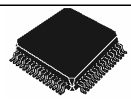
STM32F372xx STM32F373xx

ARM™-Cortex-M4 32b MCU+FPU,up to 256KB Flash+32KB SRAM 4 ADCs (12- & 16-bit), 3 DACs, 2 comp., timers, 2.0-3.6V operation

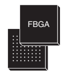
Datasheet − preliminary data

Features

- ARM 32-bit Cortex®-M4 CPU (72 MHz max), single-cycle multiplication and HW division, DSP instruction with FPU (floating-point unit) and MPU (memory protection unit)
- Memories
  - 64 to 256 Kbytes of Flash memory
  - 32 Kbytes of SRAM with HW parity check
- Clock management
  - 4 to 32 MHz crystal oscillator
  - 32 kHz oscillator for RTC with calibration
  - Internal 8 MHz RC with x 16 PLL option
  - Internal 40 kHz oscillator
- Calendar RTC
  - Alarm, periodic wakeup from Stop/Standby
- Reset and supply management
  - 2.0 to 3.6 V
  - POR, PDR and PVD
- Low power
  - Sleep, Stop, and Standby modes
  - V_{BAT} supply for RTC and backup registers (1.65 V to 3.6 V)
- Debug mode: serial wire debug (SWD), JTAG interfaces, Cortex-M4 ETM
- DMA
  - 12-channel DMA controller
  - Peripherals supported: timers, ADCs, SPIs, I^2Cs, USARTs and DACs
- Up to 3 x 16-bit Sigma Delta ADC with separate analog supply from 2.2 V to 3.6 V, up to 21 single/ 11 diff channels, 7 programmable gains per channel
- 1 x 12-bit, 1 µs ADC with separate analog supply from 2.4 V to 3.6 V



LQFP48 (7 × 7 mm)
LQFP64 (10 × 10 mm)
LQFP100 (14 × 14 mm)



UFBGA100 (7 x 7 mm)

- Up to 2 fast rail-to-rail analog comparators
- Temperature sensor
- Up to 3 x 12-bit DAC channels
- Support for up to 24 capacitive sensing keys
- Up to 84 fast I/O ports, all mappable on ext. interrupt vectors, and several 5 V-tolerant
- 17 timers
  - 2 x 32-bit timer and 3 x 16-bit timers with up to 4 IC/OC/PWM or pulse counter
  - 2 x 16-bit timers with up to 2 IC/OC/PWM or pulse counter
  - 4 x 16-bit timers with up to 1 IC/OC/PWM or pulse counter
  - 2 x watchdog timers (independent, window)
  - SysTick timer: 24-bit downcounter
  - 3 x 16-bit basic timers to drive the DAC
- Communication interfaces
  - CAN interface (2.0B Active)
  - USB 2.0 full speed interface
  - 2 x I^2C with 20 mA current sink to support Fast mode plus
  - Up to 3 USARTs (ISO 7816 interface, LIN, IrDA, modem control, autobaudrate)
  - Up to 3 SPIs, with muxed I^2S
  - CRC calculation unit, 96-bit unique ID
  - HDMI-CEC bus interface

Table 1. Device summary

Reference	Part number
STM32F372xx	STM32F372C8, STM32F372R8, STM32F372V8, STM32F372CB, STM32F372RB, STM32F372VB, STM32F372CC, STM32F372RC, STM32F372VC
STM32F373xx	STM32F373C8, STM32F373R8, STM32F373V8, STM32F373CB, STM32F373RB, STM32F373VB, STM32F373CC, STM32F373RC, STM32F373VC

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1 Description

The STM32F37x family is based on the high-performance ARM® Cortex™-M4 32-bit RISC core operating at a frequency of up to 72 MHz, and embedding a floating point unit (FPU), a memory protection unit (MPU) and an embedded trace macrocell (ETM). The family incorporates high-speed embedded memories (up to 256 Kbyte of Flash memory, up to 32 Kbytes of SRAM), and an extensive range of enhanced I/Os and peripherals connected to two APB buses.

The STM32F37x devices offer one fast 12-bit ADC (1 Msps), up to three 16-bit Sigma delta ADCs, up to two Comparators, up to two DACs (DAC1 with 2 channels and DAC2 with 1 channel), a low-power RTC, 9 general-purpose 16-bit timers, two general-purpose 32-bit timers, three basic timers.

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

The STM32F37x family operates in the -40 to +85 °C and -40 to +105 °C temperature ranges from a 2.0 to 3.6 V power supply. A comprehensive set of power-saving mode allows the design of low-power applications.

The STM32F37x family offers devices in five packages ranging from 48 pins to 100 pins. The set of included peripherals changes with the device chosen.

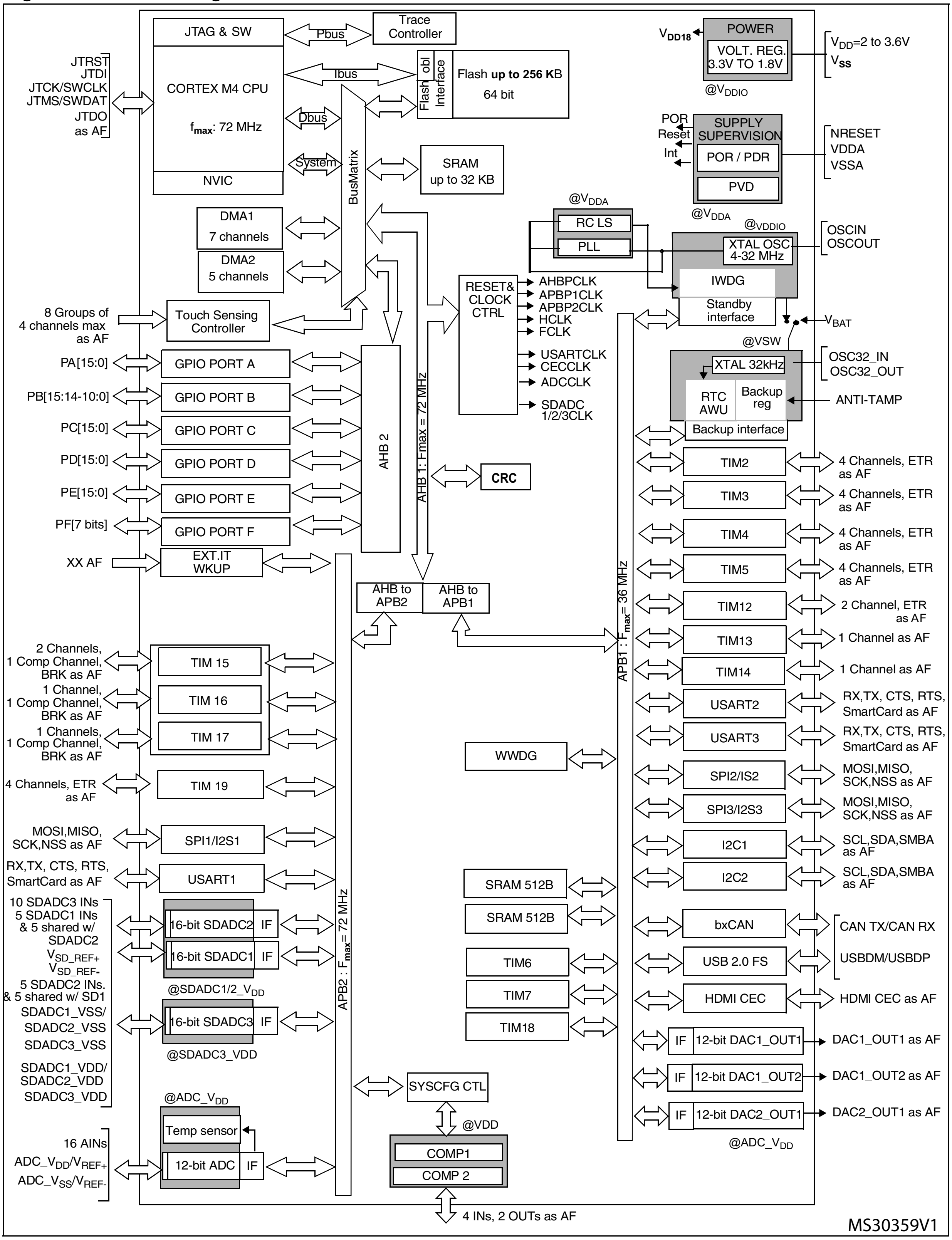
2 Device overview

Table 2. Device overview

Peripheral		STM32F 372Cx			STM32F 372Rx			STM32F 372Vx			STM32F 373Cx			STM32F 373Rx			STM32F 373Vx		
Flash (Kbytes)		64	128	256	64	128	256	64	128	256	64	128	256	64	128	256	64	128	256
SRAM (Kbytes)		16	24	32	16	24	32	16	24	32	16	24	32	16	24	32	16	24	32
Timers	General purpose	9 (16-bit) 2 (32 bit)									9 (16-bit) 2 (32 bit)								
	Basic	3 (16-bit)									3 (16-bit)								
Comm. interfaces	SPI/I2S	3									3								
	I^2C	2									2								
	USART	3									3								
	CAN	1									1								
	USB	1									1								
GPIOs		36			52			84			36			52			84		
12-bit ADCs		1									1								
16-bit ADCs Sigma- Delta		1									3								
12-bit DACs outputs		1									3								
Analog comparator		1									2								
CPU frequency		72 MHz									72 MHz								
Main operating voltage		2.0 to 3.6 V									2.0 to 3.6 V								
16-bit SDADC operating voltage		2.2 to 3.6 V									2.2 to 3.6 V								
Operating temperature		Ambient operating temperature: –40 to 85 °C / –40 to 105 °C Junction temperature: –40 to 125 °C									Ambient operating temperature: –40 to 85 °C / –40 to 105 °C Junction temperature: –40 to 125 °C								
Packages		LQFP48			LQFP64,			LQFP100 UFBGA100(1)			LQFP48			LQFP64,			LQFP100 UFBGA100(1)		

1. UFBGA100 package available on 256-KB versions only.

Figure 1. Block diagram



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

2. Example given for STM32F373xx device.

2.1 ARM® Cortex™-M4 core

2.1.1 ARM® Cortex™-M4 core with embedded Flash and SRAM

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

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

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

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

With its embedded ARM core, the STM32F37x family is compatible with all ARM tools and software.

Figure 1 shows the general block diagram of the STM32F37x family.

2.1.2 Memory protection unit

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

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

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

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

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

With its embedded ARM core, the STM32F37x devices are compatible with all ARM development tools and software.

2.2 Nested vectored interrupt controller (NVIC)

The STM32F37x devices embed a nested vectored interrupt controller (NVIC) able to handle up to 60 maskable interrupt channels and 16 priority levels.

The NVIC benefits are the following:

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

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

2.3 Extended interrupt/event controller (EXTI)

The external interrupt/event controller consists of 29 edge detector lines used to generate interrupt/event requests and wake-up the system. Each line can be independently configured to select the trigger event (rising edge, falling edge, both) and can be masked independently. A pending register maintains the status of the interrupt requests. The EXTI can detect an external line with a pulse width shorter than the internal clock period. Up to 84 GPIOs can be connected to the 16 external interrupt lines.

2.4 Embedded Flash memory

All STM32F37x devices feature up to 256 Kbytes of embedded Flash memory available for storing programs and data. The Flash memory access time is adjusted to the CPU clock frequency (0 wait state from 0 to 24 MHz, 1 wait state from 24 to 48 MHz and 2 wait states above).

2.5 CRC (cyclic redundancy check) calculation unit

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

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

2.6 Embedded SRAM

All STM32F37x devices feature up to 32 Kbytes of embedded SRAM with hardware parity check. The memory can be accessed in read/write at CPU clock speed with 0 wait states.

2.7 Clocks and startup

System clock selection is performed on startup, however the internal RC 8 MHz oscillator is selected as default CPU clock on reset. An external 4-32 MHz clock can be selected, in which case it is monitored for failure. If failure is detected, the system automatically switches back to the internal RC oscillator. A software interrupt is generated if enabled. Similarly, full interrupt management of the PLL clock entry is available when necessary (for example with failure of an indirectly used external oscillator).

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

2.8 Boot modes

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

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

The boot loader is located in system memory. It is used to reprogram the Flash memory by using USART1, USART2 or USB.

2.9 Power management

2.9.1 Power supply schemes

- V_{DD}: external power supply for I/Os and the internal regulator. It is provided externally through V_{DD} pins, and can be 2.0 to 3.6 V.
- V_{DDA} = 2.0 to 3.6 V:
  - external analog power supplies for Reset blocks, RCs and PLL
  - supply voltage for 12-bit ADC, DACs and comparators (minimum voltage to be applied to V_{DDA} is 2.4 V when the 12-bit ADC and DAC are used).
- SDADC1_VDD/SDADC2_VDD and SDADC3_VDD = 2.2 V to 3.6: supply voltages for SDADC1/2 and SDADCD3 sigma delta ADCs. Independent from V_{DD}/V_{DDA}.
- V_{BAT} = 1.65 to 3.6 V: power supply for RTC, external clock 32 kHz oscillator and backup registers (through power switch) when V_{DD} is not present.

2.9.2 Power supply supervisor

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

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

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

2.9.3 Voltage regulator

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

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

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

2.10 Low-power modes

The STM32F37x supports three low-power modes to achieve the best compromise between low power consumption, short startup time and available wakeup sources:

- Sleep mode

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

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

  The device can be woken up from Stop mode by any of the EXTI line. The EXTI line source can be one of the 16 external lines, the PVD output, the USARTs, the I2Cs, the CEC, the USB wakeup, and the RTC alarm.
- Standby mode

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

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

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

2.11 Real-time clock (RTC) and backup registers

The RTC and the backup registers are supplied through a switch that takes power either on V_{DD} supply when present or through the V_{BAT} pin.The backup registers are thirty two 32-bit registers used to store 128 bytes of user application data when V_{DD} power is not present.

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

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

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

The RTC clock sources can be:

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

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

2.13 GPIOs (general-purpose inputs/outputs)

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

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

2.14 Touch sensing controller (TSC)

The device has an embedded independent hardware controller (TSC) for controlling touch sensing acquisitions on the I/Os.

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

Table 3. Capacitive sensing GPIOs available on STM32F37x devices

Pin name	Capacitive sensing group name	Pin name	Capacitive sensing group name
PA0	G1_IO1	PA9	G4_IO1
PA1	G1_IO2	PA10	G4_IO2
PA2	G1_IO3	PA13	G4_IO3
PA3	G1_IO4	PA14	G4_IO4
PA4	G2_IO1	PB3	G5_IO1
PA5	G2_IO2	PB4	G5_IO2
PA6	G2_IO3	PB6	G5_IO3
PA7	G2_IO4	PB7	G5_IO4
PC4	G3_IO1	PB14	G6_IO1
PC5	G3_IO2	PB15	G6_IO2
PB0	G3_IO3	PD8	G6_IO3
PB1	G3_IO4	PD9	G6_IO4
PE2	G7_IO1	PD12	G8_IO1
PE3	G7_IO2	PD13	G8_IO2
PE4	G7_IO3	PD14	G8_IO3
PE5	G7_IO4	PD15	G8_IO4

Table 4. No. of capacitive sensing channels available on STM32F37x devices

Analog I/O group	Number of capacitive sensing channels		
	STM32F37xCx	STM32F37xRx	STM32F37xVx
G1	3	3	3
G2	2	3	3
G3	1	3	3
G4	3	3	3
G5	3	3	3
G6	2	2	3
G7	0	0	3
G8	0	0	3
Number of capacitive sensing channels	14	17	24

2.15 12-bit ADC (analog-to-digital converter)

The 12-bit analog-to-digital converter is based on a successive approximation register (SAR) architecture. It has up to 16 external channels (AIN15:0) and 3 internal channels (temperature sensor, voltage reference, VBAT voltage measurement) performing conversions in single-shot or scan modes. In scan mode, automatic conversion is performed on a selected group of analog inputs.

The ADC can be served by the DMA controller.

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

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

2.15.1 Temperature sensor

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

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

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

To improve the accuracy of the temperature sensor measurement, each device is individually factory-calibrated by ST. The temperature sensor factory calibration data are stored by ST in the system memory area, accessible in read-only mode.

Table 5. Temperature sensor calibration values

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

2.15.2 Internal voltage reference (V_{REFINT})

The internal voltage reference (V_{REFINT}) provides a stable (bandgap) voltage output for the ADC and Comparators. V_{REFINT} is internally connected to the ADC_IN17 input channel. The precise voltage of V_{REFINT} is individually measured for each part by ST during production test and stored in the system memory area. It is accessible in read-only mode.

Table 6. Temperature sensor calibration values

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

2.15.3 V_{BAT} battery voltage monitoring

This embedded hardware feature allows the application to measure the V_{BAT} battery voltage using the internal ADC channel ADC_IN18. As the V_{BAT} voltage may be higher than V_{DDA}, and thus outside the ADC input range, the V_{BAT} pin is internally connected to a divider by 2. As a consequence, the converted digital value is half the V_{BAT} voltage.

2.16 16-bit sigma delta analog-to-digital converters (SDADC)

Up to three 16-bit sigma-delta analog-to-digital converters are embedded in the STM32F37x. They have up to two separate supply voltages allowing the analog function voltage range to be independent from the STM32F37x power supply. They share up to 21 input pins which may be configured in any combination of single-ended (up to 21) or differential inputs (up to 11).

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

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

Up to two external reference pins (SD_V_{REF+}, SD_V_{REF-}) and an internal 1.2/1.8V reference can be used in conjunction with a programmable gain (x0.5 to x32) in order to fine-tune the input voltage range of the SDADC.

2.17 DAC (digital-to-analog converter)

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

This digital Interface supports the following features:

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

2.18 Fast comparators

The STM32F37x embeds up to 2 comparators with rail-to-rail inputs and high-speed output. The reference voltage can be internal or external (delivered by an I/O).

The threshold can be one of the following:

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

The comparators can be combined into a window comparator.

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

2.19 Timers and watchdogs

The STM32F37x includes two 32-bit and nine 16-bit general-purpose timers, three basic timers, two watchdog timers and a SysTick timer. The table below compares the features of the advanced control, general purpose and basic timers.

Table 7. Timer feature comparison

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

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

There are eleven synchronizable general-purpose timers embedded in the STM32F37x (see *Table 7* for differences). Each general-purpose timer can be used to generate PWM outputs, or act as a simple time base.

- TIM2, 3, 4, 5 and 19

  These five timers are full-featured general-purpose timers:
  - TIM2 and TIM5 have 32-bit auto-reload up/downcounters and 32-bit prescalers
  - TIM3, 4, and 19 have 16-bit auto-reload up/downcounters and 16-bit prescalers.

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

  The counters can be frozen in debug mode.

  All have independent DMA request generation and support quadrature encoders.
- TIM12, 13, 14, 15, 16, 17

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

  They have 16-bit auto-reload upcounters and 16-bit prescalers.
  - TIM12 has 2 channels
  - TIM13 and TIM14 have 1 channel
  - TIM15 has 2 channels and 1 complementary channel
  - TIM16 and TIM17 have 1 channel and 1 complementary channel

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

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

  The counters can be frozen in debug mode.

2.19.2 Basic timers (TIM6, TIM7, TIM18)

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

2.19.3 Independent watchdog (IWDG)

The independent watchdog is based on a 12-bit downcounter and 8-bit prescaler. It is clocked from an independent 40 kHz internal RC and as it operates independently from the main clock, it can operate in 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.

2.19.4 System window watchdog (WWDG)

The system window watchdog is based on a 7-bit downcounter that can be set as free running. It can be used as a watchdog to reset the device when a problem occurs. It is clocked from the APB1 clock (PCLK1) derived from the main clock. It has an early warning interrupt capability and the counter can be frozen in debug mode.

2.19.5 SysTick timer

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

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

2.20 Communication interfaces

2.20.1 I²C bus

Up to two I2C bus interfaces can operate in multimaster and slave modes. They can support standard (up to 100 kHz), fast (up to 400 kHz) and fast mode + (up to 1 MHz) modes with 20 mA output drive. They support 7-bit and 10-bit addressing modes, multiple 7-bit slave addresses (2 addresses, 1 with configurable mask). They also include programmable analog and digital noise filters.

Table 8. Comparison of I2C analog and digital filters

	Analog filter	Digital filter
Pulse width of suppressed spikes	≥ 50 ns	Programmable length from 1 to 15 I2C peripheral clocks
Benefits	Available in Stop mode	1. Extra filtering capability vs. standard requirements. 2. Stable length
Drawbacks	Variations depending on temperature, voltage, process	Disabled when Wakeup from Stop mode is enabled

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

The I2C interfaces can be served by the DMA controller

2.20.2 Universal synchronous/asynchronous receiver transmitter (USART)

The STM32F37x embeds three universal synchronous/asynchronous receiver transmitters (USART1, USART2 and USART3).

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

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

2.20.3 Serial peripheral interface (SPI)

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

The SPIs can be served by the DMA controller.

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

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

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

2.20.5 Inter-integrated sound (I^2S)

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

2.20.6 Controller area network (CAN)

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

2.20.7 Universal serial bus (USB)

The STM32F37x embeds an USB device peripheral compatible with the USB full-speed 12 Mbs. The USB interface implements a full-speed (12 Mbit/s) function interface. It has software-configurable endpoint setting and suspend/resume support. The dedicated 48 MHz clock is generated from the internal main PLL (the clock source must use a HSE crystal oscillator).

2.21 Development support

2.21.1 Serial wire JTAG debug port (SWJ-DP)

The ARM SWJ-DP Interface is embedded, and is a combined JTAG and serial wire debug port that enables either a serial wire debug or a JTAG probe to be connected to the target.

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

2.21.2 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 STM32F37x 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.

