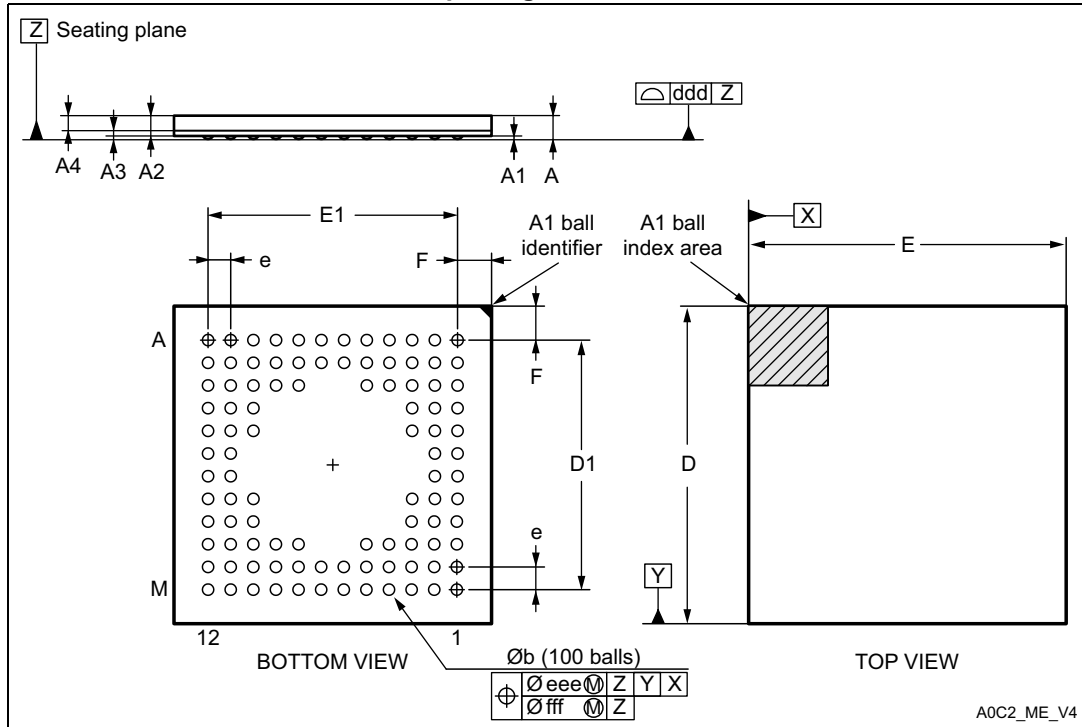
Figure 41. UFQFPN48 7 x 7 mm, 0.5 mm pitch, package top view example



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 UFBGA100 7 x 7 mm, 0.5 mm pitch, ultra thin fine-pitch ball grid array package information

Figure 42. UFBGA100, 7 x 7 mm, 0.5 mm pitch, ultra thin fine-pitch ball grid array package outline



1. Drawing is not to scale.

Table 68. UFBGA100 7 x 7 mm, 0.5 mm pitch, ultra thin fine-pitch ball grid array package mechanical data

| Symbol | millimeters | | | inches ⁽¹⁾ | | |
|--------|-------------|------|------|-----------------------|--------|--------|
| | Min | Typ | Max | Min | Typ | Max |
| A | - | - | 0.6 | - | - | 0.0236 |
| A1 | 0.05 | 0.08 | 0.11 | 0.002 | 0.0031 | 0.0043 |
| A2 | 0.4 | 0.45 | 0.5 | 0.0157 | 0.0177 | 0.0197 |
| A3 | 0.08 | 0.13 | 0.18 | 0.0031 | 0.0051 | 0.0071 |
| A4 | 0.27 | 0.32 | 0.37 | 0.0106 | 0.0126 | 0.0146 |
| b | 0.2 | 0.25 | 0.3 | 0.0079 | 0.0098 | 0.0118 |
| D | 6.95 | 7 | 7.05 | 0.2736 | 0.2756 | 0.2776 |
| D1 | 5.45 | 5.5 | 5.55 | 0.2146 | 0.2165 | 0.2185 |
| E | 6.95 | 7 | 7.05 | 0.2736 | 0.2756 | 0.2776 |
| E1 | 5.45 | 5.5 | 5.55 | 0.2146 | 0.2165 | 0.2185 |
| e | - | 0.5 | - | - | 0.0197 | - |

