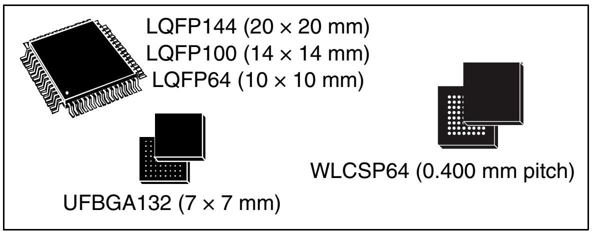
STM32L151xC
STM32L152xC

Ultralow power ARM-based 32-bit MCU with 256 KB Flash, RTC, LCD, USB, analog functions, 10 serial ports, memory I/F

Features

- Operating conditions
  - Operating power supply range: 1.65 V to 3.6 V (without BOR) or 1.8 V to 3.6 V
- Low power features
  - 7 modes: Sleep, Low-power run (11 µA at 32 kHz) , Low-power sleep (4.4 µA), Stop with RTC, Stop (650 nA), Standby with RTC, Standby (300 nA)
  - Dynamic core voltage scaling down to 233 µA/MHz
  - Ultralow leakage per I/O: 50 nA max
  - Fast wakeup time from Stop: 8 µs
  - Three wakeup pins
- Core: ARM 32-bit Cortex™-M3 CPU
  - 32 MHz maximum frequency, 33.3 DMIPS peak (Dhrystone 2.1)
  - Memory protection unit
- Reset and supply management
  - Low power, ultrasafe BOR (brownout reset)
  - Ultralow power POR/PDR
  - Programmable voltage detector (PVD)
- Clock management
  - 1 to 24 MHz crystal oscillator
  - 32 kHz oscillator for RTC with calibration
  - Internal 16 MHz factory-trimmed RC
  - Internal 37 kHz low consumption RC
  - Internal multispeed low power RC, 65 kHz to 4.2 MHz
  - PLL for CPU clock and USB (48 MHz)
- Memories
  - 256 Kbytes of Flash memory with ECC
  - 8 Kbytes of data EEPROM with ECC
  - 32 Kbytes of RAM
- Low power calendar RTC
  - Alarm, periodic wakeup from Stop/Standby
- Up to 116 fast I/Os (102 of which are 5 V-tolerant)
- DMA: 12-channel DMA controller



- LCD 8 × 40 or 4 × 44 with step-up converter
- 2 operational amplifiers
- 12-bit ADC up to 1 Msps and 40 channels
  - Operational amplifier output, temperature sensor and internal voltage reference
  - Operates down to 1.8 V
- Two 12-bit DACs with output buffers
- Two ultralow power comparators
  - Window mode and wakeup capability
- 11 timers: one 32-bit and six 16-bit general-purpose timers, two 16-bit basic timers, two watchdog timers (independent and window)
- Up to 12 communication interfaces
  - Up to two I2C interfaces (SMBus/PMBus)
  - Up to three USARTs
  - Up to three SPIs (16 Mbit/s), two with I2S
  - USB 2.0 full-speed interface
- Up to 36 capacitive sensing channels supporting touch, proximity, linear and rotary sensors
- 32-bit CRC calculation unit, 96-bit unique ID

Table 1. Device summary

Reference	Part number
STM32L151xC	STM32L151QC STM32L151RC STM32L151VC STM32L151ZC
STM32L152xC	STM32L152QC STM32L152RC STM32L152VC STM32L152ZC

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1 Introduction

This datasheet provides the ordering information and mechanical device characteristics of the medium density plus STM32L151xC and STM32L152xC ultralow power ARM Cortex™-based microcontrollers product line. Medium density plus STM32L15xxC devices are microcontrollers with a Flash memory density of 256 Kbytes.

The medium density plus ultralow power STM32L15xxC family includes devices in 5 different package types: from 64 pins to 144 pins. Depending on the device chosen, different sets of peripherals are included, the description below gives an overview of the complete range of peripherals proposed in this family.

These features make the medium density plus ultralow power STM32L15xxC 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

For information on the Cortex™-M3 core please refer to the Cortex™-M3 Technical Reference Manual, available from the *www.arm.com* website at the following address: http://infocenter.arm.com/help/index.jsp?topic=/com.arm.doc.ddi0337g.

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

2 Description

The medium density plus ultralow power STM32L15xxC incorporates the connectivity power of the universal serial bus (USB) with the high-performance ARM Cortex™-M3 32-bit RISC core operating at a 32 MHz frequency, a memory protection unit (MPU), high-speed embedded memories (Flash memory up to 256 Kbytes and RAM up to 32 Kbytes), and an extensive range of enhanced I/Os and peripherals connected to two APB buses.

All medium density plus devices offer two operational amplifiers, one 12-bit ADC, two DACs, two ultralow power comparators, one general-purpose 32-bit timer, six general-purpose 16-bit timers and two basic timers, which can be used as time bases.

Moreover, the medium density plus STM32L15xxC devices contain standard and advanced communication interfaces: up to two I^2Cs, three SPIs, two I2S, three USARTs, and a USB. Up to 36 channels are available for capacitive sensing directly driven through GPIOs and general purpose timers.

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

Finally, the integrated LCD controller has a built-in LCD voltage generator that allows you to drive up to 8 multiplexed LCDs with contrast independent of the supply voltage.

The medium density plus ultralow power STM32L15xxC operates 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. It is available in the -40 to +85 °C temperature range. A comprehensive set of power-saving modes allows the design of low-power applications.

2.1 Device overview

Table 2. Ultralow power STM32L15xxC device features and peripheral counts

Peripheral		STM32L15xRC	STM32L15xVC	STM32L15xZC STM32L15xQC
Flash - Kbytes		256	256	256
Data EEPROM		8	8	8
RAM - Kbytes		32	32	32
Timers	**32 bit**	1	1	1
	General-purpose	6	6	6
	Basic	2	2	2
Communication interfaces	**SPI**/(I2S)	3/(2)	3/(2)	3/(2)
	I^2C	2	2	2
	USART	3	3	3
	USB	1	1	1
GPIOs		51	83	115(1)
Operation amplifiers		2	2	2
12-bit synchronized ADC **Number of channels**		1 21	1 25	1 40
12-bit DAC **Number of channels**		2 2	2 2	2 2
LCD (2) **COM x SEG**		1 4x32 or 8x28	1 4x44 or 8x40	1 4x44 or 8x40
Comparators		2	2	2
Capacitive sensing **No. of channels/No. of groups**		30/10	30/10	36/11
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 temperature: –40 to +85 °C Junction temperature: –40 to + 105 °C		
Packages		LQFP64, WLCSP64	LQFP100	LQFP144, BGA132

1. 109 GPIOs in BGA132 package
2. STM32L152xx devices only.

2.2 Ultralow power device continuum

The ultralow power STM32L15xxD, STM32L162xD, and STM32L15xxC are fully pin-to-pin, software and feature compatible. Besides the full compatibility within the family, the devices are part of STMicroelectronics microcontrollers ultralow power strategy which also includes STM8L101xx and STM8L15xx devices. The STM8L and STM32L families allow a continuum of performance, peripherals, system architecture and features.

They are all based on STMicroelectronics 0.13 µm ultralow leakage process.

Note: The ultralow power STM32L and general-purpose STM32Fxxxx families are pin-to-pin compatible. The STM8L15xxx devices are pin-to-pin compatible with the STM8L101xx devices. Please refer to the STM32F and STM8L documentation for more information on these devices.

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 ultralow power performance to range from 5 up to 33.3 DMIPs.

2.2.2 Shared peripherals

STM8L15xxx, STM32L15xxx, and STM32L162xx 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, STM32L15xxx, and STM32L162xx families use a common architecture:

- Same power supply range from 1.65 V to 3.6 V.
- Architecture optimized to reach ultralow consumption both in low power modes and Run mode
- Fast startup strategy from low power modes
- Flexible system clock
- Ultrasafe reset: same reset strategy including power-on reset, power-down reset, brownout reset and programmable voltage detector.

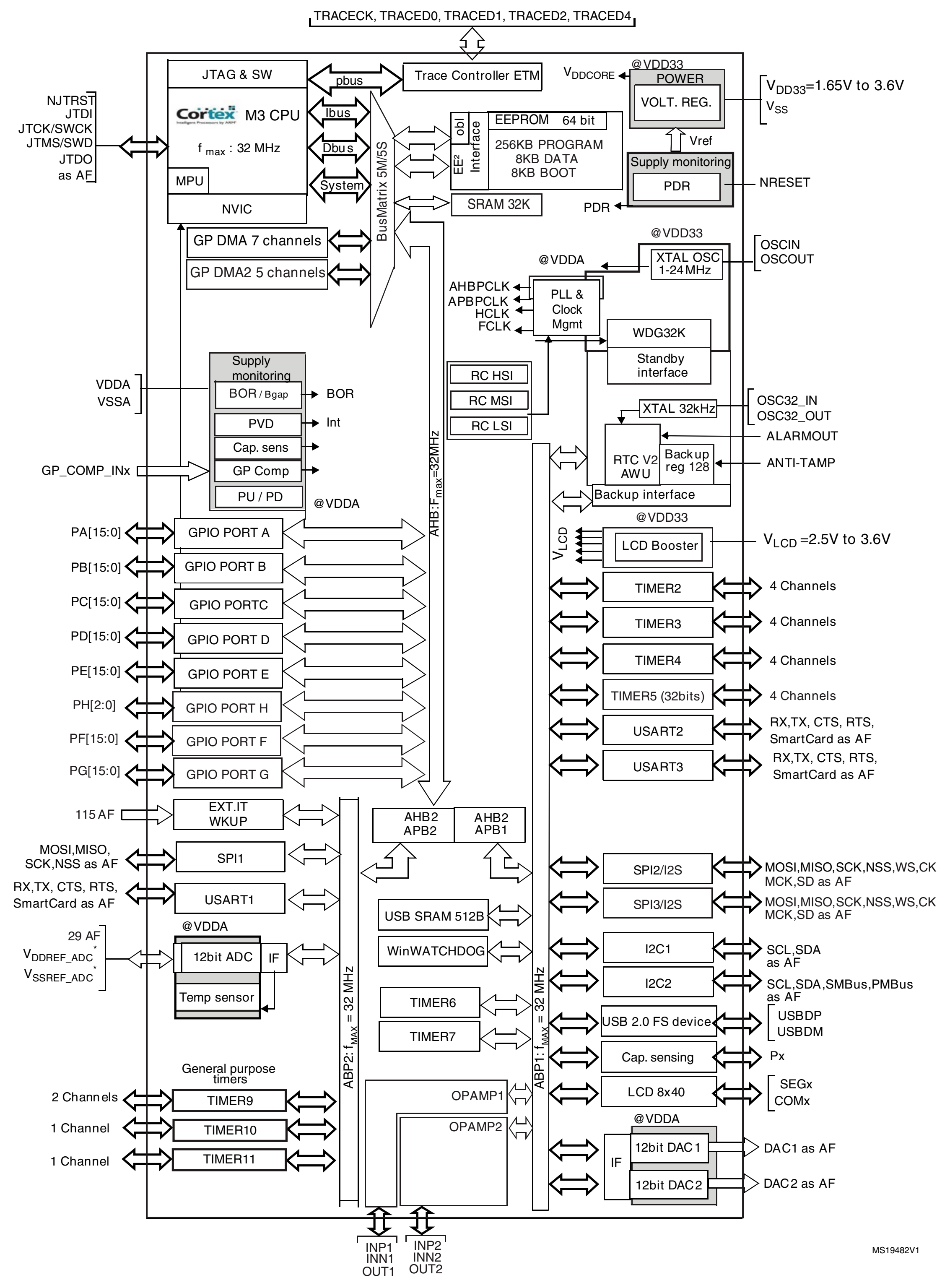
2.2.4 Features

ST ultralow 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 384 Kbytes

3 Functional overview

Figure 1. Ultralow power STM32L15xxC block diagram



1. Legend:
AF: alternate function
ADC: analog-to-digital converter
BOR: brown out reset
DMA: direct memory access
DAC: digital-to-analog converter
I²C: inter-integrated circuit multimaster interface

3.1 Low power modes

The ultralow power STM32L15xxC supports 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.

There are three power consumption ranges:

- Range 1 (V_{DD} range limited to 2.0-3.6 V), with the CPU running at up to 32 MHz
- Range 2 (full V_{DD} range), with a maximum CPU frequency of 16 MHz
- Range 3 (full V_{DD} range), with a maximum CPU frequency limited to 4 MHz (generated only with the multispeed internal RC oscillator clock source).

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 at 16 MHz is about 1 mA with all peripherals off.
- **Low power run** mode

  This mode is achieved with the multispeed internal (MSI) RC oscillator set to the minimum clock (131 kHz), execution from SRAM or Flash memory, and internal regulator in low power mode to minimize the regulator's operating current. In Low power run mode, the clock frequency and the number of enabled peripherals are both limited.
- **Low power sleep** mode

  This mode is achieved by entering Sleep mode with the internal voltage regulator in Low power mode to minimize the regulator's operating current. In 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.
- **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 µs. 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, 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 µs. 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.
- **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 µs 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 µs when an external reset (NRST pin) or a rising edge on one of the three WKUP pin occurs.

Note: The RTC, the IWDG, and the corresponding clock sources are not stopped automatically by entering Stop or Standby 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 STM32L15xxC is compatible with all ARM tools and software.

Nested vectored interrupt controller (NVIC)

The ultralow power STM32L15xxC embeds a nested vectored interrupt controller able to handle up to 53 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
- Interrupt entry 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 at power up operates between 1.65 V and 3.6 V.

As the BOR can be activated and deactivated at run time, this distinction is important only for power-up phase.

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.

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 BOR permanently: in this case, the V_{DD} min value at power down is 1.65 V.

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 (wakeup 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 from Flash usually boots at the beginning of the Flash (bank 1). An additional boot mechanism is available through user option byte, to allow booting from bank 2 when bank 2 contains valid code. This dual boot capability can be used to easily implement a secure field software update mechanism.

The boot loader is located in System memory. It is used to reprogram the Flash memory by using USART1 and USART2.

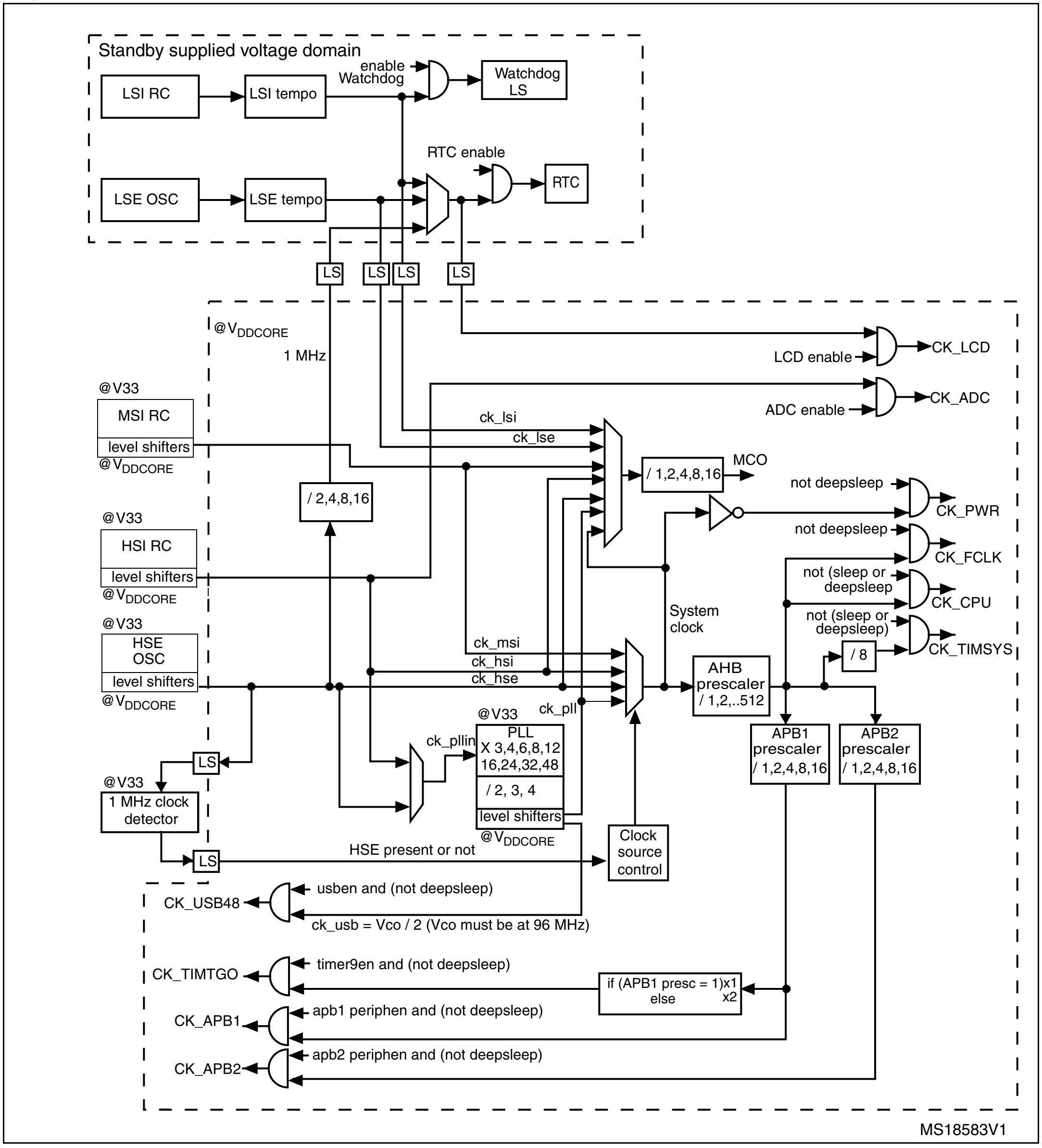
3.4 Clock management

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.
- **System clock source**: three different clock sources can be used to drive the master clock SYSCLK:
  - 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 kHz, 131 kHz, 262 kHz, 524 kHz, 1.05 MHz, 2.1 MHz, 4.2 MHz). When a 32.768 kHz clock source is available in the system (LSE), the MSI frequency can be trimmed by software down to a ±0.5% accuracy.
- **Auxiliary clock source**: two ultralow 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 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, each APB (APB1 and APB2) 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



1. For the USB function to be available, both HSE and PLL must be enabled, with the CPU running at either 24 MHz or 32 MHz.

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 µs 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 powerline.

The RTC calendar can be updated on the fly down to sub second precision, which enables network system synchronisation.

A time stamp can record an external event occurrence, and generates an interrupt.

There are thirty-two 32-bit backup registers provided to store 128 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 except for analog pins. 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 115 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 STM32L15xxC devices have the following features:

- 32 Kbyte 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:
  - 256 Kbyte of embedded Flash program memory
  - 8 Kbyte of data EEPROM
  - Options bytes

  The options bytes are used to write-protect the memory (with 4 KB 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.

3.8 DMA (direct memory access)

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

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

The DMA can be used with the main peripherals: SPI, I^2C, USART, general-purpose timers, DAC, 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

3.10 ADC (analog-to-digital converter)

A 12-bit analog-to-digital converters is embedded into STM32L15xxC devices with up to 40 external channels, performing conversions in single-shot or scan mode. In scan mode, automatic conversion is performed on a selected group of analog inputs with up to 29 external channel in a group.

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 scanned 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 triggers, 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.

Temperature sensor

The temperature sensor has to generate a voltage that varies linearly with temperature. The conversion range is between $1.8\text{ V} < V_{DDA} < 3.6\text{ V}$. The temperature sensor is internally connected to the ADC_IN16 input channel.

Voltage reference

An internal precise voltage reference can be measured through the ADC. It enables accurate monitoring of the V_{DD} value (when no external voltage, V_{REF+}, is available for ADC).

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
- Up to 10-bit output
- 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_{REF+}

Eight DAC trigger inputs are used in the STM32L15xxC. The DAC channels are triggered through the timer update outputs that are also connected to different DMA channels.

3.12 Operational amplifier

The STM32L15xxC embeds two operational amplifiers with external or internal follower routing capability (or even amplifier and filter capability with external components). When one operational amplifier is selected, one external ADC channel is used to enable output measurement.

The operational amplifiers feature:

- Low input bias current
- Low offset voltage
- Low power mode
- Rail-to-rail input

3.13 Ultralow power comparators and reference voltage

The STM32L15xxC embeds 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 a 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 µA typical).

3.14 System configuration controller and routing interface

The system configuration controller provides the capability to remap some alternate functions on different I/O ports.

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}.

3.15 Touch sensing

The STM32L15xxC devices provide a simple solution for adding capacitive sensing functionality to any application. Capacitive sensing technology is able to detect finger presence near an electrode which is protected from direct touch by a dielectric (glass, plastic, ...). The capacitive variation introduced by the finger (or any conductive object) is measured using a proven implementation based on a surface charge transfer acquisition principle. It consists of charging the electrode capacitance and then transferring a part of the accumulated charges into a sampling capacitor until the voltage across this capacitor has reached a specific threshold. In the STM32L15xxC, this acquisition is managed directly by the GPIOs, timers and analog I/O groups (see *Section 3.14: System configuration controller and routing interface*).

Reliable touch sensing solution can be quickly and easily implemented using the free STM32 touch sensing firmware library.

3.16 Timers and watchdogs

The ultralow power STM32L15xxC devices include seven general-purpose timers, two basic timers, and two watchdog timers.

Table 3 compares the features of the general-purpose and basic timers.

Table 3. 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
TIM5	32-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

3.16.1 General-purpose timers (TIM2, TIM3, TIM4, TIM5, TIM9, TIM10 and TIM11)

There are seven synchronizable general-purpose timers embedded in the STM32L15xxC devices (see *Table 3* for differences).

TIM2, TIM3, TIM4, TIM5

TIM2, TIM3, TIM4 are based on 16-bit auto-reload up/down counter. TIM5 is based on a 32-bit auto-reload up/down counter. They include a 16-bit prescaler. They feature four independent channels each for input capture/output compare, PWM or one-pulse mode output. This gives up to 16 input captures/output compares/PWMs on the largest packages.

TIM2, TIM3, TIM4, TIM5 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, TIM5 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, TIM5 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.

3.16.2 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.

3.16.3 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 downcounter with autoreload capability and a programmable clock source. It features a maskable system interrupt generation when the counter reaches 0.

3.16.4 Independent watchdog (IWDG)

The independent watchdog is based on a 12-bit downcounter 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.

3.16.5 Window watchdog (WWDG)

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

3.17 Communication interfaces

3.17.1 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.

3.17.2 Universal synchronous/asynchronous receiver transmitter (USART)

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

All USART interfaces can be served by the DMA controller.

3.17.3 Serial peripheral interface (SPI)

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

The SPIs can be served by the DMA controller.