3 Pinouts and pin description

Figure 2. STM32F37x LQFP48 pinout

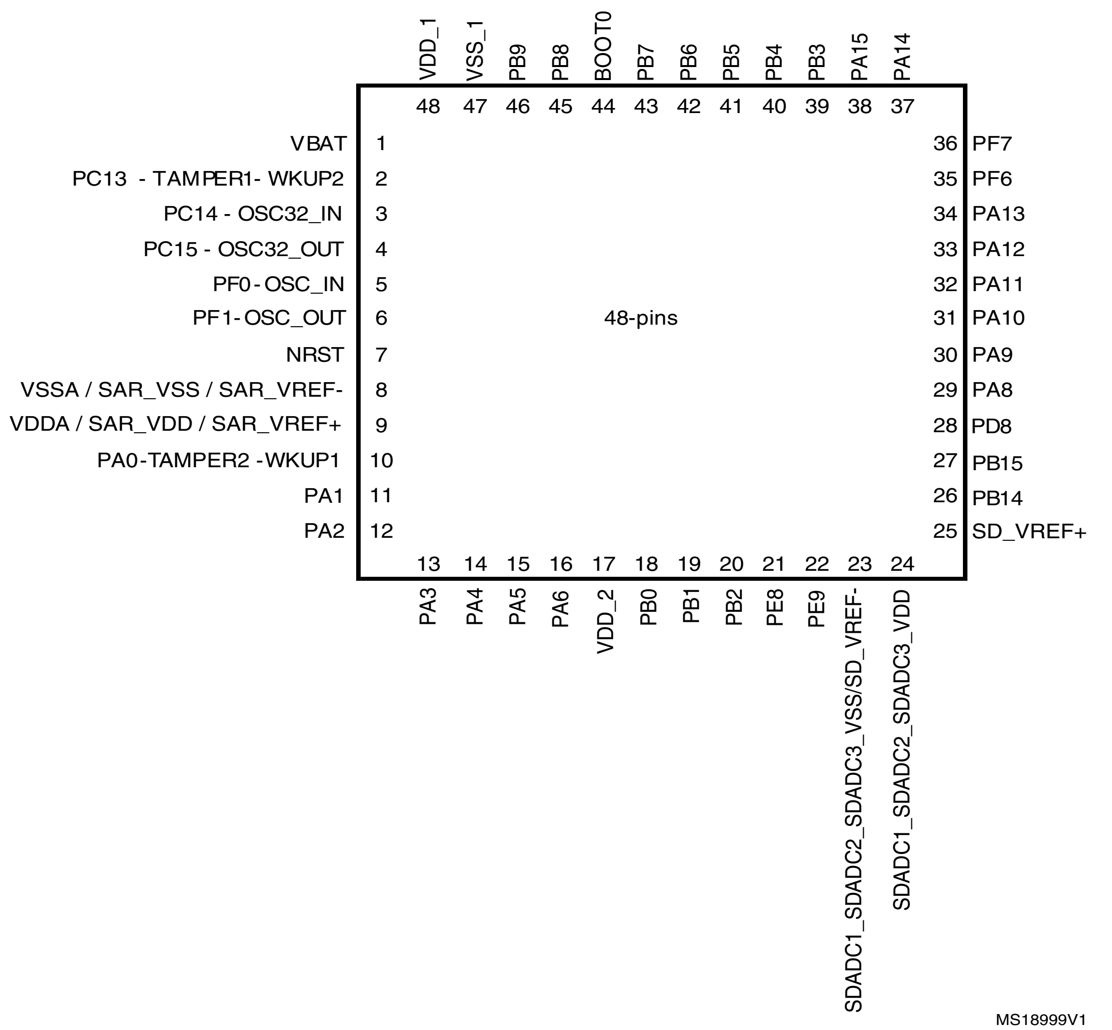


Figure 3. STM32F37x LQFP64 pinout

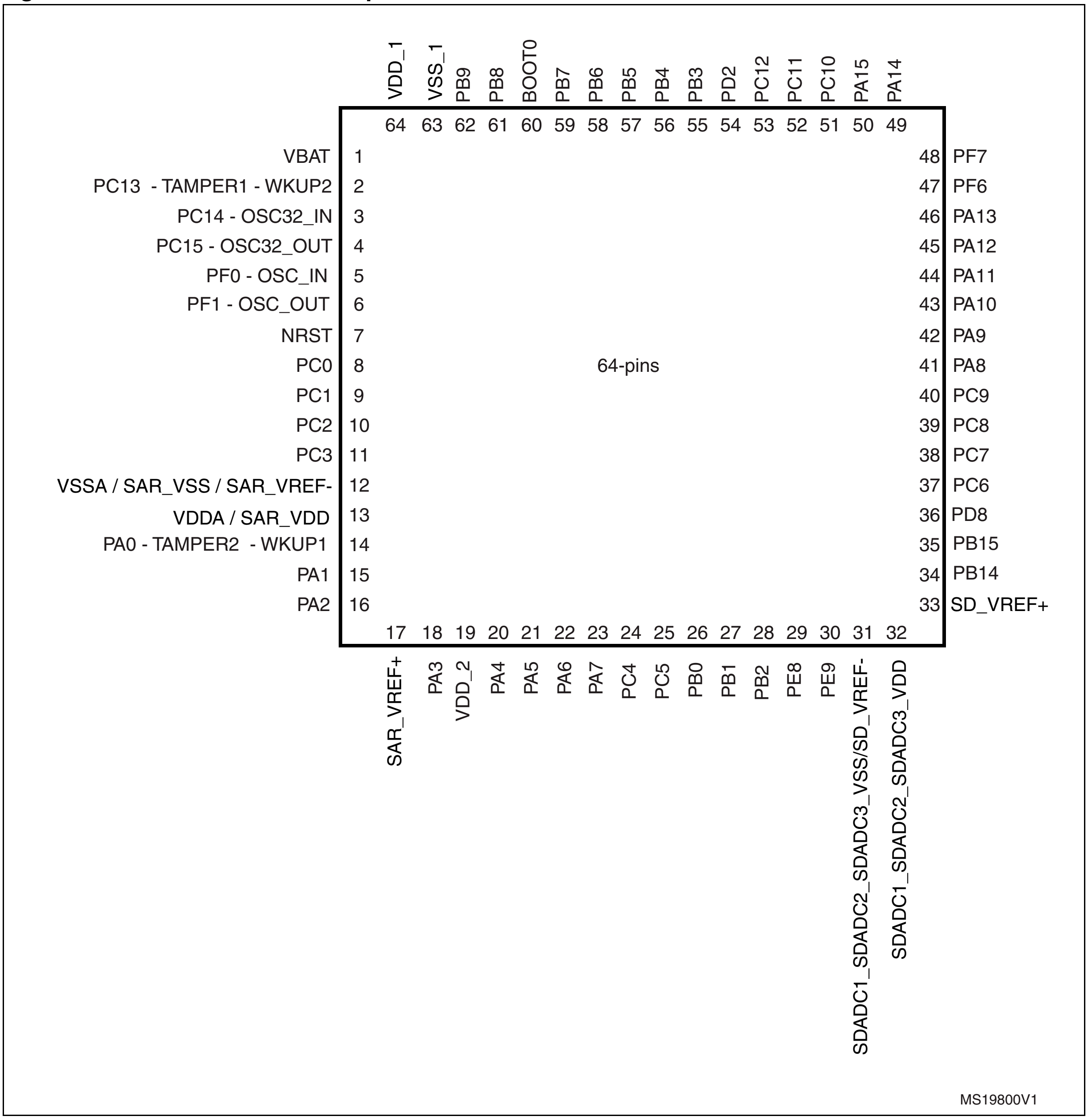


Figure 4. STM32F37x LQFP100 pinout

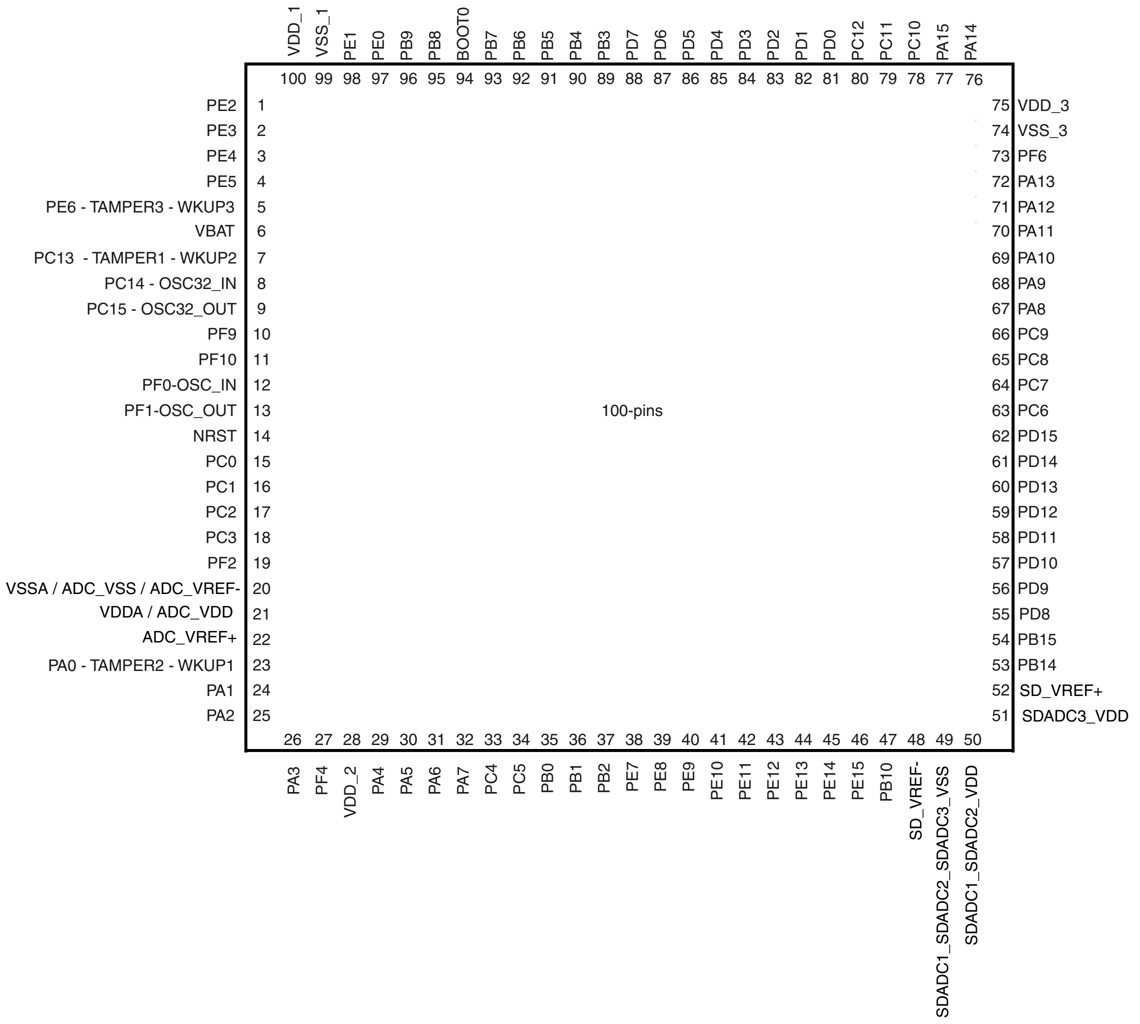


Table 9. STM32F37x BGA100 pinout

	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_TAMPER1-WKUP2	PE5	PE0	VDD_1	PB5			PD2	PD0	PC11	PF6	PA10
D	PC14-OSC32_IN	PE6-TAMPER3-WKUP3	VSS_1							PA9	PA8	PC9
E	PC15-OSC32_OUT	VBAT	PF4							PC8	PC7	PC6
F	PF0-OSC_IN	PF9									VSS_3	SDADC1_SDADC2_SDADC3_VSS
G	PF1-OSC_OUT	PF10									VDD_3	SDADC1_SDADC2_VDD
H	PC0-ADC10	NRST	VDD_2							PD15	PD14	PD13
J	PF2	PC1	PC2							PD12	PD11	PD10
K	VSSA-ADC_VSS-ADC_VREF-	PC3	PA2	PA5	PC4			PD9	PD8	PB15	PB14	SD_VREF+
L	ADC_VREF+	PA0-TAMPER2-WKUP1	PA3	PA6	PC5	PB2	PE8	PE10	PE12	PB10	SD_VREF-	SDADC3_VDD
M	VDDA-ADC_VDD	PA1	PA4	PA7	PB0	PB1	PE7	PE9	PE11	PE13	PE14	PE15

Table 10. Legend/abbreviations used in the pinout table

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

Table 11. STM32F37x pin definitions

Pin numbers				Pin name (function after reset)	Pin type	I/O structure	Pin functions	
LQFP100	BGA100	LQFP64	LQFP48				Alternate function	Additional functions
1	B2			PE2	I/O	FT	G7_IO1, TRACECLK	
2	A1			PE3	I/O	FT	G7_IO2, TRACED0	
3	B1			PE4	I/O	FT	G7_IO3, TRACED1	
4	C2			PE5	I/O	FT	G7_IO4, TRACED2	
5	D2			PE6 - TAMPER3 - WKUP3	I/O	TTa	TRACED3, RTC_TAMPER3	WKUP3
6	E2	1	1	VBAT	S			
7	C1	2	2	PC13 - TAMPER1 - WKUP2	I/O	TTa	RTC_TAMPER1	WKUP2_ALARM_OUT_ CALIB_OUT_TIMESTAMP
8	D1	3	3	PC14 - OSC32_IN	I/O	TC		OSC32_IN

Table 11. STM32F37x pin definitions (continued)

Pin numbers				Pin name (function after reset)	Pin type	I/O structure	Pin functions	
LQFP100	BGA100	LQFP64	LQFP48				Alternate function	Additional functions
9	E1	4	4	PC15 - OSC32_OUT	I/O	TC		OSC32_OUT
10	F2			PF9	I/O	FT	TIM14_CH1	
11	G2			PF10	I/O	FT		
12	F1	5	5	PF0 - OSC_IN	I/O	FT	I2C2_SDA	OSC_IN
13	G1	6	6	PF1 - OSC_OUT	I/O	FT	I2C2_SCL	OSC_OUT
14	H2	7	7	NRST	I/O	RST		
15	H1	8		PC0	I/O	TTa	TIM5_CH1_ETR	ADC_IN10
16	J2	9		PC1	I/O	TTa	TIM5_CH2	ADCIN11
17	J3	10		PC2	I/O	TTa	SPI2_MISO, I2S2_MCK, TIM5_CH3	ADC_IN12
18	K2	11		PC3	I/O	TTa	SPI2_MOSI, I2S2_SD, TIM5_CH4	ADC_IN13
19	J1			PF2	I/O	FT	I2C2_SMBAI	
20	K1	12	8	VSSA / ADC_VSS / ADC_ VREF-	S			
			9	VDDA , ADC_VDD , ADC_ VREF+	S			
21	M1	13		VDDA , ADC_VDD	S			
22	L1	17		ADC_ VREF+	S			
23	L2	14	10	PA0 - TAMPER2 - WKUP1	I/O	TTa	USART2_CTS,TIM2_CH1_ET, TIM5_CH1_ETR,TIM19_CH1, G1_IO1,COMP1_OUT	RTC_ TAMPER2, WKUP1, ADC_IN0,COMP1_INn
24	M2	15	11	PA1	I/O	TTa	SPI3_SCK_I2S3_CK, USART2_RTS,TIM2_CH2, TIM15_CH1N,TIM5_CH2, TIM19_CH2,G1_IO2, RTC_REF_CLK_IN	ADC_IN1,COMP1_INp

Table 11. STM32F37x pin definitions (continued)

Pin numbers				Pin name (function after reset)	Pin type	I/O structure	Pin functions	
LQFP100	BGA100	LQFP64	LQFP48				Alternate function	Additional functions
25	K3	16	12	PA2	I/O	TTa	COMP2_OUT ,SPI3_MISO, I2S3_MCK, USART2_TX, TIM2_CH3, TIM15_CH1, TIM5_CH3,TIM19_CH3, TIM2_OUT, G1_IO3	ADC_IN2, COMP2_INn
26	L3	18	13	PA3	I/O	TTa	SPI3_MOSI,I2S3_SD, USART2_RX,TIM2_CH4, TIM15_CH2,TIM5_CH4, TIM19_CH4,G1_IO4	ADC_IN3 ADC_IN3, COMP2_Inp
27	E3			PF4	I/O	FT		
28	H3	19	17	VDD_2	S			
29	M3	20	14	PA4	I/O	TTa	SPI1_NSS,I2S1_WS, SPI3_NSS_I2S3_WS, TIM2_CK,TIM3_CH2, TIM12_CH1,G2_IO1, COMP1_OUT	ADC_IN4, DAC1_OUT1
30	K4	21	15	PA5	I/O	TTa	SPI1_SCK,I2S1_CK,CEC, TIM2_CH1_ETR, TIM14_CH1,TIM12_CH2, G2_IO2	ADC_IN5, DAC1_OUT2
31	L4	22	16	PA6	I/O	TTa	SPI1_MISO,I2S1_MCK, TIM3_CH1, TIM13_CH1, TIM16_CH1,COMP1_OUT, G2_IO3	ADC_IN6, DAC2_OUT1
32	M4	23		PA7	I/O	TTa	G2_IO4,SPI1_MOSI,I2S1_SD, TIM14_CH1,TIM17_CH1, TIM3_CH1	COMP2_OUT,ADC_IN7
33	K5	24		PC4	I/O	TTa	TIM1_TX,TIM13_CH1,G3_IO1	ADC_IN14
34	L5	25		PC5	I/O	TTa	TIM1_RX,G3_IO2	ADC_IN15
35	M5	26	18	PB0	I/O	TTa	SPI1_MOSI,I2S1_SD, TIM3_CH3,G3_IO3	ADC_IN8, SDADC1_ADC_IN6P
36	M6	27	19	PB1	I/O	TTa	TIM3_CH4,G3_IO4/AIN9	SDADC1_5P, SDADC1_AIN6M
37	L6	28	20	PB2	I/O	TTa		SDADC1_AIN4P, SDADC2_AIN6P
38	M7			PE7	I/O	TTa		SDADC1_AIN3P, SDADC1_AIN4M, SDADC2_AIN5P, SDADC2_AIN6M
39	L7	29	21	PE8	I/O	TTa		SDADC1_AIN8P, SDADC2_AIN8P

Table 11. STM32F37x pin definitions (continued)

Pin numbers				Pin name (function after reset)	Pin type	I/O structure	Pin functions	
LQFP100	BGA100	LQFP64	LQFP48				Alternate function	Additional functions
40	M8	30	22	PE9	I/O	TTa		SDADC1_AIN7P, SDADC1_AIN8M, SDADC2_AIN7P, SDADC2_AIN8M
41	L8			PE10	I/O	TTa		SDADC1_AIN2P
42	M9			PE11	I/O	TTa		SDADC1_AIN1P, SDADC1_AIN2M, SDADC2_AIN4P
43	L9			PE12	I/O	TTa		SDADC1_AIN0P, SDADC2_AIN3P, SDADC2_AIN4M
44	M10			PE13	I/O	TTa		SDADC1_AIN0M , SDADC2_AIN2P
45	M11			PE14	I/O	TTa		SDADC2_AIN1P, SDADC2_AIN2M
46	M12			PE15	I/O	TTa	USART3_RX	SDADC2_AIN0P
47	L10			PB10	I/O	TTa	SPI2_SCK_I2S2_CK,USART3 _TX,CEC,SYNC	TIM2_CH3, SDADC2_AIN0M
48	L11			SD_VREF-	S			
49	F12			SDADC1, SDADC2_ SDADC3_ VSS	S			
		31	23	SD1_ SD2_ SDADC3_ VSS , SD_VREF-	S			
50	G12			SDADC1,SD ADC2_ VDD	S			
		32	24	SD1_ SD2 _VDD, SDADC3_ VDD	S			
51	L12			SDADC3_ VDD	S			
52	K12	33	25	SD_VREF+	S			
53	K11	34	26	PB14	I/O	TTa	SPI2_MISO,I2S2_MCK, USART3_RTS, TIM15_CH1,TIM12_CH1, G6_IO1	SDADC3_AIN8P

Table 11. STM32F37x pin definitions (continued)

Pin numbers				Pin name (function after reset)	Pin type	I/O structure	Pin functions	
LQFP100	BGA100	LQFP64	LQFP48				Alternate function	Additional functions
54	K10	35	27	PB15	I/O	TTa	SPI2_MOSI,I2S2_SD, TIM15_CH1N,TIM15_CH2, TIM12_CH2,G6_IO2	SDADC3_7P,SDADC3_AIN8 M,RTC_REFCLKIN
55	K9	36	28	PD8	I/O	TTa	SPI2_SCK,I2S2_CK,USART3_ TX,G6_IO3	SDADC3_AIN6P
56	K8			PD9	I/O	TTa	USART3_RX,G6_IO4	SDADC3_AIN5P, SDADC3_AIN6M
57	J12			PD10	I/O	TTa	USART3_CK	SDADC3_AIN4P
58	J11			PD11	I/O	TTa	USART3_CTS	SDADC3_AIN3P, SDADC3_AIN4M
59	J10			PD12	I/O	TTa	USART3_RTS	TIM4_CH1,G8_IO1, SDADC3_AIN2P
60	H12			PD13	I/O	TTa	TIM4_CH2,G8_IO2	SDADC3_AIN1P, SDADC3_AIN2M
61	H11			PD14	I/O	TTa	TIM4_CH3,G8_IO3	SDADC3_AIN0P
62	H10			PD15	I/O	TTa	TIM4_CH4,G8_IO4	SDADC3_AIN0M
63	E12	37		PC6	I/O	FT	I2S2_MCK,SPI1_NSS, I2S1_WS, TIM3_CH1	
64	E11	38		PC7	I/O	FT	I2S3_MCK,SPI1_SCK, I2S1_CK,TIM3_CH2	
65	E10	39		PC8	I/O	FT	SPI1_MISO,TIM3_CH3	
66	D12	40		PC9	I/O	FT	SPI1_MOSI,I2S1_SD, TIM3_CH4	
67	D11	41	29	PA8	I/O	FT	SPI2_SCK_I2S2_CK, I2C2_SMBAI, USART1_CK,TIM4_ETR, TIM5_CH1_ETR,CLK_CLKOU T	
68	D10	42	30	PA9	I/O	FT	SPI2_MISO_I2S2_MCK, I2C2_SCL,USART1_TX, TIM2_CH3,TIM15_BKIN, TIM13_CH1,G4_IO1	
69	C12	43	31	PA10	I/O	FT	SPI2_MOSI_I2S2_SD, TIM2_SDA,USART1_RX, TIM2_CH4,TIM17_BKIN, TIM14_CH1,G4_IO2	
70	B12	44	32	PA11	I/O	FT	SPI2_NSS,I2S2_WS,SPI1_NS S,I2S1_WS,USART1_CTS, USBDM,CAN_RX,TIM4_CH1, TIM5_CH2, COMP1_OUT	

Table 11. STM32F37x pin definitions (continued)

Pin numbers				Pin name (function after reset)	Pin type	I/O structure	Pin functions	
LQFP100	BGA100	LQFP64	LQFP48				Alternate function	Additional functions
71	A12	45	33	PA12	I/O	FT	SPI1_SCK,I2S1_CK,USART1_RTS, USBDP, CAN_TX, TIM16_CH1,TIM4_CH2, TIM5_CH3, COMP2_OUT	
72	A11	46	34	PA13	I/O	FT	SPI1_MISO,I2S1_MCK, USART3_CTS,IR_OUT, TIM16_CH1N,TIM4_CH3, TIM5_CH4,G4_IO3,SWDAT, JTMS	
73	C11	47	35	PF6	I/O	FT	SPI1_MOSI,I2S1_SD, USART2_SCL,USART3_RTS, TIM4_CH4,I2C2_SCL	
74	F11			VSS_3	S			
75	G11			VDD_3	S			
		48	36	PF7	I/O	FT	I2C2_SDA,USART2_CK	
76	A10	49	37	PA14	I/O	FT	I2C1_SDA,USART2_TX, TIM12_CH1,G4_IO4,SWCLK, JTCK	
77	A9	50	38	PA15	I/O	FT	SPI1_NSS,I2S1_WS,SPI3_NSS,I2S3_WS,I2C1_SCL, USART2_RX,TIM2_CH1_ETR, TIM12_CH2,SYNC, JTDI	
78	B11	51		PC10	I/O	FT	SPI3_SCK,I2S3_CK, USART3_TX, TIM19_CH1	
79	C10	52		PC11	I/O	FT	SPI3_MISO,I2S3_MCK, USART3_RX, TIM19_CH2	
80	B10	53		PC12	I/O	FT	SPI3_MOSI,I2S3_SD, USART3_CK, TIM19_CH3	
81	C9			PD0	I/O	FT	CAN_RX,TIM19_CH4	
82	B9			PD1	I/O	FT	CAN_TX,TIM19_ETR	
83	C8	54		PD2	I/O	FT	TIM3_ETR	
84	B8			PD3	I/O	FT	SPI2_MISO,I2S2_MCK, USART2_CTS	
85	B7			PD4	I/O	FT	SPI2_MOSI,I2S2_SD, USART2_RTS	
86	A6			PD5	I/O	FT	USART2_TX	
87	B6			PD6	I/O	FT	SPI2_NSS_I2S2_WS, USART2_RX	

Table 11. STM32F37x pin definitions (continued)