Table 68. UFBGA100 7 x 7 mm, 0.5 mm pitch, ultra thin fine-pitch ball grid array package mechanical data (continued)

| Symbol | millimeters | | | inches ⁽¹⁾ | | |
|--------|-------------|------|------|-----------------------|--------|--------|
| | Min | Typ | Max | Min | Typ | Max |
| F | 0.7 | 0.75 | 0.8 | 0.0276 | 0.0295 | 0.0315 |
| ddd | - | - | 0.1 | - | - | 0.0039 |
| eee | - | - | 0.15 | - | - | 0.0059 |
| fff | - | - | 0.05 | - | - | 0.002 |

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

Figure 43. UFBGA100 7 x 7 mm, 0.5 mm pitch, ultra thin fine-pitch ball grid array package recommended footprint

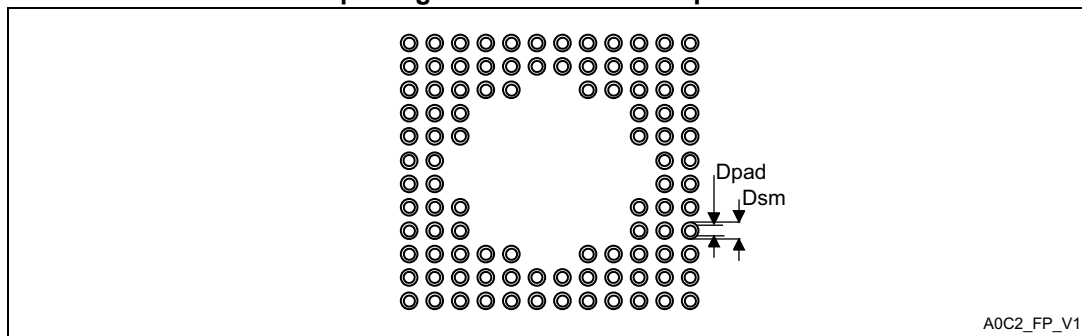


Table 69. UFBGA100 7 x 7 mm, 0.5 mm pitch, recommended PCB design rules

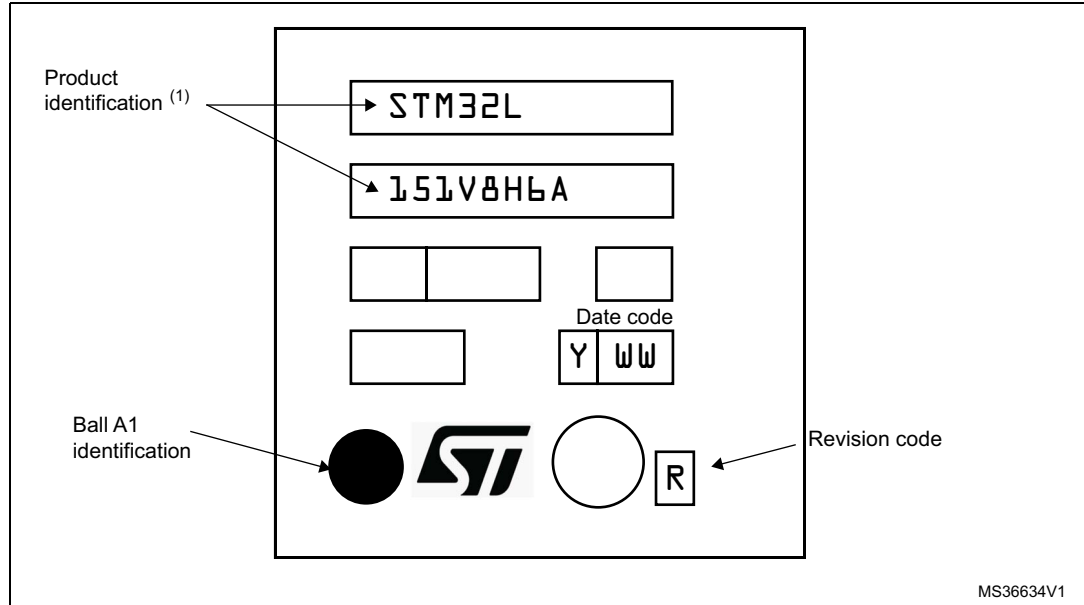
| Dimension | Recommended values |
|-------------------|--|
| Pitch | 0.5 |
| Dpad | 0.280 mm |
| Dsm | 0.370 mm typ. (depends on the soldermask registration tolerance) |
| Stencil opening | 0.280 mm |
| Stencil thickness | Between 0.100 mm and 0.125 mm |

UFBGA100 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.