3.17.4 Inter-integrated sound (I^{2}S)

Two standard I2S interfaces (multiplexed with SPI2 and SPI3) are available. They can operate in master or slave mode, and can be configured to operate with a 16-/32-bit resolution as input or output channels. Audio sampling frequencies from 8 kHz up to 96 kHz are supported. When either or both of the I2S interfaces is/are configured in master mode, the master clock can be output to the external DAC/CODEC at 256 times the sampling frequency.

3.17.5 Universal serial bus (USB)

The STM32L15xxC embeds 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).

3.18 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.

3.19 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 TMS and TCK pins are shared with SWDIO and SWCLK, respectively, and a specific sequence on the TMS 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 STM32L15xxC 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

Table 4. STM32L15xQC BGA132 ballout

	1	2	3	4	5	6	7	8	9	10	11	12
A	PE3	PE1	PB8	BOOT0	PD7	PD5	PB4	PB3	PA15	PA14	PA13	PA12
B	PE4	PE2	PB9	PB7	PB6	PD6	PD4	PD3	PD1	PC12	PC10	PA11
C	PC13-WKUP2	PE5	PE0	V_{DD_3}	PB5	PG14	PG13	PD2	PD0	PC11	PH2	PA10
D	PC14-OSC32_IN	PE6-WKUP3	V_{SS_3}	PF2	PF1	PF0	PG12	PG10	PG9	PA9	PA8	PC9
E	PC15-OSC32_OUT	VLCD	V_{SS_6}	PF3					PG5	PC8	PC7	PC6
F	PH0 OSC_IN	V_{SS_5}	PF4	PF5		V_{SS_9}	V_{SS_10}		PG3	PG4	V_{SS_2}	V_{SS_1}
G	PH1 OSC_OUT	V_{DD_5}	PF6	PF7		V_{DD_9}	V_{DD_10}		PG1	PG2	V_{DD_2}	V_{DD_1}
H	PC0	NRST	V_{DD_6}	PF8					PG0	PD15	PD14	PD13
J	V_{SSA}	PC1	PC2	PA4	PA7	PF9	PF12	PF14	PF15	PD12	PD11	PD10
K	NC	PC3	PA2	PA5	PC4	PF11	PF13	PD9	PD8	PB15	PB14	PB13
L	V_{REF+}	PA0-WKUP1	PA3	PA6	PC5	PB2	PE8	PE10	PE12	PB10	PB11	PB12
M	V_{DDA}	PA1	OPAMP1_VINM	OPAMP2_VINM	PB0	PB1	PE7	PE9	PE11	PE13	PE14	PE15

Figure 3. STM32L15xZC LQFP144 pinout

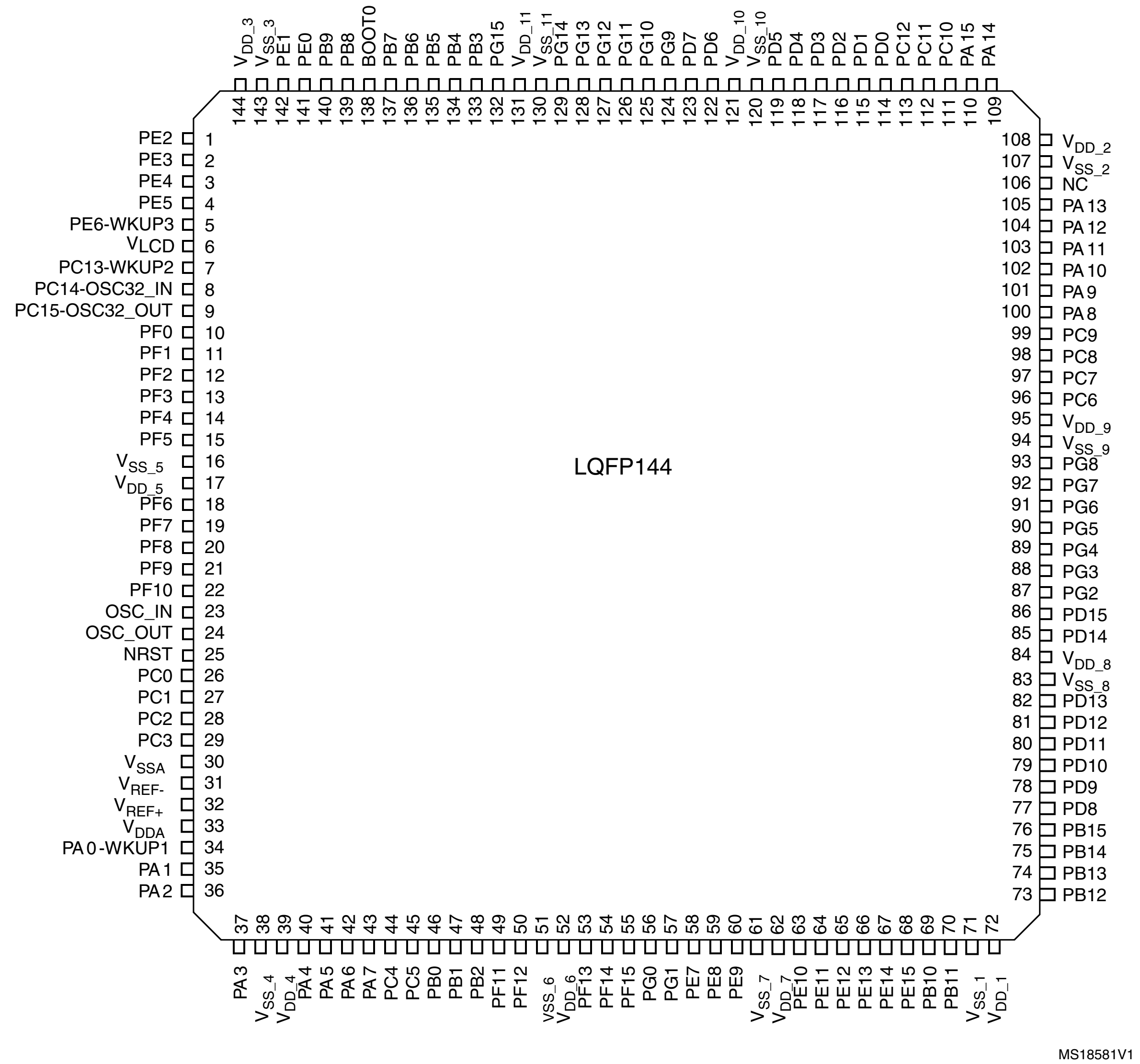


Figure 4. STM32L15xVC LQFP100 pinout

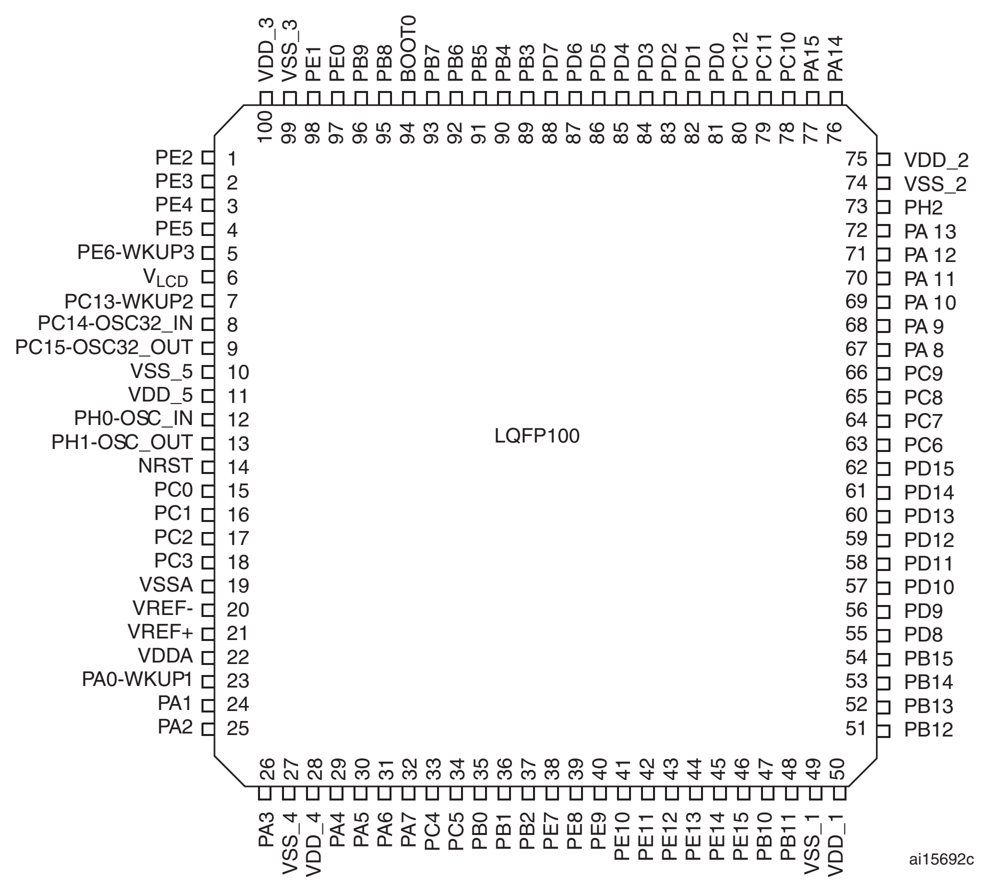


Figure 5. STM32L15xRC LQFP64 pinout

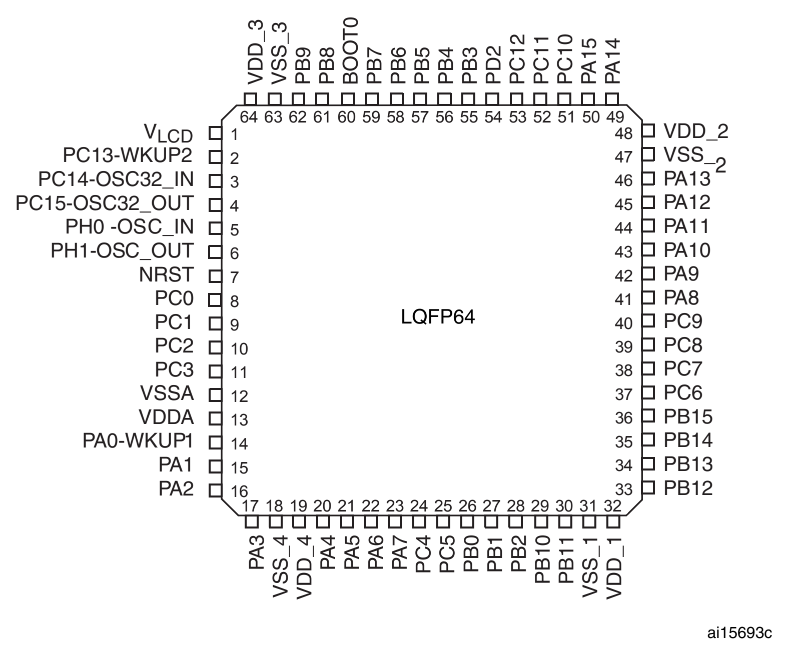


Table 5. STM32L15xRC WLCSP64 ballout

	8	7	6	5	4	3	2	1
A	V_{DD_3}	V_{SS_3}	BOOT0	PB5	PB3	PD2	PC10	V_{DD_2}
B	PC14-OSC32_IN	PC15-OSC32_OUT	PB9	PB6	PB4	PC11	PA14	V_{SS_2}
C	PC13-WKUP2	NRST	V_{LCD}	PB7	PC12	PA15	PA12	PA11
D	PH0-OSC_IN	PH1-OSC_OUT	PC2	PB8	PA13	PA10	PA9	PC9
E	PC0	V_{SSA}	PA1	PA5	PA8	PC8	PC7	PC6
F	PC1	PC3	PA0-WKUP1	V_{ss_4}	PB1	PB11	PB14	PB15
G	V_{DDA}	PA3	V_{DD_4}	PA6	PA7	PB10	PB12	PB13
H	PA2	PA4	PC4	PC5	PB0	PB2	V_{ss_1}	V_{DD_1}

Table 6. STM32L15xxC pin definitions

Pins					Pin name	Type[1]	I / O Level[2]	Main function[3] (after reset)	Alternate functions
LQFP144	UFBGA132	LQFP100	LQFP64	WLCSP64					
1	B2	1	-	-	PE2	I/O	FT	PE2	TIM3_ETR/LCD_SEG38/TRACECK
2	A1	2	-	-	PE3	I/O	FT	PE3	TIM3_CH1/LCD_SEG39/TRACED0
3	B1	3	-	-	PE4	I/O	FT	PE4	TIM3_CH2/TRACED1
4	C2	4	-	-	PE5	I/O	FT	PE5	TIM9_CH1/TRACED2
5	D2	5	-	-	PE6-WKUP3	I/O	FT	PE6	WKUP3/TAMPER3/TIM9_CH2/TRACED3
6	E2	6	1	C6	V_{LCD}[4]	S		V_{LCD}	
7	C1	7	2	C8	PC13-WKUP2	I/O	FT	PC13	WKUP2/TAMPER1/RTC_AF1
8	D1	8	3	B8	PC14-OSC32_IN[5]	I/O		PC14	OSC32_IN
9	E1	9	4	B7	PC15-OSC32_OUT	I/O		PC15	OSC32_OUT
10	D6	-	-	-	PF0	I/O	FT	PF0	
11	D5	-	-	-	PF1	I/O	FT	PF1	
12	D4	-	-	-	PF2	I/O	FT	PF2	
13	E4	-	-	-	PF3	I/O	FT	PF3	
14	F3	-	-	-	PF4	I/O	FT	PF4	
15	F4	-	-	-	PF5	I/O	FT	PF5	
16	F2	10	-	-	V_{SS_5}	S		V_{SS_5}	
17	G2	11	-	-	V_{DD_5}	S		V_{DD_5}	
18	G3	-	-	-	PF6	I/O	FT	PF6	TIM5_CH1/TIM5_ETR/ADC_IN27
19	G4	-	-	-	PF7	I/O	FT	PF7	TIM5_CH2/ADC_IN28/COMP1_INP
20	H4	-	-	-	PF8	I/O	FT	PF8	TIM5_CH3/ADC_IN29/COMP1_INP
21	J6	-	-	-	PF9	I/O	FT	PF9	TIM5_CH4/ADC_IN30/COMP1_INP
22	-	-	-	-	PF10	I/O	FT	PF10	ADC_IN30/COMP1_INP
23	F1	12	5	D8	PH0-OSC_IN[6]	I		PH0	OSC_IN
24	G1	13	6	D7	PH1-OSC_OUT[6]	O		PH1	OSC_VOUT
25	H2	14	7	C7	NRST	I/O		NRST	
26	H1	15	8	E8	PC0	I/O	FT	PC0	LCD_SEG18/ADC_IN10/COMP1_INP
27	J2	16	9	F8	PC1	I/O	FT	PC1	LCD_SEG19/ADC_IN11/COMP1_INP
28	-	17	10	D6	PC2	I/O	FT	PC2	LCD_SEG20/ADC_IN12/COMP1_INP
-	J3	-	-	-	PC2	I/O	FT	PC2	LCD_SEG20/ADC_IN12/COMP1_INP
-	K1	-	-	-	NC	I			
29	K2	18	11	F7	PC3	I/O		PC3	LCD_SEG21/ADC_IN13/COMP1_INP
30	J1	19	12	E7	V_{SSA}	S		V_{SSA}	
31	-	20	-	-	V_{REF-}	S		V_{REF-}	

Table 6. STM32L15xxC pin definitions (continued)

Pins					Pin name	Type[1]	I / O Level[2]	Main function[3] (after reset)	Alternate functions
LQFP144	UFBGA132	LQFP100	LQFP64	WLCSP64					
32	L1	21	-	-	V_{REF+}	S		V_{REF+}	
33	M1	22	13	G8	V_{DDA}	S		V_{DDA}	
34	L2	23	14	F6	PA0-WKUP1	I/O	FT	PA0	WKUP1/TAMPER2/TIM2_CH1_ETR/TIM5_CH1/ USART2_CTS/ADC_IN0/COMP1_INP
35	M2	24	15	E6	PA1	I/O	FT	PA1	TIM2_CH2/TIM5_CH2/ USART2_RTS/LCD_SEG0/ ADC_IN1/COMP1_INP/OPAMP1_VINP
36	-	25	16	H8	PA2	I/O	FT	PA2	TIM2_CH3/TIM5_CH3/TIM9_CH1/USART2_TX/ LCD_SEG1/ADC_IN2/ COMP1_INP/OPAMP1_VINM
-	K3	-	-	-	PA2	I/O	FT	PA2	TIM2_CH3/TIM5_CH3/TIM9_CH1/USART2_TX/ LCD_SEG1/ADC_IN2/ COMP1_INP
-	M3	-	-	-	OPAMP1_VINM	I		OPAMP1_VINM	
37	L3	26	17	G7	PA3	I/O		PA3	TIM2_CH4/TIM5_CH4/TIM9_CH2/USART2_RX/ LCD_SEG2/ ADC_IN3/COMP1_INP/OPAMP1_OUT
38	-	27	18	F5	V_{SS_4}	S		V_{SS_4}	
39	-	28	19	G6	V_{DD_4}	S		V_{DD_4}	
40	J4	29	20	H7	PA4	I/O		PA4	SPI1_NSS/SPI3_NSS/ I2S3_WS/USART2_CK/ ADC_IN4/DAC_OUT1/COMP1_INP
41	K4	30	21	E5	PA5	I/O		PA5	TIM2_CH1_ETR/SPI1_SCK/ADC_IN5/DAC_OUT2/ COMP1_INP
42	L4	31	22	G5	PA6	I/O	FT	PA6	TIM3_CH1/TIM10_CH1/SPI1_MISO/LCD_SEG3/ ADC_IN6/COMP1_INP/OPAMP2_VINP
43	-	32	23	G4	PA7	I/O	FT	PA7	TIM3_CH2/TIM11_CH1/ SPI1_MOSI/LCD_SEG4/ ADC_IN7/COMP1_INP/OPAMP2_VINM
-	J5	-	-	-	PA7	I/O	FT	PA7	TIM3_CH2/TIM11_CH1/ SPI1_MOSI/LCD_SEG4/ ADC_IN7/COMP1_INP
-	M4	-	-	-	OPAMP2_VINM	I		OPAMP2_VINM	
44	K5	33	24	H6	PC4	I/O	FT	PC4	LCD_SEG22/ADC_IN14/COMP1_INP
45	L5	34	25	H5	PC5	I/O	FT	PC5	LCD_SEG23/ADC_IN15/COMP1_INP
46	M5	35	26	H4	PB0	I/O		PB0	TIM3_CH3/LCD_SEG5/ADC_IN8/COMP1_INP/ VREF_OUT/ OPAMP2_VOUT
47	M6	36	27	F4	PB1	I/O	FT	PB1	TIM3_CH4/LCD_SEG6/ADC_IN9/COMP1_INP/ VREF_OUT
48	L6	37	28	H3	PB2	I/O	FT	PB2/BOOT1	ADC_IN0b/COMP1_INP
49	K6	-	-	-	PF11	I/O	FT	PF11	ADC_IN1b/COMP1_INP
50	J7	-	-	-	PF12	I/O	FT	PF12	ADC_IN2b/COMP1_INP

Table 6. STM32L15xxC pin definitions (continued)

Pins					Pin name	Type[1]	I / O Level[2]	Main function[3] (after reset)	Alternate functions
LQFP144	UFBGA132	LQFP100	LQFP64	WLCSP64					
51	E3	-	-	-	V_{SS_6}	S		V_{SS_6}	
52	H3	-	-	-	V_{DD_6}	S		V_{DD_6}	
53	K7	-	-	-	PF13	I/O	FT	PF13	ADC_IN3b/COMP1_INP
54	J8	-	-	-	PF14	I/O	FT	PF14	ADC_IN6b/COMP1_INP
55	J9	-	-	-	PF15	I/O	FT	PF15	ADC_IN7b/COMP1_INP
56	H9	-	-	-	PG0	I/O	FT	PG0	ADC_IN8b/COMP1_INP
57	G9	-	-	-	PG1	I/O	FT	PG1	ADC_IN9b/COMP1_INP
58	M7	38	-	-	PE7	I/O		PE7	ADC_IN22/COMP1_INP
59	L7	39	-	-	PE8	I/O		PE8	ADC_IN23/COMP1_INP
60	M8	40	-	-	PE9	I/O		PE9	TIM2_CH1_ETR/ADC_IN24/COMP1_INP
61	-	-	-	-	V_{SS_7}	S		V_{SS_7}	
62	-	-	-	-	V_{DD_7}	S		V_{DD_7}	
63	L8	41	-	-	PE10	I/O		PE10	TIM2_CH2/ADC_IN25/COMP1_INP
64	M9	42	-	-	PE11	I/O	FT	PE11	TIM2_CH3
65	L9	43	-	-	PE12	I/O	FT	PE12	TIM2_CH4/SPI1_NSS
66	M10	44	-	-	PE13	I/O	FT	PE13	SPI1_SCK
67	M11	45	-	-	PE14	I/O	FT	PE14	SPI1_MISO
68	M12	46	-	-	PE15	I/O	FT	PE15	SPI1_MOSI
69	L10	47	29	G3	PB10	I/O	FT	PB10	TIM2_CH3/I2C2_SCL/USART3_TX/LCD_SEG10
70	L11	48	30	F3	PB11	I/O	FT	PB11	TIM2_CH4/I2C2_SDA/ USART3_RX/LCD_SEG11
71	F12	49	31	H2	V_{SS_1}	S		V_{SS_1}	
72	G12	50	32	H1	V_{DD_1}	S		V_{DD_1}	
73	L12	51	33	G2	PB12	I/O	FT	PB12	TIM10_CH1/I2C2_SMBA/SPI2_NSS/I2S2_WS/ USART3_CK/ LCD_SEG12/ADC_IN18/COMP1_INP
74	K12	52	34	G1	PB13	I/O	FT	PB13	TIM9_CH1/SPI2_SCK/ I2S2_CK/ USART3_CTS/ LCD_SEG13/ADC_IN19/COMP1_INP
75	K11	53	35	F2	PB14	I/O	FT	PB14	TIM9_CH2/SPI2_MISO/ USART3_RTS/LCD_SEG14/ ADC_IN20/COMP1_INP
76	K10	54	36	F1	PB15	I/O	FT	PB15	TIM11_CH1/SPI2_MOSI/I2S2_SD/LCD_SEG15/ ADC_IN21/COMP1_INP/RTC_50_60Hz
77	K9	55	-	-	PD8	I/O	FT	PD8	USART3_TX/LCD_SEG28
78	K8	56	-	-	PD9	I/O	FT	PD9	USART3_RX/LCD_SEG29
79	J12	57	-	-	PD10	I/O	FT	PD10	USART3_CK/LCD_SEG30
80	J11	58	-	-	PD11	I/O	FT	PD11	USART3_CTS/LCD_SEG31
81	J10	59	-	-	PD12	I/O	FT	PD12	TIM4_CH1 / USART3_RTS/LCD_SEG32
82	H12	60	-	-	PD13	I/O	FT	PD13	TIM4_CH2/LCD_SEG33