Pin numbers				Pin name (function after reset)	Pin type	I/O structure	Pin functions	
LQFP100	BGA100	LQFP64	LQFP48				Alternate function	Additional functions
88	A5			PD7	I/O	FT	SPI2_SCK_I2S2_CK, USART2_CK	
89	A8	55	39	PB3	I/O	FT	SPI1_SCK,I2S1_CK,SPI3_SCK,I2S3_CK,USART2_TX, TIM2_CH2,TIM3_ETR, TIM4_ETR,TIM13_CH1,G5_IO1,JTDO, TRACESWO	
90	A7	56	40	PB4	I/O	FT	SPI1_MISO,I2S1_MCK,SPI3_MISO,I2S3_MCK,USART2_RX TIM16_CH1,TIM3_CH1, TIM17_BKIN,TIM15_CH1N, G5_IO2, JNTRST	
91	C5	57	41	PB5	I/O	FT	SPI1_MOSI,I2S1_SD, SPI3_MOSI,I2S3_SD,I2C1_SMBAI,USART2_CK,TIM16_BKIN,TIM3_CH2,TIM17_CH1, TIM19_ETR	
92	B5	58	42	PB6	I/O	FT	I2C1_SCL,USART1_TX,TIM16_CH1N,TIM3_CH3,TIM4_CH1, TIM19_CH1, TIM15_CH1,G5_IO3	
93	B4	59	43	PB7	I/O	FT	I2C1_SDA,USART1_RX, TIM17_CH1N, TIM3_CH4,TIM4_CH2, TIM19_CH2, TIM15_CH2,G5_IO4	
94	A4	60	44	BOOT0	I	B		
95	A3	61	45	PB8	I/O	FT	SPI2_SCK,I2S2_CK,I2C1_SCL,USART3_TX,CAN_RX,CEC, TIM16_CH1,TIM4_CH3, TIM19_CH3, COMP1_OUT,SYNC	
96	B3	62	46	PB9	I/O	FT	SPI2_NSS,I2S2_WS,I2C1_SDA,USART3_RX,CAN_TX,IR_OUT,TIM17_CH1,TIM4_CH4, TIM19_CH4, COMP2_OUT	
97	C3			PE0	I/O	FT	USART1_TX,TIM4_ETR	
98	A2			PE1	I/O	FT	USART1_RX	
99	D3	63	47	VSS_1	S			
100	C4	64	48	VDD_1	S			

Table 12. Alternate functions

AF n°	Port & Pin Name	AF0	AF1	AF2	AF3	AF4	AF5	AF6	AF7	AF8	AF9	AF10	AF11	AF12	AF13	AF14	AF15
7	PA0		TIM2_CH1_ETR	TIM5_CH1_ETR	G1_IO1				USART2_CTS	COMP1_OUT			TIM19_CH1				EVENTOUT
8	PA1		TIM2_CH2	TIM5_CH2	G1_IO2			SPI3_SCK / 3_CK	USART2_RTS		TIM15_CH1N		TIM19_CH2				EVENTOUT
9	PA2		TIM2_CH3	TIM5_CH3	G1_IO3			SPI3_MISO / 3_MCK	USART2_TX	COMP2_OUT	TIM15_CH1		TIM19_CH3				EVENTOUT
8	PA3		TIM2_CH4	TIM5_CH4	G1_IO4			SPI3_MOSI / 3_SD	USART2_RX		TIM15_CH2		TIM19_CH4				EVENTOUT
7	PA4			TIM3_CH2	G2_IO1		SPI1_NSS / 1_WS	SPI3_NSS / 3_WS	USART2_CK			TIM12_CH1					EVENTOUT
7	PA5		TIM2_CH1_ETR		G2_IO2		SPI1_SCK / 1_CK		CEC		TIM14_CH1	TIM12_CH2					EVENTOUT
7	PA6		TIM16_CH1	TIM3_CH1	G2_IO3		SPI1_MISO / 1_MCK			COMP1_OUT	TIM13_CH1						EVENTOUT
7	PA7		TIM17_CH1	TIM3_CH2	G2_IO4		SPI1_MOSI / 1_SD			COMP2_OUT	TIM14_CH1						EVENTOUT

Table 12. Alternate functions (continued)

AF n°	Port & Pin Name	AF0	AF1	AF2	AF3	AF4	AF5	AF6	AF7	AF8	AF9	AF10	AF11	AF12	AF13	AF14	AF15
7	PA8	MCO		TIM5_CH1_ETR		I2C2_SMBAI	SPI2_SCK / 2_CK		USART1_CK			TIM4_ETR					EVENTOUT
8	PA9			TIM13_CH1	G4_IO1	I2C2_SCL	SPI2_MISO / 2_MCK		USART1_TX		TIM15_BKIN	TIM2_CH3					EVENTOUT
8	PA10		TIM17_BKIN		G4_IO2	I2C2_SDA	SPI2_MOSI / 2_SD		USART1_RX		TIM14_CH1	TIM2_CH4					EVENTOUT
9	PA11			TIM5_CH2			SPI2_NSS / 2_WS	SPI1_NSS / 1_WS	USART1_CTS	COMP1_OUT	CAN_RX	TIM4_CH1				USBDM	EVENTOUT
9	PA12		TIM16_CH1	TIM5_CH3				SPI1_SCK / 1_CK	USART1_RTS	COMP2_OUT	CAN_TX	TIM4_CH2				USBDP	EVENTOUT
9	PA13	JTMS-SWDAT	TIM16_CH1N	TIM5_CH4	G4_IO3		IR-Out	SPI1_MISO / 1_MCK	USART3_CTS			TIM4_CH3					EVENTOUT
5	PA14	JTCK-SWCLK			G4_IO4	I2C1_SDA						TIM12_CH1					EVENTOUT
8	PA15	JTDI	TIM2_CH1_ETR		SYNCH	I2C1_SCL	SPI1_NSS / 1_WS	SPI3_NSS / 3_WS				TIM12_CH2					EVENTOUT
5	PB0			TIM3_CH3	G3_IO3		SPI_MOSI / 1_SD					TIM3_CH2					EVENTOUT
3	PB1			TIM3_CH4	G3_IO4												EVENTOUT

Table 12. Alternate functions (continued)

AF n°	Port & Pin Name	AF0	AF1	AF2	AF3	AF4	AF5	AF6	AF7	AF8	AF9	AF10	AF11	AF12	AF13	AF14	AF15
1	PB2																EVENTOUT
10	PB3	JTDO/TRACESWO	TIM2_CH2	TIM4_ETR	G5_IO1		SPI1_SCK/1_CK	SPI3_SCK/3_CK	USART2_TX		TIM13_CH1	TIM3_ETR					EVENTOUT
10	PB4	JTRST	TIM16_CH1	TIM3_CH1	G5_IO2		SPI1_MISO/1_MCK	SPI3_MISO / 3_MCK	USART2_RX		TIM15_CH1N	TIM17_BKIN					EVENTOUT
9	PB5		TIM16_BKIN	TIM3_CH2		I2C1_SMBAI	SPI1_MOSI/1_SD	SPI3_MOSI/3_SD	USART2_CK			TIM17_CH1	TIM19_ETR				EVENTOUT
9	PB6		TIM16_CH1N	TIM4_CH1	G5_IO3	I2C1_SCL			USART1_TX		TIM15_CH1	TIM3_CH3	TIM19_CH1				EVENTOUT
9	PB7		TIM17_CH1N	TIM4_CH2	G5_IO4	I2C1_SDA			USART1_RX		TIM15_CH2	TIM3_CH4	TIM19_CH2				EVENTOUT
11	PB8		TIM16_CH1	TIM4_CH3	SYNCH	I2C1_SCL	SPI2_SCK/2_CK	CEC	USART3_TX	COMP1_OUT	CAN_RX		TIM19_CH3				EVENTOUT
10	PB9		TIM17_CH1	TIM4_CH4		I2C1_SDA	SPI2_NSS/2_WS	IR-Out	USART3_RX	COMP2_OUT	CAN_TX		TIM19_CH4				EVENTOUT
6	PB10		TIM2_CH3		SYNCH		SPI2_SCK/2_CK	CEC	USART3_TX								EVENTOUT
6	PB14		TIM15_CH1		G6_IO1		SPI2_MISO/2_MCK		USART3_RTS		TIM12_CH1						EVENTOUT

Table 12. Alternate functions (continued)

AF n°	Port & Pin Name	AF0	AF1	AF2	AF3	AF4	AF5	AF6	AF7	AF8	AF9	AF10	AF11	AF12	AF13	AF14	AF15
6	PB15		TIM 15_ CH2	TIM 15_ CH1N	G6_ IO2		SPI2_ MOSI / 2_SD				TIM12 _CH2						EVEN TOUT
2	PC0		EVENT OUT	TIM5 _CH1 _ETR													
2	PC1		EVENT OUT	TIM5 _CH2													
3	PC2		EVENT OUT	TIM5 _CH3			SPI2_ MISO / 2_MCK										
3	PC3		EVENT OUT	TIM5 _CH4			SPI2_ MOSI / 2_SD										
4	PC4		EVENT OUT	TIM 13_ CH1	G3_ IO1				USART 1_TX								
3	PC5		EVENT OUT		G3_ IO2				USART 1_RX								
3	PC6		EVENT OUT	TIM3 _CH1			SPI1_ NSS / 1_WS										
3	PC7		EVENT OUT	TIM3 _CH2			SPI1_ SCK / 1_CK										
3	PC8		EVENT OUT	TIM3 _CH3			SPI1_ MISO										

Table 12. Alternate functions (continued)

AF n°	Port & Pin Name	AF0	AF1	AF2	AF3	AF4	AF5	AF6	AF7	AF8	AF9	AF10	AF11	AF12	AF13	AF14	AF15
3	PC9		EVENTOUT	TIM3_CH4			SPI1_MOSI / 1_SD										
4	PC10		EVENTOUT	TIM19_CH1				SPI3_SCK / 3_CK	USART3_TX								
4	PC11		EVENTOUT	TIM19_CH2				SPI3_MISO / 3_MCK	USART3_RX								
4	PC12		EVENTOUT	TIM19_CH3				SPI3_MOSI / 3_SD	USART3_CK								
0	PC13																
0	PC14																
0	PC15																
3	PD0		EVENTOUT	TIM19_CH4					CAN_RX								
3	PD1		EVENTOUT	TIM19_ETR					CAN_TX								
2	PD2		EVENTOUT	TIM3_ETR													
3	PD3		EVENTOUT				SPI2_MISO / 2_MCK		USART2_CTS								

Table 12. Alternate functions (continued)

AF n°	Port & Pin Name	AF0	AF1	AF2	AF3	AF4	AF5	AF6	AF7	AF8	AF9	AF10	AF11	AF12	AF13	AF14	AF15
3	PD4		EVENT OUT				SPI2_ MOSI / 2_SD		USART 2_RTS								
2	PD5		EVENT OUT						USART 2_TX								
3	PD6		EVENT OUT				SPI2_ NSS / 2_WS		USART 2_RX								
3	PD7		EVENT OUT				SPI2_ SCK / 2_CK		USART 2_CK								
4	PD8		EVENT OUT		G6_ IO3		SPI2_ SCK / 2_CK		USART 3_TX								
3	PD9		EVENT OUT		G6_ IO4				USART 3_RX								
2	PD10		EVENT OUT						USART 3_CK								
2	PD11		EVENT OUT						USART 3_CTS								
4	PD12		EVENT OUT	TIM4 _CH1	G8_ IO1				USART 3_RTS								
3	PD13		EVENT OUT	TIM4 _CH2	G8_ IO2												
3	PD14		EVENT OUT	TIM4 _CH3	G8_ IO3												
3	PD15		EVENT OUT	TIM4 _CH4	G8_ IO4												

Table 12. Alternate functions (continued)

AF n°	Port & Pin Name	AF0	AF1	AF2	AF3	AF4	AF5	AF6	AF7	AF8	AF9	AF10	AF11	AF12	AF13	AF14	AF15
3	PE0		EVENT OUT	TIM4 _ETR					USART 1_TX								
2	PE1		EVENT OUT						USART 1_RX								
3	PE2	TRACE CLK	EVENT OUT		G7_ IO1												
3	PE3	TRACE D0	EVENT OUT		G7_ IO2												
3	PE4	TRACE D1	EVENT OUT		G7_ IO3												
3	PE5	TRACE D2	EVENT OUT		G7_ IO4												
2	PE6	TRACE D3	EVENT OUT														
1	PE7		EVENT OUT														
1	PE8		EVENT OUT														
1	PE9		EVENT OUT														
1	PE10		EVENT OUT														
1	PE11		EVENT OUT														
1	PE12		EVENT OUT														

Table 12. Alternate functions (continued)

AF n°	Port & Pin Name	AF0	AF1	AF2	AF3	AF4	AF5	AF6	AF7	AF8	AF9	AF10	AF11	AF12	AF13	AF14	AF15
1	PE13		EVENT OUT														
1	PE14		EVENT OUT														
2	PE15		EVENT OUT						USART 3_RX								
1	PF0					I2C2_ SDA											
1	PF1					I2C2_ SCL											
2	PF2		EVENT OUT			I2C2_ SMBAI											
1	PF4		EVENT OUT														
5	PF6		EVENT OUT	TIM4 _CH4		I2C2_ SCL	SPI1_ MOSI / 1_SD		USART 3_RTS								
3	PF7		EVENT OUT			I2C2_ SDA			USART 2_CK								
2	PF9		EVENT OUT	TIM 14_ CH1													
1	PF10		EVENT OUT														

4 Memory mapping

Figure 5. STM32F37x memory map

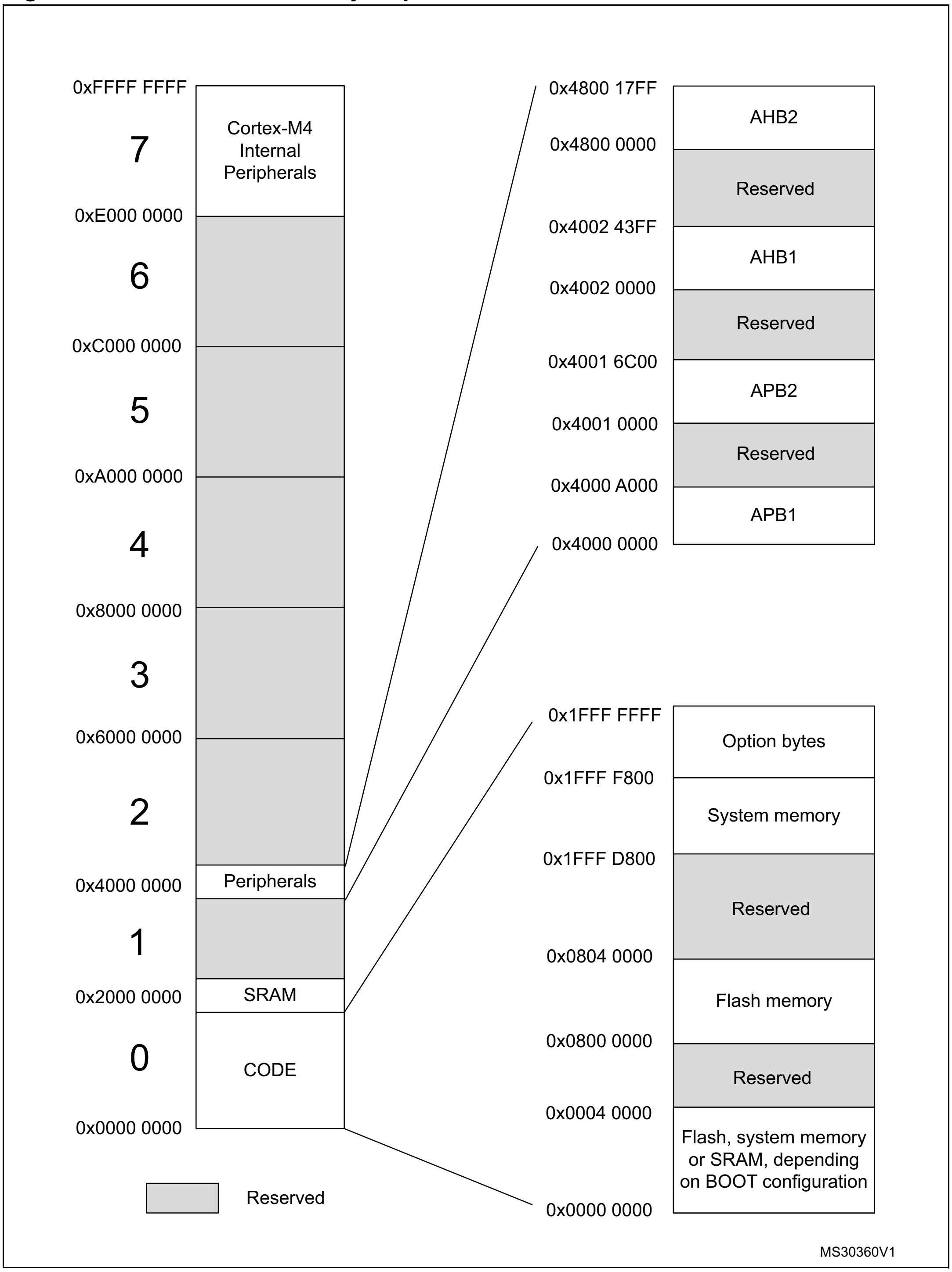


Table 13. STM32F37x peripheral register boundary addresses

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

Table 13. STM32F37x peripheral register boundary addresses (continued)

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

Table 13. STM32F37x peripheral register boundary addresses (continued)

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

5 Electrical characteristics

5.1 Parameter conditions

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

5.1.1 Minimum and maximum values

Unless otherwise specified, the minimum and maximum values are guaranteed in the worst conditions of ambient temperature, supply voltage and frequencies by tests in production on 100% of the devices with an ambient temperature at T_A = 25 °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).

5.1.2 Typical values

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

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

5.1.3 Typical curves

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

5.1.4 Loading capacitor

The loading conditions used for pin parameter measurement are shown in *Figure 6*.

5.1.5 Pin input voltage

The input voltage measurement on a pin of the device is described in *Figure 7*.

Figure 6. Pin loading conditions

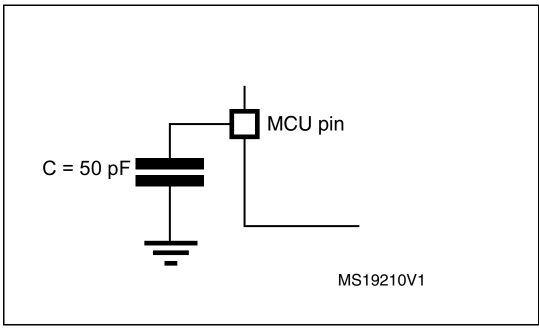
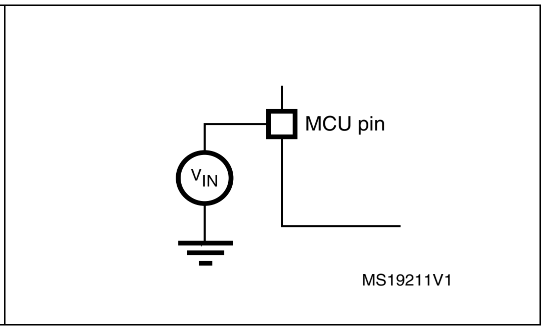
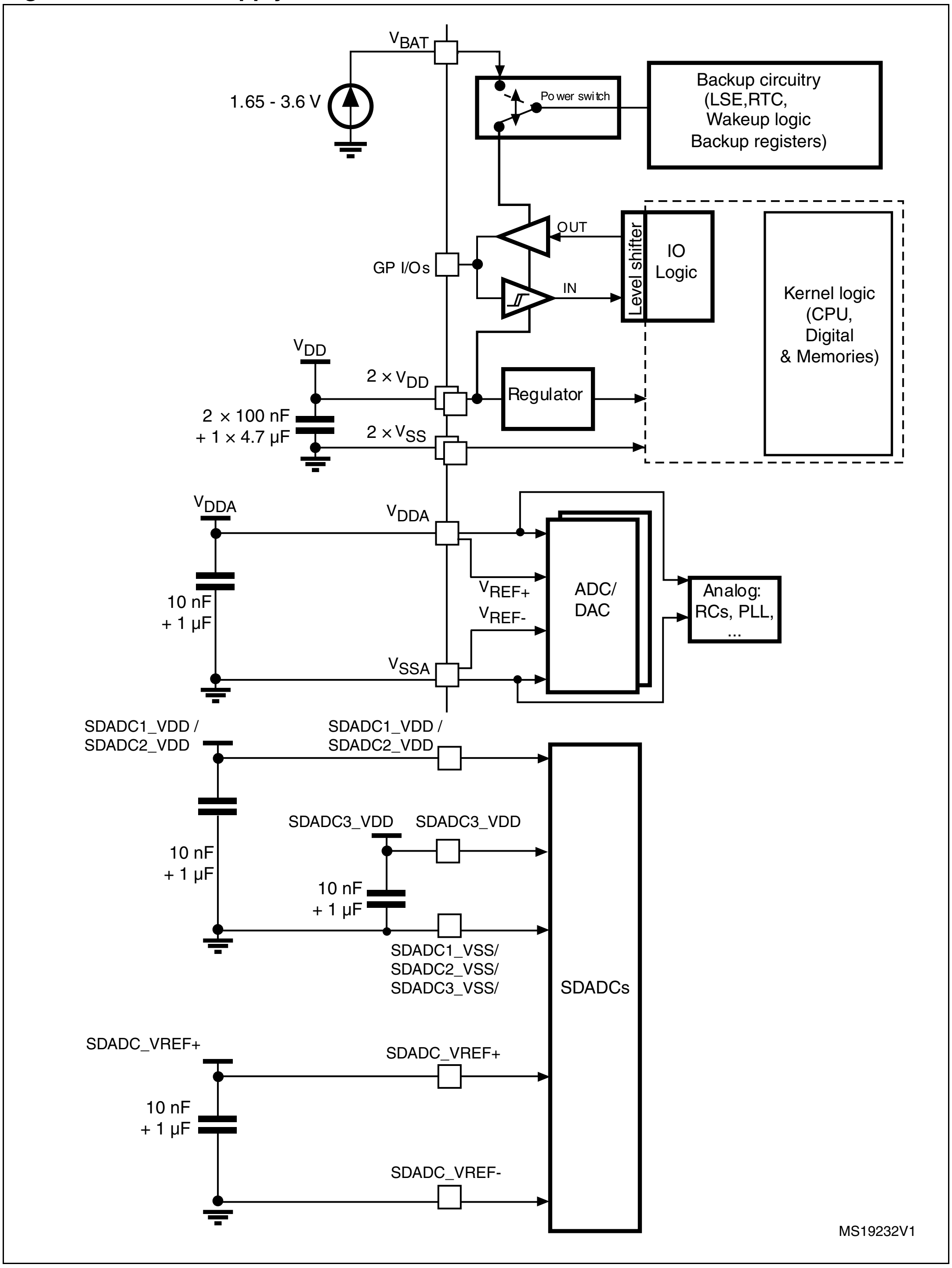


Figure 7. Pin input voltage



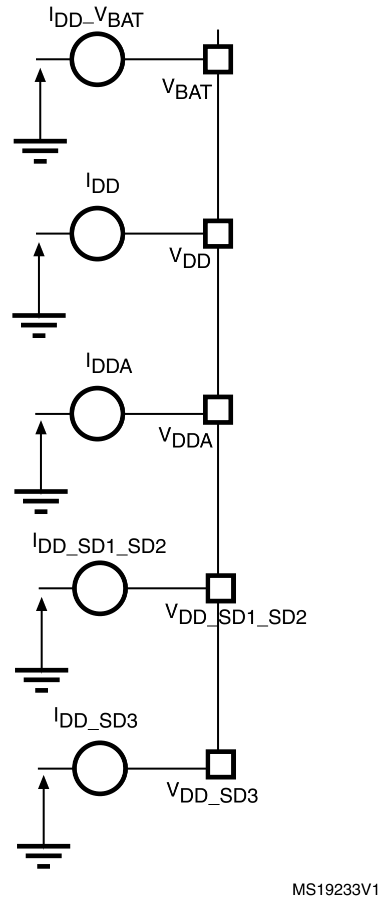
5.1.6 Power supply scheme

Figure 8. Power supply scheme



5.1.7 Current consumption measurement

Figure 9. Current consumption measurement scheme



5.2 Absolute maximum ratings

Stresses above the absolute maximum ratings listed in *Table 14: Voltage characteristics*, *Table 15: Current characteristics*, and *Table 16: 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 14. Voltage characteristics

Symbol	Ratings	Min	Max	Unit
V_{DD}–V_{SS}	External main supply voltage (including V_{DDA}, SDADCx_V_{DD} and V_{DD})	–0.3	4.0	V
V_{DD}–V_{DDA}	Allowed voltage difference for V_{DD} > V_{DDA}		0.4	
SDADC_VDD - V_{DDA}	Allowed voltage difference for SDADC_VDD > V_{DDA}		0.4	
V_{IN}	Input voltage on FT and FTf pins	V_{SS} – 0.3	V_{DD} + 4.0	
	Input voltage on TTa pins in anaolog mode	V_{SS} – 0.3	V_{DDA} + 0.3	
	Input voltage on TTa pins in digital mode	V_{SS} – 0.3	V_{DD} + 0.3	
	Input voltage on TTa pins on SDADCx channels inputs[1]	V_{SS}-0.3	SDADCx_VDD +0.3	
	Input voltage on any other pin	V_{SS} – 0.3	4.0	
$\|V_{SSX} - V_{SS}\|$	Variations between all the different ground pins		50	mV
$V_{ESD(HBM)}$	Electrostatic discharge voltage (human body model)	see *Section 5.3.11: Electrical sensitivity characteristics*		

1. SDADC1_VDD/SDADC2_VDD is external power supply for PB0 to PB2, PB10, and PE7 to PE15 I/O pins (I/O pin ground is internally connected to V_{SS}). SDADC3_VDD is external power supply for PB14 to PB15 and PD8 to PD15 I/O pins (I/O pin ground is internally connected to V_{SS})

All main power (V_{DD}, SDADC1_VDD/SDADC2_VDD, SDADC3_V_{DD} and V_{DDA}) and ground (V_{SS}, SDADC1_VSS/SDADC2_VSS, SDADC3_V_{SS} and V_{SSA}) pins must always be connected to the external power supply, in the permitted range.