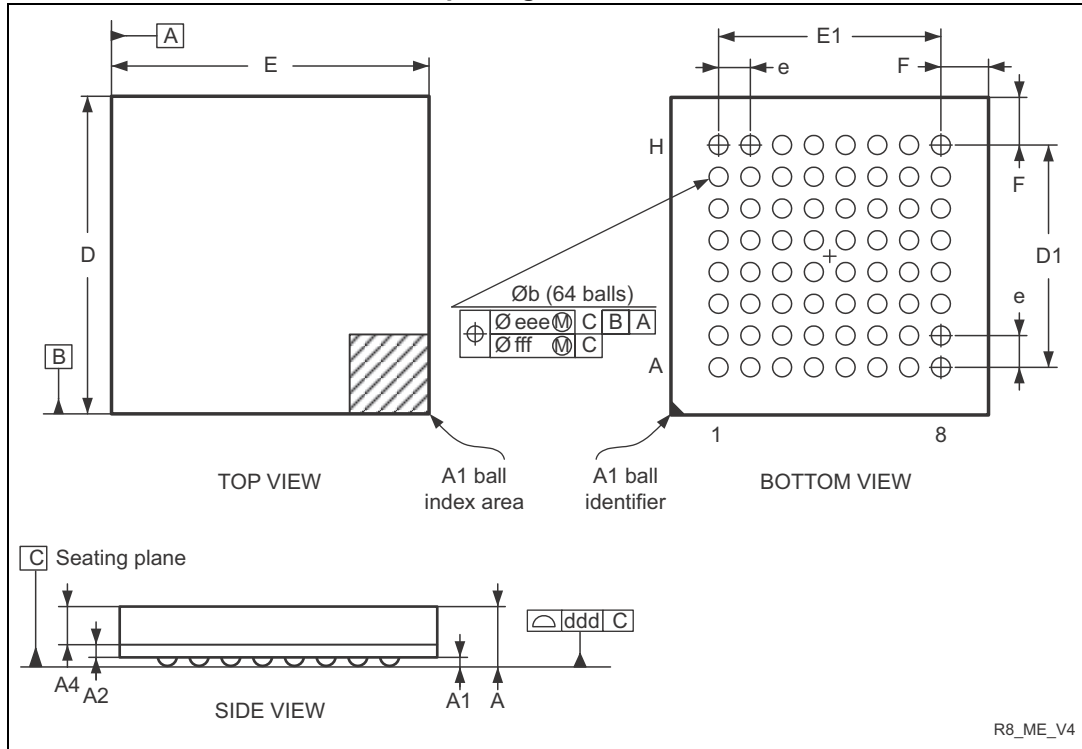
Figure 44. UFBGA100 7 x 7 mm, 0.5 mm pitch, package top view example



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 TFBGA64 5 x 5 mm, 0.5 mm pitch, thin fine-pitch ball grid array package information

Figure 45. TFBGA64 5 x 5 mm, 0.5 mm pitch, thin fine-pitch ball grid array package outline



1. Drawing is not to scale.

Table 70. TFBGA64 5 x 5 mm, 0.5 mm pitch, thin fine-pitch ball grid array package mechanical data

| Symbol | millimeters | | | inches ⁽¹⁾ | | |
|--------|-------------|-------|-------|-----------------------|--------|--------|
| | Min | Typ | Max | Min | Typ | Max |
| A | - | - | 1.200 | - | - | 0.0472 |
| A1 | 0.150 | - | - | 0.0059 | - | - |
| A2 | - | 0.200 | - | - | 0.0079 | - |
| A4 | - | - | 0.600 | - | - | 0.0236 |
| b | 0.250 | 0.300 | 0.350 | 0.0098 | 0.0118 | 0.0138 |
| D | 4.850 | 5.000 | 5.150 | 0.1909 | 0.1969 | 0.2028 |
| D1 | - | 3.500 | - | - | 0.1378 | - |
| E | 4.850 | 5.000 | 5.150 | 0.1909 | 0.1969 | 0.2028 |
| E1 | - | 3.500 | - | - | 0.1378 | - |
| e | - | 0.500 | - | - | 0.0197 | - |
| F | - | 0.750 | - | - | 0.0295 | - |