Table 6. STM32L15xxC pin definitions (continued)

Pins					Pin name	Type[1]	I / O Level[2]	Main function[3] (after reset)	Alternate functions
LQFP144	UFBGA132	LQFP100	LQFP64	WLCSP64					
83	-	-	-	-	V_{SS_8}	S		V_{SS_8}	
84	-	-	-	-	V_{DD_8}	S		V_{DD_8}	
85	H11	61	-	-	PD14	I/O	FT	PD14	TIM4_CH3/LCD_SEG34
86	H10	62	-	-	PD15	I/O	FT	PD15	TIM4_CH4/LCD_SEG35
87	G10	-	-	-	PG2	I/O	FT	PG2	ADC_IN10b/COMP1_INP
88	F9	-	-	-	PG3	I/O	FT	PG3	ADC_IN11b/COMP1_INP
89	F10	-	-	-	PG4	I/O	FT	PG4	ADC_IN12b/COMP1_INP
90	E9	-	-	-	PG5	I/O	FT	PG5	
91	-	-	-	-	PG6	I/O	FT	PG6	
92	-	-	-	-	PG7	I/O	FT	PG7	
93	-	-	-	-	PG8	I/O	FT	PG8	
94	F6	-	-	-	V_{SS_9}	S		V_{SS_9}	
95	G6	-	-	-	V_{DD_9}	S		V_{DD_9}	
96	E12	63	37	E1	PC6	I/O	FT	PC6	TIM3_CH1/I2S2_MCK/LCD_SEG24
97	E11	64	38	E2	PC7	I/O	FT	PC7	TIM3_CH2/I2S3_MCK/LCD_SEG25
98	E10	65	39	E3	PC8	I/O	FT	PC8	TIM3_CH3/LCD_SEG26
99	D12	66	40	D1	PC9	I/O	FT	PC9	TIM3_CH4/LCD_SEG27
100	D11	67	41	E4	PA8	I/O	FT	PA8	USART1_CK/MCO/LCD_COM0
101	D10	68	42	D2	PA9	I/O	FT	PA9	USART1_TX / LCD_COM1
102	C12	69	43	D3	PA10	I/O	FT	PA10	USART1_RX / LCD_COM2
103	B12	70	44	C1	PA11	I/O	FT	PA11	USART1_CTS/ USB_DM/SPI1_MISO
104	A12	71	45	C2	PA12	I/O	FT	PA12	USART1_RTS/USB_DP/SPI1_MOSI
105	A11	72	46	D4	PA13	I/O	FT	JTMS-SWDIO	PA13
106	C11	73	-	-	PH2	I/O	FT	PH2	
107	F11	74	47	B1	V_{SS_2}	S		V_{SS_2}	
108	G11	75	48	A1	V_{DD_2}	S		V_{DD_2}	
109	A10	76	49	B2	PA14	I/O	FT	JTCK-SWCLK	PA14
110	A9	77	50	C3	PA15	I/O	FT	JTDI	TIM2_CH1_ETR/ SPI1_NSS/SPI3_NSS/ I2S3_WS/LCD_SEG17
111	B11	78	51	A2	PC10	I/O	FT	PC10	SPI3_SCK/I2S3_CK/USART3_TX/ LCD_SEG28/LCD_SEG40/LCD_COM4
112	C10	79	52	B3	PC11	I/O	FT	PC11	SPI3_MISO/USART3_RX/ LCD_SEG29/LCD_SEG41/LCD_COM5/
113	B10	80	53	C4	PC12	I/O	FT	PC12	SPI3_MOSI/I2S3_SD/USART3_CK/ LCD_SEG30/ LCD_SEG42/LCD_COM6
114	C9	81	-	-	PD0	I/O	FT	PD0	TIM9_CH1/SPI2_NSS/I2S2_WS

Table 6. STM32L15xxC pin definitions (continued)

Pins					Pin name	Type[1]	I / O Level[2]	Main function[3] (after reset)	Alternate functions
LQFP144	UFBGA132	LQFP100	LQFP64	WLCSP64					
115	B9	82	-	-	PD1	I/O	FT	PD1	SPI2_SCK/I2S2_CK
116	C8	83	54	A3	PD2	I/O	FT	PD2	TIM3_ETR/LCD_SEG31/LCD_SEG43/LCD_COM 7
117	B8	84	-	-	PD3	I/O	FT	PD3	SPI2_MISO/USART2_CTS
118	B7	85	-	-	PD4	I/O	FT	PD4	SPI2_MOSI/I2S2_SD/ USART2_RTS
119	A6	86	-	-	PD5	I/O	FT	PD5	USART2_TX
120	F7	-	-	-	V_{SS_10}	S		V_{SS_10}	
121	G7	-	-	-	V_{DD_10}	S		V_{DD_10}	
122	B6	87	-	-	PD6	I/O	FT	PD6	USART2_RX
123	A5	88	-	-	PD7	I/O	FT	PD7	TIM9_CH2/USART2_CK
124	D9	-	-	-	PG9	I/O	FT	PG9	
125	D8	-	-	-	PG10	I/O	FT	PG10	
126	-	-	-	-	PG11	I/O	FT	PG11	
127	D7	-	-	-	PG12	I/O	FT	PG12	
128	C7	-	-	-	PG13	I/O	FT	PG13	
129	C6	-	-	-	PG14	I/O	FT	PG14	
130	-	-	-	-	V_{SS_11}	S		V_{SS_11}	
131	-	-	-	-	V_{DD_11}	S		V_{DD_11}	
132	-	-	-	-	PG15	I/O	FT	PG15	
133	A8	89	55	A4	PB3	I/O	FT	JTDO	TIM2_CH2/SPI1_SCK/SPI3_SCK/ I2S3_CK/ LCD_SEG7/COMP2_INM/TRACESWO
134	A7	90	56	B4	PB4	I/O	FT	NJTRST	TIM3_CH1/ SPI1_MISO/SPI3_MISO/LCD_SEG8/ COMP2_INP
135	C5	91	57	A5	PB5	I/O	FT	PB5	TIM3_CH2 /I2C1_SMBAI/SPI1_MOSI/SPI3_MOSI/ I2S3_SD/LCD_SEG9/COMP2_INP
136	B5	92	58	B5	PB6	I/O	FT	PB6	TIM4_CH1/I2C1_SCL/USART1_TX/COMP2_INP
137	B4	93	59	C5	PB7	I/O	FT	PB7	TIM4_CH2/I2C1_SDA/USART1_RX/PVD_IN/ COMP2_INP
138	A4	94	60	A6	BOOT0	I		BOOT0	
139	A3	95	61	D5	PB8	I/O	FT	PB8	TIM4_CH3/TIM10_CH1/I2C1_SCL/LCD_SEG16
140	B3	96	62	B6	PB9	I/O	FT	PB9	TIM4_CH4/ TIM11_CH1/I2C1_SDA/LCD_COM3
141	C3	97	-	-	PE0	I/O	FT	PE0	TIM4_ETR/TIM10_CH1/LCD_SEG36
142	A2	98	-	-	PE1	I/O	FT	PE1	TIM11_CH1/LCD_SEG37
143	D3	99	63	A7	V_{SS_3}	S		V_{SS_3}	
144	C4	100	64	A8	V_{DD_3}	S		V_{DD_3}	

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

2. FT = 5 V tolerant.
3. Function availability depends on the chosen device.
4. Applicable to STM32L152xC devices only. In STM32L151xC devices, this pin should be connected to V_{DD}.
5. 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 PH0/PH1 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 STM32L15xxx reference manual (RM0048).
6. 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.

Table 7. Alternate function input/output

Port name	Digital alternate function number													
	AFIO0	AFIO1	AFIO2	AFIO3	AFIO4	AFIO5	AFIO6	AFIO7	..	AFIO10	AFIO11	..	AFIO14	AFIO15
	Alternate function													
	SYSTEM	TIM2	TIM3/4/5	TIM9/ 10/11	I2C1/2	SPI1/2	SPI3	USART1/2/3		USB	LCD		CPRI	SYSTEM
BOOT0	BOOT0													EVENT OUT
NRST	NRST													
PA0-WKUP1	WKUP1/ TAMPER2	TIM2_CH1_ ETR	TIM5_CH1					USART2_CTS					COMP1_INP/ TIMx_IC1_0/ G1IO1	EVENT OUT
PA1		TIM2_CH2	TIM5_CH2					USART2_RTS			SEG0		COMP1_INP/ TIMx_IC2_0 G1IO2	EVENT OUT
PA2		TIM2_CH3	TIM5_CH3	TIM9_CH1				USART2_TX			SEG1		COMP1_INP/ TIMx_IC3_0/ G1IO3	EVENT OUT
PA3		TIM2_CH4	TIM5_CH4	TIM9_CH2				USART2_RX			SEG2		COMP1_INP/ TIMx_IC4_0/ G1IO4	EVENT OUT
PA4						SPI1_NSS	SPI3_NSS I2S3_WS	USART2_CK					COMP1_INP/ TIMx_IC1_1	EVENT OUT
PA5		TIM2_CH1_ETR*				SPI1_SCK							COMP1_INP/ TIMx_IC2_1	EVENT OUT
PA6			TIM3_CH1	TIM10_ CH1		SPI1_MISO					SEG3		COMP1_INP/ TIMx_IC3_1 G2IO1	EVENT OUT
PA7			TIM3_CH2	TIM11_ CH1		SPI1_MOSI					SEG4		COMP1_INP/ TIMx_IC4_1/ G2IO2	EVENT OUT
PA8	MCO							USART1_CK			COM0		TIMx_IC1_2/ G4IO1	EVENT OUT
PA9								USART1_TX			COM1		TIMx_IC2_2/ G4IO2	EVENT OUT
PA10								USART1_RX			COM2		TIMx_IC3_2/ G4IO3	EVENT OUT
PA11						SPI1_MISO		USART1_CTS		USBDM			TIMx_IC4_2/ G4IO4	EVENT OUT

Table 7. Alternate function input/output (continued)

Port name	Digital alternate function number													
	AFIO0	AFIO1	AFIO2	AFIO3	AFIO4	AFIO5	AFIO6	AFIO7	..	AFIO10	AFIO11	..	AFIO14	AFIO15
	Alternate function													
	SYSTEM	TIM2	TIM3/4/5	TIM9/ 10/11	I2C1/2	SPI1/2	SPI3	USART1/2/3		USB	LCD		CPRI	SYSTEM
PA12						SPI1_MOSI		USART1_RTS		USBDP			TIMx_IC1_3/	EVENT OUT
PA13	JTMS-SWDIO												TIMx_IC2_3/ G5IO1	EVENT OUT
PA14	JTCK-SWCLK												TIMx_IC3_3/ G5IO2	EVEN TOUT
PA15	JTDI	TIM2_CH1_ETR				SPI1_NSS	SPI3_NSS I2S3_WS				SEG17		TIMx_IC4_3/ G5IO3	EVEN TOUT
PB0			TIM3_CH3								SEG5		COMP1_INP/ G3IO1	EVEN TOUT
PB1			TIM3_CH4								SEG6		COMP1_INP/ G3IO2	EVENT OUT
PB2	BOOT1												COMP1_INP/ G3IO3	EVENT OUT
PB3	JTDO	TIM2_CH2				SPI1_SCK	SPI3_SCK I2S3_CK				SEG7			EVENT OUT
PB4	JTRST		TIM3_CH1			SPI1_MISO	SPI3_MISO				SEG8		G6IO1	EVENT OUT
PB5			TIM3_CH2		I2C1_ SMBA	SPI1_MOSI	SPI3_MOSII2 S3_SD				SEG9		G6IO2	EVENT OUT
PB6			TIM4_CH1		I2C1_SCL			USART1_TX					G6IO3	EVENT OUT
PB7			TIM4_CH2		I2C1_SDA			USART1_RX					G6IO4	EVENT OUT
PB8			TIM4_CH3	TIM10_ CH1	I2C1_SCL						SEG16			EVENT OUT
PB9			TIM4_CH4	TIM11_ CH1	I2C1_SDA						COM3			EVENT OUT
PB10		TIM2_CH3			I2C_SCL			USART3_TX			SEG10			EVENT OUT
PB11		TIM2_CH4			I2C_SDA			USART3_RX			SEG11			EVENT OUT
PB12				TIM10_ CH1	I2C_SMBA	SPI2_NSS I2S2_WS		USART3_CK			SEG12		COMP1_INP/ G7IO1	EVENT OUT

Table 7. Alternate function input/output (continued)

Port name	Digital alternate function number													
	AFIO0	AFIO1	AFIO2	AFIO3	AFIO4	AFIO5	AFIO6	AFIO7	..	AFIO10	AFIO11	..	AFIO14	AFIO15
	Alternate function													
	SYSTEM	TIM2	TIM3/4/5	TIM9/ 10/11	I2C1/2	SPI1/2	SPI3	USART1/2/3		USB	LCD		CPRI	SYSTEM
PB13				TIM9_ CH1		SPI2_SCK I2S2_CK		USART3_CTS			SEG13		COMP1_INP/ G7IO2	EVENT OUT
PB14				TIM9_ CH2		SPI2_MISO		USART3_RTS			SEG14		COMP1_INP/ G7IO3	EVENT OUT
PB15	RTC 50/60 Hz			TIM11_ CH1		SPI2_MOSII 2S2_SD					SEG15		COMP1_INP/ G7IO4	EVENT OUT
PC0											SEG18		COMP1_INP/ TIMx_IC1_4/ G8IO1	EVENT OUT
PC1											SEG19		COMP1_INP/ TIMx_IC2_4/ G8IO2	EVENT OUT
PC2											SEG20		COMP1_INP/ TIMx_IC3_4/ G8IO3	EVENT OUT
PC3											SEG21		COMP1_INP/ TIMx_IC4_4/ G8IO4	EVENT OUT
PC4											SEG22		COMP1_INP/ TIMx_IC1_5/ G9IO1	EVENT OUT
PC5											SEG23		COMP1_INP/ TIMx_IC2_5/ G9IO2	EVENT OUT
PC6			TIM3_CH1			I2S2_MCK					SEG24		TIMx_IC3_5/ G10IO1	EVENT OUT
PC7			TIM3_CH2				I2S3_MCK				SEG25		TIMx_IC4_5/ G10IO2	EVENT OUT
PC8			TIM3_CH3								SEG26		TIMx_IC1_6/ G10IO3	EVENT OUT
PC9			TIM3_CH4								SEG27		TIMx_IC2_6/ G10IO4	EVENT OUT

Table 7. Alternate function input/output (continued)

Port name	Digital alternate function number													
	AFIO0	AFIO1	AFIO2	AFIO3	AFIO4	AFIO5	AFIO6	AFIO7	..	AFIO10	AFIO11	..	AFIO14	AFIO15
	Alternate function													
	SYSTEM	TIM2	TIM3/4/5	TIM9/ 10/11	I2C1/2	SPI1/2	SPI3	USART1/2/3		USB	LCD		CPRI	SYSTEM
PC10							SPI3_SCK I2S3_CK	USART3_TX			COM4/ SEG28/ SEG40		TIMx_IC3_6/ G5IO4	EVENT OUT
PC11							SPI3_MISO	USART3_RX			COM5/ SEG29 /SEG41		TIMx_IC4_6	EVENT OUT
PC12							SPI3_MOSI I2S3_SD	USART3_CK			COM6/ SEG30/ SEG42		TIMx_IC1_7	EVENT OUT
PC13- WKUP2	WKUP2/ TAMPER1/ TIMESTAMP/ ALARM_OUT/512Hz												TIMx_IC2_7	EVENT OUT
PC14 OSC32_IN	OSC32_IN												TIMx_IC3_7	EVENT OUT
PC15 OSC32_ OUT	OSC32_OUT												TIMx_IC4_7	EVENT OUT
PD0				TIM9_CH1		SPI2_NSS I2S2_WS							TIMx_IC1_8	EVENT OUT
PD1						SPI2 SCK I2S2_CK							TIMx_IC2_8	EVENT OUT
PD2			TIM3_ETR								COM7/ SEG31/ SEG43		TIMx_IC3_8	EVENT OUT
PD3						SPI2_MISO		USART2_CTS					TIMx_IC4_8	EVENT OUT
PD4						SPI2_MOSI I2S2_SD		USART2_RTS					TIMx_IC1_9	EVENT OUT
PD5								USART2_TX					TIMx_IC2_9	EVENT OUT
PD6								USART2_RX					TIMx_IC3_9	EVENT OUT
PD7				TIM9_CH2				USART2_CK					TIMx_IC4_9	EVENT OUT

Table 7. Alternate function input/output (continued)

Port name	Digital alternate function number													
	AFIO0	AFIO1	AFIO2	AFIO3	AFIO4	AFIO5	AFIO6	AFIO7	..	AFIO10	AFIO11	..	AFIO14	AFIO15
	Alternate function													
	SYSTEM	TIM2	TIM3/4/5	TIM9/ 10/11	I2C1/2	SPI1/2	SPI3	USART1/2/3		USB	LCD		CPRI	SYSTEM
PD8								USART3_TX			SEG28		TIMx_IC1_10	EVENT OUT
PD9								USART3_RX			SEG29		TIMx_IC2_10	EVENT OUT
PD10								USART3_CK			SEG30		TIMx_IC3_10	EVENT OUT
PD11								USART3_CTS			SEG31		TIMx_IC4_10	EVENT OUT
PD12			TIM4_CH1					USART3_RTS			SEG32		TIMx_IC1_11	EVENT OUT
PD13			TIM4_CH2								SEG33		TIMx_IC2_11	EVENT OUT
PD14			TIM4_CH3								SEG34		TIMx_IC3_11	EVENT OUT
PD15			TIM4_CH4								SEG35		TIMx_IC4_11	EVENT OUT
PE0			TIM4_ETR	TIM10_CH1							SEG36		TIMx_IC1_12	EVENT OUT
PE1				TIM11_CH1							SEG37		TIMx_IC2_12	EVENT OUT
PE2	TRACECK		TIM3_ETR								SEG 38		TIMx_IC3_12	EVENT OUT
PE3	TRACED0		TIM3_CH1								SEG 39		TIMx_IC4_12	EVENT OUT
PE4	TRACED1		TIM3_CH2										TIMx_IC1_13	EVENT OUT
PE5	TRACED2			TIM9_CH1									TIMx_IC2_13	EVENT OUT
PE6-WKUP3	WKUP3/TAMPER3 / TRACED3			TIM9_CH2									TIMx_IC3_13	EVENT OUT
PE7													COMP1_INP/ TIMx_IC4_13	EVENT OUT
PE8													COMP1_INP/ TIMx_IC1_14	EVENT OUT
PE9		TIM2_CH1_ETR											COMP1_INP/ TIMx_IC2_14	EVENT OUT
PE10		TIM2_CH2											COMP1_INP/ TIMx_IC3_14	EVENT OUT
PE11		TIM2_CH3											TIMx_IC4_14	EVENT OUT

Table 7. Alternate function input/output (continued)

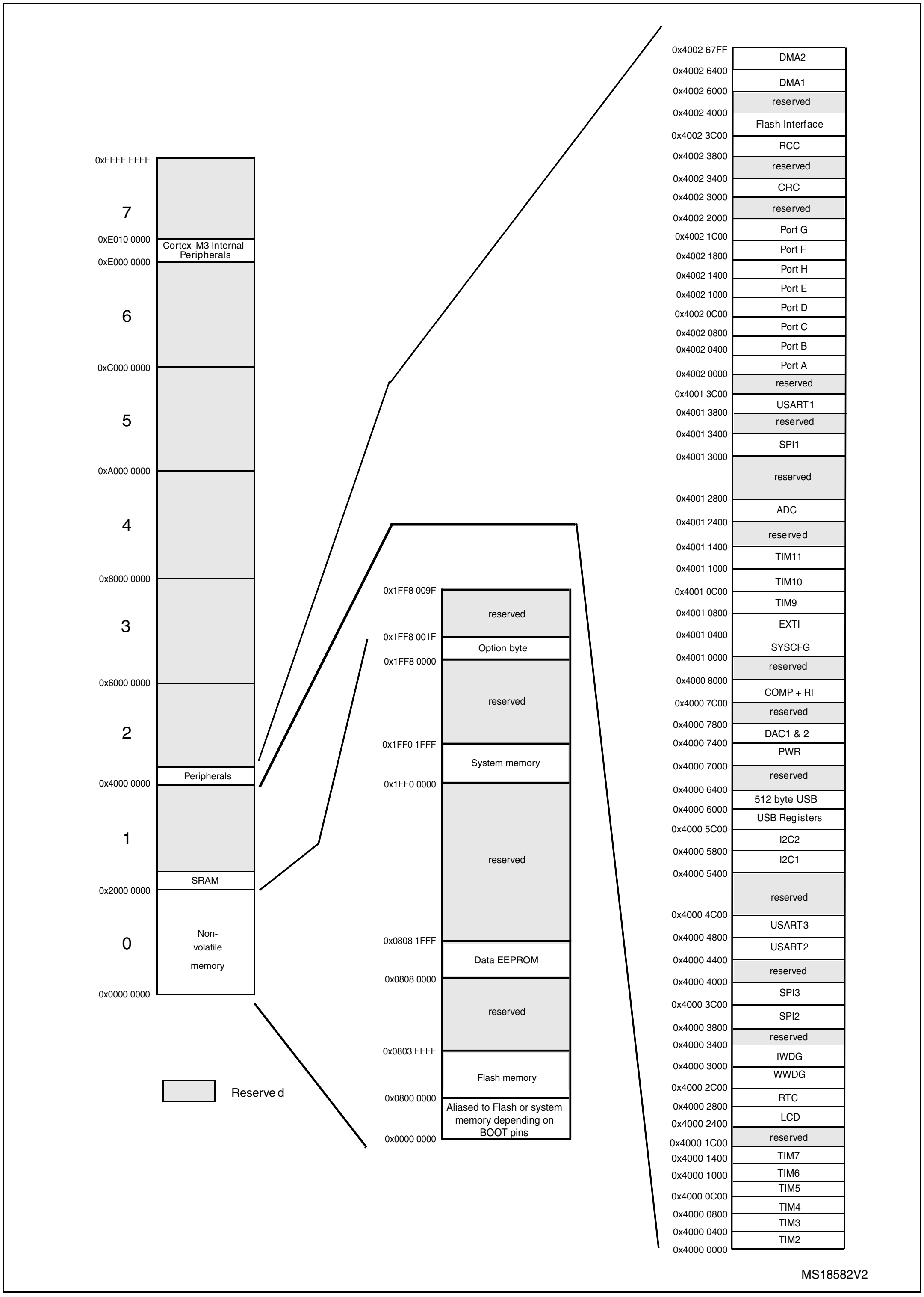
Port name	Digital alternate function number													
	AFIO0	AFIO1	AFIO2	AFIO3	AFIO4	AFIO5	AFIO6	AFIO7	..	AFIO10	AFIO11	..	AFIO14	AFIO15
	Alternate function													
	SYSTEM	TIM2	TIM3/4/5	TIM9/ 10/11	I2C1/2	SPI1/2	SPI3	USART1/2/3		USB	LCD		CPRI	SYSTEM
PE12		TIM2_CH4				SPI1_NSS							TIMx_IC1_15	EVENT OUT
PE13						SPI1_SCK							TIMx_IC2_15	EVENT OUT
PE14						SPI1_MISO							TIMx_IC3_15	EVENT OUT
PE15						SPI1_MOSI							TIMx_IC4_15	EVENT OUT
PF0														EVENT OUT
PF1														EVENT OUT
PF2														EVENT OUT
PF3														EVENT OUT
PF4														EVENT OUT
PF5														EVENT OUT
PF6			TIM5_CH1_ ETR										COMP1_INP G11IO1	EVENT OUT
PF7			TIM5_CH2										COMP1_INP G11IO2	EVENT OUT
PF8			TIM5_CH3										COMP1_INP G11IO3	EVENT OUT
PF9			TIM5_CH4										COMP1_INP G11IO4	EVENT OUT
PF10													COMP1_INP G11IO5	EVENT OUT
PF11													COMP1_INP G3IO4	EVENT OUT
PF12													G3IO5	EVENT OUT
PF13													G9IO3	EVENT OUT
PF14													G9IO4	EVENT OUT
PF15													G2IO3	EVENT OUT
PG0													G2IO4	EVENT OUT

Table 7. Alternate function input/output (continued)

Port name	Digital alternate function number													
	AFIO0	AFIO1	AFIO2	AFIO3	AFIO4	AFIO5	AFIO6	AFIO7	..	AFIO10	AFIO11	..	AFIO14	AFIO15
	Alternate function													
	SYSTEM	TIM2	TIM3/4/5	TIM9/ 10/11	I2C1/2	SPI1/2	SPI3	USART1/2/3		USB	LCD		CPRI	SYSTEM
PG1													G2IO5	EVENT OUT
PG2													G7IO5	EVENT OUT
PG3													G7IO6	EVENT OUT
PG4													G7IO7	EVENT OUT
PG5														EVENT OUT
PG6														EVENT OUT
PG7														EVENT OUT
PG8														EVENT OUT
PG9														EVENT OUT
PG10														EVENT OUT
PG11														EVENT OUT
PG12														EVENT OUT
PG13														EVENT OUT
PG14														EVENT OUT
PG15														EVENT OUT
PH0OSC_ IN	OSC_IN													
PH1OSC_ OUT	OSC_OUT													
PH2														

5 Memory mapping

Figure 6. 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 °C and T_A = $T_A$max (given by the selected temperature range).