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

The following relationship must be respected between V_{DDA} and SDADC1_VDD/SDADC2_VDD: V_{DDA} must power on before or at the same time as SDADC1_VDD/SDADC2_VDD or SDADC3_VDDin the power up sequence. V_{DDA} must be greater than or equal to SDADC1_VDD/SDADC2_VDD or SDADC3_VDD.

The following relationship must be respected between SDADC1_VDD/SDADC2_VDD and SDADC3_VDD: SDADC3_VDD must power on before or at the same time as SDADC1_VDD/SDADC2_VDD in the power up sequence.

Table 15. Current characteristics(1)

Symbol	Ratings	Max.	Unit
I_{VDD}	Total current into V_{DD} power lines (source)(2)	TBD	mA
I_{VSS}	Total current out of V_{SS} ground lines (sink)(2)	TBD	
I_{IO}	Output current sunk by any I/O and control pin	25	
	Output current source by any I/Os and control pin	– 25	
$I_{INJ(PIN)}$(3)	Injected current on FT and FTf pins(4)	-5/+NA	
	Injected current on any other pin(5)	± 5	
$\Sigma I_{INJ(PIN)}$	Total injected current (sum of all I/O and control pins)(6)	± 25	

1. TBD stands for "to be defined".
2. All main power (V_{DD}, SDADC1_VDD/SDADC2_VDD, SDADC3_VDD and V_{DDA}) and ground (V_{SS}, SDADC1_VSS/SDADC2_VSS, SDADC3_VSS and V_{SSA}) pins must always be connected to the external power supply, in the permitted range.
3. Negative injection disturbs the analog performance of the device. See note 2 below *Table 58 on page 96*.
4. Positive injection is not possible on these I/Os and does not occur for input voltages lower than the specified maximum value. A negative injection is induced by $V_{IN}<V_{SS}$. $I_{INJ(PIN)}$ must never be exceeded. Refer to *Table 14: Voltage characteristics* for the maximum allowed input voltage values.
5. A positive injection is induced by $V_{IN}>V_{DD}$ while a negative injection is induced by $V_{IN}<V_{SS}$. $I_{INJ(PIN)}$ must never be exceeded. Refer to *Table 14: Voltage characteristics* for the maximum allowed input voltage values.
6. When several inputs are submitted to a current injection, the maximum $\Sigma I_{INJ(PIN)}$ is the absolute sum of the positive and negative injected currents (instantaneous values).

Table 16. Thermal characteristics

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

5.3 Operating conditions

5.3.1 General operating conditions

Table 17. General operating conditions[1]

Symbol	Parameter	Conditions	Min	Max	Unit
f_{HCLK}	Internal AHB clock frequency		0	72	MHz
f_{PCLK1}	Internal APB1 clock frequency		0	36	
f_{PCLK2}	Internal APB2 clock frequency		0	72	
V_{DD}	Standard operating voltage		2	3.6	V
V_{DDA}[2]	Analog operating voltage (ADC and DAC not used)	Must have a potential equal to or higher than V_{DD}	2	3.6	V
	Analog operating voltage (ADC and DAC used)		2.4	3.6	
SDADC1_VDD/ SDADC2_VDD	SDADC1 / SDADC2 operating voltage		2.2	3.6	V
SDADC3_VDD	SDADC3 operating voltage		2.2	3.6	V
V_{BAT}	Backup operating voltage		1.65	3.6	V
P_D	Power dissipation at T_A = 85 °C for suffix 6 or T_A = 105 °C for suffix 7[3]	WLCSP66			mW
		LQFP100		434	
		LQFP64		444	
		LQFP48		364	
TA	Ambient temperature for 6 suffix version	Maximum power dissipation	–40	85	°C
		Low power dissipation[4]	–40	105	
	Ambient temperature for 7 suffix version	Maximum power dissipation	–40	105	°C
		Low power dissipation[4]	–40	125	
TJ	Junction temperature range	6 suffix version	–40	105	°C
		7 suffix version	–40	125	

1. TBD stands for “to be defined”.
2. When the ADC is used, refer to *Table 56: ADC characteristics*.
3. If T_A is lower, higher P_D values are allowed as long as T_J does not exceed T_{Jmax} (see *Table 16: Thermal characteristics*).
4. In low power dissipation state, T_A can be extended to this range as long as T_J does not exceed T_{Jmax} (see *Table 16: Thermal characteristics*).

5.3.2 Operating conditions at power-up / power-down

The parameters given in *Table 18* are derived from tests performed under the ambient temperature condition summarized in *Table 17*.

Table 18. Operating conditions at power-up / power-down(1)

Symbol	Parameter	Conditions	Min	Max	Unit
t_{VDD}	V_{DD} rise time rate		0		µs/V
	V_{DD} fall time rate		20		
t_{VDDA}	V_{DDA} rise time rate		0		
	V_{DDA} fall time rate		20		

1. TBD stands for “to be defined”.

5.3.3 Embedded reset and power control block characteristics

The parameters given in *Table 19* are derived from tests performed under ambient temperature and V_{DD} supply voltage conditions summarized in *Table 17*.

Table 19. Embedded reset and power control block characteristics

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

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

Table 20. Programmable voltage detector characteristics

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

1. Data based on characterization results only, not tested in production.
2. Guaranteed by design, not tested in production.

5.3.4 Embedded reference voltage

The parameters given in *Table 21* are derived from tests performed under ambient temperature and V_{DD} supply voltage conditions summarized in *Table 17*.

Table 21. Embedded internal reference voltage

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{REFINT}	Internal reference voltage	–40 °C < T_A < +105 °C	1.18	1.21	1.24	V
$T_{S\_vrefint}$(1)	ADC sampling time when reading the internal reference voltage		10	-	-	µs
V_{REFINT_s}(2)	Internal reference voltage spread over the temperature range	V_{DD} = 3 V	-		10	mV
T_{Coeff}(2)	Temperature coefficient		-		100	ppm/°C
t_{START}(2)	Startup time		-	6	10	µs

1. Shortest sampling time can be determined in the application by multiple iterations.
2. Guaranteed by design, not tested in production.

5.3.5 Supply current characteristics

The current consumption is a function of several parameters and factors such as the operating voltage, ambient temperature, I/O pin loading, device software configuration, operating frequencies, I/O pin switching rate, program location in memory and executed binary code.
The current consumption is measured as described in *Figure 9: Current consumption measurement scheme*.
All Run-mode current consumption measurements given in this section are performed with a reduced code that gives a consumption equivalent to CoreMark x.x code.

Typical and maximum current consumption

The MCU is placed under the following conditions:

- All I/O pins are in input mode with a static value at V_{DD} or V_{SS} (no load)
- All peripherals are disabled except when explicitly mentioned
- The Flash memory access time is adjusted to the f_{HCLK} frequency (0 wait state from 0 to 24 MHz, 1 wait state from 24 to 48 MHz and 2 wait states from 48 MHz to 72 MHz)
- Prefetch in ON (reminder: this bit must be set before clock setting and bus prescaling)
- When the peripherals are enabled $f_{APB1} = f_{AHB}/2$, $f_{APB2} = f_{AHB}$

The parameters given in *Table 22* to *Table 33* are derived from tests performed under ambient temperature and supply voltage conditions summarized in *Table 17*.

Table 22. Typical and maximum current consumption from V_{DD} supply at V_{DD} = 3.6 V

Symbol	Parameter	Conditions	f_{HCLK}	All peripherals enabled				All peripherals disabled				Unit
				Typ	Max @ T_A (1)			Typ	Max @ T_A (1)			
					25 °C	85 °C	105 °C		25 °C	85 °C	105 °C	
I_{DD}	Supply current in Run mode, code executing from Flash	External clock (HSE bypass)	72 MHz	65				39				mA
			64 MHz									
			48 MHz	45								
			32 MHz									
			24 MHz	25								
			8 MHz	8.8								
			1 MHz									
		Internal clock (HSI)	64 MHz	58				35				
			48 MHz	45				27				
			32 MHz									
			24 MHz	26				15				
			8 MHz	8.5				5.3				
	Supply current in Run mode, code executing from RAM	External clock (HSE bypass)	72 MHz	62								
			64 MHz									
			48 MHz									
			32 MHz									
			24 MHz									
			8 MHz									
			1 MHz									
		Internal clock (HSI)	64 MHz	56								
			48 MHz	43								
			32 MHz									
			24 MHz									
			8 MHz									

Table 22. Typical and maximum current consumption from V_{DD} supply at V_{DD} = 3.6 V

Symbol	Parameter	Conditions	f_{HCLK}	All peripherals enabled				All peripherals disabled				Unit
				Typ	Max @ T_A(1)			Typ	Max @ T_A(1)			
					25 °C	85 °C	105 °C		25 °C	85 °C	105 °C	
I_{DD}	Supply current in Sleep mode, code executing from Flash or RAM	External clock (HSE bypass)	72 MHz	40				8.6				mA
			64 MHz									
			48 MHz									
			32 MHz									
			24 MHz									
			8 MHz									
			1 MHz									
		Internal clock (HSI)	64 MHz	35				7				
			48 MHz	27				5.8				
			32 MHz									
			24 MHz									
			8 MHz									

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

Table 23. Typical and maximum current consumption from V_{DDA} supply

Symbol	Parameter	Conditions	f_{HCLK}	V_{DDA}= 2.4 V				V_{DDA}= 3.6 V				Unit
				Typ	Max @ T_A(1)			Typ	Max @ T_A(1)			
					25 °C	85 °C	105 °C		25 °C	85 °C	105 °C	
I_{DDA}	Supply current in Run or Sleep mode, code executing from Flash or RAM	External clock (HSE bypass)	72 MHz					260				µA
			64 MHz									
			48 MHz					170				
			32 MHz									
			24 MHz					92				
			8 MHz					2				
			1 MHz									
		Internal clock (HSI)	64 MHz					297				
			48 MHz					240				
			32 MHz									
			24 MHz					162				
			8 MHz					73				

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

Table 24. Typical and maximum V_{DD} consumption in Stop and Standby modes

Symbol	Parameter	Conditions	Typ@V_{DD}(V_{DD}=V_{DDA})						Max			Unit
			2.0 V	2.4 V	2.7 V	3.0 V	3.3 V	3.6 V	T_A= 25 °C	T_A= 85 °C	T_A= 105 °C	
I_{DD}	Supply current in Stop mode	Regulators in run mode, all oscillators OFF						21.9				µA
		Regulators in low-power mode, all oscillators OFF						9.5				
	Supply current in Standby mode	LSI ON and IWDG ON						1.73				
		LSI OFF and IWDG OFF						1.23				

Note: V_{DDA} monitoring is OFF and SDADC12_VDD monitoring is OFF

Table 25. Typical and maximum V_{DDA} consumption in Stop and Standby modes

Symbol	Parameter	Conditions		Typ@V_{DD}(V_{DD}=V_{DDA})						Max(1)			Unit
				2.0 V	2.4 V	2.7 V	3.0 V	3.3 V	3.6 V	T_A= 25 °C	T_A= 85 °C	T_A= 105 °C	
I_{DDA}	Supply current in Stop mode	V_{DDA} and SDADC12_VDD monitoring ON	Regulator in run mode, all oscillators OFF										µA
			Regulator in low-power mode, all oscillators OFF										
	Supply current in Standby mode		LSI ON and IWDG ON										
			LSI OFF and IWDG OFF						2.71				
	Supply current in Stop mode	V_{DDA} and SDADC12_VDD monitoring OFF	Regulator in run mode, all oscillators OFF						1.4				
			Regulator in low-power mode, all oscillators OFF						1.4				
	Supply current in Standby mode		LSI ON and IWDG ON						2.13				
			LSI OFF and IWDG OFF						1.29				

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

Table 26. Typical and maximum current consumption from V_{BAT} supply

Symbol	Parameter	Conditions	Typ @ V_{BAT}						Max(1)			Unit
			= 1.65 V	= 1.8 V	= 2.4 V	= 2.7 V	= 3.3 V	= 3.6 V	T_A= 25 °C	T_A= 85 °C	T_A= 105 °C	
I_{DD_VBAT}	Backup domain supply current	LSE & RTC ON; "Xtal mode" lower driving capability; LSEDRV[1:0] = '00'										µA
		LSE & RTC ON; "Xtal mode" higher driving capability; LSEDRV[1:0] = '11'										

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

Typical current consumption

The MCU is placed under the following conditions:

- V_{DD}=V_{DDA}= SDADC1_SDADC2_VDD = SDADC3_VDD = 3.3 V
- All I/O pins are in analog input configuration
- The Flash access time is adjusted to f_{HCLK} frequency (0 wait states from 0 to 24 MHz, 1 wait state from 24 to 48 MHz and 2 wait states from 48 MHz to 72 MHz)
- Prefetech is ON when the peripherals are enabled, otherwise it is OFF
- When the peripherals are enabled, f_{APB1} = $f_{AHB/2}$, f_{APB2} = f_{AHB}
- PLL is used for frequencies greater than 8 MHz
- AHB prescaler of 2, 4, 8 and 16 is used for the frequencies 4 MHz, 2 MHz, 1 MHz and 500 kHz respectively

Table 27. Typical current consumption in Run mode, code with data processing running from Flash

Symbol	Parameter	Conditions	f_{HCLK}	Typ		Unit
				Peripherals enabled	Peripherals disabled	
I_{DD}	Supply current in Run mode from V_{DD} supply	Running from HSE crystal clock 8 MHz, code executing from Flash	72 MHz	64.35	38.42	mA
			64 MHz			
			48 MHz	45.34		
			36 MHz			
			32 MHz			
			24 MHz	25.57		
			16 MHz			
			8 MHz	8.91		
			4 MHz			
			2 MHz			
			1 MHz			
			500 kHz			
I_{DDA}	Supply current in Run mode from V_{DDA} supply		72 MHz	250	250	µA
			64 MHz			
			48 MHz	165		
			36 MHz			
			32 MHz			
			24 MHz	89		
			16 MHz			
			8 MHz	1.5		
			4 MHz			
			2 MHz			
			1 MHz			
			500 kHz			
ISDADC12 + ISDADC3	Supply currents in Run mode from SDADC1_SDADC2 _VDD and SDADC3_VDD (SDADCs are off)		72 MHz			
			8 MHz			
			1 MHz			

Table 28. Typical current consumption in Sleep mode, code running from Flash or RAM

Symbol	Parameter	Conditions	f_{HCLK}	Typ		Unit
				Peripherals enabled	Peripherals disabled	
I_{DD}	Supply current in Sleep mode from V_{DD} supply	Running from HSE crystal clock 8 MHz, code executing from Flash or RAM	72 MHz	36.7	7.6	mA
			64 MHz			
			48 MHz			
			32 MHz			
			24 MHz			
			16 MHz			
			8 MHz			
			4 MHz			
			2 MHz			
			1 MHz			
			500 kHz			
			125 kHz			
I_{DDA}	Supply current in Sleep mode from V_{DDA} supply		72 MHz	237	237	µA
			64 MHz			
			48 MHz			
			36 MHz			
			32 MHz			
			24 MHz			
			16 MHz			
			8 MHz			
			4 MHz			
			2 MHz			
			1 MHz			
			500 kHz			
			125 kHz			
ISDADC12 + ISDADC3	Supply currents in Sleep mode from SDADC1_SDADC2 _VDD and SDADC3_VDD (SDADCs are off)		72 MHz			
			8 MHz			
			1 MHz			

I/O system current consumption

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

I/O static current consumption

All the I/Os used as inputs with pull-up generate current consumption when the pin is externally held low. The value of this current consumption can be simply computed by using the pull-up/pull-down resistors values given in *Table 44: I/O static characteristics*.

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

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

Caution: Any floating input pin can also settle to an intermediate voltage level or switch inadvertently, as a result of external electromagnetic noise. To avoid current consumption related to floating pins, they must either be configured in analog mode, or forced internally to a definite digital value. This can be done either by using pull-up/down resistors or by configuring the pins in output mode.

I/O dynamic current consumption

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

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

where

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

V_{DD} is the MCU supply voltage

f_{SW} is the I/O switching frequency

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

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

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

On-chip peripheral current consumption

The current consumption of the on-chip peripherals is given in *Table 34*. 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
- ambient operating temperature and V_{DD} supply voltage conditions summarized in *Table 14*

5.3.6 External clock source characteristics

High-speed external user clock generated from an external source

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

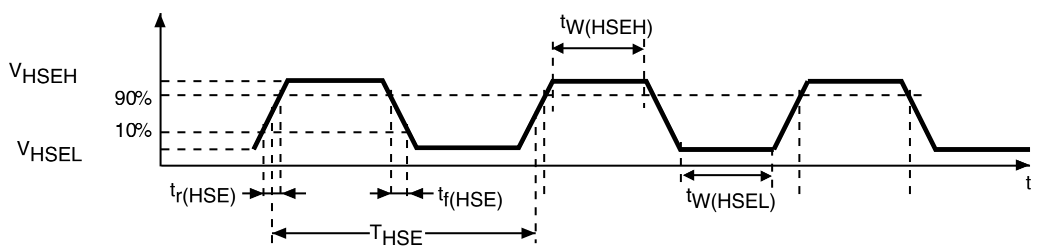
The external clock signal has to respect the I/O characteristics in *Section 5.3.13*. However, the recommended clock input waveform is shown in *Figure 10*.

Table 29. High-speed external user clock characteristics

Symbol	Parameter[1]	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}		$0.3V_{DD}$	V
$t_{w(HSEH)}$ $t_{w(HSEL)}$	OSC_IN high or low time		15			ns
$t_{r(HSE)}$ $t_{f(HSE)}$	OSC_IN rise or fall time				20	ns

1. Guaranteed by design, not tested in production.

Figure 10. High-speed external clock source AC timing diagram



Low-speed external user clock generated from an external source

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

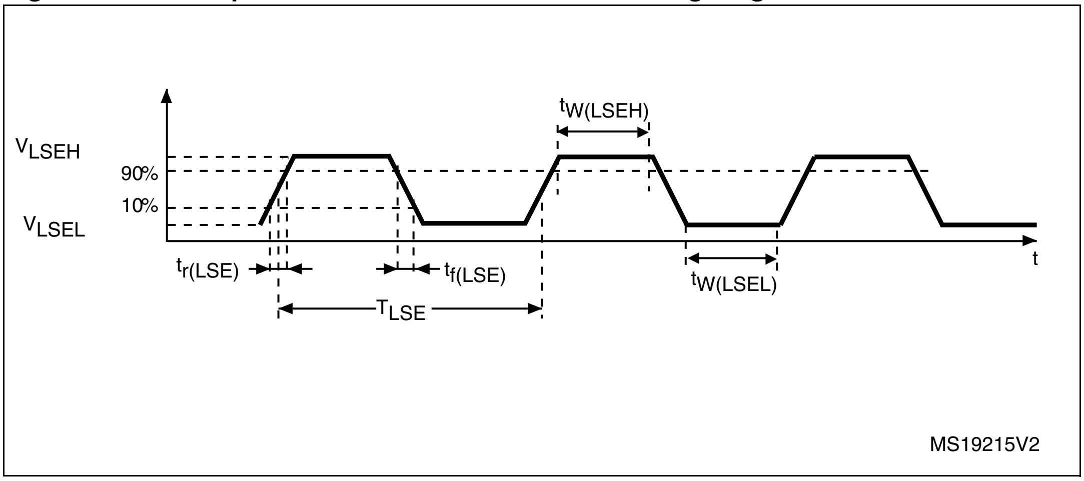
The external clock signal has to respect the I/O characteristics in *Section 5.3.13*. However, the recommended clock input waveform is shown in *Figure 11*.

Table 30. Low-speed external user clock characteristics

Symbol	Parameter[1]	Conditions	Min	Typ	Max	Unit
f_{LSE_ext}	User External clock source frequency			32.768	1000	kHz
V_{LSEH}	OSC32_IN input pin high level voltage		$0.7V_{DD}$		V_{DD}	V
V_{LSEL}	OSC32_IN input pin low level voltage		V_{SS}		$0.3V_{DD}$	
$t_{w(LSEH)}$ $t_{w(LSEL)}$	OSC32_IN high or low time		450			ns
$t_{r(LSE)}$ $t_{f(LSE)}$	OSC32_IN rise or fall time				50	

1. Guaranteed by design, not tested in production.

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



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

The high-speed external (HSE) clock can be supplied with a 4 to 32 MHz crystal/ceramic resonator oscillator. All the information given in this paragraph are based on design simulation results obtained with typical external components specified in *Table 31*. 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 31. HSE oscillator characteristics

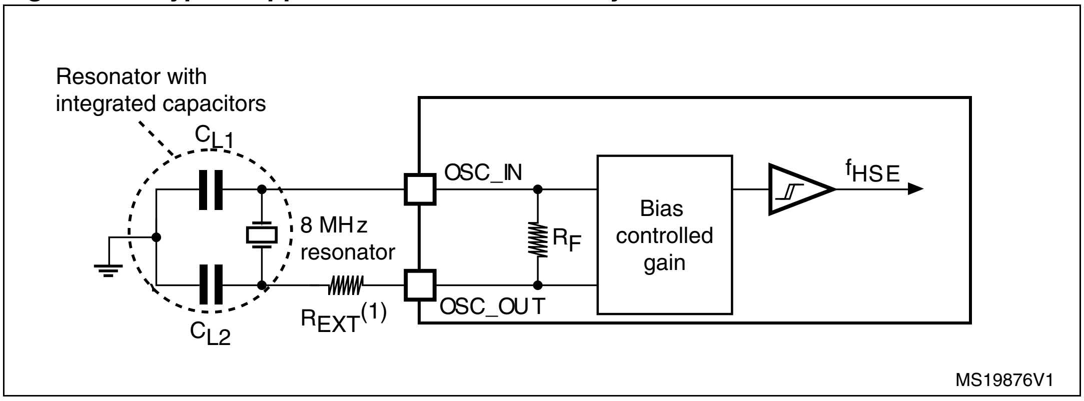
Symbol	Parameter	Conditions(1)	Min(2)	Typ	Max(2)	Unit
f_{OSC_IN}	Oscillator frequency		4	8	32	MHz
R_F	Feedback resistor			200		kΩ
I_{DD}	HSE current consumption	During startup(3)			8.5	mA
		V_{DD}=3.3 V, Rm= 30Ω, CL=10 pF@8 MHz		0.4		
		V_{DD}=3.3 V, Rm= 45Ω, CL=10 pF@8 MHz		0.5		
		V_{DD}=3.3 V, Rm= 30Ω, CL=5 pF@32 MHz		0.8		
		V_{DD}=3.3 V, Rm= 30Ω, CL=10 pF@32 MHz		1		
		V_{DD}=3.3 V, Rm= 30Ω, CL=20 pF@32 MHz		1.5		
g_m	Oscillator transconductance	Startup	10			mA/V
$t_{SU(HSE)}$(4)	Startup time	V_{DD} is stabilized		2		ms

1. Resonator characteristics given by the crystal/ceramic resonator manufacturer.
2. Guaranteed by design, not tested in production.
3. This consumption level occurs during the first 2/3 of the $t_{SU(HSE)}$ startup time
4. $t_{SU(HSE)}$ is the startup time measured from the moment it is enabled (by software) to a stabilized 8 MHz oscillation is reached. This value is measured for a standard crystal resonator and it can vary significantly with the crystal manufacturer

For C_{L1} and C_{L2}, it is recommended to use high-quality external ceramic capacitors in the 5 pF to 20 pF range (typ.), designed for high-frequency applications, and selected to match the requirements of the crystal or resonator (see *Figure 12*). C_{L1} and C_{L2} are usually the same size. The crystal manufacturer typically specifies a load capacitance which is the series combination of C_{L1} and C_{L2}. PCB and MCU pin capacitance must be included (10 pF can be used as a rough estimate of the combined pin and board capacitance) when sizing C_{L1} and C_{L2}.