Table 70. TFBGA64 5 x 5 mm, 0.5 mm pitch, thin fine-pitch ball grid array package mechanical data (continued)

| Symbol | millimeters | | | inches ⁽¹⁾ | | |
|--------|-------------|-----|-------|-----------------------|-----|--------|
| | Min | Typ | Max | Min | Typ | Max |
| ddd | - | - | 0.080 | - | - | 0.0031 |
| eee | - | - | 0.15 | - | - | 0.0059 |
| fff | - | - | 0.05 | - | - | 0.002 |

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

Figure 46. TFBGA64, 5 x 5 mm, 0.5 mm pitch, thin fine-pitch ball grid array package recommended footprint

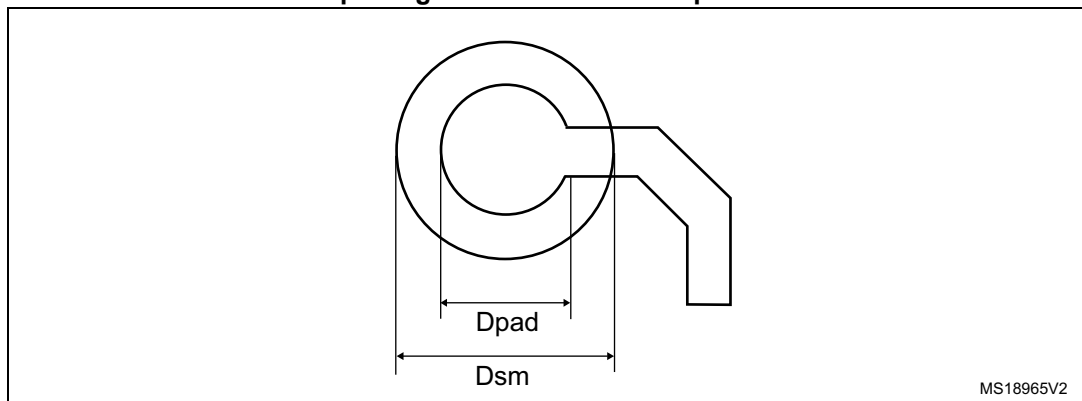


Table 71. TFBGA64 5 x 5 mm, 0.5 mm pitch, recommended PCB design rules

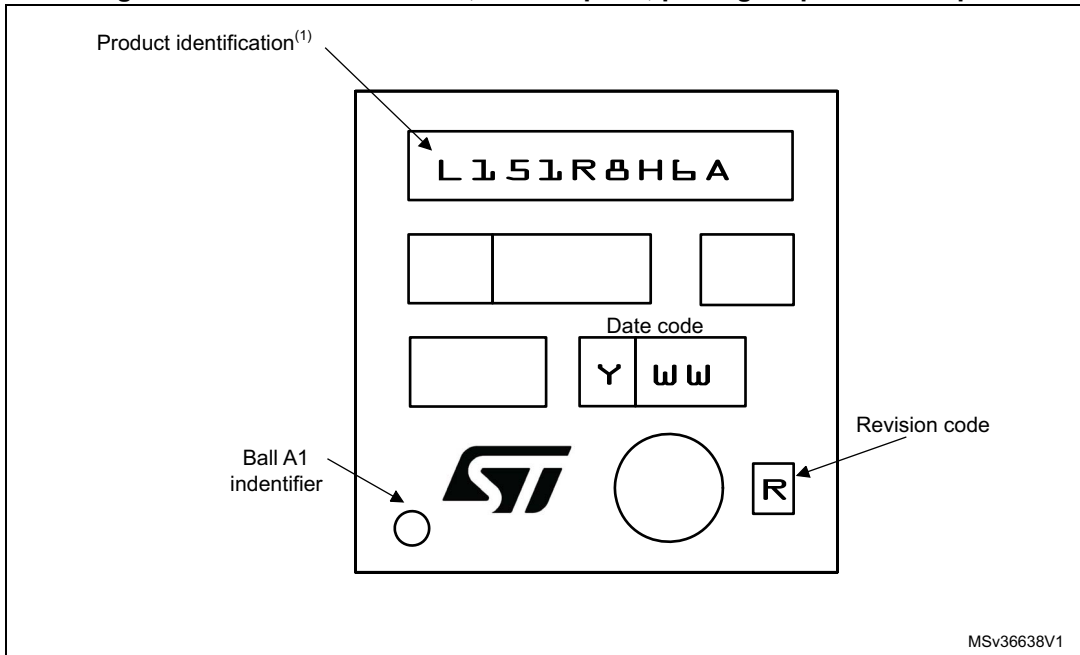
| Dimension | Recommended values |
|--------------|---|
| Pitch | 0.5 |
| Dpad | 0.27 mm |
| Dsm | 0.35 mm typ. (depends on the soldermask registration tolerance) |
| Solder paste | 0.27 mm aperture diameter. |