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

6.1.2 Typical values

Unless otherwise specified, typical data are based on T_A = 25 °C, V_{DD} = 3.6 V (for the 1.65 V $\leq V_{DD} \leq$3.6 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 (mean±2Σ).

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 7*.

6.1.5 Pin input voltage

The input voltage measurement on a pin of the device is described in *Figure 8*.

Figure 7. Pin loading conditions

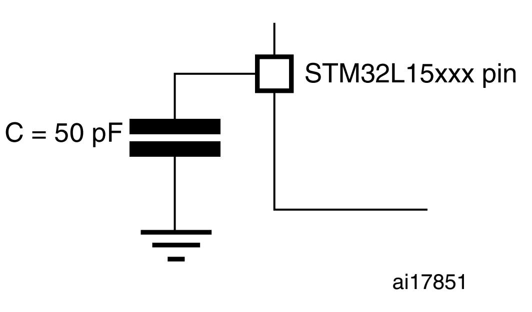
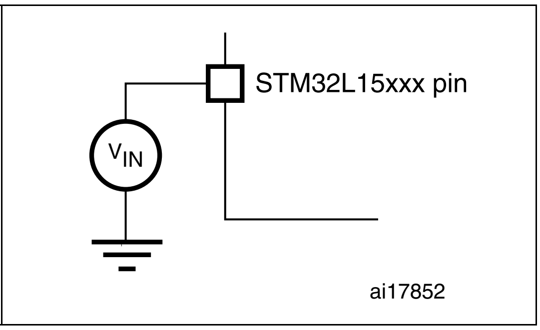
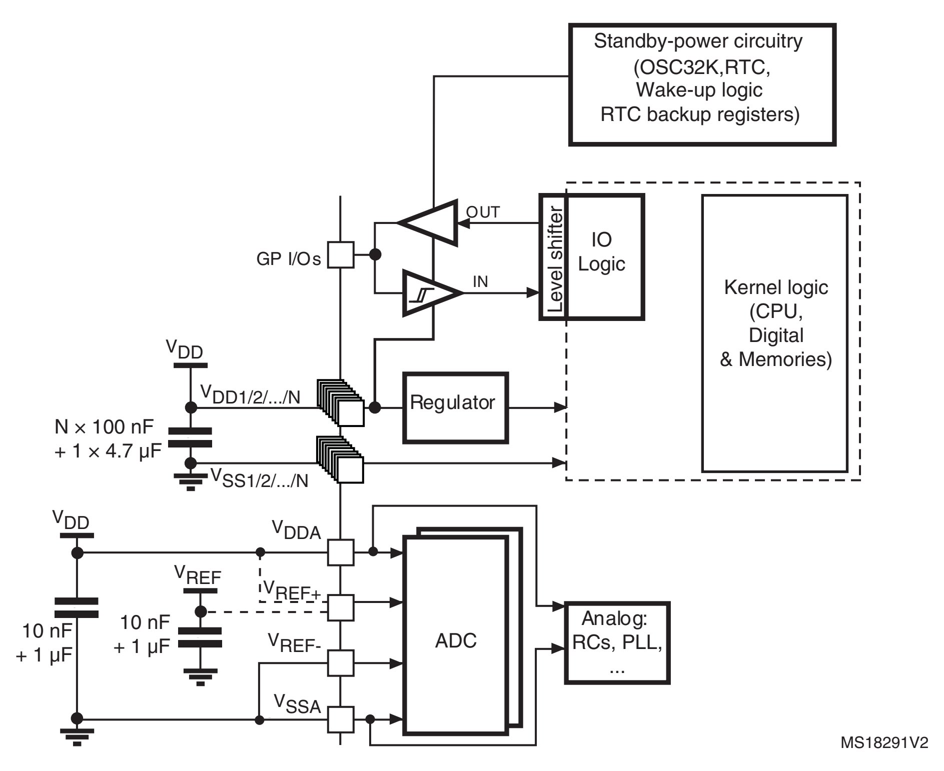


Figure 8. Pin input voltage



6.1.6 Power supply scheme

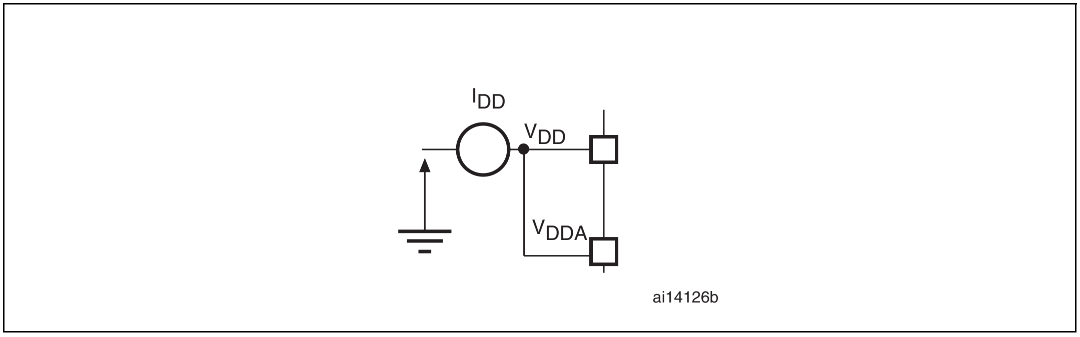
Figure 9. Power supply scheme



Caution: In this figure, the 4.7 µF capacitor must be connected to V_{DD2}.

6.1.7 Current consumption measurement

Figure 10. Current consumption measurement scheme



6.2 Absolute maximum ratings

Stresses above the absolute maximum ratings listed in *Table 8: Voltage characteristics*, *Table 9: Current characteristics*, and *Table 10: 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 8. 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		50	
$V_{ESD(HBM)}$	Electrostatic discharge voltage (human body model)	see *Section 6.3.10*		

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 9* for maximum allowed injected current values.

Table 9. Current characteristics

Symbol	Ratings	Max.	Unit
I_{VDD}	Total current into V_{DD}/V_{DDA} power lines (source)(1)	80	mA
I_{VSS}	Total current out of V_{SS} ground lines (sink)(1)	80	
I_{IO}	Output current sunk by any I/O and control pin	25	
	Output current sourced by any I/O and control pin	- 25	
$I_{INJ(PIN)}$ (2)	Injected current on five-volt tolerant I/O(3)	+0 /-5	
	Injected current on any other pin (4)	± 5	
$\Sigma I_{INJ(PIN)}$	Total injected current (sum of all I/O and control pins)(5)	± 25	

1. All main power (V_{DD}, V_{DDA}) and ground (V_{SS}, V_{SSA}) pins must always be connected to the external power supply, in the permitted range.
2. Negative injection disturbs the analog performance of the device. See note in *Section 6.3.16*.
3. 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 8* for maximum allowed input voltage values.
4. A positive injection is induced by $V_{IN} > V_{DD}$ while a negative injection is induced by $V_{IN} < V_{SS}$. $I_{INJ(PIN)}$ must never be exceeded. Refer to *Table 8: Voltage characteristics* for the maximum allowed input voltage values.
5. When several inputs are submitted to a current injection, the maximum $\Sigma I_{INJ(PIN)}$ is the absolute sum of the positive and negative injected currents (instantaneous values).

Table 10. Thermal characteristics

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

6.3 Operating conditions

6.3.1 General operating conditions

Table 11. 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	
P_D	Power dissipation at T_A = 85 °C(3)			290	mW
T_A	Temperature range	Maximum power dissipation	–40	85	°C
		Low power dissipation(4)	–40	105	
T_J	Junction temperature range	-40 °C ≤ T_A ≤ 105 °C	–40	105	°C

1. When the ADC is used, refer to *Table 51: ADC characteristics*.
2. It is recommended to power V_{DD} and V_{DDA} from the same source. A maximum difference of 300 mV between V_{DD} and V_{DDA} can be tolerated during power-up and operation.
3. If T_A is lower, higher P_D values are allowed as long as T_J does not exceed T_J max (see *Table 65: Thermal characteristics on page 105*).
4. In low power dissipation state, T_A can be extended to this range as long as T_J does not exceed T_J max (see *Table 65: Thermal characteristics on page 105*).

Table 12. Functionalities depending on the operating power supply range

	Functionalities depending on the operating power supply range				
Operating power supply range	**DAC and ADC operation**	**USB**	**V_{CORE}**	**Maximum CPU frequency (f_{CPU} max)**	**I/O operation**
V_{DD} = 1.65 to 1.8 V	Not functional	Not functional	Range 2 or range 3	16 MHz (1ws) 8MHz (0ws)	Degraded speed performance
V_{DD} = 1.8 to 2.0 V	Conversion time up to 500 Ksps	Not functional	Range 2 or range 3	16 MHz (1ws) 8MHz (0ws)	Degraded speed performance
V_{DD} = 2.0 to 2.4 V	Conversion time up to 500 Ksps	Functional(1)	Range 1, range 2 or range 3	32 MHz (1ws) 16MHz (0ws)	Full speed operation
V_{DD} = 2.4 to 3.6 V	Conversion time up to 1 Msps	Functional(1)	Range 1, range 2 or range 3	32 MHz (1ws) 16MHz (0ws)	Full speed operation

1. To be USB compliant from the IO voltage standpoint, the minimum V_{DD} is 3.0 V.

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 *Table 11*.

Table 13. 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	0.4	0.7	1.6	

Table 13. Embedded reset and power control block characteristics (continued)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$V_{POR/PDR}$	Power on/power down reset threshold	Falling edge	1	1.5	1.65	V
		Rising edge	1.3	1.5	1.65	
V_{BOR0}	Brown-out reset threshold 0	Falling edge	1.67	1.7	1.74	
		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	
		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 characterisation, not tested in production.

6.3.3 Embedded internal reference voltage

The parameters given in *Table 14* are based on characterization results, unless otherwise specified.

Table 14. Embedded internal reference voltage

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$V_{REFINT\ out}$(1)	Internal reference voltage	$-40\ °C < T_J < +105\ °C$	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	$-40\ °C < T_J < +105\ °C$		20	50	ppm/°C
		$0\ °C < T_J < +50\ °C$			20	
A_{Coeff}(3)	Long-term stability	1000 hours, T= 25 °C			1000	ppm
VDDCoeff(3)	Voltage coefficient	$3.0\ V < V_{DDA} < 3.6\ V$			2000	ppm/V
$T_{S\_vrefint}$(3)(4)	ADC sampling time when reading the internal reference voltage			5	10	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. Tested in production;
2. The internal V_{REF} value is individually measured in production and stored in dedicated EEPROM bytes.
3. Guaranteed by design, not tested in production.
4. Shortest sampling time can be determined in the application by multiple iterations.
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 10: Current consumption measurement scheme*.

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

Maximum current consumption

The MCU is placed under the following conditions:

- V_{DD} = 3.6 V
- All I/O pins are in input mode with a static value at V_{DD} or V_{SS} (no load)
- All peripherals are disabled except when explicitly mentioned
- The Flash memory access time is adjusted depending on f_{HCLK} frequency and voltage range
- Prefetch and 64-bit access are enabled in configurations with 1 wait state

The parameters given in *Table 15*, *Table 11* and *Table 13* are derived from tests performed under ambient temperature and V_{DD} supply voltage conditions summarized in *Table 11*.

Table 15. Current consumption in Run mode, code with data processing running from Flash

Symbol	Parameter	Conditions		f_{HCLK}	Typ	Max(1)			Unit
						55 °C	85 °C	105 °C	
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	360	500	500	500	µA
				2 MHz	620	750	750	750	
				4 MHz	1070	1200	1200	1200	
			Range 2, V_{CORE}=1.5 V VOS[1:0] = 10	4 MHz	1.30	1.6	1.6	1.6	mA
				8 MHz	2.4	2.9	2.9	2.9	
				16 MHz	4.6	5.2	5.2	5.2	
			Range 1, V_{CORE}=1.8 V VOS[1:0] = 01	8 MHz	2.9	3.5	3.5	3.5	
				16 MHz	5.7	6.5	6.5	6.5	
				32 MHz	10.4	12	12	12	
		HSI clock source (16 MHz)	Range 2, V_{CORE}=1.5 V VOS[1:0] = 10	16 MHz	4.5	5.2	5.2	5.2	
			Range 1, V_{CORE}=1.8 V VOS[1:0] = 01	32 MHz	10.9	12.3	12.3	12.3	
		MSI clock, 65 kHz	Range 3, V_{CORE}=1.2 V VOS[1:0] = 11	65 kHz	0.05	0.079	0.092	0.13	
		MSI clock, 524 kHz		524 kHz	0.17	0.2	0.21	0.25	
		MSI clock, 4.2 MHz		4.2 MHz	1.0	1.1	1.1	1.2	

1. Based on characterization, not tested in production, unless otherwise specified.
2. Oscillator bypassed (HSEBYP = 1 in RCC_CR register).

Table 16. Current consumption in Run mode, code with data processing running from RAM

Symbol	Parameter	Conditions		f_{HCLK}	Typ	Max(1)			Unit
						55 °C	85 °C	105 °C	
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	310	470	470	470	µA
				2 MHz	590	780	780	780	
				4 MHz	1030	1200	1200	1200(3)	
			Range 2, V_{CORE}=1.5 V VOS[1:0] = 10	4 MHz	1.2	1.5	1.5	1.5	mA
				8 MHz	2.3	3	3	3	
				16 MHz	4.3	5	5	5	
			Range 1, V_{CORE}=1.8 V VOS[1:0] = 01	8 MHz	2.7	3.5	3.5	3.5	
				16 MHz	5.0	5.55	5.55	5.55	
				32 MHz	9.8	10.9	10.9	10.9	
		HSI clock source (16 MHz)	Range 2, V_{CORE}=1.5 V VOS[1:0] = 10	16 MHz	4.3	4.8	4.8	4.8	
			Range 1, V_{CORE}=1.8 V VOS[1:0] = 01	32 MHz	10.1	11.7	11.7	11.7	
		MSI clock, 65 kHz	Range 3, V_{CORE}=1.2 V VOS[1:0] = 11	65 kHz	40	48.5	63	100	µA
		MSI clock, 524 kHz		524 kHz	148	175	183	215	
		MSI clock, 4.2 MHz		4.2 MHz	990	1032	1034	1100	

1. Based on characterization, not tested in production, unless otherwise specified.
2. Oscillator bypassed (HSEBYP = 1 in RCC_CR register).
3. Tested in production.

Table 17. Current consumption in Sleep mode

Symbol	Parameter	Conditions		f_{HCLK}	Typ	Max(1)			Unit
						55 °C	85 °C	105 °C	
I_{DD} (Sleep)	Supply current in Sleep 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	180	220	220	220	µA
				2 MHz	225	300	300	300	
				4 MHz	300	380	380	380(3)	
			Range 2, V_{CORE}=1.5 V VOS[1:0] = 10	4 MHz	360	500	500	500	
				8 MHz	570	700	700	700	
				16 MHz	990	1100	1100	1100	
			Range 1, V_{CORE}=1.8 V VOS[1:0] = 01	8 MHz	675	800	800	800	
				16 MHz	1150	1250	1250	1250	
				32 MHz	2300	2700	2700	2700	
		HSI clock source (16 MHz)	Range 2, V_{CORE}=1.5 V VOS[1:0] = 10	16 MHz	1025	1100	1100	1100	
			Range 1, V_{CORE}=1.8 V VOS[1:0] = 01	32 MHz	2460	2700	2700	2700	
		MSI clock, 65 kHz	Range 3, V_{CORE}=1.2 V VOS[1:0] = 11	65 kHz	30	36	46	72	
		MSI clock, 524 kHz		524 kHz	50	58	67	92	
		MSI clock, 4.2 MHz		4.2 MHz	210	245	251	273	
	Supply current in Sleep mode, code executed from Flash	HSE = 16 MHz(2) (PLL ON for f_{HCLK} above 16 MHz)	Range 3, V_{CORE}=1.2 V VOS[1:0] = 11	1 MHz	190	250	250	250	µA
				2 MHz	235	300	300	300	
				4 MHz	315	380	380	380	
			Range 2, V_{CORE}=1.5 V VOS[1:0] = 10	4 MHz	390	500	500	500	
				8 MHz	600	700	700	700	
				16 MHz	1000	1120	1120	1120	
			Range 1, V_{CORE}=1.8 V VOS[1:0] = 01	8 MHz	690	800	800	800	
				16 MHz	1160	1300	1300	1300	
				32 MHz	2310	2700	2700	2700	
		HSI clock source (16 MHz)	Range 2, V_{CORE}=1.5 V VOS[1:0] = 10	16 MHz	1040	1160	1160	1160	
			Range 1, V_{CORE}=1.8 V VOS[1:0] = 01	32 MHz	2500	2800	2800	2800	
I_{DD} (Sleep)	Supply current in Sleep mode, code executed from Flash	MSI clock, 65 kHz	Range 3, V_{CORE}=1.2V VOS[1:0] = 11	65 kHz	42	50	60	90	µA
		MSI clock, 524 kHz		524 kHz	63	72	82	110	
		MSI clock, 4.2 MHz		4.2 MHz	230	263	265	290	

1. Based on characterization, not tested in production, unless otherwise specified.
2. Oscillator bypassed (HSEBYP = 1 in RCC_CR register)
3. Tested in production.