Note: For information on electing the crystal, refer to the application note AN2867 “Oscillator design guide for ST microcontrollers” available from the ST website www.st.com.

Figure 12. Typical application with an 8 MHz crystal



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

Low-speed external clock generated from a crystal resonator

The low-speed external (LSE) clock can be supplied with a 32.768 kHz crystal resonator oscillator. All the information given in this paragraph are based on design simulation results obtained with typical external components specified in *Table 32*. 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).

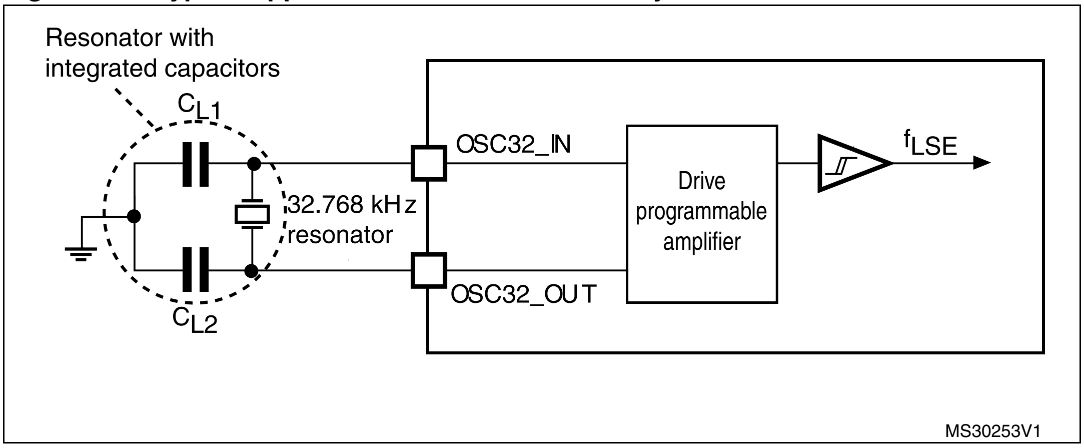
Table 32. LSE oscillator characteristics (f_{LSE} = 32.768 kHz)

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

1. Refer to the note and caution paragraphs below the table, and to the application note AN2867 “Oscillator design guide for ST microcontrollers”.
2. Guaranteed by design, not tested in production.
3. $t_{SU(LSE)}$ is the startup time measured from the moment it is enabled (by software) to a stabilized 32.768 kHz oscillation is reached. This value is measured for a standard crystal and it can vary significantly with the crystal manufacturer

Note: For information on selecting the crystal, refer to the application note AN2867 “Oscillator design guide for ST microcontrollers” available from the ST website www.st.com.

Figure 13. Typical application with a 32.768 kHz crystal



Note: An external resistor is not required between OSC32_IN and OSC32_OUT and it is forbidden to add one.

5.3.7 Internal clock source characteristics

The parameters given in *Table 33* are derived from tests performed under ambient temperature and supply voltage conditions summarized in *Table 17*.

High-speed internal (HSI) RC oscillator

Table 33. HSI oscillator characteristics(1)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
f_{HSI}	Frequency			8		MHz
TRIM	HSI user trimming step				1(2)	%
$DuCy_{(HSI)}$	Duty cycle		45(2)		55(2)	%
ACC_{HSI}	Accuracy of the HSI oscillator (factory calibrated)	T_A = –40 to 105 °C	–2(3)		2.5(3)	%
		T_A = –10 to 85 °C	–1.5(3)		2.2(3)	%
		T_A = 0 to 70 °C	–1.3(3)		2(3)	%
		T_A = 25 °C	–1.1		1.8	%
$t_{su(HSI)}$	HSI oscillator startup time		1(3)		2(3)	µs
$I_{DD(HSI)}$	HSI oscillator power consumption			80	100(3)	µA

1. V_{DDA} =3.3 V, T_A = –40 to 105 °C unless otherwise specified.
2. Guaranteed by design, not tested in production.
3. Data based on characterization results, not tested in production.

Low-speed internal (LSI) RC oscillator

Table 34. LSI oscillator characteristics(1)

Symbol	Parameter	Min	Typ	Max	Unit
f_{LSI}	Frequency	30	40	60	kHz
$t_{su(LSI)}$(2)	LSI oscillator startup time			85	µs
$I_{DD(LSI)}$(2)	LSI oscillator power consumption		0.75	1.2	µA

1. V_{DDA} = 3.3 V, T_A = –40 to 105 °C unless otherwise specified.
2. Guaranteed by design, not tested in production.

Wakeup time from low-power mode

The wakeup times given in is measured on a wakeup phase with a 8-MHz HSI RC oscillator. The clock source used to wake up the device depends from the current operating mode:

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

All timings are derived from tests performed under ambient temperature and V_{DD} supply voltage conditions summarized in *Table 17*.

Table 35. Low-power mode wakeup timings

Symbol	Parameter	Conditions	Typ @VDD					Max	Unit
			= 2.0 V	= 2.4 V	= 2.7 V	= 3 V	= 3.3 V		
t_{WUSTOP}	Wakeup from Stop mode	Regulator in run mode	5.88				5.43		µs
		Regulator in low power mode	9.35				7.26		
$t_{WUSTANDBY}$	Wakeup from Standby mode								
$t_{WUSLEEP}$	Wakeup from Sleep mode		3.2	3.2	3.2	3.2	3.2		

5.3.8 PLL characteristics

The parameters given in *Table 36* are derived from tests performed under ambient temperature and supply voltage conditions summarized in *Table 17*.

Table 36. PLL characteristics

Symbol	Parameter	Value			Unit
		Min	Typ	Max	
f_{PLL_IN}	PLL input clock(1)	1(2)		24(2)	MHz
	PLL input clock duty cycle	40(2)		60(2)	%

Table 36. PLL characteristics (continued)

Symbol	Parameter	Value			Unit
		Min	Typ	Max	
f_{PLL_OUT}	PLL multiplier output clock	16(2)		72	MHz
t_{LOCK}	PLL lock time			200(2)	µs
Jitter	Cycle-to-cycle jitter			300(2)	ps

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

5.3.9 Memory characteristics

Flash memory

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

Table 37. Flash memory characteristics

Symbol	Parameter	Conditions	Min	Typ	Max(1)	Unit
t_{prog}	16-bit programming time	T_A = –40 to +105 °C	40	52.5	70	µs
t_{ERASE}	Page (1 KB) erase time	T_A = –40 to +105 °C	20		40	ms
t_{ME}	Mass erase time	T_A = –40 to +105 °C	20		40	ms
I_{DD}	Supply current	Read mode f_{HCLK} = 72 MHz with 2 wait states, V_{DD} = 3.3 V			TBD	mA
		Write mode V_{DD} = 3.3V			TBD	mA
		Erase mode V_{DD} = 3.3V			TBD	mA
		Power-down / Halt mode, V_{DD} = 3.0 to 3.6 V			50	µA
V_{prog}	Programming voltage		2		3.6	V

1. Guaranteed by design, not tested in production.

Table 38. Flash memory endurance and data retention

Symbol	Parameter	Conditions	Value Min(1)	Unit
N_{END}	Endurance	T_A = –40 to +85 °C (6 suffix versions) T_A = –40 to +105 °C (7 suffix versions)	10	kcycles
t_{RET}	Data retention	1 kcycle(2) at T_A = 85 °C	30	Years
		1 kcycle(2) at T_A = 105 °C	10	
		10 kcycles(2) at T_A = 55 °C	20	

1. Data based on characterization results, not tested in production.
2. Cycling performed over the whole temperature range.

5.3.10 EMC characteristics

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

Functional EMS (electromagnetic susceptibility)

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

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

A device reset allows normal operations to be resumed.

The test results are given in *Table 39*. They are based on the EMS levels and classes defined in application note AN1709.

Table 39. 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, $f_{HCLK} = 72$ MHz conforms to IEC 61000-4-2	TBD
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, $f_{HCLK} = 72$ MHz conforms to IEC 61000-4-4	TBD

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 40. EMI characteristics

Symbol	Parameter	Conditions	Monitored frequency band	Max vs. [f_{HSE}/f_{HCLK}]		Unit
				8/72 MHz	TBD	
S_{EMI}	Peak level	V_{DD} = 3.3V, T_A = 25 °C, LQFP64 package compliant with IEC 61967-2	0.1 to 30 MHz	8	TBD	dBμV
			30 to 130 MHz	31	TBD	
			130 MHz to 1GHz	28	TBD	
			SAE EMI Level	4	TBD	-

5.3.11 Electrical sensitivity characteristics

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

Electrostatic discharge (ESD)

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

Table 41. ESD absolute maximum ratings(1)

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

1. TBD stands for “to be defined”.
2. Data based on characterization results, not tested in production.

Static latch-up

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

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

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

Table 42. Electrical sensitivities(1)

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

1. TBD stands for “to be defined”.

5.3.12 I/O current injection characteristics

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

Functional susceptibility to I/O current injection

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

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

The test results are given in *Table 43*

Table 43. I/O current injection susceptibility(1)

Symbol	Description	Functional susceptibility		Unit
		Negative injection	Positive injection	
I_{INJ}	Injected current on OSC_IN32, OSC_OUT32, PA4, PA5, PC13	TBD	TBD	mA
	Injected current on all FT pins	TBD	TBD	
	Injected current on all FTf pins	TBD	TBD	
	Injected current on all TTa pins	TBD	TBD	
	Injected current on any other pin	TBD	TBD	

1. TBD stands for “to be defined”.

5.3.13 I/O port characteristics

General input/output characteristics

Unless otherwise specified, the parameters given in *Table 44* are derived from tests performed under the conditions summarized in *Table 17*. All I/Os are CMOS and TTL compliant.

Table 44. I/O static characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{IL}	Standard I/O input low level voltage		–0.3		$0.3V_{DD}+0.07$	V
	TTa I/O input low level voltage		–0.3		$0.3V_{DD}+0.07$	
	FT and FTf[1] I/O input low level voltage		–0.3		$0.475V_{DD}-0.2$	
V_{IH}	Standard I/O input high level voltage		$0.445V_{DD}+0.398$		$V_{DD}+0.3$	
	TTa I/O input high level voltage		$0.445V_{DD}+0.398$		$V_{DD}+0.3$	
	FT and FTf[1] I/O input high level voltage		$0.5V_{DD}+0.2$		5.5	
V_{hys}	Standard I/O Schmitt trigger voltage hysteresis[2]		200			mV
	TTa I/O Schmitt trigger voltage hysteresis[2]		200			
	FT and FTf I/O Schmitt trigger voltage hysteresis[2]		100			
I_{lkg}	Input leakage current [3]	$V_{SS} \leq V_{IN} \leq V_{DD}$ I/O TC, FT and FTf			±0.1	µA
		$V_{SS} \leq V_{IN} \leq V_{DD}$ $2\ V \leq V_{DD} \leq V_{DDA} \leq 3.6\ V$ I/O TTa used in digital mode			±0.1	
		$V_{IN} = 5\ V$ I/O FT and FTf			10	
		$V_{IN} = 3.6\ V$, $2\ V \leq V_{DD} \leq V_{IN}$ $V_{DDA} = 3.6\ V$ I/O TTa used in digital mode			1	
		$V_{SS} \leq V_{IN} \leq V_{DDA}$ $2\ V \leq V_{DD} \leq V_{DDA} \leq 3.6\ V$ I/O TTa used in analog mode			±0.2	

Table 44. I/O static characteristics (continued)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
R_{PU}	Weak pull-up equivalent resistor(4)	$V_{IN} = V_{SS}$	30	40	50	kΩ
R_{PD}	Weak pull-down equivalent resistor(4)	$V_{IN} = V_{DD}$	30	40	50	kΩ
C_{IO}	I/O pin capacitance			5		pF

1. To sustain a voltage higher than V_{DD}+0.3 the internal pull-up/pull-down resistors must be disabled.
2. Hysteresis voltage between Schmitt trigger switching levels. Data based on characterization, not tested in production.
3. Leakage could be higher than max. if negative current is injected on adjacent pins.
4. Pull-up and pull-down resistors are designed with a true resistance in series with a switchable PMOS/NMOS. This MOS/NMOS contribution to the series resistance is minimum (~10% order).

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

- PB0 to PB2, PB10, and PE7 to PE15 I/O pins are powered from SDADC1_SDADC2_VDD

- PB14 to PB15 and PD8 to PD15 I/O pins are powered from SDADC3_VDD. All I/O pin ground is internally connected to V_{SS}

V_{DD} mentioned in the Table 44. represents power voltage for given I/O pin (V_{DD} or SDADC1_SDADC2_VDD or SDADC3_VDD).

All I/Os are CMOS and TTL compliant (no software configuration required). Their characteristics cover more than the strict CMOS-technology or TTL parameters. The coverage of these requirements is shown in *Figure 14* and *Figure 15* for standard I/Os, and in *Figure 16* and *Figure 17* for 5 V tolerant I/Os.

Figure 14. TC and TTa I/O input characteristics - CMOS port

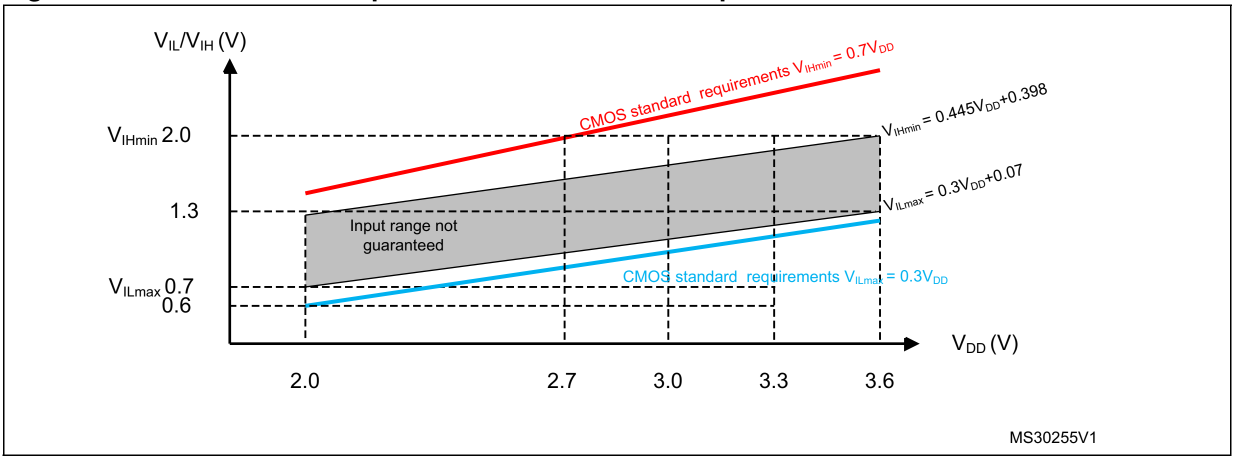


Figure 15. TC and TTa I/O input characteristics - TTL port

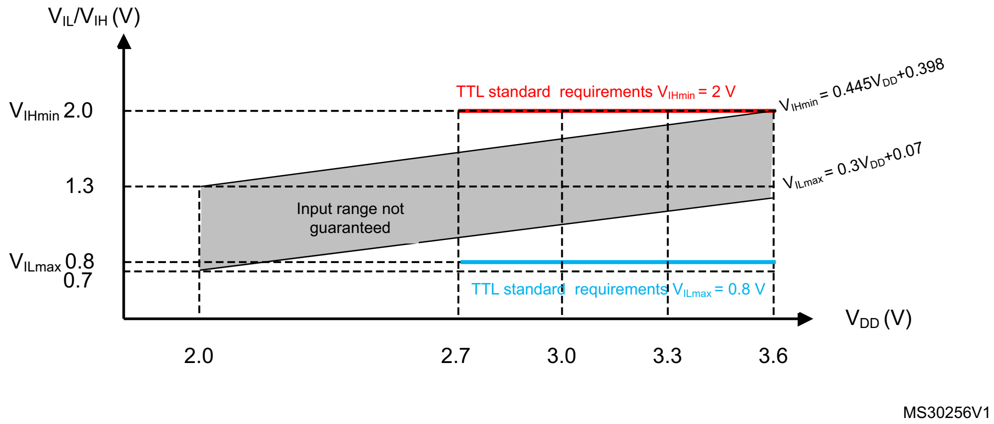


Figure 16. Five volt tolerant (FT and FTf) I/O input characteristics - CMOS port

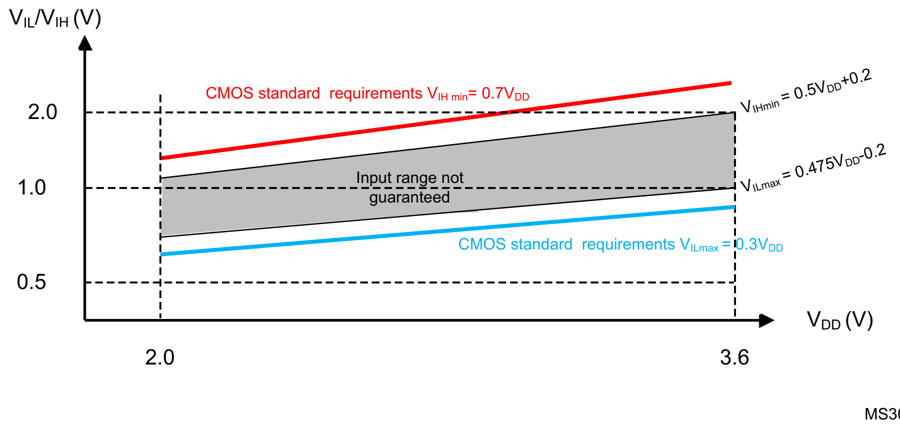
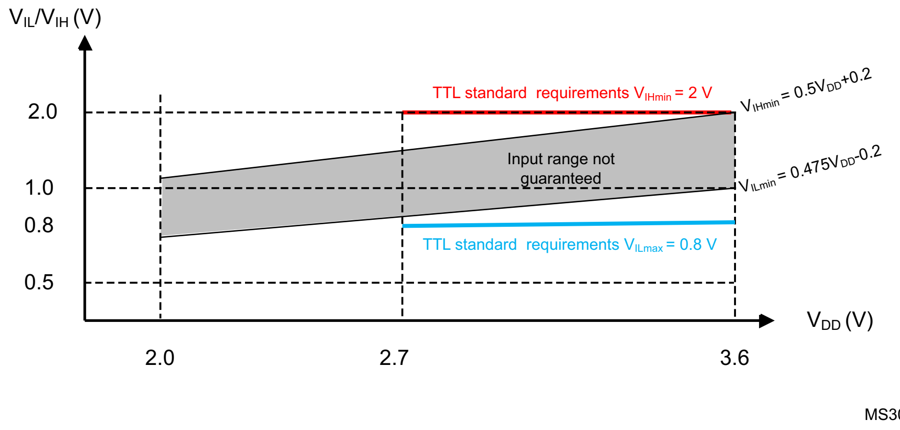


Figure 17. Five volt tolerant (FT and FTf) I/O input characteristics - TTL port



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 a relaxed V_{OL}/V_{OH}).

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

- The sum of the currents sourced by all the I/Os on $V_{DD,}$ plus the maximum Run consumption of the MCU sourced on $V_{DD,}$ cannot exceed the absolute maximum rating I_{VDD} (see *Table 15*).
- 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 15*).

Output voltage levels

Unless otherwise specified, the parameters given in *Table 45* are derived from tests performed under ambient temperature and V_{DD} supply voltage conditions summarized in *Table 17*. All I/Os are CMOS and TTL compliant (FT, TTa or TC unless otherwise specified).

Table 45. Output voltage characteristics

Symbol	Parameter	Conditions		Min	Max	Unit
		STM32F37xVx	STM32F37xCx, STM32F37xRx			
V_{OL} (1)	Output low level voltage for an I/O pin when 8 pins are sunk at same time	CMOS port(2) I_{IO} = +8 mA 2.7 V < V_{DD} < 3.6 V	CMOS port(2) I_{IO} = +8 mA 2.7 V < V_{DD} < 3.6 V		0.4	V
V_{OH} (3)	Output high level voltage for an I/O pin when 8 pins are sourced at same time		CMOS port(2) I_{IO} = +4 mA 2.7 V < V_{DD} < 3.6 V	V_{DD}–0.4		
V_{OL} (1)	Output low level voltage for an I/O pin when 8 pins are sunk at same time	TTL port(2) I_{IO} = +8 mA 2.7 V < V_{DD} < 3.6 V	TTL port(2) I_{IO} =+ 8 mA 2.7 V < V_{DD} < 3.6 V		0.4	V
V_{OH} (3)	Output high level voltage for an I/O pin when 8 pins are sourced at same time		TTL port(2) I_{IO} =+ 4 mA 2.7 V < V_{DD} < 3.6 V	2.3		
V_{OL} (1)(4)	Output low level voltage for a TTL pin when 8 pins are sunk at same time	I_{IO} = +20 mA 2.7 V < V_{DD} < 3.6 V	I_{IO} = +20 mA 2.7 V < V_{DD} < 3.6 V		1.3	V
V_{OH} (3)(4)	Output high level voltage for an I/O pin when 8 pins are sourced at same time		I_{IO} = +10 mA 2.7 V < V_{DD} < 3.6 V	V_{DD}–1.3		

Table 45. Output voltage characteristics (continued)

Symbol	Parameter	Conditions		Min	Max	Unit
		STM32F37xVx	STM32F37xCx, STM32F37xRx			
V_{OL}[(1)(4)]	Output low level voltage for an I/O pin when 8 pins are sunk at same time	I_{IO} = +6 mA 2 V < V_{DD} < 2.7 V	I_{IO} = +5 mA 2 V < V_{DD} < 2.7 V		0.4	V
V_{OH}[(3)(4)]	Output high level voltage for an I/O pin when 8 pins are sourced at same time			V_{DD}–0.4		
V_{OLFM+}	Output low level voltage for a FTf I/O pins in FM+ mode	I_{IO} = +20 mA 2 V < V_{DD} < 3.6 V	I_{IO} = +20 mA 2 V < V_{DD} < 3.6 V		0.4	V

1. The I_{IO} current sunk by the device must always respect the absolute maximum rating specified in *Table 15* and the sum of I_{IO} (I/O ports and control pins) must not exceed I_{VSS}.
2. TTL and CMOS outputs are compatible with JEDEC standards JESD36 and JESD52.
3. The I_{IO} current sourced by the device must always respect the absolute maximum rating specified in *Table 15* and the sum of I_{IO} (I/O ports and control pins) must not exceed I_{VDD}.
4. Data based on characterization results, not tested in production.