TFBGA64 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 47. TFBGA64 5 x 5 mm, 0.5 mm pitch, package top view example



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,
- Θ_{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 72. Thermal characteristics

| Symbol | Parameter | Value | Unit |
|---------------|--|-------|------|
| Θ_{JA} | Thermal resistance junction-ambient UFBGA100 - 7 x 7 mm | 59 | °C/W |
| | Thermal resistance junction-ambient LQFP100 - 14 x 14 mm / 0.5 mm pitch | 46 | |
| | Thermal resistance junction-ambient TFBGA64 - 5 x 5 mm | 65 | |
| | Thermal resistance junction-ambient LQFP64 - 10 x 10 mm / 0.5 mm pitch | 45 | |
| | Thermal resistance junction-ambient LQFP48 - 7 x 7 mm / 0.5 mm pitch | 55 | |
| | Thermal resistance junction-ambient UFQFPN48 - 7 x 7 mm / 0.5 mm pitch | 33 | |

Figure 48. Thermal resistance suffix 6

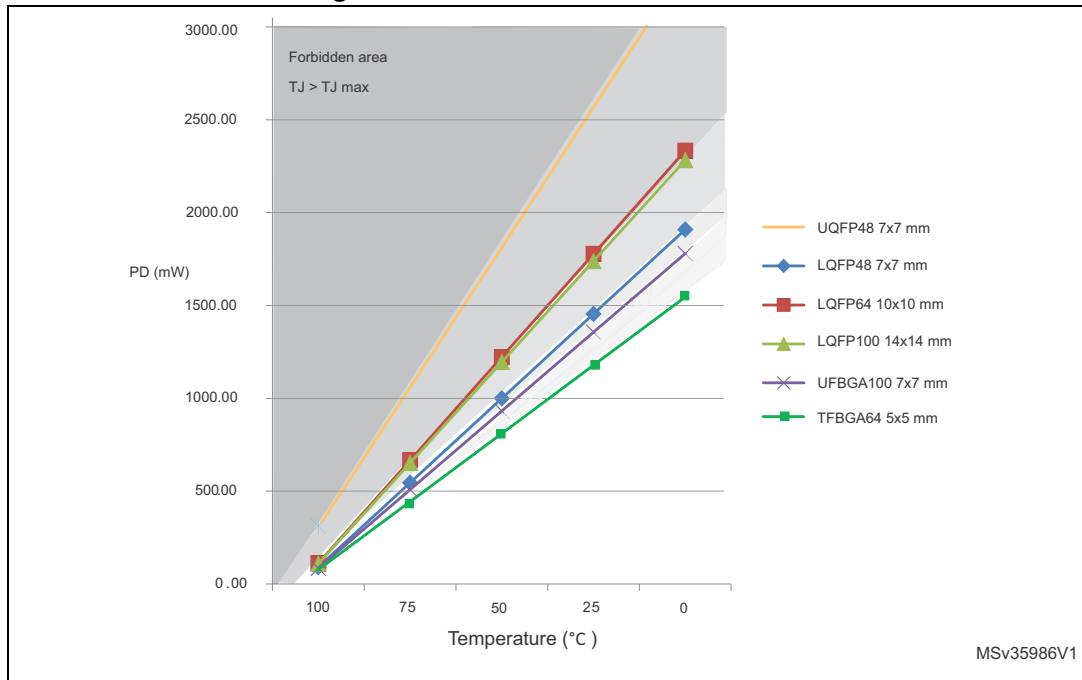
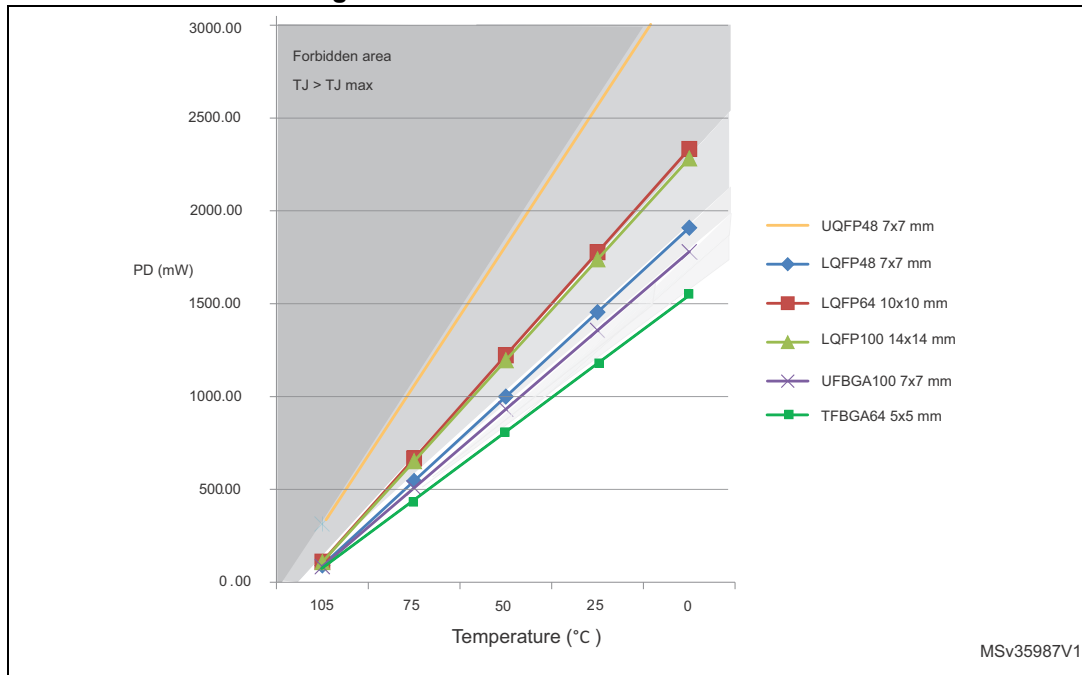