Table 18. 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	11	14	µA
				T_A = 85 °C	26	32	
				T_A = 105 °C	53	72	
			MSI clock, 65 kHz f_{HCLK} = 65 kHz	T_A =-40 °C to 25 °C	18	21	
				T_A = 85 °C	33	40	
				T_A = 105 °C	60	78	
			MSI clock, 131 kHz f_{HCLK} = 131 kHz	T_A = -40 °C to 25 °C	36	41	
				T_A = 55 °C	39	44	
				T_A = 85 °C	50	58	
				T_A = 105 °C	78	95	
		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	36	40.5	
				T_A = 85 °C	53	60	
				T_A = 105 °C	81	100	
			MSI clock, 65 kHz f_{HCLK} = 65 kHz	T_A = -40 °C to 25 °C	44	49	
				T_A = 85 °C	61	67	
				T_A = 105 °C	89	107	
			MSI clock, 131 kHz f_{HCLK} = 131 kHz	T_A = -40 °C to 25 °C	64	71	
				T_A = 55 °C	68	73	
				T_A = 85 °C	80	88	
				T_A = 105 °C	101	110	
I_{DD} max (LP Run)	Max allowed current in Low power run mode	V_{DD} from 1.65 V to 3.6 V				200	

1. Based on characterization, not tested in production, unless otherwise specified.

Table 19. 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	4.4		µA
			MSI clock, 65 kHz f_{HCLK} = 32 kHz Flash ON	T_A = -40 °C to 25 °C	18	21	
				T_A = 85 °C	24	27	
				T_A = 105 °C	35	43	
			MSI clock, 65 kHz f_{HCLK} = 65 kHz, Flash ON	T_A = -40 °C to 25 °C	18.6	21	
				T_A = 85 °C	24.5	28	
				T_A = 105 °C	35	42	
			MSI clock, 131 kHz f_{HCLK} = 131 kHz, Flash ON	T_A = -40 °C to 25 °C	22	25	
				T_A = 55 °C	23.5	26	
				T_A = 85 °C	28.5	31	
				T_A = 105 °C	39	45	
		TIM9 and USART1 enabled, Flash ON, 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	18	20.5	
				T_A = 85 °C	24	27	
				T_A = 105 °C	35	43	
			MSI clock, 65 kHz f_{HCLK} = 65 kHz	T_A = -40 °C to 25 °C	18.6	21	
				T_A = 85 °C	24.5	28	
				T_A = 105 °C	35	42	
			MSI clock, 131 kHz f_{HCLK} = 131 kHz	T_A = -40 °C to 25 °C	22	25	
				T_A = 55 °C	23.5	26	
				T_A = 85 °C	28.5	31	
				T_A = 105 °C	39	45	
I_{DD} max (LP Sleep)	Max allowed current in Low power Sleep mode	V_{DD} from 1.65 V to 3.6 V				200	

1. Based on characterization, not tested in production, unless otherwise specified.

Table 20. Typical and maximum current consumptions in Stop mode

Symbol	Parameter	Conditions			Typ	Max(1)	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°C to 25°C	1.7	4	μA
				T_A = 55°C	2.7	6	
				T_A= 85°C	7	10	
				T_A = 105°C	15	23	
			LCD ON (static duty)(2)	T_A = -40°C to 25°C	3.8	6	
				T_A = 55°C	4.7	7	
				T_A= 85°C	9	12	
				T_A = 105°C	19	27	
			LCD ON (1/8 duty)(3)	T_A = -40°C to 25°C	7.8	10	
				T_A = 55°C	8.5	11	
				T_A= 85°C	13	16	
				T_A = 105°C	26	44	
		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°C to 25°C	TBD	TBD	
				T_A = 55°C	TBD	TBD	
				T_A= 85°C	TBD	TBD	
				T_A = 105°C	TBD	TBD	
			LCD ON (static duty)(2)	T_A = -40°C to 25°C	TBD	TBD	
				T_A = 55°C	TBD	TBD	
				T_A= 85°C	TBD	TBD	
				T_A = 105°C	TBD	TBD	
			LCD ON (1/8 duty)(3)	T_A = -40°C to 25°C	TBD	TBD	
				T_A = 55°C	TBD	TBD	
				T_A= 85°C	TBD	TBD	
				T_A = 105°C	TBD	TBD	
		RTC clocked by LSE (no independent watchdog)(4)	LCD OFF	T_A = -40°C to 25°C V_{DD} = 1.8V	TBD		
				T_A = -40°C to 25°C V_{DD} = 3.0V	TBD		
				T_A = -40°C to 25°C V_{DD} = 3.6V	TBD		
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	1.6	2.2	μA
		Regulator in LP mode, LSI, HSI and HSE OFF (no independent watchdog)		T_A = -40°C to 25°C	0.65	1	
				T_A = 55°C	1.6	3	
				T_A= 85°C	6	9	
				T_A = 105°C	14	22(5)	

Table 20. Typical and maximum current consumptions in Stop mode (continued)

Symbol	Parameter	Conditions		Typ	Max(1)	Unit
I_{DD} (WU from Stop)	Supply current during wakeup from Stop mode	MSI = 4.2 MHz	T_A = -40°C to 25°C	TBD		mA
		MSI = 1.05 MHz		TBD		
		MSI = 65 kHz		TBD		

1. Based on characterization, not tested in production, unless otherwise specified
2. LCD enabled with external VLCD, static duty, division ratio = 256, all pixels active, no LCD connected
3. LCD enabled with external VLCD, 1/4 duty, 1/3 bias, division ratio = 64, all pixels active, no LCD connected.
4. Based on characterization done with a 32.768 kHz crystal (MC306-G-06Q-32.768, manufacturer JFVNY) with two 6.8 pF loading capacitors.
5. Tested in production.

Table 21. Typical and maximum current consumptions in Standby mode

Symbol	Parameter	Conditions		Typ	Max(1)	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	1.3	1.9	µA
			T_A = 55 °C	1.5	2.2	
			T_A= 85 °C	2.15	4	
			T_A = 105 °C	3.8	8.3(2)	
		RTC clocked by LSE (no independent watchdog)(3)	T_A = -40 °C to 25 °C	TBD		
			T_A = 55 °C	TBD		
			T_A= 85 °C	TBD		
			T_A = 105 °C	TBD		
I_{DD} (Standby)	Supply current in Standby mode (RTC disabled)	Independent watchdog and LSI enabled	T_A = -40 °C to 25 °C	1.3	1.7	
		Independent watchdog and LSI OFF	T_A = -40 °C to 25 °C	0.35	0.6	
			T_A = 55 °C	0.47	0.9	
			T_A = 85 °C	1.2	2.75	
			T_A = 105 °C	2.9	7(2)	
I_{DD} (WU from Standby)	Supply current during wakeup from Standby mode		T_A = -40 °C to 25 °C	TBD		

1. Based on characterization, not tested in production, unless otherwise specified
2. Tested in production.
3. Based on characterization done with a 32.768 kHz crystal (MC306-G-06Q-32.768, manufacturer JFVNY) with two 6.8pF loading capacitors.

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 11*.

Table 22. Typical and maximum timings in Low power modes

Symbol	Parameter	Conditions	Typ	Max[1]	Unit
$t_{WUSLEEP}$	Wakeup from Sleep mode	f_{HCLK} = 32 MHz	0.4		µs
$t_{WUSLEEP\_LP}$	Wakeup from Low power sleep mode f_{HCLK} = 262 kHz	f_{HCLK} = 262 kHz Flash enabled	46		
		f_{HCLK} = 262 kHz Flash switched OFF	46		
t_{WUSTOP}	Wakeup from Stop mode, regulator in Run mode	f_{HCLK} = f_{MSI} = 4.2 MHz	TBD		
	Wakeup from Stop mode, regulator in low power mode	f_{HCLK} = f_{MSI} = 4.2 MHz Voltage range 1 and 2	7.7	8.9	
		f_{HCLK} = f_{MSI} = 4.2 MHz Voltage range 3	8.2	13.1	
		f_{HCLK} = f_{MSI} = 2.1 MHz	10.2	13.4	
		f_{HCLK} = f_{MSI} = 1.05 MHz	16	20	
		f_{HCLK} = f_{MSI} = 524 kHz	31	37	
		f_{HCLK} = f_{MSI} = 262 kHz	57	66	
		f_{HCLK} = f_{MSI} = 131 kHz	112	123	
		f_{HCLK} = MSI = 65 kHz	221	236	
$t_{WUSTDBY}$	Wakeup from Standby mode FWU bit = 1	f_{HCLK} = MSI = 2.1 MHz	58	104	
	Wakeup from Standby mode FWU bit = 0	f_{HCLK} = MSI = 2.1 MHz	2.6	3.25	ms

1. Based on characterization, not tested in production, unless otherwise specified

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

6.3.5 External clock source characteristics

High-speed external user clock generated from an external source

Table 23. High-speed external user clock characteristics[1]

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
f_{HSE_ext}	User external clock source frequency		1	8	32	MHz
V_{HSEH}	OSC_IN input pin high level voltage		$0.7V_{DD}$		V_{DD}	V
V_{HSEL}	OSC_IN input pin low level voltage		V_{SS}		$0.3V_{DD}$	
$t_{w(HSE)}$ $t_{w(HSE)}$	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
$DuCy_{(HSE)}$	Duty cycle		45		55	%
I_L	OSC_IN Input leakage current	$V_{SS} \leq V_{IN} \leq V_{DD}$			±1	µA

1. Guaranteed by design, not tested in production.

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 11*.

Table 24. Low-speed external user clock characteristics(1)

Symbol	Parameter	Conditions	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
V_{LSEL}	OSC32_IN input pin low level voltage		V_{SS}		$0.3V_{DD}$	
$t_{w(LSE)}$ $t_{w(LSE)}$	OSC32_IN high or low time		TBD			ns
$t_{r(LSE)}$ $t_{f(LSE)}$	OSC32_IN rise or fall time				TBD	
$C_{IN(LSE)}$	OSC32_IN input capacitance			0.6		pF
$DuCy_{(LSE)}$	Duty cycle		TBD		TBD	%
I_L	OSC32_IN Input leakage current	$V_{SS} \leq V_{IN} \leq V_{DD}$			±1	µA

1. Guaranteed by design, not tested in production

Figure 11. Low-speed external clock source AC timing diagram

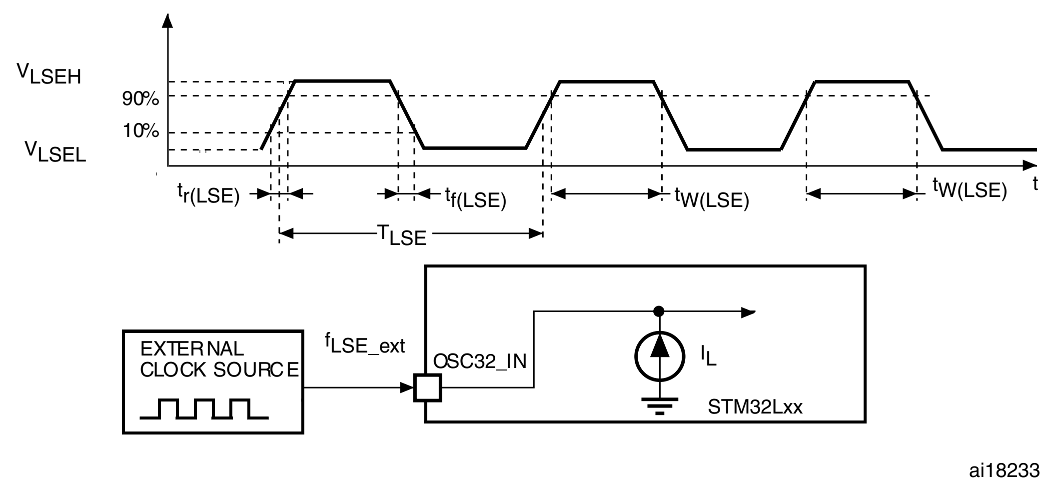
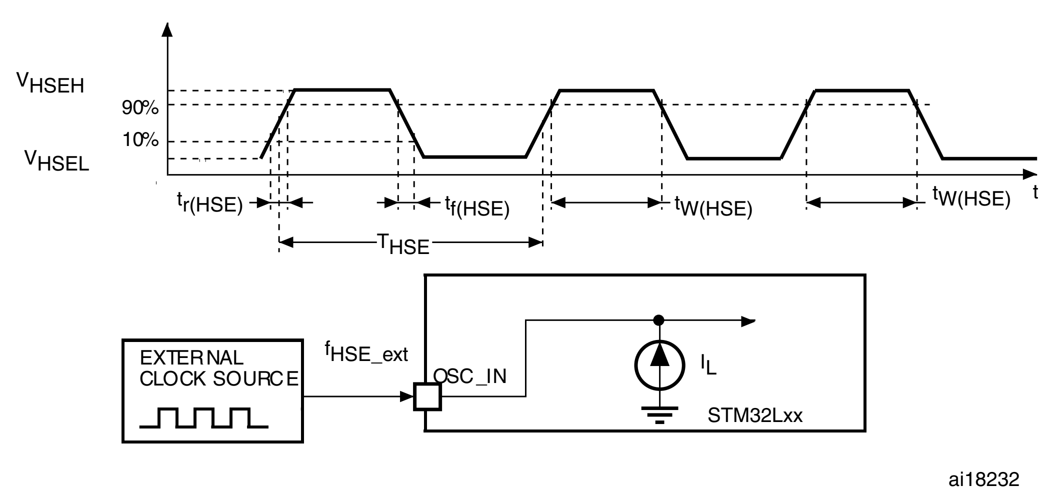


Figure 12. High-speed external clock source AC timing diagram



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 25*. 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).

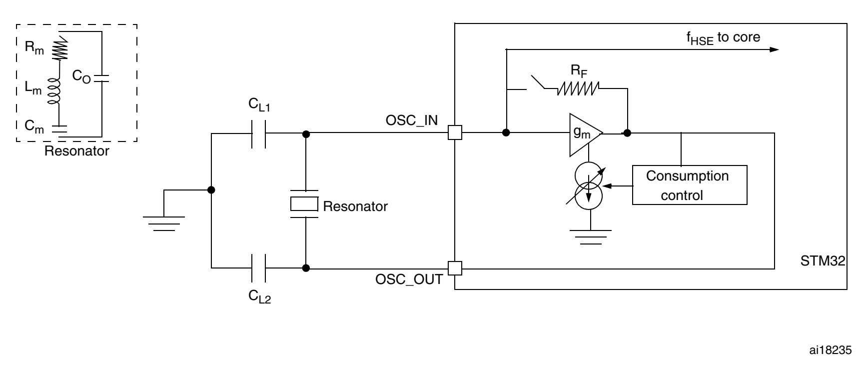
Table 25. HSE 1-24 MHz oscillator characteristics(1)(2)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
f_{OSC_IN}	Oscillator frequency		1		24	MHz
R_F	Feedback resistor			200		kΩ
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. Based on characterization results, not tested in production.
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 13*). 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 13. HSE oscillator circuit diagram



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

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

The low-speed external (LSE) clock can be supplied with a 32.768 kHz crystal/ceramic resonator oscillator. All the information given in this paragraph are based on characterization results obtained with typical external components specified in *Table 26*. 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 26. LSE oscillator characteristics (f_{LSE} = 32.768 kHz)(1)

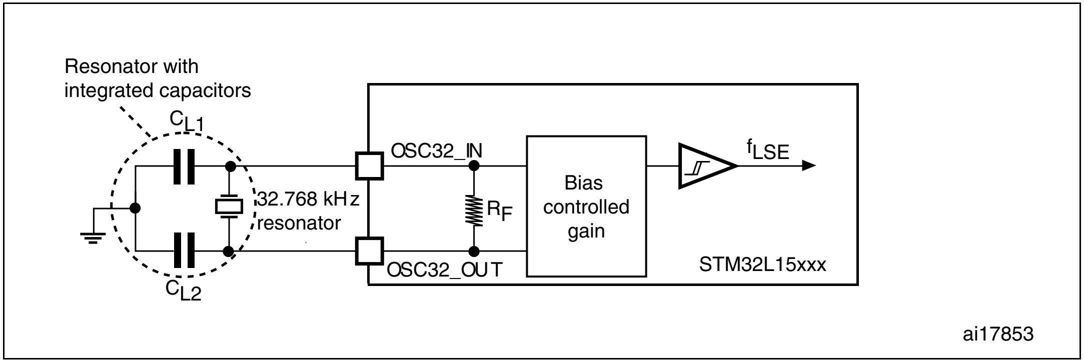
Symbol	Parameter	Conditions	Min	Typ	Max	Unit
f_{LSE}	Low speed external oscillator frequency			32.768		kHz
R_F	Feedback resistor			1.2		MΩ
C(2)	Recommended load capacitance versus equivalent serial resistance of the crystal (R_S)(3)	R_S = 30 kΩ		8		pF
I_{LSE}	LSE driving current	V_{DD} = 3.3 V, V_{IN}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

1. Based on characterization, not tested in production.
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 an 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 C_{L1} and C_{L2}, it is recommended to use high-quality ceramic capacitors in the 5 pF to 15 pF range selected to match the requirements of the crystal or resonator (see Figure 14). C_{L1} and C_{L2}, are usually the same size. The crystal manufacturer typically specifies a load capacitance which is the series combination of C_{L1} and C_{L2}.*
Load capacitance C_L has the following formula: $C_L = C_{L1} \times C_{L2} / (C_{L1} + C_{L2}) + C_{stray}$ where C_{stray} is the pin capacitance and board or trace PCB-related capacitance. Typically, it is between 2 pF and 7 pF.

Caution: To avoid exceeding the maximum value of C_{L1} and C_{L2} (15 pF) it is strongly recommended to use a resonator with a load capacitance $C_L \leq 7$ pF. Never use a resonator with a load capacitance of 12.5 pF.
Example: if you choose a resonator with a load capacitance of C_L = 6 pF and C_{stray} = 2 pF, then $C_{L1} = C_{L2}$ = 8 pF.

Figure 14. Typical application with a 32.768 kHz crystal



6.3.6 Internal clock source characteristics

The parameters given in *Table 27* are derived from tests performed under ambient temperature and V_{DD} supply voltage conditions summarized in *Table 11*.

High-speed internal (HSI) RC oscillator

Table 27. HSI oscillator characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
f_{HSI}	Frequency	V_{DD} = 3.0 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 V, T_A = 25 °C	-1(3)		1(3)	%
		V_{DDA} = 3.0 V, T_A = 0 to 55 °C	-1.5		1.5	%
		V_{DDA} = 3.0 V, T_A = -10 to 70 °C	-2		2	%
		V_{DDA} = 3.0 V, T_A = -10 to 85 °C	-2.5		2	%
		V_{DDA} = 3.0 V, T_A = -10 to 105 °C	-4		2	%
		V_{DDA} = 1.65 V to 3.6 V T_A = -40 to 105 °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. Based on characterization, not tested in production.
3. Tested in production.

Low-speed internal (LSI) RC oscillator

Table 28. 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°C ≤ T_A ≤ 85°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. Tested in production.
2. This is a deviation for an individual part, once the initial frequency has been measured.
3. Guaranteed by design, not tested in production.

Multi-speed internal (MSI) RC oscillator

Table 29. MSI oscillator characteristics

Symbol	Parameter	Condition	Typ	Max	Unit
f_{MSI}	Frequency after factory calibration, done at V_{DD}= 3.3 V and T_A = 25 °C	MSI range 0	65.5		kHz
		MSI range 1	131		
		MSI range 2	262		
		MSI range 3	524		
		MSI range 4	1.05		MHz
		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 °C ≤ T_A ≤ 85 °C		±3		%
$D_{VOLT(MSI)}$(1)	MSI oscillator frequency drift 1.65 V ≤ V_{DD} ≤ 3.6 V, T_A = 25 °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		

Table 29. MSI oscillator characteristics (continued)

Symbol	Parameter	Condition	Typ	Max	Unit
$t_{SU(MSI)}$	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		
$t_{STAB(MSI)}$(2)	MSI oscillator stabilization time	MSI range 0		40	
		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	
$f_{OVER(MSI)}$	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. Based on characterization, not tested in production.

6.3.7 PLL characteristics

The parameters given in *Table 30* are derived from tests performed under ambient temperature and V_{DD} supply voltage conditions summarized in *Table 11*.

Table 30. PLL characteristics

Symbol	Parameter	Value			Unit
		Min	Typ	Max[1]	
f_{PLL_IN}	PLL input clock[2]	2		24	MHz
	PLL input clock duty cycle	45		55	%
f_{PLL_OUT}	PLL output clock	2		32	MHz
t_{LOCK}	Worst case PLL lock time PLL input = 2 MHz PLL VCO = 96 MHz		100	130	μs
Jitter	Cycle-to-cycle jitter			±600	ps
I_{DDA}(PLL)	Current consumption on V_{DDA}		220	450	μA
I_{DD}(PLL)	Current consumption on V_{DD}		120	150	

1. Based on characterization, not tested in production.
2. Take care of using the appropriate multiplier factors so as to have PLL input clock values compatible with the range defined by f_{PLL_OUT}.

6.3.8 Memory characteristics

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

RAM memory

Table 31. 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

Table 32. Flash memory characteristics

Symbol	Parameter	Conditions	Min	Typ	Max(1)	Unit
V_{DD}	Operating voltage Read / Write / Erase		1.65		3.6	V
t_{prog}	Programming time for word or half-page	Erasing		3.28	3.94	ms
		Programming		3.28	3.94	
I_{DD}	Average current during the whole programming / erase operation	T_A = 25 °C, V_{DD} = 3.6 V		600	TBD	µA
	Maximum current (peak) during the whole programming / erase operation			1.5	TBD	mA

1. Guaranteed by design, not tested in production.

Table 33. Flash memory endurance and data retention

Symbol	Parameter	Conditions	Value			Unit
			Min(1)	Typ	Max	
N_{CYC}(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	T_{RET} = +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	T_{RET} = +105 °C	10			
	Data retention (EEPROM data memory) after 300 kcycles at T_A = 105 °C		10			

1. Based on characterization not tested in production.
2. Characterization is done according to JEDEC JESD22-A117.

6.3.9 EMC characteristics

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

Functional EMS (electromagnetic susceptibility)

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

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

A device reset allows normal operations to be resumed.

The test results are given in *Table 34*. They are based on the EMS levels and classes defined in application note AN1709.

Table 34. 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 V, LQFP100, T_A = +25 °C, f_{HCLK} = 32 MHz conforms to IEC 61000-4-2	2B
V_{EFTB}	Fast transient voltage burst limits to be applied through 100 pF on V_{DD} and V_{SS} pins to induce a functional disturbance	V_{DD} = 3.3 V, LQFP100, T_A = +25 °C, f_{HCLK} = 32 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 35. 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	3	-6	-5	dBµV
			30 to 130 MHz	18	4	-7	
			130 MHz to 1GHz	15	5	-7	
			SAE EMI Level	2.5	2	1	-

6.3.10 Absolute maximum ratings (electrical sensitivity)

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

Electrostatic discharge (ESD)

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

Table 36. ESD absolute maximum ratings

Symbol	Ratings	Conditions	Class	Maximum value[1]	Unit
$V_{ESD(HBM)}$	Electrostatic discharge voltage (human body model)	$T_A = +25$ °C, conforming to JESD22-A114	2	2000	V
$V_{ESD(CDM)}$	Electrostatic discharge voltage (charge device model)	$T_A = +25$ °C, conforming to JESD22-C101	II	500	

1. Based on characterization results, not tested in production.

Static latch-up

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

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

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

Table 37. Electrical sensitivities

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

6.3.11 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, out of spec current injection on adjacent pins or other functional failure (for example reset, oscillator frequency deviation, LCD levels, etc.).

The test results are given in the following table.

Table 38. I/O current injection susceptibility

Symbol	Description	Functional susceptibility		Unit
		Negative injection	Positive injection	
I_{INJ}	Injected current on true open-drain pins	-5	+0	mA
	Injected current on all 5 V tolerant (FT) pins	-5	+0	
	Injected current on any other pin	-5	+5	

6.3.12 I/O port characteristics

General input/output characteristics

Unless otherwise specified, the parameters given in *Table 39* are derived from tests performed under the conditions summarized in *Table 11*. All I/Os are CMOS and TTL compliant.

Table 39. I/O static characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{IL}	Input low level voltage	TTL ports 2.7 V $\leq V_{DD} \leq$ 3.6 V	V_{SS} - 0.3		0.8	V
V_{IH}	Standard I/O input high level voltage		2(1)		V_{DD}+0.3	
	FT(2) I/O input high level voltage				5.5V	
V_{IL}	Input low level voltage	CMOS ports 1.65 V $\leq V_{DD} \leq$ 3.6 V	–0.3		0.3V_{DD}(3)	
V_{IH}	Standard I/O Input high level voltage	CMOS ports 1.65 V $\leq V_{DD} \leq$ 3.6 V	0.7 V_{DD}(3)(4)		V_{DD}+0.3	
	FT(5) I/O input high level voltage	CMOS ports 1.65 V $\leq V_{DD} \leq$ 2.0 V			5.25	
		CMOS ports 2.0 V $\leq V_{DD} \leq$ 3.6 V			5.5	
V_{hys}	Standard I/O Schmitt trigger voltage hysteresis(6)		10% V_{DD}(7)			
I_{lkg}	Input leakage current (8)(3)	$V_{SS} \leq V_{IN} \leq V_{DD}$ I/Os with LCD			±50	nA
		$V_{SS} \leq V_{IN} \leq V_{DD}$ I/Os with analog switches			±50	
		$V_{SS} \leq V_{IN} \leq V_{DD}$ I/Os with analog switches and LCD			±50	
		$V_{SS} \leq V_{IN} \leq V_{DD}$ I/Os with USB			TBD	
		$V_{SS} \leq V_{IN} \leq V_{DD}$ Standard I/Os			±50	
R_{PU}	Weak pull-up equivalent resistor(9)(3)	$V_{IN} = V_{SS}$	30	45	60	kΩ
R_{PD}	Weak pull-down equivalent resistor(9)(3)	$V_{IN} = V_{DD}$	30	45	60	kΩ
C_{IO}	I/O pin capacitance			5		pF

1. Guaranteed by design.
2. FT = 5V tolerant. To sustain a voltage higher than VDD +0.5 the internal pull-up/pull-down resistors must be disabled.
3. Tested in production
4. 0.7V_{DD} for 5V-tolerant receiver
5. FT = Five-volt tolerant.
6. Hysteresis voltage between Schmitt trigger switching levels. Based on characterization, not tested in production.
7. With a minimum of 200 mV. Based on characterization, not tested in production.