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

- PB0 to PB2, PB10, and PE7 to PE15 I/O pins are powered from SDADC1_SDADC2_VDD

- PB14 to PB15 and PD8 to PD15 I/O pins are powered from SDADC3_VDD. All I/O pin ground is internally connected to V_{SS}

V_{DD} mentioned in the Table 45. represents power voltage for given I/O pin (V_{DD} or SDADC1_SDADC2_VDD or SDADC3_VDD).

Input/output AC characteristics

The definition and values of input/output AC characteristics are given in *Figure 18* and *Table 46*, respectively.

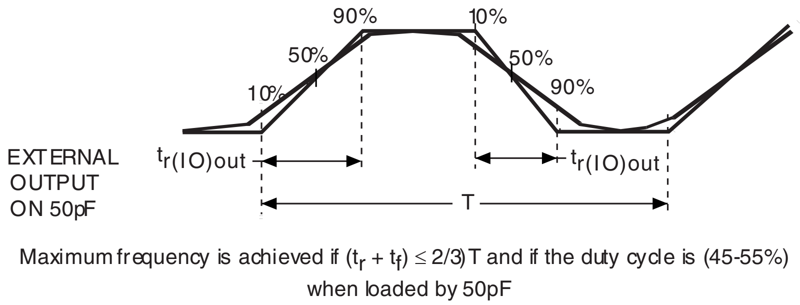
Unless otherwise specified, the parameters given are derived from tests performed under ambient temperature and V_{DD} supply voltage conditions summarized in *Table 17*.

Table 46. I/O AC characteristics(1)

OSPEEDRy [1:0] value(1)	Symbol	Parameter	Conditions	Min	Max	Unit
x0	$f_{max(IO)out}$	Maximum frequency(2)	C_L = 50 pF, V_{DD} = 2 V to 3.6 V		2	MHz
	$t_{f(IO)out}$	Output high to low level fall time	C_L = 50 pF, V_{DD} = 2 V to 3.6 V		125(3)	ns
	$t_{r(IO)out}$	Output low to high level rise time			125(3)	
01	$f_{max(IO)out}$	Maximum frequency(2)	C_L = 50 pF, V_{DD} = 2 V to 3.6 V		10	MHz
	$t_{f(IO)out}$	Output high to low level fall time	C_L = 50 pF, V_{DD} = 2 V to 3.6 V		25(3)	ns
	$t_{r(IO)out}$	Output low to high level rise time			25(3)	
11	$f_{max(IO)out}$	Maximum frequency(2)	C_L = 30 pF, V_{DD} = 2.7 V to 3.6 V		50	MHz
			C_L = 50 pF, V_{DD} = 2.7 V to 3.6 V		30	MHz
			C_L = 50 pF, V_{DD} = 2 V to 2.7 V		20	MHz
	$t_{f(IO)out}$	Output high to low level fall time	C_L = 30 pF, V_{DD} = 2.7 V to 3.6 V		5(3)	ns
			C_L = 50 pF, V_{DD} = 2.7 V to 3.6 V		8(3)	
			C_L = 50 pF, V_{DD} = 2 V to 2.7 V		12(3)	
	$t_{r(IO)out}$	Output low to high level rise time	C_L = 30 pF, V_{DD} = 2.7 V to 3.6 V		5(3)	
			C_L = 50 pF, V_{DD} = 2.7 V to 3.6 V		8(3)	
			C_L = 50 pF, V_{DD} = 2 V to 2.7 V		12(3)	
FM+ configuration(4)	$f_{max(IO)out}$	Maximum frequency(2)	TBD		TBD	MHz
	$t_{f(IO)out}$	Output high to low level fall time	TBD		TBD	ns
	$t_{r(IO)out}$	Output low to high level rise time	TBD		TBD	
	t_{EXTIpw}	Pulse width of external signals detected by the EXTI controller		10		ns

1. The I/O speed is configured using the OSPEEDRx[1:0] bits. Refer to the RM0091 reference manual for a description of GPIO Port configuration register.
2. The maximum frequency is defined in *Figure 18*.
3. Guaranteed by design, not tested in production.
4. The I/O speed configuration is bypassed in FM+ I/O mode. Refer to the STM32F05xxx reference manual RM0091 for a description of FM+ I/O mode configuration.

Figure 18. I/O AC characteristics definition



5.3.14 NRST pin characteristics

The NRST pin input driver uses CMOS technology. It is connected to a permanent pull-up resistor, R_{PU} (see *Table 44*).

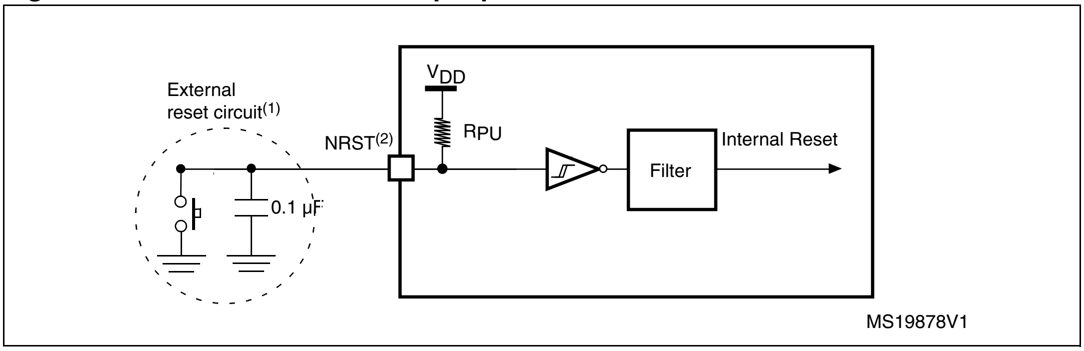
Unless otherwise specified, the parameters given in *Table 47* are derived from tests performed under ambient temperature and V_{DD} supply voltage conditions summarized in *Table 17*.

Table 47. NRST pin characteristics

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

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

Figure 19. 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 47*. Otherwise the reset will not be taken into account by the device.

5.3.15 BOOT0 pin characteristics

The BOOT0 pin input driver does not have a standard CMOS threshold value. The threshold value does not depend on the V_{DD} voltage.

Unless otherwise specified, the parameters given in *Table 49* are derived from tests performed under ambient temperature and V_{DD} supply voltage conditions summarized in *Table 17*.

Table 48. BOOT0 pin characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{IL}(BOOT0)	BOOT0 Input low level voltage				0.4	V
V_{IH}(BOOT0)	BOOT0 Input high level voltage		1.0			V

5.3.16 Timer characteristics

The parameters given in *Table 49* are guaranteed by design.

Refer to *Section 5.3.13: I/O port characteristics* for details on the input/output alternate function characteristics (output compare, input capture, external clock, PWM output).

Table 49. TIMx[(1)] characteristics

Symbol	Parameter	Conditions	Min	Max	Unit
$t_{res(TIM)}$	Timer resolution time		1		$t_{TIMxCLK}$
		$f_{TIMxCLK}$ = 72 MHz	13.9		ns
f_{EXT}	Timer external clock frequency on CH1 to CH4		0	$f_{TIMxCLK}/2$	MHz
		$f_{TIMxCLK}$ = 72 MHz	0	24	MHz
Res_{TIM}	Timer resolution	TIMx (except TIM2)		16	bit
		TIM2		32	
$t_{COUNTER}$	16-bit counter clock period		1	65536	$t_{TIMxCLK}$
		$f_{TIMxCLK}$ = 72 MHz	0.0139	910	μs

Table 49. TIMx[1] characteristics (continued)

Symbol	Parameter	Conditions	Min	Max	Unit
t_{MAX_COUNT}	Maximum possible count with 32-bit counter			65536 × 65536	$t_{TIMxCLK}$
		$f_{TIMxCLK}$ = 72 MHz		59.65	s

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

Table 50. IWDG min/max timeout period at 40 kHz (LSI) [1]

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

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

Table 51. WWDG min-max timeout value @72 MHz (PCLK)

Prescaler	WDGTB	Min timeout value	Max timeout value
1	0	TBD	TBD
2	1	TBD	TBD
4	2	TBD	TBD
8	3	TBD	TBD

5.3.17 Communications interfaces

I^2C interface characteristics

Unless otherwise specified, the parameters given in *Table 52* are derived from tests performed under ambient temperature, f_{PCLK1} frequency and V_{DD} supply voltage conditions summarized in *Table 17*.

The I^2C interface meets the requirements of the standard I^2C communication protocol with the following restrictions: the I/O pins SDA and SCL are mapped to are not “true” open-drain. When configured as open-drain, the PMOS connected between the I/O pin and V_{DD} is disabled, but is still present.

The I^2C characteristics are described in *Table 52*. Refer also to *Section 5.3.13: I/O port characteristics* for more details on the input/output alternate function characteristics (SDA and SCL).

Table 52. I^2C characteristics(1)

Symbol	Parameter	Standard mode		Fast mode		Fast mode Plus		Unit
		Min	Max	Min	Max	Min	Max	
$t_{w(SCLL)}$	SCL clock low time	4.7		1.3		0.5		µs
$t_{w(SCLH)}$	SCL clock high time	4.0		0.6		0.26		µs
$t_{su(SDA)}$	SDA setup time	250		100		50		ns
$t_{h(SDA)}$	SDA data hold time	0(2)	3450(3)	0(2)	900(3)	0(4)	450(3)	ns
$t_{r(SDA)}$ $t_{r(SCL)}$	SDA and SCL rise time		1000		300		120	ns
$t_{f(SDA)}$ $t_{f(SCL)}$	SDA and SCL fall time		300		300		120	ns
$t_{h(STA)}$	Start condition hold time	4.0		0.6		0.26		µs
$t_{su(STA)}$	Repeated Start condition setup time	4.7		0.6		0.26		µs
$t_{su(STO)}$	Stop condition setup time	4.0		0.6		0.26		µs
$t_{w(STO:STA)}$	Stop to Start condition time (bus free)	4.7		1.3		0.5		µs
C_b	Capacitive load for each bus line		400		400		550	pF

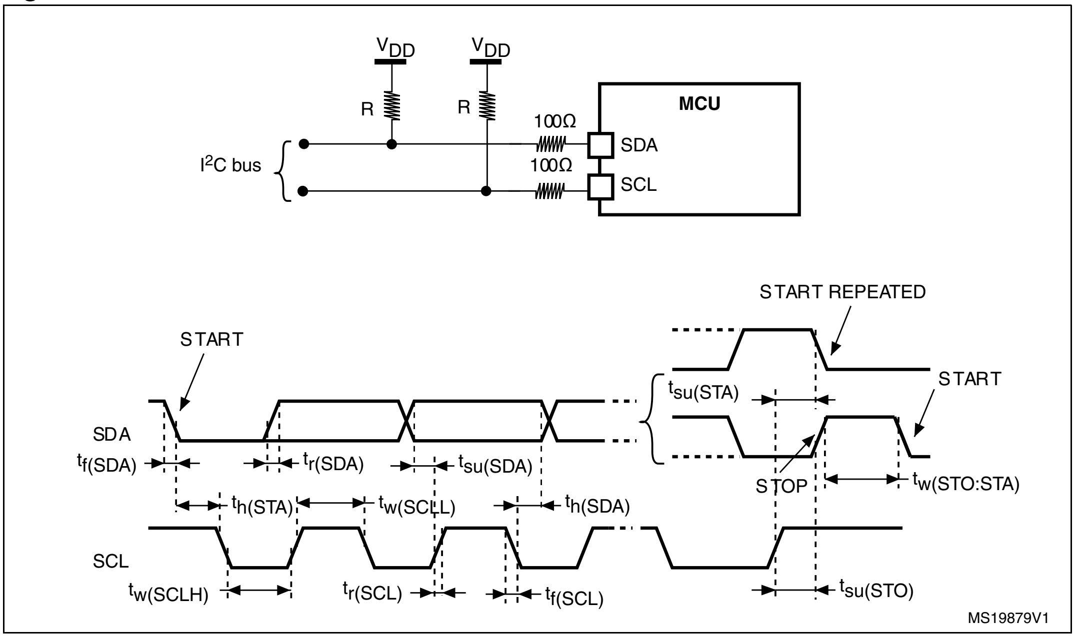
1. The I2C characteristics are the requirements from I2C bus specification rev03. They are guaranteed by design when I2Cx_TIMING register is correctly programmed (Refer to reference manual). These characteristics are not tested in production.
2. The device must internally provide a hold time of at least 300ns for the SDA signal in order to bridge the undefined region of the falling edge of SCL.
3. The maximum Data hold time has only to be met if the interface does not stretch the low period of SCL signal.
4. The device must internally provide a hold time of at least 120ns for the SDA signal in order to bridge the undefined region of the falling edge of SCL.

Table 53. I2C analog filter characteristics[(1)]

Symbol	Parameter	Min	Max	Unit
t_{SP}	Pulse width of spikes that are suppressed by the analog filter	50	260	ns

1. Guaranteed by design, not tested in production.

Figure 20. I^{2}C bus AC waveforms and measurement circuit



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

SPI/I2S characteristics

Unless otherwise specified, the parameters given in *Table 54* for SPI or in *Table 55* for I2S are derived from tests performed under ambient temperature, f_{PCLKx} frequency and V_{DD} supply voltage conditions summarized in *Table 17*.

Refer to *Section 5.3.13: I/O port characteristics* for more details on the input/output alternate function characteristics (NSS, SCK, MOSI, MISO for SPI and WS, CK, SD for I2S).

Table 54. SPI characteristics

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

1. Data based on characterization results, not tested in production.
2. Min time is for the minimum time to drive the output and the max time is for the maximum time to validate the data.
3. Min time is for the minimum time to invalidate the output and the max time is for the maximum time to put the data in Hi-Z.

Figure 21. SPI timing diagram - slave mode and CPHA = 0

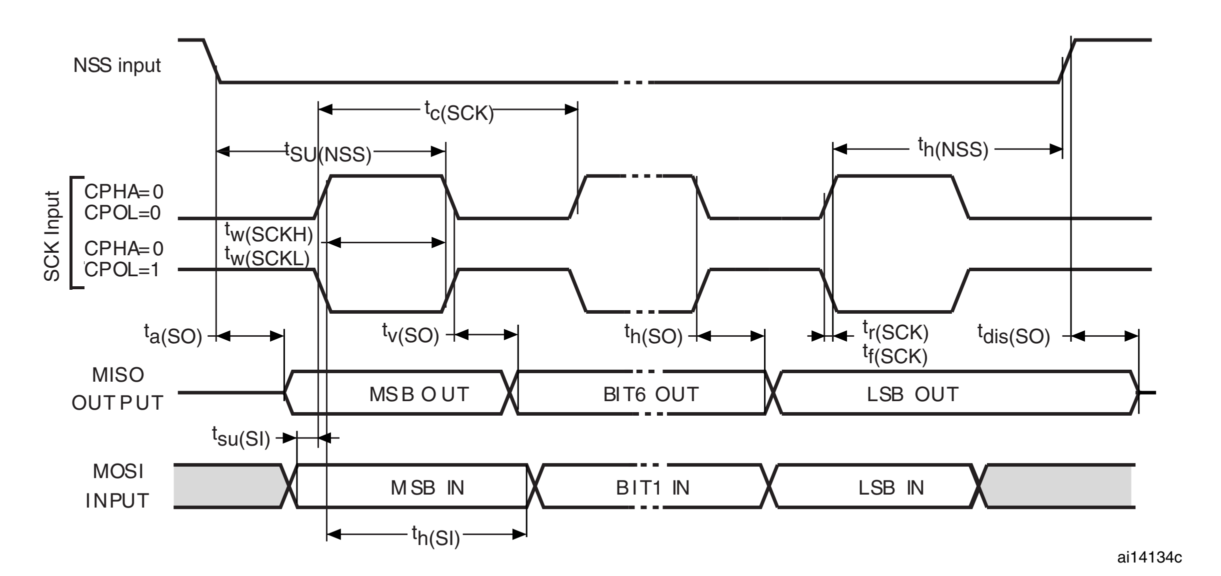
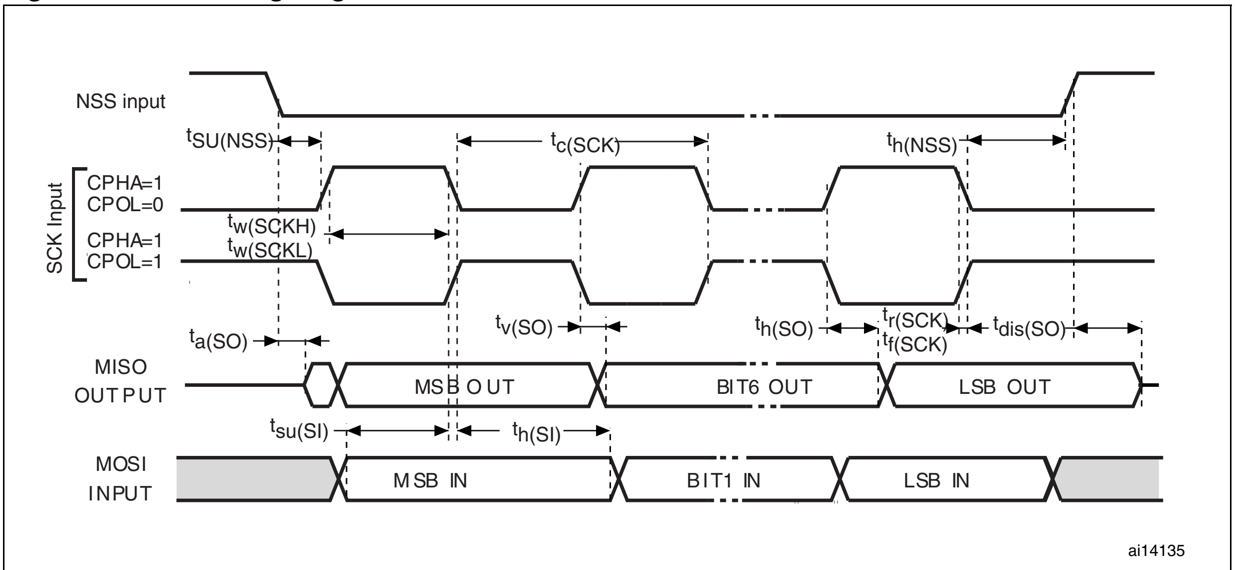
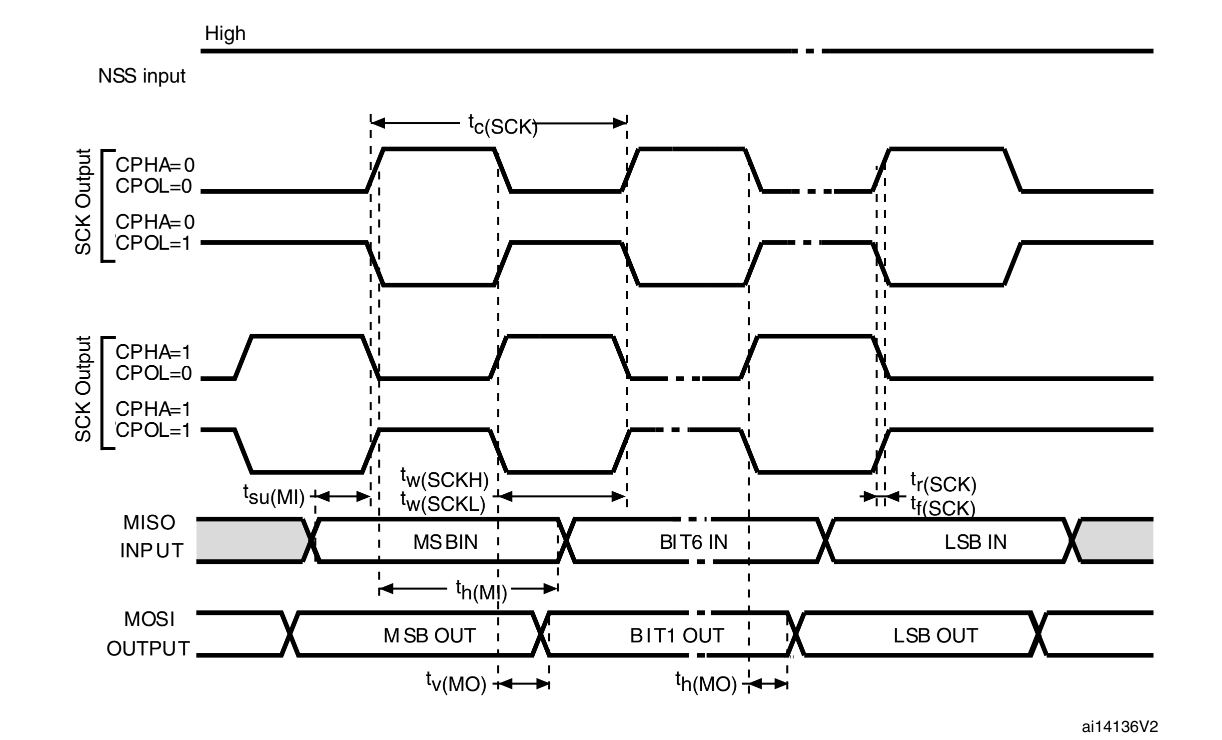


Figure 22. SPI timing diagram - slave mode and CPHA = 1(1)



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

Figure 23. SPI timing diagram - master mode[(1)]



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

Table 55. I^2S characteristics

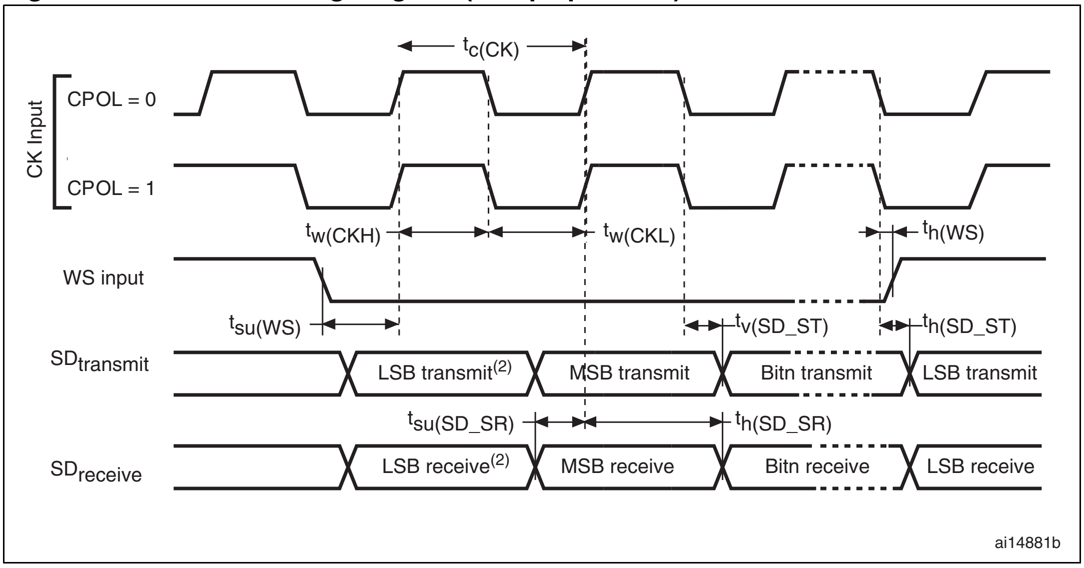
Symbol	Parameter	Conditions	Min	Max	Unit
DuCy(SCK)	I2S slave input clock duty cycle	Slave mode	TBD	TBD	%
f_{CK} $1/t_{c(CK)}$	I^2S clock frequency	Master mode (data: 16 bits, Audio frequency = 48 kHz)	TBD	TBD	MHz
		Slave mode	TBD	TBD	