Figure 49. Thermal resistance suffix 7



7.7.1 Reference document

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

8 Ordering information

Table 73. Ordering information scheme

| Example: | STM32 | L | 152 | R | B | T | 6 | A | D | TR |
|---|-------|---|-----|---|---|---|---|---|---|----|
| Device family STM32 = ARM-based 32-bit microcontroller | | | | | | | | | | |
| Product type L = Low-power | | | | | | | | | | |
| Device subfamily 151: Devices without LCD 152: Devices with LCD | | | | | | | | | | |
| Pin count C = 48 pins R = 64 pins V = 100 pins | | | | | | | | | | |
| Flash memory size 6 = 32 Kbytes of Flash memory 8 = 64 Kbytes of Flash memory B = 128 Kbytes of Flash memory | | | | | | | | | | |
| Package H = BGA T = LQFP U = UFQFPN | | | | | | | | | | |
| Temperature range 6 = Industrial temperature range, -40 to 85 °C 7 = Industrial temperature range, -40 to 105 °C | | | | | | | | | | |
| Options A = device generation A | | | | | | | | | | |
| No character = VDD range: 1.8 to 3.6 V and BOR enabled D = VDD range: 1.65 to 3.6 V and BOR disabled | | | | | | | | | | |
| Packing TR = tape and reel No character = tray or tube | | | | | | | | | | |