8. The max. value may be exceeded if negative current is injected on adjacent pins.
9. Pull-up and pull-down resistors are designed with a true resistance in series with a switchable PMOS/NMOS. This MOS/NMOS contribution to the series resistance is minimum (~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 40*.

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 I_{VDD} (see *Table 9*).
- The sum of the currents sunk by all the I/Os on V_{SS} plus the maximum Run consumption of the MCU sunk on V_{SS} cannot exceed the absolute maximum rating I_{VSS} (see *Table 9*).

Output voltage levels

Unless otherwise specified, the parameters given in *Table 40* are derived from tests performed under ambient temperature and V_{DD} supply voltage conditions summarized in *Table 11*. All I/Os are CMOS and TTL compliant.

Table 40. Output voltage characteristics

Symbol	Parameter	Conditions	Min	Max	Unit
V_{OL}(1)(2)	Output low level voltage for an I/O pin when 8 pins are sunk at same time	I_{IO} = +8 mA 2.7 V < V_{DD} < 3.6 V		0.4	V
V_{OH}(3)(2)	Output high level voltage for an I/O pin when 8 pins are sourced at same time		2.4		
V_{OL} (1)(4)	Output low level voltage for an I/O pin when 8 pins are sunk at same time	I_{IO} =+ 4 mA 1.65 V < V_{DD} < 2.7 V		0.45	
V_{OH} (3)(4)	Output high level voltage for an I/O pin when 8 pins are sourced at same time		V_{DD}-0.45		
V_{OL}(1)(4)	Output low level voltage for an I/O pin when 4 pins are sunk at same time	I_{IO} = +20 mA 2.7 V < V_{DD} < 3.6 V		1.3	
V_{OH}(3)(4)	Output high level voltage for an I/O pin when 4 pins are sourced at same time		V_{DD}-1.3		

1. The I_{IO} current sunk by the device must always respect the absolute maximum rating specified in *Table 9* and the sum of I_{IO} (I/O ports and control pins) must not exceed I_{VSS}.
2. Tested in production.
3. The I_{IO} current sourced by the device must always respect the absolute maximum rating specified in *Table 9* and the sum of I_{IO} (I/O ports and control pins) must not exceed I_{VDD}.
4. Based on characterization data, not tested in production.

Input/output AC characteristics

The definition and values of input/output AC characteristics are given in *Figure 15* and *Table 41*, respectively.

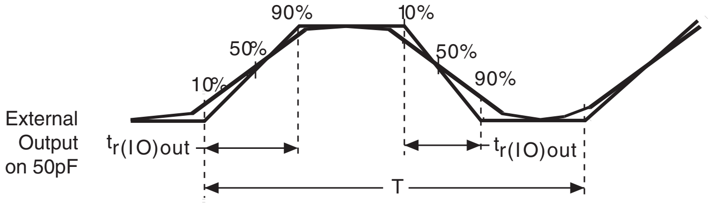
Unless otherwise specified, the parameters given in *Table 41* are derived from tests performed under ambient temperature and V_{DD} supply voltage conditions summarized in *Table 11*.

Table 41. I/O AC characteristics(1)

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

1. The I/O speed is configured using the OSPEEDRx[1:0] bits. Refer to the STM32L15xxx reference manual for a description of GPIO Port configuration register.
2. Guaranteed by design. Not tested in production.
3. The maximum frequency is defined in *Figure 15*.

Figure 15. I/O AC characteristics definition



Maximum frequency is achieved if (t_r + t_f)   2/3)T and if the duty cycle is (45-55%) when loaded by 50 pF

6.3.13 NRST pin characteristics

The NRST pin input driver uses CMOS technology.

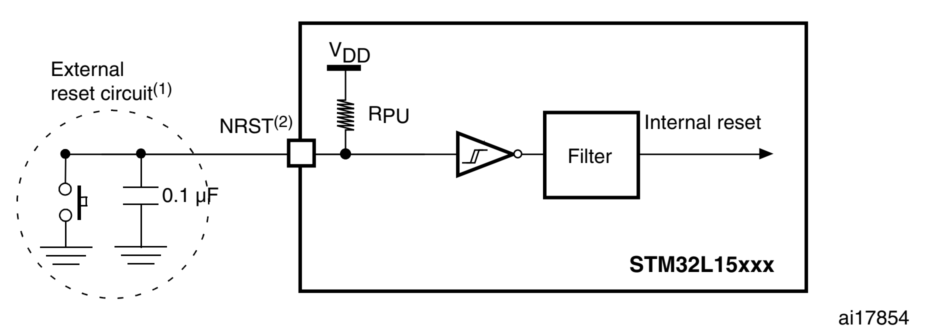
Unless otherwise specified, the parameters given in *Table 42* are derived from tests performed under ambient temperature and V_{DD} supply voltage conditions summarized in *Table 11*.

Table 42. NRST pin characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$V_{IL(NRST)}$(1)	NRST input low level voltage		V_{SS}		0.8	V
$V_{IH(NRST)}$(1)	NRST input high level voltage		1.4		V_{DD}	
$V_{OL(NRST)}$(1)	NRST output low level voltage	I_{OL} = 2 mA 2.7 V < V_{DD} < 3.6 V			0.4	
		I_{OL} = 1.5 mA 1.65 V < V_{DD} < 2.7 V				
$V_{hys(NRST)}$(1)	NRST Schmitt trigger voltage hysteresis		10%V_{DD}(2)			mV
R_{PU}	Weak pull-up equivalent resistor(3)	$V_{IN} = V_{SS}$	30	45	60	kΩ
$V_{F(NRST)}$(1)	NRST input filtered pulse				50	ns
$V_{NF(NRST)}$(1)	NRST input not filtered pulse		350			ns

1. Guaranteed by design, not tested in production.
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 16. Recommended NRST pin protection



1. The reset network protects the device against parasitic resets.
2. The user must ensure that the level on the NRST pin can go below the $V_{IL(NRST)}$ max level specified in *Table 42*. Otherwise the reset will not be taken into account by the device.

6.3.14 TIM timer characteristics

The parameters given in the following table are guaranteed by design.

Refer to *Section 6.3.11: I/O current injection characteristics* for details on the input/output alternate function characteristics (output compare, input capture, external clock, PWM output).

Table 43. TIMx(1) characteristics

Symbol	Parameter	Conditions	Min	Max	Unit
$t_{res(TIM)}$	Timer resolution time		1		$t_{TIMxCLK}$
		$f_{TIMxCLK}$ = 32 MHz	31.25		ns
f_{EXT}	Timer external clock frequency on CH1 to CH4		0	$f_{TIMxCLK}/2$	MHz
		$f_{TIMxCLK}$ = 32 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 MHz	0.0312	2048	µs
t_{MAX_COUNT}	Maximum possible count			65536 × 65536	$t_{TIMxCLK}$
		$f_{TIMxCLK}$ = 32 MHz		134.2	s

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

6.3.15 Communications interfaces

I^2C interface characteristics

Unless otherwise specified, the parameters given in *Table 44* are derived from tests performed under ambient temperature, f_{PCLK1} frequency and V_{DD} supply voltage conditions summarized in *Table 11*.

The product line I^2C interface meets the requirements of the standard I^2C 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.

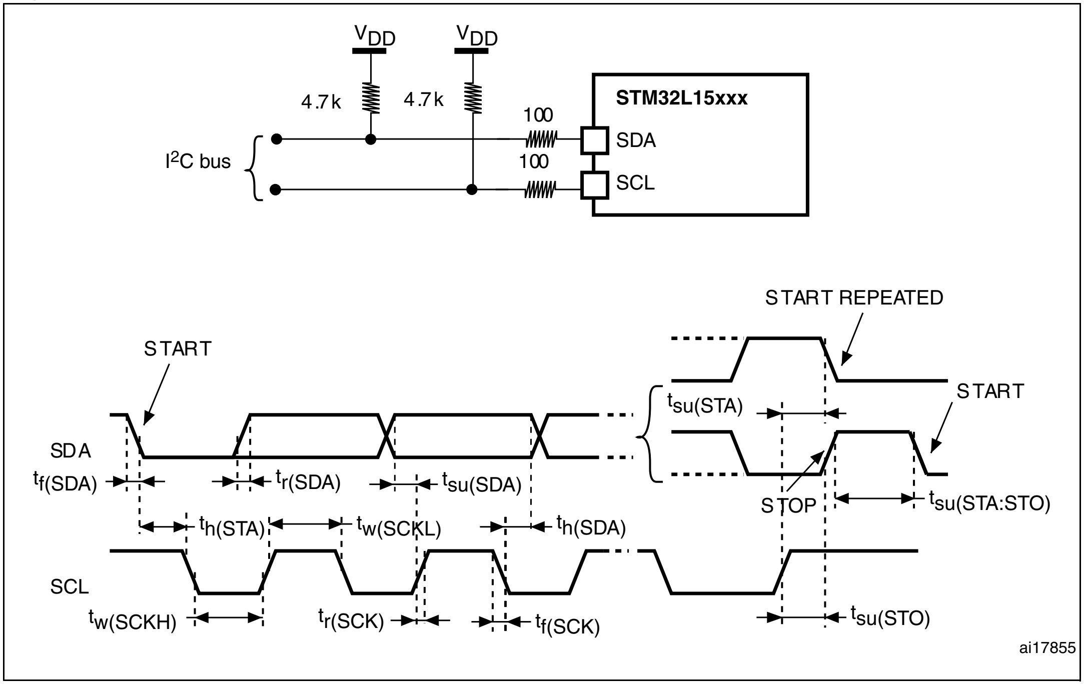
The I^2C characteristics are described in *Table 44*. Refer also to *Section 6.3.11: I/O current injection characteristics* for more details on the input/output alternate function characteristics (SDA and SCL).

Table 44. I^2C characteristics

Symbol	Parameter	Standard mode $I^2C^{(1)}$		Fast mode $I^2C^{(1)(2)}$		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	$0^{(3)}$		$0^{(4)}$	$900^{(3)}$	
$t_{r(SDA)}$ $t_{r(SCL)}$	SDA and SCL rise time		1000	$20 + 0.1C_b$	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

1. Guaranteed by design, not tested in production.
2. f_{PCLK1} must be higher than 2 MHz to achieve standard mode I^2C frequencies. It must be higher than 4 MHz to achieve fast mode I^2C frequencies. It must be a multiple of 10 MHz to reach the 400 kHz maximum I^2C fast mode clock.
3. The maximum hold time of the Start condition has only to be met if the interface does not stretch the low period of SCL signal.
4. The device must internally provide a hold time of at least 300 ns for the SDA signal in order to bridge the undefined region of the falling edge of SCL.

Figure 17. I^2C bus AC waveforms and measurement circuit



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

Table 45. SCL frequency (f_{PCLK1}= 32 MHz, V_{DD} = 3.3 V)$^{(1)(2)}$

f_{SCL} (kHz)	I2C_CCR value
	R_P = 4.7 kΩ
400	0x801B
300	0x8024
200	0x8035
100	0x00A0
50	0x0140
20	0x0320

1. R_P = External pull-up resistance, f_{SCL} = I^2C speed.
2. For speeds around 200 kHz, the tolerance on the achieved speed is of ±5%. For other speed ranges, the tolerance on the achieved speed is ±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 11*.

Refer to *Section 6.3.11: I/O current injection characteristics* for more details on the input/output alternate function characteristics (NSS, SCK, MOSI, MISO).

Table 46. 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	
$t_{r(SCK)}$ $t_{f(SCK)}$	SPI clock rise and fall time	Capacitive load: C = 30 pF		TBD	ns
DuCy(SCK)	SPI slave input clock duty cycle	Slave mode	30	70	%
$t_{su(NSS)}$	NSS setup time	Slave mode	$4t_{PCLK}$		ns
$t_{h(NSS)}$	NSS hold time	Slave mode	$2t_{PCLK}$		
$t_{w(SCKH)}$ $t_{w(SCKL)}$	SCK high and low time	Master mode, f_{PCLK} = 16 MHz, presc = 4	TBD	TBD	
$t_{su(MI)}$ $t_{su(SI)}$	Data input setup time	Master mode	5		
		Slave mode	5		
$t_{h(MI)}$	Data input hold time	Master mode	5		
$t_{h(SI)}$		Slave mode	4		
$t_{a(SO)}$(3)	Data output access time	Slave mode, f_{PCLK} = 20 MHz	0	$3t_{PCLK}$	
$t_{dis(SO)}$(4)	Data output disable time	Slave mode	TBD	TBD	
$t_{v(SO)}$ (2)	Data output valid time	Slave mode (after enable edge)		TBD	
$t_{v(MO)}$(2)	Data output valid time	Master mode (after enable edge)		TBD	
$t_{h(SO)}$(2)	Data output hold time	Slave mode (after enable edge)	TBD		
$t_{h(MO)}$(2)		Master mode (after enable edge)	TBD		

1. Remapped SPI1 characteristics to be determined.
2. Based on characterization, not tested in production.
3. Min time is for the minimum time to drive the output and max time is for the maximum time to validate the data.
4. Min time is for the minimum time to invalidate the output and max time is for the maximum time to put the data in Hi-Z.

Figure 18. SPI timing diagram - slave mode and CPHA = 0

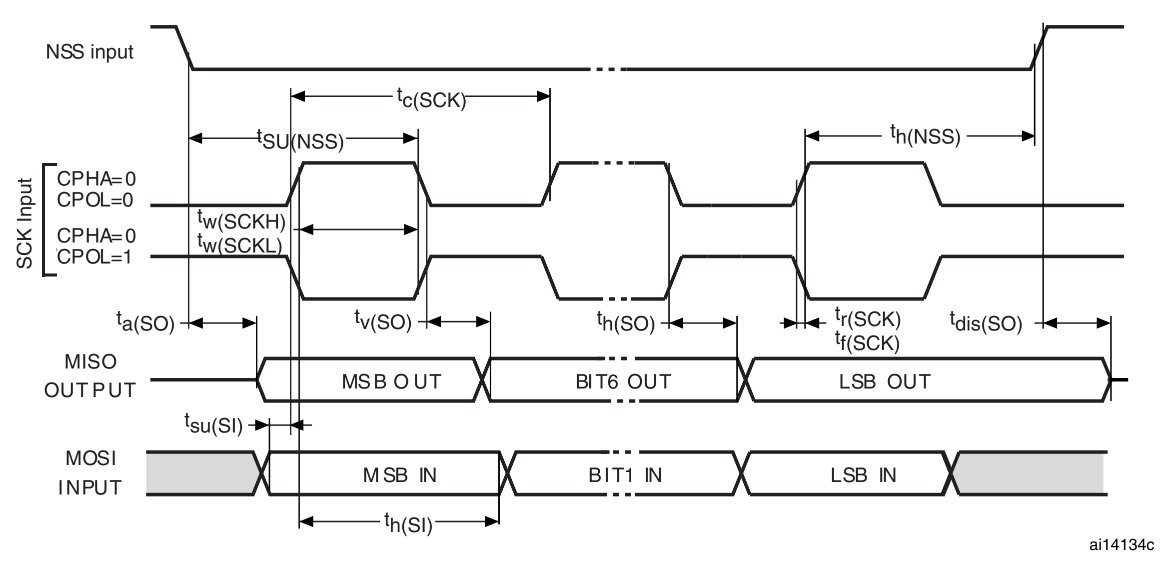
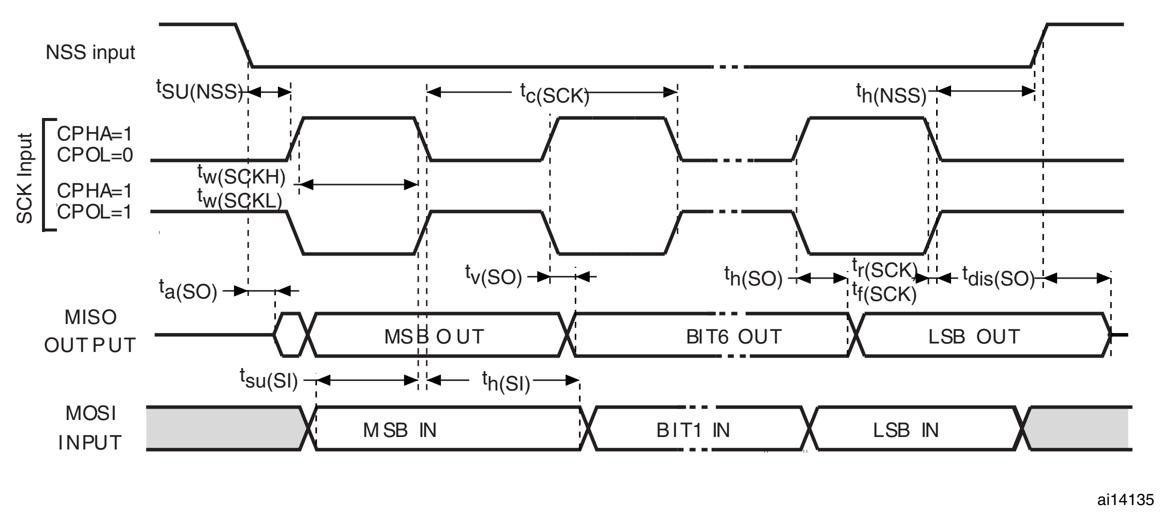
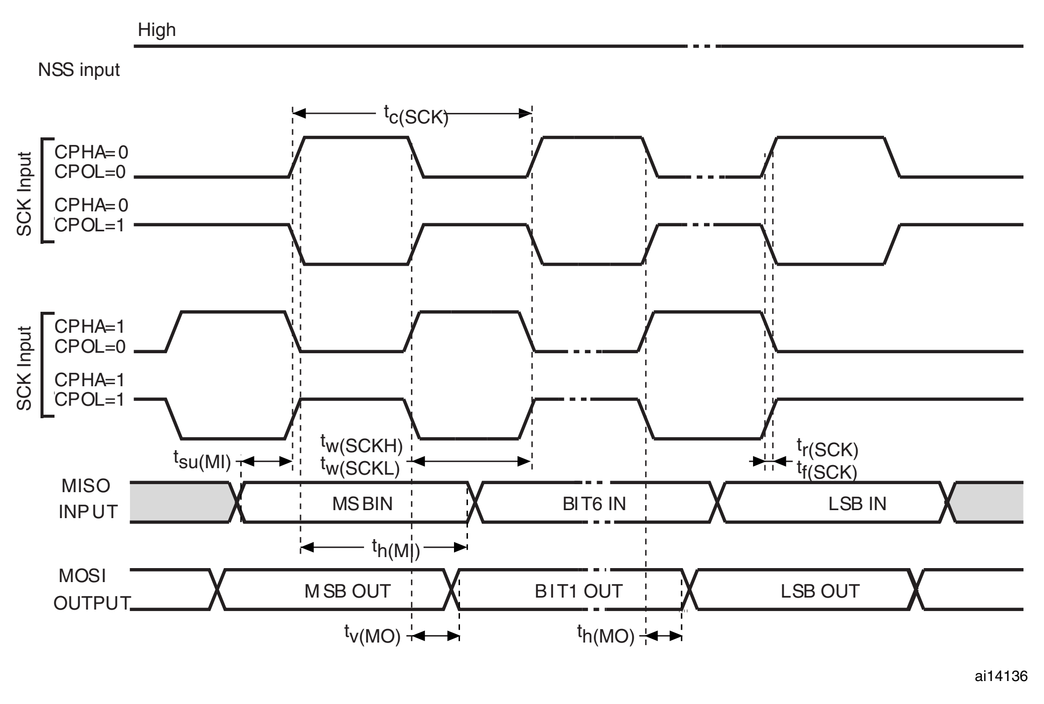


Figure 19. SPI timing diagram - slave mode and CPHA = 1[(1)]



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

Figure 20. 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 47. USB startup time

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

1. Guaranteed by design, not tested in production.

Table 48. USB DC electrical characteristics

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

1. All the voltages are measured from the local ground potential.
2. Guaranteed by characterization, not tested in production.
3. Tested in production.
4. R_L is the load connected on the USB drivers.

Figure 21. USB timings: definition of data signal rise and fall time

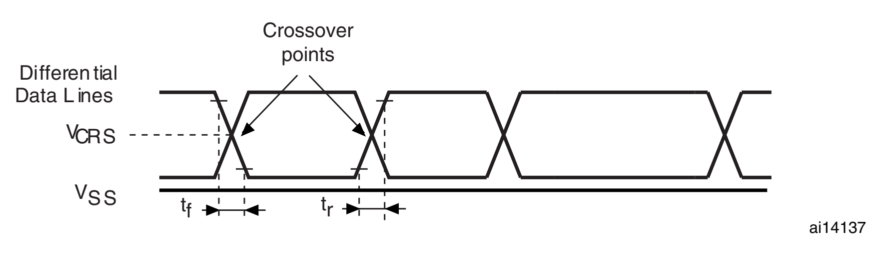


Table 49. USB: full speed electrical characteristics

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, not tested in production.
2. Measured from 10% to 90% of the data signal. For more detailed informations, please refer to USB Specification - Chapter 7 (version 2.0).

6.3.16 12-bit ADC characteristics

Unless otherwise specified, the parameters given in *Table 51* are guaranteed by design.