Table 55. I^2S characteristics (continued)

Symbol	Parameter	Conditions	Min	Max	Unit
$t_{r(CK)}$ $t_{f(CK)}$	I^2S clock rise and fall time	Capacitive load C_L = 50 pF	TBD	TBD	ns
$t_{v(WS)}$ [1]	WS valid time	Master mode	TBD	TBD	
$t_{h(WS)}$ [1]	WS hold time	Master mode	TBD	TBD	
$t_{su(WS)}$ [1]	WS setup time	Slave mode	TBD	TBD	
$t_{h(WS)}$ [1]	WS hold time	Slave mode	TBD	TBD	
$t_{w(CKH)}$ [1]	CK high and low time	Master f_{PCLK}= 16 MHz, audio frequency = 48 kHz	TBD	TBD	
$t_{w(CKL)}$ [1]			TBD	TBD	
$t_{su(SD\_MR)}$ [1]	Data input setup time	Master receiver	TBD	TBD	
$t_{su(SD\_SR)}$ [1]	Data input setup time	Slave receiver	TBD	TBD	
$t_{h(SD\_MR)}$ [1][2]	Data input hold time	Master receiver	TBD	TBD	
$t_{h(SD\_SR)}$ [1][2]		Slave receiver	TBD	TBD	
$t_{v(SD\_ST)}$ [1][2]	Data output valid time	Slave transmitter (after enable edge)	TBD	TBD	
$t_{h(SD\_ST)}$ [1]	Data output hold time	Slave transmitter (after enable edge)	TBD	TBD	
$t_{v(SD\_MT)}$ [1][2]	Data output valid time	Master transmitter (after enable edge)	TBD	TBD	
$t_{h(SD\_MT)}$ [1]	Data output hold time	Master transmitter (after enable edge)	TBD	TBD	

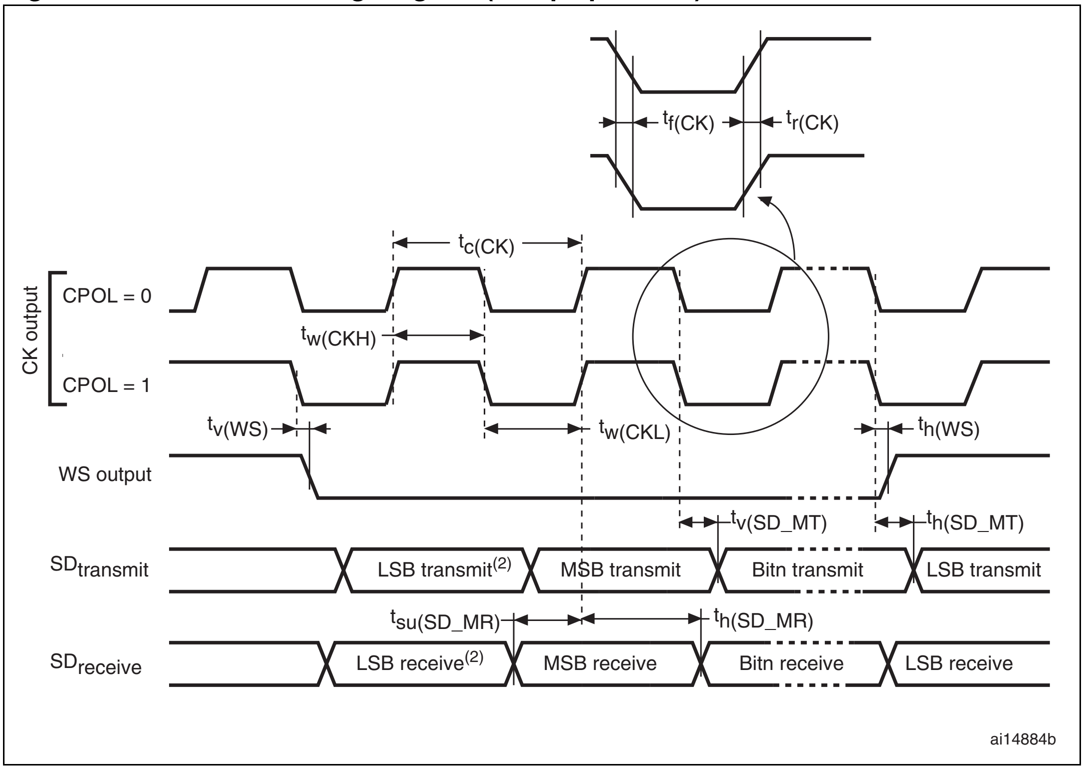
1. Data based on design simulation and/or characterization results, not tested in production.
2. Depends on f_{PCLK}. For example, if f_{PCLK}=8 MHz, then T_{PCLK} = 1/f_{PLCLK} =125 ns.

Figure 24. I²S slave timing diagram (Philips protocol)(1)



1. Measurement points are done at CMOS levels: $0.3 \times V_{DD}$ and $0.7 \times V_{DD}$.
2. LSB transmit/receive of the previously transmitted byte. No LSB transmit/receive is sent before the first byte.

Figure 25. I²S master timing diagram (Philips protocol)(1)



1. Data based on characterization results, not tested in production.
2. LSB transmit/receive of the previously transmitted byte. No LSB transmit/receive is sent before the first byte.

5.3.18 12-bit ADC characteristics

Unless otherwise specified, the parameters given in *Table 56* are preliminary values derived from tests performed under ambient temperature, f_{PCLK2} frequency and V_{DDA} supply voltage conditions summarized in *Table 17*.

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

Table 56. ADC characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{DDA}	Analog supply voltage for ADC ON		2.4		3.6	V
f_{ADC}	ADC clock frequency		0.6		14	MHz
f_S(1)	Sampling rate		0.05		1	MHz
f_{TRIG}(1)	External trigger frequency	f_{ADC} = 14 MHz			823	kHz
					17	$1/f_{ADC}$
V_{AIN}	Conversion voltage range		0		V_{REF+}	V
R_{AIN}(1)	External input impedance	See *Equation 1* and *Table 57* for details			50	kΩ
R_{ADC}(1)	Sampling switch resistance				1	kΩ
C_{ADC}(1)	Internal sample and hold capacitor				8	pF
t_{CAL}(1)	Calibration time	f_{ADC} = 14 MHz	5.9			µs
			83			$1/f_{ADC}$
t_{latr}(1)	Trigger conversion latency	f_{ADC} = 14 MHz			0.143	µs
					2	$1/f_{ADC}$
t_S(1)	Sampling time	f_{ADC} = 14 MHz	0.107		17.1	µs
			1.5		239.5	$1/f_{ADC}$
t_{STAB}(1)	Power-up time		0	0	1	µs
t_{CONV}(1)	Total conversion time (including sampling time)	f_{ADC} = 14 MHz	1		18	µs
			14 to 252 (t_S for sampling +12.5 for successive approximation)			$1/f_{ADC}$

1. Guaranteed by design, not tested in production.

Equation 1: R_{AIN} max formula

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

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

Table 57. R_{AIN} max for f_{ADC} = 14 MHz(1)

T_s (cycles)	t_S (µs)	R_{AIN} max (kΩ)
1.5	0.11	0.4
7.5	0.54	5.9
13.5	0.96	11.4
28.5	2.04	25.2
41.5	2.96	37.2
55.5	3.96	50
71.5	5.11	50
239.5	17.1	50

1. Guaranteed by design, not tested in production.

Table 58. ADC accuracy(1)(2) (3)

Symbol	Parameter	Test conditions	Typ	Max(4)	Unit
ET	Total unadjusted error	f_{ADC} = 14 MHz, R_{AIN} < 10 kΩ, V_{DDA} = 3 V to 3.6 V T_A = 25 °C	±1.3	±3	LSB
EO	Offset error		±1	±2	
EG	Gain error		±0.5	±1.5	
ED	Differential linearity error		±0.7	±1	
EL	Integral linearity error		±0.8	±1.5	
ET	Total unadjusted error	f_{ADC} = 14 MHz, R_{AIN} < 10 kΩ, V_{DDA} = 2.5 V to 3.6 V T_A = -40 to 105 °C (5)	±2	±5	LSB
EO	Offset error		±1.5	±2.5	
EG	Gain error		±1.5	±3	
ED	Differential linearity error		±1	±2	
EL	Integral linearity error		±1.5	±3	

1. ADC DC accuracy values are measured after internal calibration.
2. ADC accuracy vs. negative injection current: Injecting a negative current on any analog input pins should be avoided as this significantly reduces the accuracy of the conversion being performed on another analog input. It is recommended to add a Schottky diode (pin to ground) to analog pins which may potentially inject negative currents.
Any positive injection current within the limits specified for $I_{INJ(PIN)}$ and $\Sigma I_{INJ(PIN)}$ in *Section 5.3.13* does not affect the ADC accuracy.
3. Better performance may be achieved in restricted V_{DDA}, frequency and temperature ranges.
4. Data based on characterization results, not tested in production.
5. V_{DDA} = 2.4 to 3.6 V if T_A = 0 to 105 °C

Figure 26. ADC accuracy characteristics

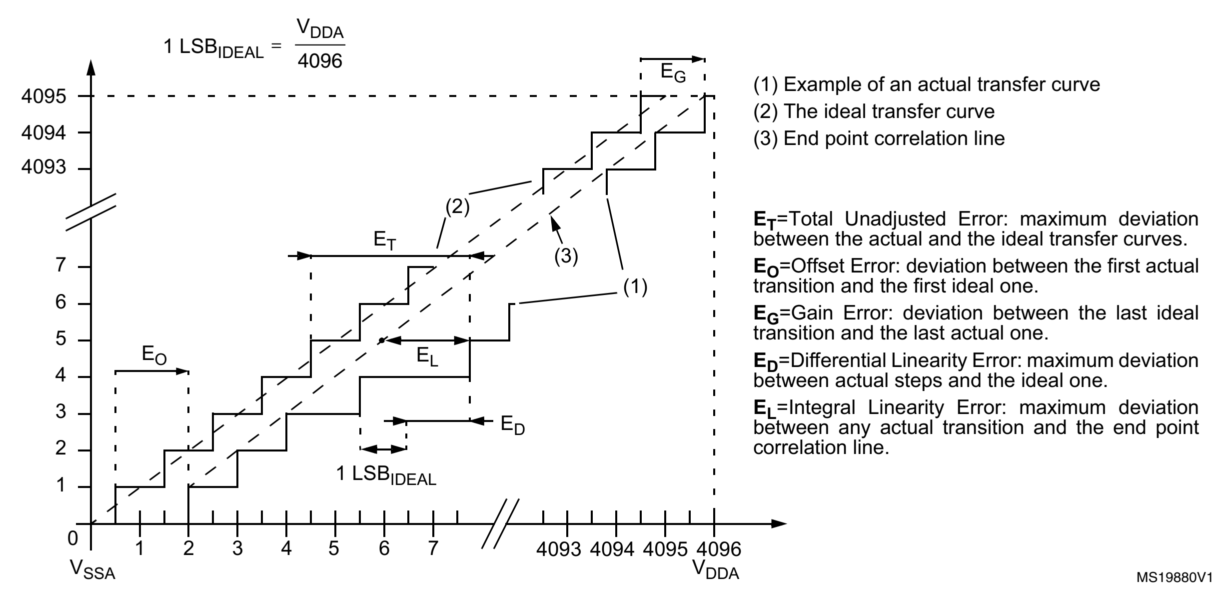
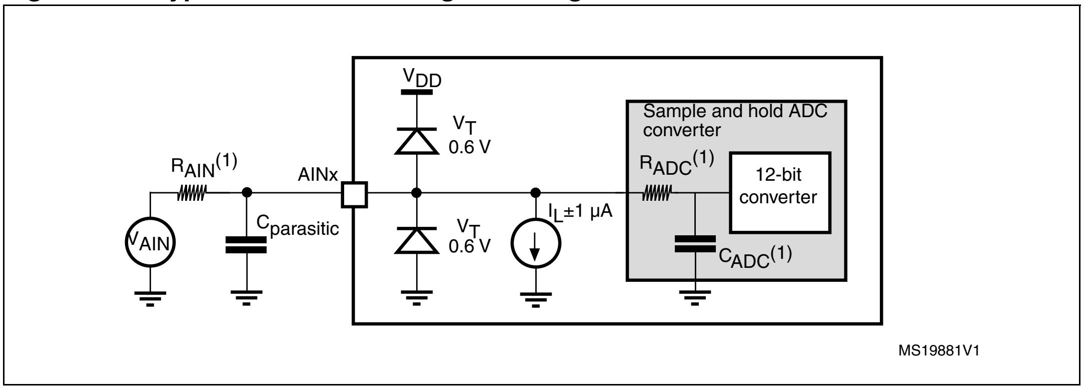


Figure 27. Typical connection diagram using the ADC



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

General PCB design guidelines

Power supply decoupling should be performed as shown in *Figure 8*. The 10 nF capacitor should be ceramic (good quality) and it should be placed as close as possible to the chip.

5.3.19 DAC electrical specifications

Table 59. DAC characteristics

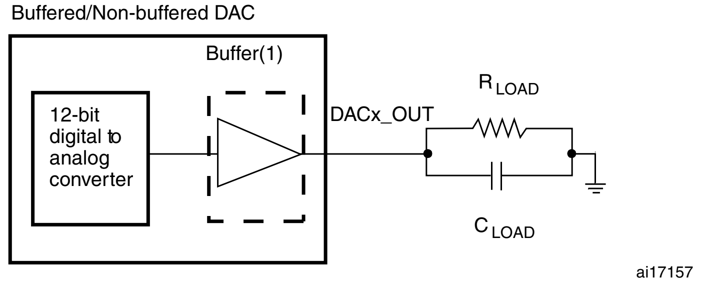
Symbol	Parameter	Min	Typ	Max	Unit	Comments
V_{DDA}	Analog supply voltage	2.4	-	3.6	V	
V_{REF+}	Reference supply voltage	2.4	-	3.6	V	V_{REF+} must always be below V_{DDA}
V_{SSA}	Ground	0	-	0	V	
R_{LOAD}(1)	Resistive load with buffer ON	5	-		kΩ	
R_{O}(1)	Impedance output with buffer OFF	-	-	15	kΩ	When the buffer is OFF, the Minimum resistive load between DAC_OUT and V_{SS} to have a 1% accuracy is 1.5 MΩ
C_{LOAD}(1)	Capacitive load	-	-	50	pF	Maximum capacitive load at DAC_OUT pin (when the buffer is ON).
DAC_OUT min(1)	Lower DAC_OUT voltage with buffer ON	0.2	-	-	V	It gives the maximum output excursion of the DAC. It corresponds to 12-bit input code (0x0E0) to (0xF1C) at V_{REF+} = 3.6 V and (0x155) and (0xEAB) at V_{REF+} = 2.4 V
DAC_OUT max(1)	Higher DAC_OUT voltage with buffer ON	-	-	V_{DDA} – 0.2	V	
DAC_OUT min(1)	Lower DAC_OUT voltage with buffer OFF	-	0.5		mV	It gives the maximum output excursion of the DAC.
DAC_OUT max(1)	Higher DAC_OUT voltage with buffer OFF	-		V_{REF+} – 1LSB	V	
$I_{DDVREF+}$	DAC DC current consumption in quiescent mode (Standby mode)	-		220	µA	With no load, worst code (0xF1C) at V_{REF+} = 3.6 V in terms of DC consumption on the inputs
I_{DDA}	DAC DC current consumption in quiescent mode (Standby mode)	-		380	µA	With no load, middle code (0x800) on the inputs
		-		480	µA	With no load, worst code (0xF1C) at V_{REF+} = 3.6 V in terms of DC consumption on the inputs
DNL(2)	Differential non linearity Difference between two consecutive code-1LSB)	-		±0.5	LSB	Given for the DAC in 10-bit configuration
		-		±2	LSB	Given for the DAC in 12-bit configuration
INL(2)	Integral non linearity (difference between measured value at Code i and the value at Code i on a line drawn between Code 0 and last Code 1023)	-	-	±1	LSB	Given for the DAC in 10-bit configuration
		-	-	±4	LSB	Given for the DAC in 12-bit configuration

Table 59. DAC characteristics (continued)

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

1. Guaranteed by design, not tested in production.
2. Guaranteed by characterization, not tested in production.

Figure 28. 12-bit buffered /non-buffered DAC



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

5.3.20 Comparator characteristics

Table 60. Comparator characteristics

Symbol	Parameter	Conditions		Min	Typ	Max(1)	Unit
V_{DDA}	Analog supply voltage			2		3.6	V
V_{IN}	Comparator input voltage range			0		V_{DDA}	V
V_{BG}	Scaler input voltage				1.2		V
V_{SC}	Scaler offset voltage				±5	±10	mV
t_{S_SC}	Scaler startup time from power down					0.1	ms
t_{START}	Comparator startup time	Startup time to reach propagation delay specification				60	µs
t_D	Propagation delay for 200 mV step with 100 mV overdrive	Ultra-low power mode			2	4.5	µs
		Low power mode			0.7	1.5	µs
		Medium power mode			0.3	0.6	µs
		High speed power mode	$V_{DDA} \geq 2.7$ V		50	100	ns
			$V_{DDA} < 2.7$ V		100	240	ns
	Propagation delay for full range step with 100 mV overdrive	Ultra-low power mode			2	7	µs
		Low power mode			0.7	2.1	µs
		Medium power mode			0.3	1.2	µs
		High speed power mode	$V_{DDA} \geq 2.7$ V		90	180	ns
			$V_{DDA} < 2.7$ V		110	300	ns
V_{offset}	Comparator offset error				±4	±10	mV
dV_{offset}/dT	Offset error temperature coefficient				18		µV/°C
$I_{DD(COMP)}$	COMP current consumption	Ultra-low power mode			1.2	1.5	µA
		Low power mode			3	5	µA
		Medium power mode			10	15	µA
		High speed power mode			75	100	µA

Table 60. Comparator characteristics (continued)

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

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

5.3.21 Temperature sensor characteristics

Table 61. TS characteristics

Symbol	Parameter	Min	Typ	Max	Unit
T_L	V_{SENSE} linearity with temperature		±1	±2	°C
Avg_Slope	Average slope	4.0	4.3	4.6	mV/°C
V_{25}	Voltage at 25 °C	1.34	1.43	1.52	V
t_{START}(1)	Startup time	4		10	µs
T_{S_temp}(2)(1)	ADC sampling time when reading the temperature	17.1			µs

1. Guaranteed by design, not tested in production.
2. Shortest sampling time can be determined in the application by multiple iterations.

5.3.22 V_{BAT} monitoring characteristics

Table 62. V_{BAT} monitoring characteristics

Symbol	Parameter	Min	Typ	Max	Unit
R	Resistor bridge for V_{BAT}	-	50	-	KΩ
Q	Ratio on V_{BAT} measurement	-	2	-	
Er(1)	Error on Q	-1	-	+1	%
T_{S_vbat}(2)	ADC sampling time when reading the V_{BAT} 1mV accuracy	5	-	-	µs

1. Guaranteed by design, not tested in production.
2. Shortest sampling time can be determined in the application by multiple iterations.

5.3.23 USB characteristics

Table 63. 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 64. USB DC electrical characteristics

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

1. All the voltages are measured from the local ground potential.
2. To be compliant with the USB 2.0 full-speed electrical specification, the USBDP (D+) pin should be pulled up with a 1.5 kΩ resistor to a 3.0-to-3.6 V voltage range.
3. The STM32F3xxx USB functionality is ensured down to 2.7 V but not the full USB electrical characteristics which are degraded in the 2.7-to-3.0 V V_{DD} voltage range.
4. Guaranteed by design, not tested in production.
5. R_L is the load connected on the USB drivers

Figure 29. USB timings: definition of data signal rise and fall time (to be added)

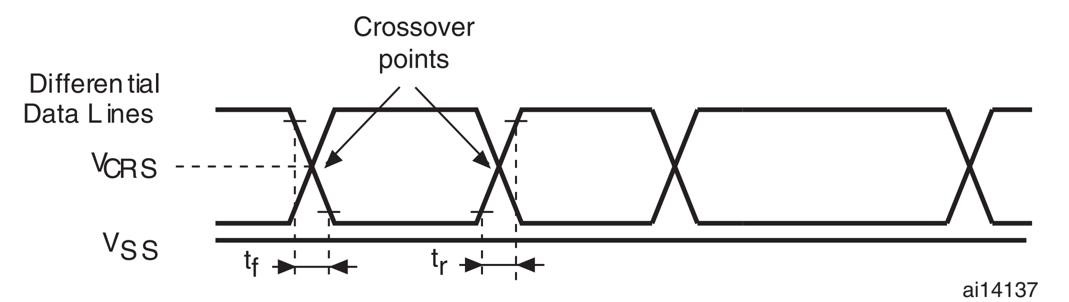


Table 65. USB: Full-speed electrical characteristics(1)

Symbol	Parameter	Conditions	Min	Max	Unit
Driver characteristics					
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).

5.3.24 CAN (controller area network) interface

Refer to *Section 5.3.13: I/O port characteristics* for more details on the input/output alternate function characteristics (CAN_TX and CAN_RX).