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

9 Revision history

Table 74. Document revision history

| Date | Revision | Changes |
|-------------|----------|--|
| 04-Feb-2014 | 1 | Initial release. |
| 12-Mar-2014 | 2 | <p>Updated Section 3.5: Low-power real-time clock and backup registers, Section 6.1.2: Typical values and Section 6.3.4: Supply current characteristics.</p> <p>Updated General PCB design guidelines.</p> <p>Updated Table 5: Working mode-dependent functionalities (from Run/active down to standby), Table 14: General operating conditions, Table 21: Current consumption in Low-power run mode, Table 22: Current consumption in Low-power sleep mode, Table 23: Typical and maximum current consumptions in Stop mode, Table 24: Typical and maximum current consumptions in Standby mode, Table 25: Peripheral current consumption, Table 42: I/O current injection susceptibility, Table 43: I/O static characteristics and Table 46: NRST pin characteristics.</p> <p>Updated Figure 14: Current consumption measurement scheme.</p> |
| 04-Feb-2015 | 3 | <p>Updated DMIPS features in cover page and Section 2: Description.</p> <p>Updated max temperature at 105°C instead of 85°C in the whole datasheet.</p> <p>Updated current consumption in Table 20: Current consumption in Sleep mode.</p> <p>Updated Table 25: Peripheral current consumption with new measured values.</p> <p>Updated Table 57: Maximum source impedance RAIN max adding note 2.</p> <p>Updated Section 7: Package information with new package device marking.</p> <p>Updated Figure 9: Memory map.</p> |

Table 74. Document revision history (continued)

| Date | Revision | Changes |
|-------------|----------|--|
| 25-Apr-2016 | 4 | <p>Updated Section 7: Package information structure: Paragraph titles and paragraph heading level.</p> <p>Updated Section 7: Package information for all package device markings, adding text for device orientation versus pin 1/ ball A1 identifier.</p> <p>Updated Figure 32: LQFP100 14 x 14 mm, 100-pin package top view example removing gate mark.</p> <p>Updated Table 65: LQFP64 10 x 10 mm, 64-pin low-profile quad flat package mechanical data.</p> <p>Updated Section 7.5: UFBGA100 7 x 7 mm, 0.5 mm pitch, ultra thin fine-pitch ball grid array package information adding Table 69: UFBGA100 7 x 7 mm, 0.5 mm pitch, recommended PCB design rules and Figure 43: UFBGA100 7 x 7 mm, 0.5 mm pitch, ultra thin fine-pitch ball grid array package recommended footprint.</p> <p>Updated Section 7.6: TFBGA64 5 x 5 mm, 0.5 mm pitch, thin fine-pitch ball grid array package information adding Table 71: TFBGA64 5 x 5 mm, 0.5 mm pitch, recommended PCB design rules and changing Figure 46: TFBGA64, 5 x 5 mm, 0.5 mm pitch, thin fine-pitch ball grid array package recommended footprint.</p> <p>Updated Table 17: Embedded internal reference voltage temperature coefficient at 100ppm/°C and table note 3: “guaranteed by design” changed by “guaranteed by characterization results”.</p> <p>Updated Table 62: Comparator 2 characteristics new maximum threshold voltage temperature coefficient at 100ppm/°C.</p> <p>Updated Table 40: ESD absolute maximum ratings CDM class.</p> <p>Updated all the notes, removing ‘not tested in production’.</p> <p>Updated Table 11: Voltage characteristics adding note about V_{REF}-pin.</p> <p>Updated Table 3: Functionalities depending on the operating power supply range LSI and LSE functionalities putting “Y” in Standby mode.</p> <p>Removed note 1 below Figure 2: Clock tree.</p> <p>Updated Table 58: DAC characteristics resistive load.</p> |

Table 74. Document revision history (continued)

| Date | Revision | Changes |
|-------------|----------|---|
| 25-Aug-2017 | 5 | <p>Updated Table 43: I/O static characteristics pull-up and pull-down values.</p> <p>Updated Table 46: NRST pin characteristics pull-up values.</p> <p>Updated Section 7: Package information adding information about other optional marking or inset/upset marks.</p> <p>Updated note 1 below all the package device marking figures.</p> <p>Updated Nested vectored interrupt controller (NVIC) in Section 3.2: ARM® Cortex®-M3 core with MPU about process state automatically saved.</p> <p>Updated Table 3: Functionalities depending on the operating power supply range removing I/O operation column and adding note about GPIO speed.</p> <p>Updated Table 42: I/O current injection susceptibility note by 'injection is not possible'.</p> <p>Updated Figure 20: Recommended NRST pin protection note about the 0.1uF capacitor.</p> <p>Updated Section 3.1: Low-power modes Low-power run mode (MSI) RC oscillator clock.</p> <p>Updated Table 5: Working mode-dependent functionalities (from Run/active down to standby) disabling I2C functionality in Low-power Run and Low-power Sleep modes.</p> |

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