Table 50. ADC clock frequency

Symbol	Parameter	Conditions			Min	Max	Unit
f_{ADC}	ADC clock frequency	Voltage range 1 & 2	2.4 V $\le V_{DDA} \le$ 3.6 V	$V_{REF+} = V_{DDA}$	0.480	16	MHz
				$V_{REF+} < V_{DDA}$ $V_{REF+} >$ 2.4 V		8	
				$V_{REF+} < V_{DDA}$ $V_{REF+} \le$ 2.4 V		4	
			1.8 V $\le V_{DDA} \le$ 2.4 V	$V_{REF+} = V_{DDA}$		8	
				$V_{REF+} < V_{DDA}$		4	
		Voltage range 3				4	

Table 51. 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 $\le V_{DDA} \le$ 3.6 V V_{REF+} must be below or equal to V_{DDA}	1.8(1)		V_{DDA}	
V_{REF-}	Negative reference voltage			V_{SSA}		
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	
		Average			450	
V_{AIN}	Conversion voltage range(3)		0(4)		V_{REF+}	V
f_S	12-bit sampling rate	Direct channels	0.03		1	Msps
		Multiplexed channels	0.03		0.76	
	10-bit sampling rate	Direct channels	0.03		1.07	Msps
		Multiplexed channels	0.03		0.8	
	8-bit sampling rate	Direct channels	0.03		1.23	Msps
		Multiplexed channels	0.03		0.89	
	6-bit sampling rate	Direct channels	0.03		1.54	Msps
		Multiplexed channels	0.03		1	

Table 51. ADC characteristics (continued)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
t_S	Sampling time	Direct channels 2.4 V $\leq V_{DDA} \leq$ 3.6 V	0.25(5)			µs
		Multiplexed channels 2.4 V $\leq V_{DDA} \leq$ 3.6 V	0.56(5)			
		Direct channels 1.8 V $\leq V_{DDA} \leq$ 2.4 V	0.56(5)			
		Multiplexed channels 1.8 V $\leq V_{DDA} \leq$ 2.4 V	1(5)			
			4		384	$1/f_{ADC}$
t_{CONV}	Total conversion time (including sampling time)	f_{ADC} = 16 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			Tconv+1	$1/f_{ADC}$
		6/8/10-bit conversions			Tconv	$1/f_{ADC}$
f_{TRIG}	External trigger frequency Injected sequencer	12-bit conversions			Tconv+2	$1/f_{ADC}$
		6/8/10-bit conversions			Tconv+1	$1/f_{ADC}$
R_{AIN}(6)	External input impedance				50	kΩ
					0.5	
t_{lat}	Injection trigger conversion latency	f_{ADC} = 16 MHz	219		281	ns
			3.5		4.5	$1/f_{ADC}$
t_{latr}	Regular trigger conversion latency	f_{ADC} = 16 MHz	156		219	ns
			2.5		3.5	$1/f_{ADC}$
t_{STAB}	Power-up time				3.5	µs

1. The Vref+ input can be grounded iif neither the ADC nor the DAC are used (this allows to shut down an external voltage reference).
2. The current consumption through VREF is composed of two parameters:

   - one constant (max 300 µA)

   - one variable (max 400 µA), only during sampling time + 2 first conversion pulses.

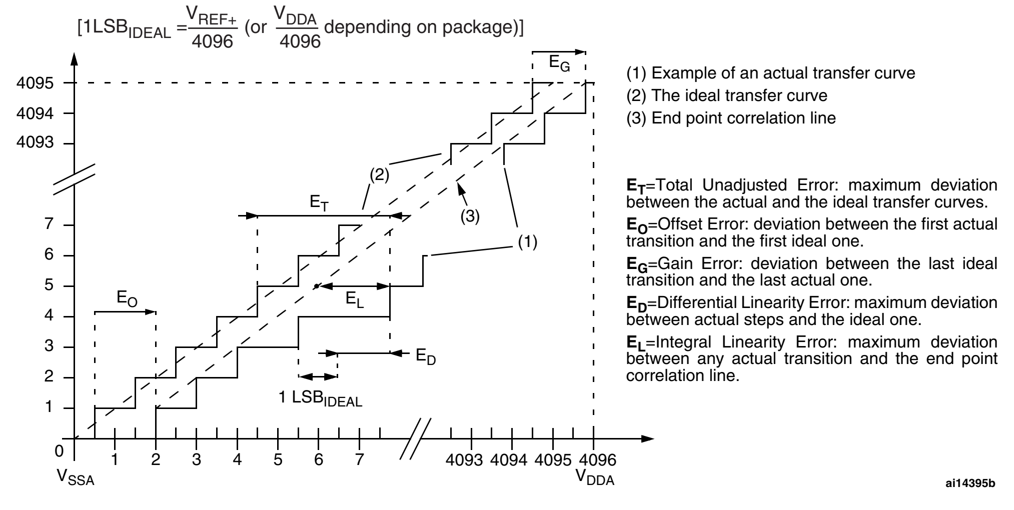
   So, peak consumption is 300+400 = 700 µA and average consumption is 300 + [(4 sampling + 2) /16] x 400 = 450 µA at 1Msps
3. V_{REF+} can be internally connected to V_{DDA} and V_{REF-} can be internally connected to V_{SSA}, depending on the package. Refer to *Section 4: Pin descriptions* for further details.
4. V_{SSA} or V_{REF-} must be tied to ground.
5. Minimum sampling and conversion time is reached for maximum Rext = 0.5 kΩ.
6. For 1 Msps, maximum Rext is 0.5 kΩ.

Table 52. ADC accuracy(1)(2)

Symbol	Parameter	Test conditions	Min(3)	Typ	Max(3)	Unit
ET	Total unadjusted error	2.4 V $\leq V_{DDA} \leq$ 3.6 V 2.4 V $\leq V_{REF+} \leq$ 3.6 V f_{ADC} = 8 MHz, R_{AIN} = 50 Ω T_A = -40 to 105 °C	-	2	4	LSB
EO	Offset error		-	1	2	
EG	Gain error		-	1.5	3.5	
ED	Differential linearity error		-	1	2	
EL	Integral linearity error		-	1.7	3	
ENOB	Effective number of bits	2.4 V $\leq V_{DDA} \leq$ 3.6 V $V_{DDA} = V_{REF+}$ f_{ADC} = 16 MHz, R_{AIN} = 50 Ω T_A = -40 to 105 °C 1 kHz $\leq F_{input} \leq$ 100 kHz	9.2	10	-	bits
SINAD	Signal-to-noise and distorsion ratio		57.5	62	-	dB
SNR	Signal-to-noise ratio		57.5	62	-	
THD	Total harmonic distorsion		-74	-75	-	
ET	Total unadjusted error	2.4 V $\leq V_{DDA} \leq$ 3.6 V 1.8 V $\leq V_{REF+} \leq$ 2.4 V f_{ADC} = 4 MHz, R_{AIN} = 50 Ω T_A = -40 to 105 °C	-	4	6.5	LSB
EO	Offset error		-	2	4	
EG	Gain error		-	4	6	
ED	Differential linearity error		-	1	2	
EL	Integral linearity error		-	1.5	3	
ET	Total unadjusted error	1.8 V $\leq V_{DDA} \leq$ 2.4 V 1.8 V $\leq V_{REF+} \leq$ 2.4 V f_{ADC} = 4 MHz, R_{AIN} = 50 Ω T_A = -40 to 105 °C		2	3	LSB
EO	Offset error			1	1.5	
EG	Gain error			1.5	2	
ED	Differential linearity error			1	2	
EL	Integral linearity error			1	1.5	

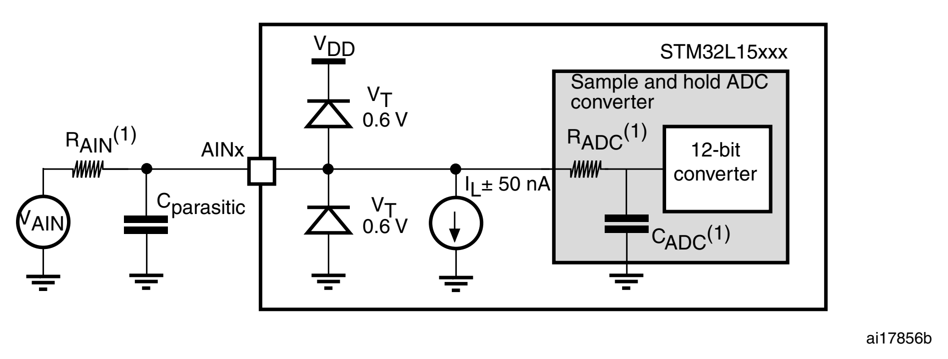
1. ADC DC accuracy values are measured after internal calibration.
2. ADC accuracy vs. negative injection current: injecting negative current on any of the standard (non-robust) analog input pins should be avoided as this significantly reduces the accuracy of the conversion being performed on another analog input. It is recommended to add a Schottky diode (pin to ground) to standard analog pins which may potentially inject negative current.
   Any positive injection current within the limits specified for $I_{INJ(PIN)}$ and $\Sigma I_{INJ(PIN)}$ in *Section 6.3.11* does not affect the ADC accuracy.
3. Based on characterization, not tested in production.

Figure 22. ADC accuracy characteristics



E_T=Total Unadjusted Error: maximum deviation between the actual and the ideal transfer curves.
E_O=Offset Error: deviation between the first actual transition and the first ideal one.
E_G=Gain Error: deviation between the last ideal transition and the last actual one.
E_D=Differential Linearity Error: maximum deviation between actual steps and the ideal one.
E_L=Integral Linearity Error: maximum deviation between any actual transition and the end point correlation line.

Figure 23. Typical connection diagram using the ADC



1. Refer to *Table 51* for the values of R_{AIN}, R_{ADC} and C_{ADC}.
2. $C_{parasitic}$ represents the capacitance of the PCB (dependent on soldering and PCB layout quality) plus the pad capacitance (roughly 7 pF). A high $C_{parasitic}$ value will downgrade conversion accuracy. To remedy this, f_{ADC} should be reduced.

Figure 24. Maximum dynamic current consumption on V_{REF+} supply pin during ADC conversion

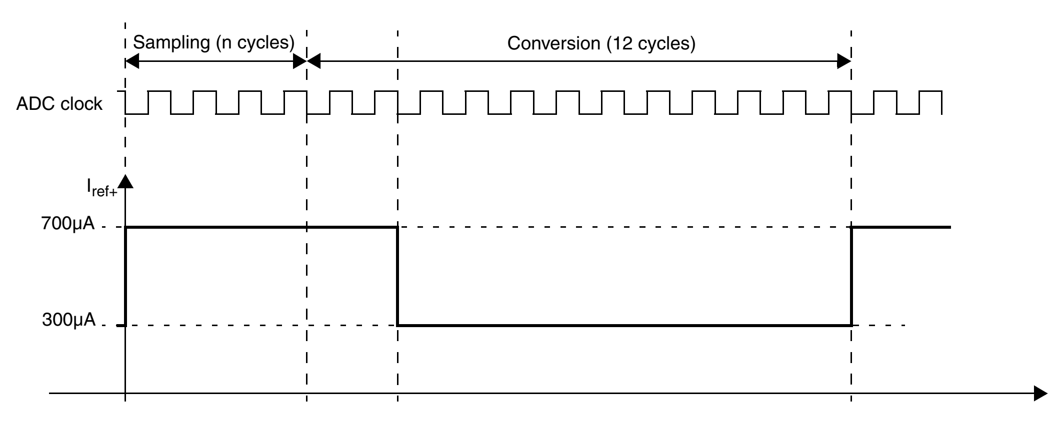


Table 53. R_{AIN} max for f_{ADC} = 16 MHz[1]

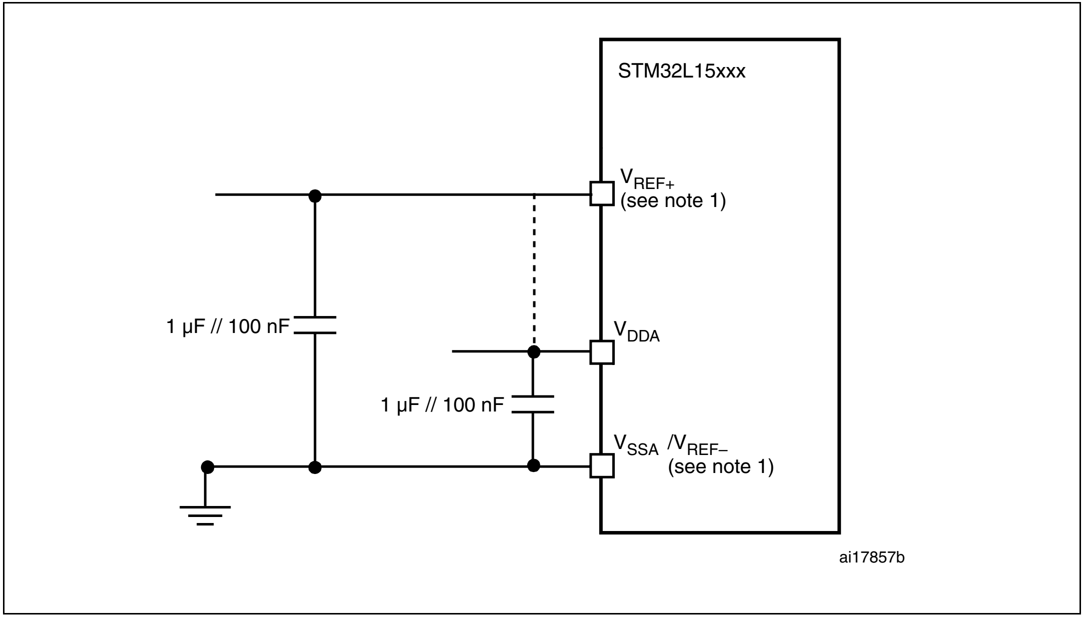
Ts (cycles)	Ts (µs)	R_{AIN} max (kΩ)			
		Multiplexed channels		Direct channels	
		2.4 V < V_{DDA} < 3.6 V	1.8 V < V_{DDA} < 2.4 V	2.4 V < V_{DDA} < 3.3 V	1.8 V < V_{DDA} < 2.4 V
4	0.25	Not allowed	Not allowed	0.7	Not allowed
9	0.5625	0.8	Not allowed	2.0	1.0
16	1	2.0	0.8	4.0	3.0
24	1.5	3.0	1.8	6.0	4.5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

1. Guaranteed by design, not tested in production.

General PCB design guidelines

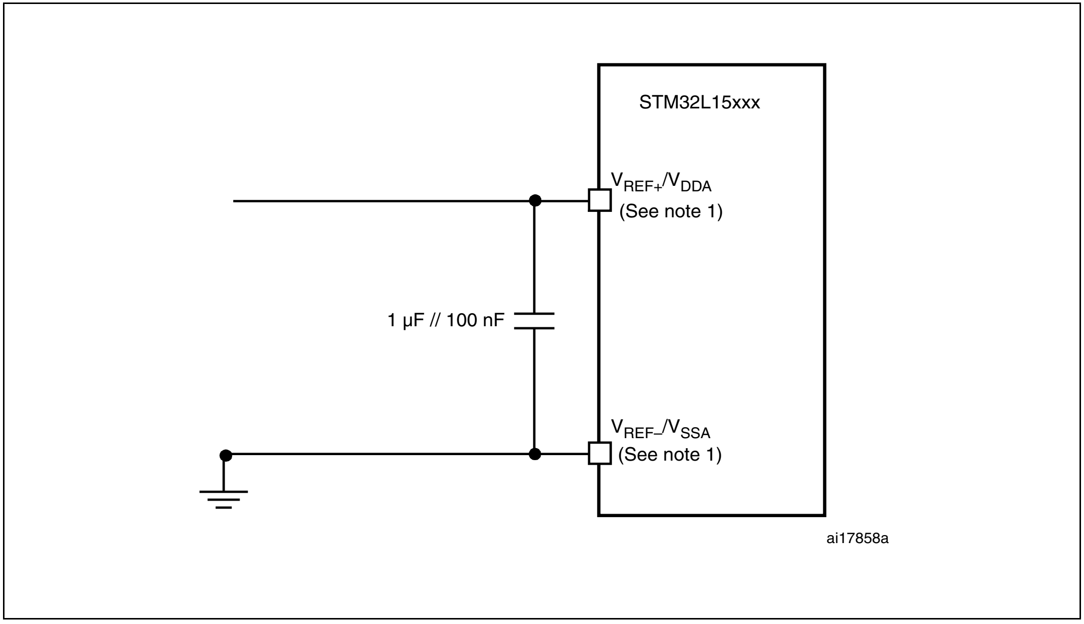
Power supply decoupling should be performed as shown in *Figure 25* or *Figure 26*, depending on whether V_{REF+} is connected to V_{DDA} or not. The 10 nF capacitors should be ceramic (good quality). They should be placed as close as possible to the chip.

Figure 25. Power supply and reference decoupling (V_{REF+} not connected to V_{DDA})



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

Figure 26. Power supply and reference decoupling (V_{REF+} connected to V_{DDA})



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

6.3.17 DAC electrical specifications

Data guaranteed by design, not tested in production, unless otherwise specified.

Table 54. 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_{REF-}	Lower reference voltage		V_{SSA}			
$I_{DDVREF+}$(1)	Current consumption on V_{REF+} supply $V_{REF+} = 3.3$ V	No load, middle code (0x800)		130	220	µA
		No load, worst code (0x000)		220	350	
I_{DDA}(1)	Current consumption on V_{DDA} supply $V_{DDA} = 3.3$ V	No load, middle code (0x800)		210	320	
		No load, worst code (0xF1C)		320	520	
R_L(2)	Resistive load	DAC output buffer ON	5			kΩ
C_L(2)	Capacitive load				50	pF
R_O	Output impedance	DAC output buffer OFF	6	8	10	kΩ
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		$V_{REF+} - 1$LSB	mV
DNL(1)	Differential non linearity(3)	$C_L \leq 50$ pF, $R_L \geq 5$ kΩ DAC output buffer ON		1.5	3	LSB
		No R_{LOAD}, $C_L \leq 50$ pF DAC output buffer OFF		1.5	3	
INL(1)	Integral non linearity(4)	$C_L \leq 50$ pF, $R_L \geq 5$ kΩ DAC output buffer ON		2	4	
		No R_{LOAD}, $C_L \leq 50$ pF DAC output buffer OFF		2	4	
Offset(1)	Offset error at code 0x800 (5)	$C_L \leq 50$ pF, $R_L \geq 5$ kΩ DAC output buffer ON		±10	±25	
		No R_{LOAD}, $C_L \leq 50$ pF DAC output buffer OFF		±5	±8	
Offset1(1)	Offset error at code 0x001(6)	No R_{LOAD}, $C_L \leq 50$ pF DAC output buffer OFF		±1.5	±5	

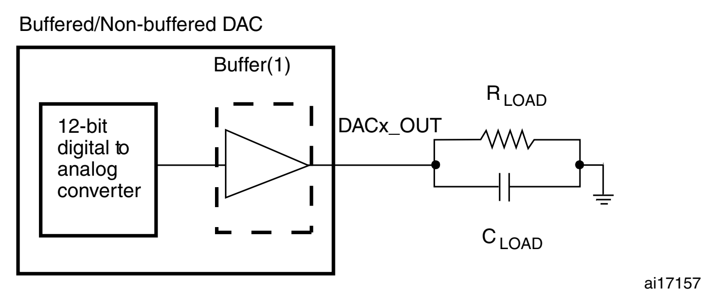
Table 54. DAC characteristics (continued)

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(7)	$C_L \leq 50$ pF, $R_L \geq 5$ kΩ DAC output buffer ON		+0.1 / -0.2%	+0.2 / -0.5%	%
		No R_{LOAD}, $C_L \leq 50$ 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	$C_L \leq 50$ pF, $R_L \geq 5$ kΩ DAC output buffer ON		12	30	LSB
		No R_{LOAD}, $C_L \leq 50$ 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	$C_L \leq 50$ pF, $R_L \geq 5$ 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	$C_L \leq 50$ pF, $R_L \geq 5$ kΩ			1	Msps
t_{WAKEUP}	Wakeup time from off state (setting the ENx bit in the DAC Control register)(8)	$C_L \leq 50$ pF, $R_L \geq 5$ kΩ		9	15	µs
PSRR+	V_{DDA} supply rejection ratio (static DC measurement)	$C_L \leq 50$ pF, $R_L \geq 5$ kΩ		-60	-35	dB

1. Data based on characterization results.
2. Connected between DAC_OUT and V_{SSA}.
3. Difference between two consecutive codes - 1 LSB.
4. Difference between measured value at Code i and the value at Code i on a line drawn between Code 0 and last Code 4095.

5. Difference between the value measured at Code (0x800) and the ideal value = $V_{REF+}/2$.
6. Difference between the value measured at Code (0x001) and the ideal value.
7. Difference between ideal slope of the transfer function and measured slope computed from code 0x000 and 0xFFF when buffer is OFF, and from code giving 0.2 V and (V_{DDA} – 0.2) V when buffer is ON.
8. In buffered mode, the output can overshoot above the final value for low input code (starting from min value).

Figure 27. 12-bit buffered /non-buffered DAC



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

6.3.18 Operational amplifier characteristics

Table 55. Operational amplifier characteristics

Symbol	Parameter		Condition(1)	Min(2)	Typ	Max(2)	Unit
CMIR	Common mode input range			0		V_{DD}	
VI_{OFFSET}	Input offset voltage	Maximum calibration range				±15	mV
		After offset calibration				±1.5	
ΔVI_{OFFSET}	Input offset voltage drift	Normal mode				±40	μV/°C
		Low power mode				±80	
I_{IB}	Input current bias	Dedicated input	75 °C			1	nA
		General purpose input				10	
I_{LOAD}	Drive current	Normal mode				500	μA
		Low power mode				100	
I_{DD}	Consumption	Normal mode	No load, quiescent mode		100	220	μA
		Low power mode			30	60	
CMRR	Common mode rejection ration	Normal mode			-85		dB
		Low power mode			-90		
PSRR	Power supply rejection ratio	Normal mode	DC		-85		dB
		Low power mode			-90		

Table 55. Operational amplifier characteristics (continued)

Symbol	Parameter		Condition[1]	Min[2]	Typ	Max[2]	Unit
GBW	Bandwidth	Normal mode	V_{DD}>2.4 V	400	1000	3000	kHZ
		Low power mode		150	300	800	
		Normal mode	V_{DD}<2.4 V	200	500	2200	
		Low power mode		70	150	800	
SR	Slew rate	Normal mode	V_{DD}>2.4 V (between 0.1 V and V_{DD}-0.1 V)		700		V/ms
		Low power mode	V_{DD}>2.4 V		100		
		Normal mode	V_{DD}<2.4 V		300		
		Low power mode			50		
AO	Open loop gain	Normal mode		55	100		dB
		Low power mode		65	110		
R_{LOAD}	Resistive load	Normal mode	V_{DD}<2.4 V	4			kΩ
		Low power mode		20			
C_{LOAD}	Capacitive load					50	pF
VOH_{SAT}	High saturation voltage	Normal mode	I_{LOAD} = max or R_{LOAD} = min	V_{DD}-100			mV
		Low power mode		V_{DD}-50			
VOL_{SAT}	Low saturation voltage	Normal mode				100	
		low power mode				50	
φm	Phase margin				60		°
GM	Gain margin				-12		dB
$t_{OFFTRIM}$	Offset trim time: during calibration, minimum time needed between two steps to have 1 mV accuracy				1		ms
t_{WAKEUP}	Wakeup time	Normal mode	C_{LOAD} ≤50 pf, R_{LOAD} ≥ 4 kΩ		10		µs
		Low power mode	C_{LOAD} ≤50 pf, R_{LOAD} ≥ 20 kΩ		30		

1. Operating conditions are limited to junction temperature (0 °C to 105 °C) when V_{DD} is below 2 V. Otherwise, the operating temperature range is 105 °C to -40 °C.
2. Data based on characterization results, not tested in production.