5.3.25 SDADC characteristics

Table 66. SDADC characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Unit	Note
SDADC_VDD	Power supply	Slow mode (f_{ADC} = 1.5 MHz)	2.2		V_{DDA}	V	
		Fast mode (f_{ADC} = 6 MHz)	2.4		V_{DDA}		
f_{ADC}	SDADC clock frequency	Slow mode (f_{ADC} = 1.5 MHz)	0.5	1.5	1.65	MHz	
		Fast mode (f_{ADC} = 6 MHz)	0.5	6	6.3		
V_{REF+}	Positive ref. voltage		1.1		SDADC_VDD	V	
V_{REF-}	Negative ref. voltage			VSSA		V	
I_{SD_VDD}	Supply current (SDADC_VDD = 3.3V)	Fast mode (f_{ADC} = 6 MHz)		800	1200	µA	
		Slow mode (f_{ADC} = 1.5 MHz)			600		
		Standby			200		
		Power down			10		
		SD_ADC off			10		
V_{AIN}	Common input voltage range	Single ended mode (zero reference)	V_{SSA}		V_{REF}/gain	V	Voltage on AINP or AINN pin
		Single ended offset mode	V_{SSA}		V_{REF}/gain/2		
		Differential mode	V_{SSA}		SDADC_VDD		
V_{DIFF}	Differential input voltage	Differential mode only	V_{REF}/gain/2		V_{REF}/gain/2		Differential voltage between AINP and AINN
f_S	Sampling rate	Slow mode (f_{ADC} = 1.5 MHz)		4.166		kHz	f_{ADC}/360
		Slow mode one channel only (f_{ADC} = 1.5 MHz)		12.5			f_{ADC}/120
		Fast mode multiplexed channel (f_{ADC} = 6 MHz)		16.66			f_{ADC}/360
		Fast mode one channel only (f_{ADC} = 6 MHz)		50			f_{ADC}/120

Table 66. SDADC characteristics (continued)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit	Note
t_{CONV}	Conversion time			1/fs		s	
Rain	Analog input impedance	One channel, gain = 0.5, f_{ADC} = 1.5 MHz		540		kΩ	see reference manual for detailed description
		One channel, gain = 0.5, f_{ADC} = 6 MHz		135			
		One channel, gain = 8, f_{ADC} = 6 MHz		47			
t_{CALIB}	Calibration time	f_{ADC} = 6 MHz, one offset calibration		5120		µs	30720/f_{ADC}
t_{STAB}	Stabilization time	From power down f_{ADC} = 6 MHz		100		µs	600/f_{ADC}, 75/f_{ADC} if SLOWCK=1
$t_{STANDBY}$	Wakeup from standby time	f_{ADC} = 6 MHz		50		µs	300/f_{ADC}
		f_{ADC} = 1.5 MHz		50			75/f_{ADC} if SLOWCK=1
EO	Offset error	Differential mode, gain =1, f_{ADC} = 1.5 MHz, SDADC_VDD = 3.3, V_{REF} = 3.3		0	100	uV	after offset calibration
		Differential mode, gain =1, f_{ADC} = 6 MHz, SDADC_VDD = 3.3, V_{REF} = 1.2		0	110		
		Differential mode, gain =1, f_{ADC} = 6 MHz, SDADC_VDD = 3.3, V_{REF} = 3.3		0	70		
		Differential mode, gain =8, f_{ADC} = 6 MHz, SDADC_VDD = 3.3, V_{REF} = 1.2		0	60		
		Differential mode, gain =8, f_{ADC} = 6 MHz, SDADC_VDD = 3.3, V_{REF} = 3.3		0	100		
		Differential mode, gain =8, f_{ADC} = 1.5 MHz, SDADC_VDD = 3.3, V_{REF} = 3.3		0	90		
		Single ended mode, gain =1, SDADC_VDD = 3.3, V_{REF} = 1.2		0	1800		
		Single ended mode, gain =1, SDADC_VDD = 3.3, V_{REF} = 3.3		0	1800		
		Single ended mode, gain =8, SDADC_VDD = 3.3, V_{REF} = 1.2		0	1500		
		Single ended mode, gain =8, SDADC_VDD = 3.3, V_{REF} = 3.3		0	1500		
Dvoffsettemp	Offset drift with temperature	Differential or single ended mode, gain = 1, SDADC_VDD = 3.3 V		10	15	uV/K	
EG	Gain error	gain = 0.5, differential mode, single ended mode	3.6	4.5	5	%	
		gain = 1, differential mode, single ended mode	3.6	4.5	5		
		gain = 2, differential mode, single ended mode	3.6	4.5	5		
		gain = 4, differential mode, single ended mode	3.6	4.5	5		
		gain = 8, differential mode, single ended mode	3.6	4.5	5		

Table 66. SDADC characteristics (continued)

Symbol	Parameter	Conditions					Min	Typ	Max	Unit	Note
EGT	Gain drift with temperature	gain = 1, differential mode, single ended mode								ppm/K	
EL	Integral linearity error	Differential mode	gain =1		SDADC _VDD= 3.3	V_{REF} = 1.2			16	LSB	
						V_{REF} = 3.3			14		
			gain =8			V_{REF} = 1.2			26		
						V_{REF} = 3.3			14		
		Single ended mode	gain =1			V_{REF} = 1.2			31		
						V_{REF} = 3.3			23		
			gain =8			V_{REF} = 1.2			80		
						V_{REF} = 3.3			35		
ED	Differential linearity error	Differential mode	gain =1		SDADC _VDD= 3.3	V_{REF} = 1.2			2.3	LSB	
						V_{REF} = 3.3			1.8		
			gain =8			V_{REF} = 1.2			3.5		
						V_{REF} = 3.3			2.9		
		Single ended mode	gain =1			V_{REF} = 1.2			2.9		
						V_{REF} = 3.3			2.8		
			gain =8			V_{REF} = 1.2			4.1		
						V_{REF} = 3.3			3.3		

Table 66. SDADC characteristics (continued)

Symbol	Parameter	Conditions					Min	Typ	Max	Unit	Note
SNR(3)	Signal to noise ratio	Differential mode	gain =1	f_{ADC} = 1.5 MHz	SDADC _VDD = 3.3	V_{REF} = 3.3(1)	84	85		dB	
				f_{ADC} = 6 MHz		V_{REF} = 1.2(2)	86	88			
						V_{REF} = 3.3	88	92			
			gain =8	f_{ADC} = 6 MHz		V_{REF} = 1.2(2)	74	77			
						V_{REF} = 3.3	82	86			
				f_{ADC} = 1.5 MHz		V_{REF} = 3.3(1)	74	80			
		Single ended mode	gain =1	f_{ADC} = 1.5MHz		V_{REF} = 3.3	78	82			
				f_{ADC} = 6 MHz		V_{REF} = 1.2(2)	74	80			
						V_{REF} = 3.3	84	88			
			gain =8			V_{REF} = 1.2(2)	65	70			
						V_{REF} = 3.3	73	77			
SINAD (3)	Signal to noise and distortion ratio	Differential mode	gain =1	f_{ADC} = 1.5 MHz	SDADC _VDD = 3.3	V_{REF} = 3.3(1)	76	77		dB	ENOB = SINAD/6.02 -0.292
				f_{ADC} = 6 MHz		V_{REF} = 1.2(2)	75	76			
						V_{REF} = 3.3	76	77			
			gain =8	f_{ADC} = 6 MHz		V_{REF} = 1.2(2)	68	72			
						V_{REF} = 3.3	79	85			
				f_{ADC} = 1.5 MHz		V_{REF} = 3.3(1)	74	80			
		Single ended mode	gain =1	f_{ADC} = 1.5MHz		V_{REF} = 3.3	72	73			
				f_{ADC} = 6 MHz		V_{REF} = 1.2(2)	68	71			
						V_{REF} = 3.3	72	73			
			gain =8			V_{REF} = 1.2(2)	60	64			
						V_{REF} = 3.3	67	70			

Table 66. SDADC characteristics (continued)

Symbol	Parameter	Conditions					Min	Typ	Max	Unit	Note
THD(3)	Total harmonic distortion	Differential mode	gain =1	f_{ADC} = 1.5 MHz	SDADC _VDD = 3.3	V_{REF} = 3.3(1)		-77	-76	dB	
				f_{ADC} = 6 MHz		V_{REF} = 1.2(2)		-77	-76		
						V_{REF} = 3.3		-77	-76		
			gain =8	f_{ADC} = 6 MHz		V_{REF} = 1.2(2)		-85	-70		
						V_{REF} = 3.3		-93	-80		
				f_{ADC} = 1.5 MHz		V_{REF} = 3.3(1)		-95	-83		
		Single ended mode	gain =1	f_{ADC} = 6 MHz		V_{REF} = 1.2(2)		-72	-68		
						V_{REF} = 3.3		-74	-72		
			gain =8			V_{REF} = 1.2(2)		-66	-61		
						V_{REF} = 3.3		-75	-70		
ET	Total unadjusted error	gain = 0.5, V_{REF} = 3.3 V, Slow mode								LSB	EO+EL+EG
		gain = 1, SD_VDD = 3.3 V, Slow mode									
		gain = 8, SD_VDD = 3.3 V, Slow mode									
		gain = 0.5, SD_VDD = 3.3 V, Fast mode									
		gain = 1, SD_VDD = 3.3 V, Fast mode									
		gain = 8, SD_VDD = 3.3 V, Fast mode									
CMRR	Common mode rejection ratio	gain = 1, SD_VDD = 3.3 V								dB	

1. For f_{ADC} lower than 5 MHz, there will be a performance degradation of around 2 dB due to flicker noise increase.
2. If the reference value is lower than 2.4 V, there will be a performance degradation proportional to the reference supply drop, according to this formula: 20*log10(V_{REF}/2.4) dB
3. SNR, THD, SINAD parameters are valid for frequency bandwidth 20Hz - 1kHz. Input signal frequency is 300Hz (for f_{ADC}=6MHz) and 100Hz (for f_{ADC}=1.5MHz).

Table 67. SDVREF+ pin characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Unit	Note
V_{REFINT}	Internal reference voltage	Buffered embedded reference voltage (1.2 V)		1.2		V	See *Section 5.3.4: Embedded reference voltage on page 56*
		Embedded reference voltage amplified by factor 1.5		1.8			
C_{SDVREF}(1)	Reference voltage filtering capacitor	$V_{SDVREF+} = V_{REFINT}$	1000		10000	nF	
$R_{SDVERF+}$	Reference voltage input impedance	Fast mode (f_{ADC} = 6 MHz)		238		kΩ	See reference manual for detailed description
		Slow mode (f_{ADC} = 1.5 MHz)		952			

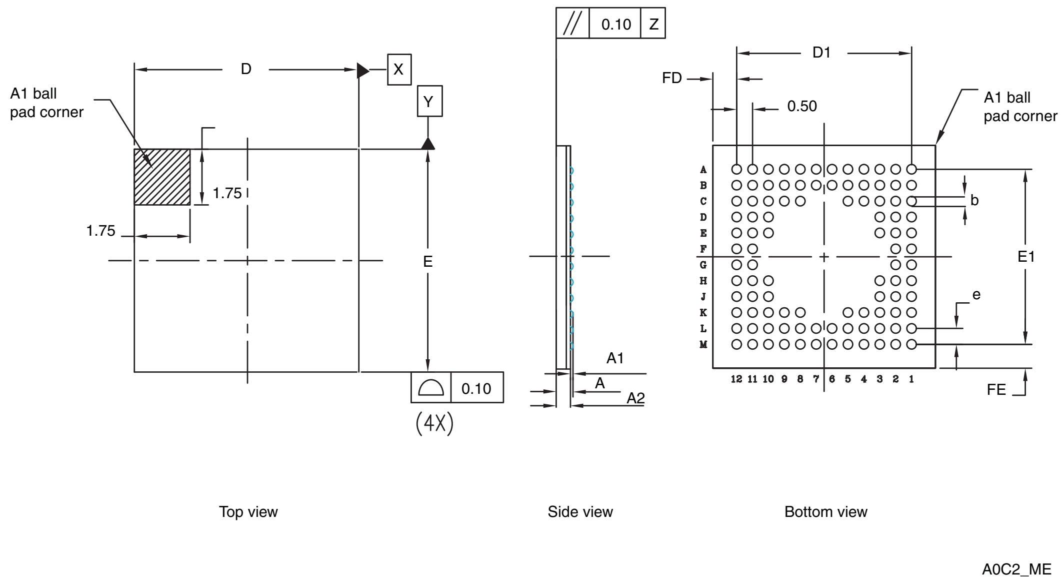
1. If internal reference voltage is selected then this capacitor is charged through internal resistance - typ. 300 ohm. Before next usage of SDADC user firmware must wait for capacitor charging.

6 Package characteristics

6.1 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 30. UFBGA100 – ultra fine pitch ball grid array, 7 x 7 mm, 0.50 mm pitch, package outline



1. Drawing is not to scale.

Table 68. UFBGA100 – ultra fine pitch ball grid array, 7 x 7 mm, 0.50 mm pitch, package mechanical data

Symbol	millimeters			inches(1)		
	Min	Typ	Max	Min	Typ	Max
A	0.46	0.53	0.6	0.0181	0.0209	0.0236
A1	0.06	0.08	0.1	0.0024	0.0031	0.0039
A2	0.4	0.45	0.5	0.0157	0.0177	0.0197
b	0.2	0.25	0.3	0.0079	0.0098	0.0118
D		7			0.2756	
D1		5.5			0.2165	
E		7			0.2756	
E1		5.5			0.2165	
e		0.5			0.0197	
FD		0.75			0.0295	
FE		0.75			0.0295	

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

Figure 31. LQFP100 –14 x 14 mm 100-pin low-profile quad flat package outline[(1)]

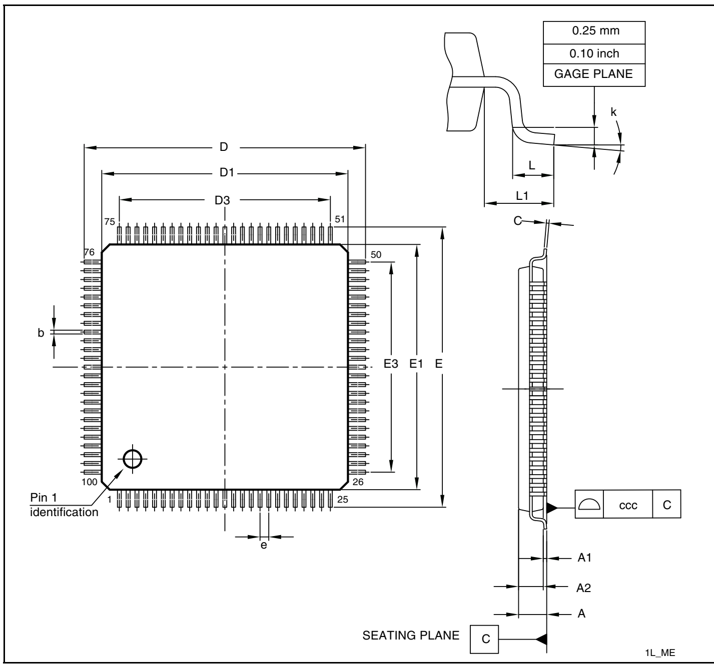
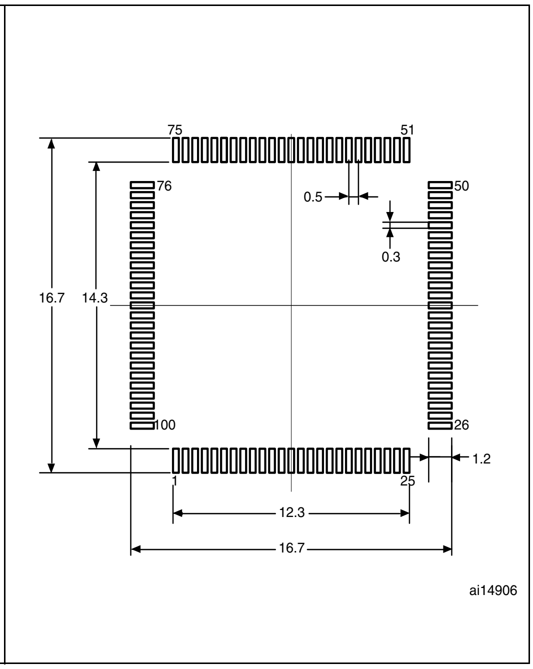


Figure 32. Recommended footprint[(1)(2)]



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

Table 69. 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			1.60			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	15.80	16.00	16.20	0.622	0.6299	0.6378
D1	13.80	14.00	14.20	0.5433	0.5512	0.5591
D3		12.00			0.4724	
E	15.80	16.00	16.20	0.622	0.6299	0.6378
E1	13.80	14.00	14.20	0.5433	0.5512	0.5591
E3		12.00			0.4724	
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 33. LQFP64 – 10 x 10 mm 64 pin low-profile quad flat package outline(1)

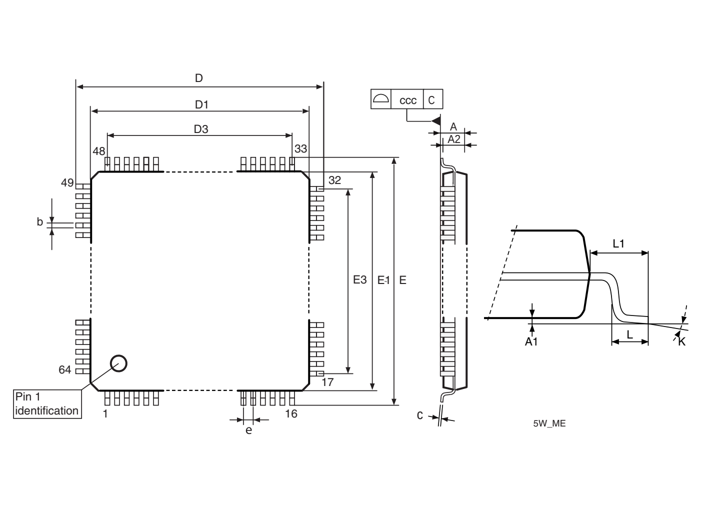
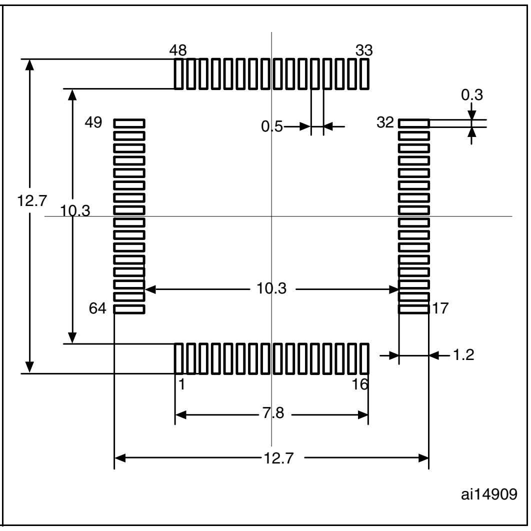


Figure 34. Recommended footprint(1)(2)



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

Table 70. 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			1.600			0.0630
A1	0.050		0.150	0.0020		0.0059
A2	1.350	1.400	1.450	0.0531	0.0551	0.0571
b	0.170	0.220	0.270	0.0067	0.0087	0.0106
c	0.090		0.200	0.0035		0.0079
D	11.800	12.000	12.200	0.4646	0.4724	0.4803
D1	9.800	10.000	10.200	0.3858	0.3937	0.4016
D.		7.500				
E	11.800	12.000	12.200	0.4646	0.4724	0.4803
E1	9.800	10.00	10.200	0.3858	0.3937	0.4016
e		0.500			0.0197	
k	0°	3.5°	7°	0°	3.5°	7°
L	0.450	0.600	0.75	0.0177	0.0236	0.0295
L1		1.000			0.0394	
ccc	0.080			0.0031		
N	Number of pins					
	64					

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

Figure 35. LQFP48 – 7 x 7 mm, 48-pin low-profile quad flat package outline(1)

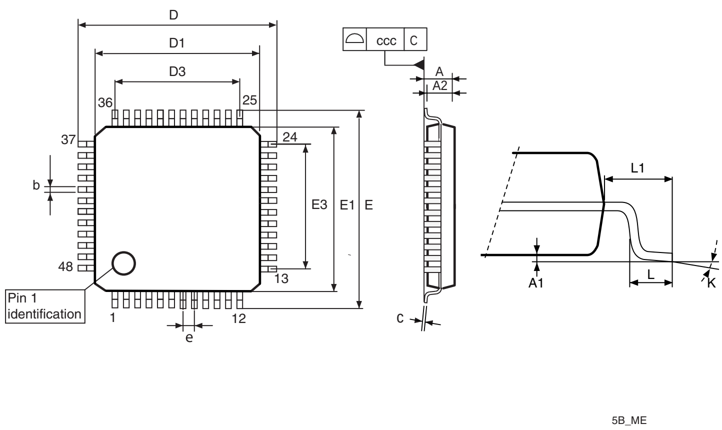
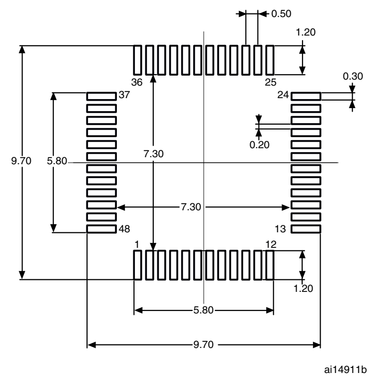


Figure 36. Recommended footprint(1)(2)



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

Table 71. LQFP48 – 7 x 7 mm 48-pin low-profile quad flat package mechanical data

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

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

6.2 Thermal characteristics

The maximum chip junction temperature ($T_J$max) must never exceed the values given in *Table 17: General operating conditions on page 53*.

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 72. Package thermal characteristics

Symbol	Parameter	Value	Unit
Θ_{JA}	**Thermal resistance junction-ambient** LQFP64 - 10 × 10 mm / 0.5 mm pitch	45	°C/W
	Thermal resistance junction-ambient LQFP48 - 7 × 7 mm	55	
	Thermal resistance junction-ambient LQFP100 - 14 × 14 mm / 0.5 mm pitch	46	
	Thermal resistance junction-ambient BGA100 - 7 x 7 mm	50	

6.2.1 Reference document

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

6.2.2 Selecting the product temperature range

When ordering the microcontroller, the temperature range is specified in the ordering information scheme shown in *Section 7: Ordering information scheme*.

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

As applications do not commonly use the STM32F05xx at maximum dissipation, it is useful to calculate the exact power consumption and junction temperature to determine which temperature range will be best suited to the application.

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

Example 1: High-performance application

Assuming the following application conditions:

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

P_{INTmax} = 50 mA × 3.5 V= 175 mW

P_{IOmax} = 20 × 8 mA × 0.4 V + 8 × 20 mA × 1.3 V = 272 mW

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

P_{Dmax} = 175 + 272 = 447 mW

Thus: P_{Dmax} = 447 mW

Using the values obtained in *Table 72* T_{Jmax} is calculated as follows:

– For LQFP64, 45°C/W

T_{Jmax} = 82 °C + (45°C/W × 447 mW) = 82 °C + 20.6 °C = 102.6 °C

This is within the range of the suffix 6 version parts (–40 < T_J < 105 °C).

In this case, parts must be ordered at least with the temperature range suffix 6 (see *Section 7: Ordering information scheme*).

Example 2: High-temperature application

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

Assuming the following application conditions:

Maximum ambient temperature T_{Amax} = 115 °C (measured according to JESD51-2), I_{DDmax} = 20 mA, V_{DD} = 3.5 V, maximum 20 I/Os used at the same time in output at low level with I_{OL} = 8 mA, V_{OL}= 0.4 V

P_{INTmax} = 20 mA × 3.5 V= 70 mW

P_{IOmax} = 20 × 8 mA × 0.4 V = 64 mW

This gives: P_{INTmax} = 70 mW and P_{IOmax} = 64 mW:

P_{Dmax} = 70 + 64 = 134 mW

Thus: P_{Dmax} = 134 mW

Using the values obtained in *Table 72* T_{Jmax} is calculated as follows:

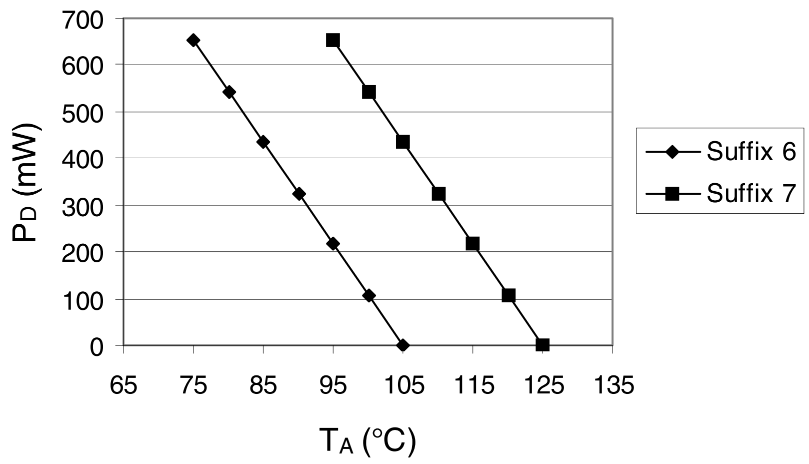
– For LQFP64, 45°C/W

T_{Jmax} = 115 °C + (45°C/W × 134 mW) = 115 °C + 6.2 °C = 121.2 °C

This is within the range of the suffix 7 version parts (–40 < T_J < 125 °C).

In this case, parts must be ordered at least with the temperature range suffix 7 (see *Section 7: Ordering information scheme*).

Figure 37. LQFP64 P_D max vs. T_A



7 Ordering information scheme

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

Example: STM32 F 372 R 8 T 6 x

Device family
STM32 = ARM-based 32-bit microcontroller

Product type
F = General-purpose

Sub-family
372 = STM32F372xx
373 = STM32F373xx

Pin count
C = 48 pins
R = 64 pins
V = 100 pins

Code size
8 = 64 Kbytes of Flash memory
B = 128 Kbytes of Flash memory
C = 256 Kbytes of Flash memory

Package
T = LQFP
H = BGA

Temperature range
6 = Industrial temperature range, –40 to 85 °C
7 = Industrial temperature range, –40 to 105 °C

Options
xxx = programmed parts
TR = tape and real

8 Revision history

Table 73. Document revision history

Date	Revision	Changes
18-Jun-2012	1	Initial release.