6.3.19 Temperature sensor characteristics

Table 56. TS characteristics

Symbol	Parameter	Min	Typ	Max	Unit
T_L(1)	V_{SENSE} linearity with temperature		±1	±2	°C
Avg_Slope(1)	Average slope	TBD	1.66	TBD	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}(4)(3)	ADC sampling time when reading the temperature		5	10	

1. Guaranteed by characterization, not tested in production.
2. Measured at V_{DD} = 3 V ±10 mV. V110 ADC conversion result is stored in the TS_Factory_CONV_V110 byte.
3. Guaranteed by design, not tested in production.
4. Shortest sampling time can be determined in the application by multiple iterations.

6.3.20 Comparator

Table 57. 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
td	Propagation delay(2)			3	10	
Voffset	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. Based on characterization, not tested in production.
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 58. 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	µs
		Slow mode		20	25	
$t_{d\ slow}$	Propagation delay[2] in slow mode	$1.65\ V \leq V_{DDA} \leq 2.7\ V$		1.8	3.5	
		$2.7\ V \leq V_{DDA} \leq 3.6\ V$		2.5	6	
$t_{d\ fast}$	Propagation delay[2] in fast mode	$1.65\ V \leq V_{DDA} \leq 2.7\ V$		0.8	2	
		$2.7\ V \leq V_{DDA} \leq 3.6\ V$		1.2	4	
V_{offset}	Comparator offset error			±4	±20	mV
dThreshold/ dt	Threshold voltage temperature coefficient	$V_{DDA} = 3.3V$ $T_A = 0$ to 50 °C $V- = V_{REF+}$, 3/4 V_{REF+}, 1/2 V_{REF+}, 1/4 V_{REF+}.		15	30	ppm /°C
I_{COMP2}	Current consumption[3]	Fast mode		3.5	5	µA
		Slow mode		0.5	2	

1. Based on characterization, not tested in production.
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

The embeds 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 59. 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	MΩ
R_L(2)	High drive resistive network total value	192	240	288	kΩ
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			
ΔVxx(3)	Segment/Common level voltage error T_A = -40 to 85 °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 design, not tested in production.
3. Based on characterization, not tested in production.

7 Package characteristics

7.1 Package mechanical data

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.

Figure 28. LQFP144, 20 x 20 mm, 144-pin low-profile quad flat package outline

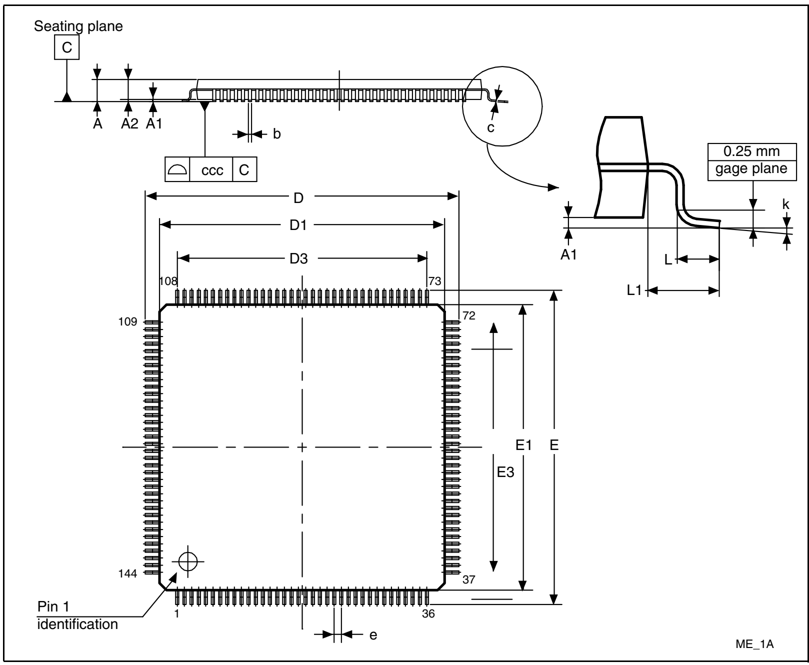
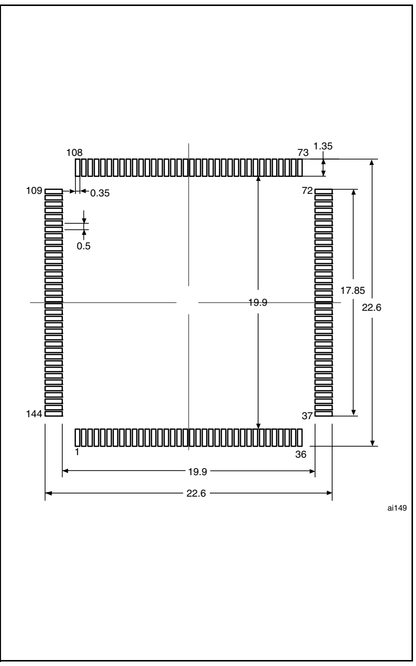


Figure 29. Recommended footprint



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

Table 60. LQFP144, 20 x 20 mm, 144-pin low-profile quad flat package mechanical data

Symbol	millimeters			inches[1]		
	Min	Typ	Max	Min	Typ	Max
A			1.60			0.063
A1	0.05		0.15	0.002		0.0059
A2	1.35	1.40	1.45	0.0531	0.0551	0.0571
b	0.17	0.22	0.27	0.0067	0.0087	0.0106
c	0.09		0.20	0.0035		0.0079
D	21.80	22.00	22.20	0.8583	0.8661	0.874
D1	19.80	20.00	20.20	0.7795	0.7874	0.7953
D3		17.50			0.689	
E	21.80	22.00	22.20	0.8583	0.8661	0.874
E1	19.80	20.00	20.20	0.7795	0.7874	0.7953
E3		17.50			0.689	
e		0.50			0.0197	
L	0.45	0.60	0.75	0.0177	0.0236	0.0295
L1		1.00			0.0394	
k	0°	3.5°	7°	0°	3.5°	7°
ccc	0.08			0.0031		

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

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

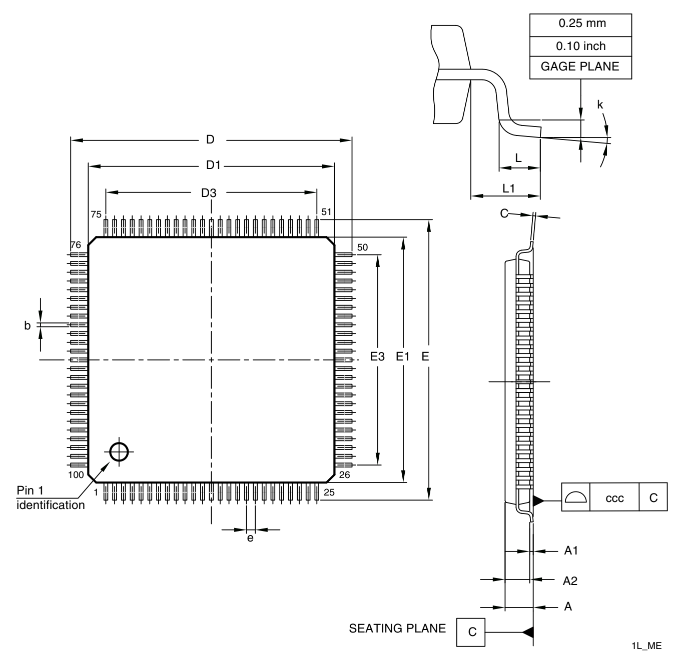
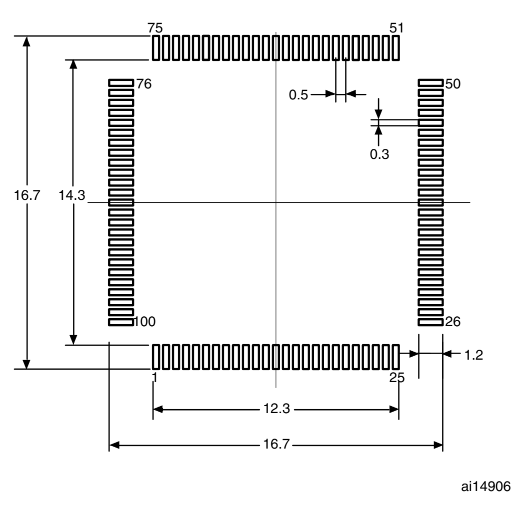


Figure 31. Recommended footprint



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

Table 61. 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			1.6			0.063
A1	0.05		0.15	0.002		0.0059
A2	1.35	1.4	1.45	0.0531	0.0551	0.0571
b	0.17	0.22	0.27	0.0067	0.0087	0.0106
c	0.09		0.2	0.0035		0.0079
D	15.8	16	16.2	0.622	0.6299	0.6378
D1	13.8	14	14.2	0.5433	0.5512	0.5591
D3		12			0.4724	
E	15.8	16	16.2	0.622	0.6299	0.6378
E1	13.8	14	14.2	0.5433	0.5512	0.5591
E3		12			0.4724	
e		0.5			0.0197	
L	0.45	0.6	0.75	0.0177	0.0236	0.0295
L1		1			0.0394	
k	0.0°	3.5°	7.0°	0.0°	3.5°	7.0°
ccc	0.08			0.0031		

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

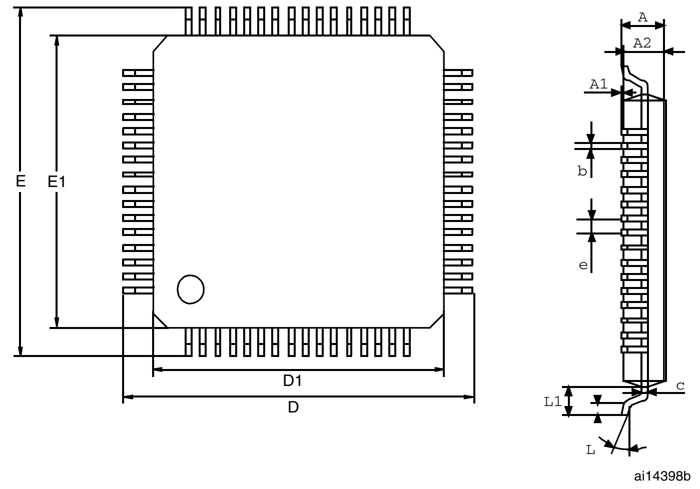


Figure 32. LQFP64, 10 x 10 mm, 64-pin low-profile quad flat package outline

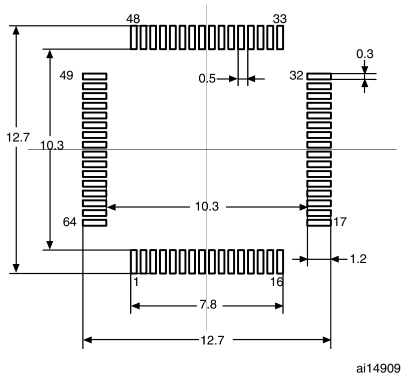


Figure 33. Recommended footprint

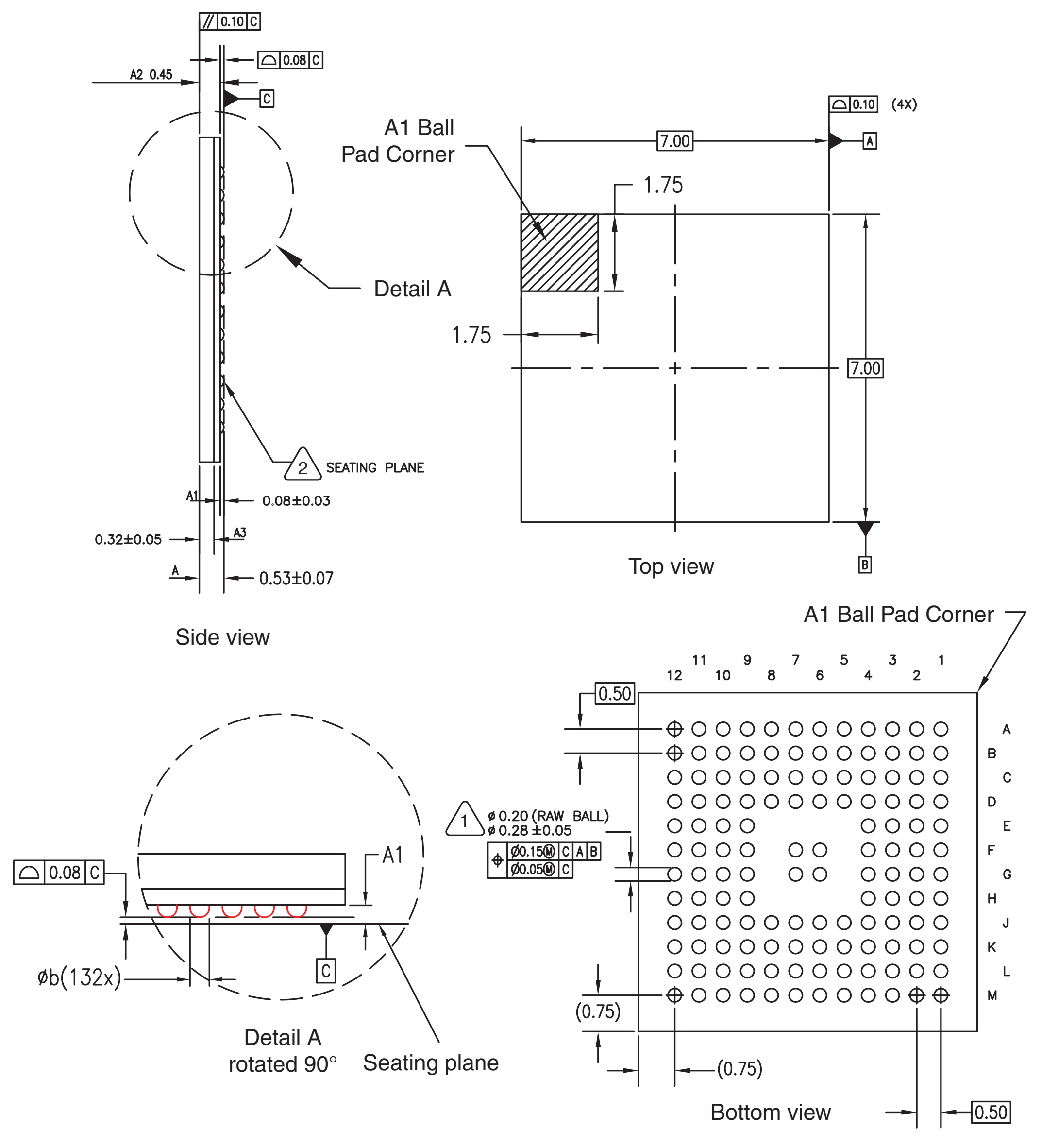
1. Drawing is not to scale. Dimensions are in millimeters.

Table 62. LQFP64, 10 x 10 mm, 64-pin low-profile quad flat package mechanical data

Symbol	millimeters			inches[1]		
	Min	Typ	Max	Min	Typ	Max
A			1.60			0.0630
A1	0.05		0.15	0.0020		0.0059
A2	1.35	1.40	1.45	0.0531	0.0551	0.0571
b	0.17	0.22	0.27	0.0067	0.0087	0.0106
c	0.09		0.20	0.0035		0.0079
D		12.00			0.4724	
D1		10.00			0.3937	
E		12.00			0.4724	
E1		10.00			0.3937	
e		0.50			0.0197	
θ	0°	3.5°	7°	0°	3.5°	7°
L	0.45	0.60	0.75	0.0177	0.0236	0.0295
L1		1.00			0.0394	
N	Number of pins					
	64					

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

Figure 34. UFBGA132, 7 x 7 mm, 132-ball ultra thin, fine-pitch ball grid array package outline



1. Primary datum C and seating plane are defined by the spherical crowns of the solder balls.
2. Dimension is measured at the maximum solder ball diameter, parallel to primary datum C.

Table 63. UFBGA132 package mechanical data

Symbol	millimeters			inches[1]		
	Min	Typ	Max	Min	Typ	Max
A	0.46	0.53	0.60	0.0181	0.0209	0.0236
A1	0.05	0.08	0.11	0.0020	0.0032	0.0043
A2	0.40	0.45	0.50	0.0157	0.0177	0.0197
b	0.17	0.28	0.33	0.0067	0.0110	0.0130

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

Figure 35. WLCSP64, 0.400 mm pitch wafer level chip size package outline

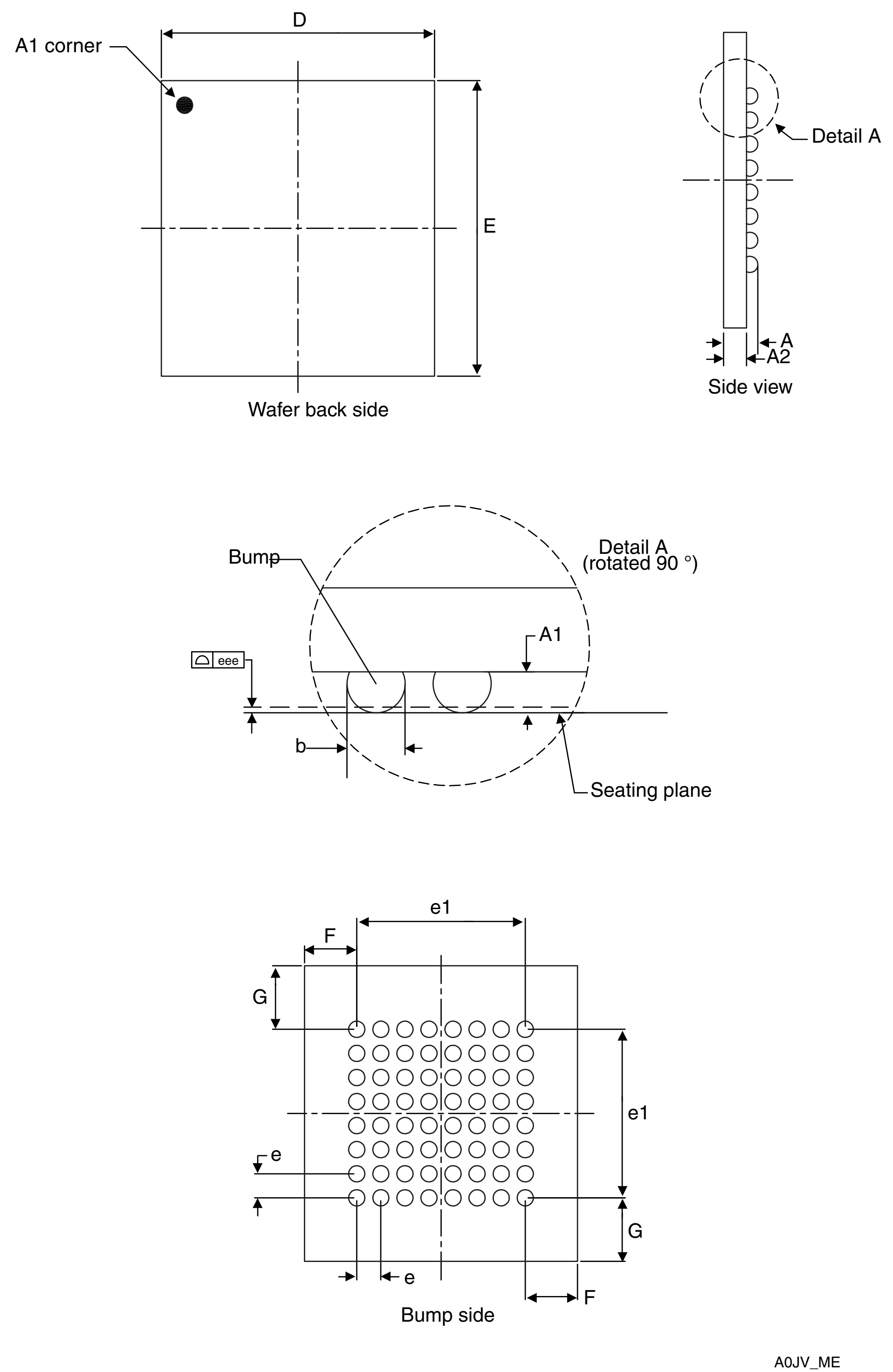


Table 64. WLCSP64, 0.400 mm pitch wafer level chip size package mechanical data

Symbol	millimeters			inches[1]		
	Min	Typ	Max	Min	Typ	Max
A	0.520	0.570	0.620	0.0205	0.0224	0.0244
A1	0.170	0.190	0.210	0.0067	0.0075	0.0083
A2	0.350	0.380	0.410	0.0138	0.0150	0.0161
b	0.240	0.270	0.300	0.0094	0.0106	0.0118
D	4.519	4.539	4.559	0.1779	0.1787	0.1795
E	4.891	4.911	4.931	0.1926	0.1933	0.1941
e		0.400			0.0157	
e1		2.800			0.1102	
F		0.870			0.0342	
G		1.056			0.0416	
eee		0.050			0.0020	

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

7.2 Thermal characteristics

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

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

Where:

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

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

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

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

Table 65. Thermal characteristics

Symbol	Parameter	Value	Unit
Θ_{JA}	**Thermal resistance junction-ambient** LQFP144 - 20 x 20 mm / 0.5 mm pitch	40	°C/W
	Thermal resistance junction-ambient BGA132 - 7 x 7 mm	60	
	Thermal resistance junction-ambient LQFP100 - 14 x 14 mm / 0.5 mm pitch	43	
	Thermal resistance junction-ambient LQFP64 - 10 x 10 mm / 0.5 mm pitch	46	

7.2.1 Reference document

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

8 Ordering information scheme

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.

Table 66. STM32L15xxC ordering information scheme

Example: STM32 L 151 R C T 6 D xxx

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

R = 64 pins
V = 100 pins
Z = 144 pins
Q = 132 pins

Flash memory size

C = 256 Kbytes of Flash memory

Package

H = BGA
T = LQFP
Y = WLCSP

Temperature range

6 = Industrial temperature range, –40 to 85 °C

Options

No character = V_{DD} range: 1.8 to 3.6 V and BOR enabled
D = V_{DD} range: 1.65 to 3.6 V and BOR disabled

Packing

TR = tape and reel
No character = tray or tube

9 Revision history

Table 67. Document revision history

Date	Revision	Changes
21-Feb-2012	1	Initial release.

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