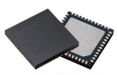
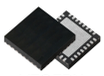
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STM32WB06xC STM32WB07xC

Datasheet

Ultra-low-power wireless 32-bit MCUs Arm®-based Cortex®-M0+ with Bluetooth® Low Energy and 2.4 GHz radio solution


VFQFPN48
(6 x 6 mm)


VFQFPN
(5 x 5 mm)


WLCSP49
(3.140 x 3.140 mm)

Product status	
STM32WB06xC	STM32WB06CC
	STM32WB06KC
STM32WB07xC	STM32WB07CC
	STM32WB07KC

Features

Includes ST state-of-the-art patented technology.

Bluetooth® Low Energy system-on-chip supporting Bluetooth 5.4 specifications

- 2 Mbps data rate
- Long range (Coded PHY)
- Advertising extensions
- Channel selection algorithm #2
- GATT caching
- LE Ping procedure
- Periodic advertising and periodic advertising sync transfer
- Periodic advertising with response
- Advertising coding selection
- Encrypted advertising
- LE L2CAP connection-oriented channel
- LE power control and path loss monitoring
- LE channel classification
- Enhanced ATT (EATT)
- Connection subrating
- Broadcast isochronous streams (BIS)
- Connection isochronous streams (CIS)

Radio

- Rx sensitivity level: -97 dBm @ 1 Mbps, -104 dBm @ 125 kbps (long range)
- Programmable output power up to +8 dBm (at antenna connector)
- Data rate supported: 2 Mbps, 1 Mbps, 500 kbps, and 125 kbps
- 128 physical connections
- Integrated balun
- Support for external PA
- STM32WB0xxC core coprocessor (DMA based) for Bluetooth® Low Energy timing critical operation
- 2.4 GHz proprietary radio driver
- Suitable for systems requiring compliance with the following radio frequency regulations: ETSI EN 300 328, EN 300 440, FCC CFR47 part 15, ARIB STD-T66
- Available integrated passive device (IPD) companion chip for optimized matching and filtering

Ultra-low-power features (ultra-low-power devices)

- 10 nA in Shutdown mode (1.8 V)
- 0.6 µA in Deepstop mode (with external LSE and Bluetooth® Low Energy wake-up sources, 1.8 V)

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- 0.9 µA in Deepstop mode (with internal LSI and Bluetooth® Low Energy wake-up sources, 1.8 V)
- 4.3 mA peak current in Tx (@ 0 dBm, 3.3 V)
- 3.4 mA peak current in Rx (@ sensitivity level, 3.3 V)
- High performance and ultralow power Arm® Cortex®-M0+ 32-bit, running up to 64 MHz
- Dynamic current consumption: 16.5 µA/MHz
- Operating supply voltage: from 1.7 to 3.6 V

Security

- Flash read/write protection
- SWD disabling
- Secure bootloader
- True random number generator (RNG)
- Hardware encryption AES maximum 128-bit security coprocessor
- Hardware public key accelerator (PKA)
- CRC calculation unit
- 64-bit unique ID

Clock management

- High efficiency embedded SMPS step-down converter with intelligent bypass mode
- Ultra-low-power power-on-reset (POR) and power-down-reset (PDR)
- Programmable voltage detector (PVD)
- Fail-safe 32 MHz crystal oscillator with integrated trimming capacitors
- 32 kHz crystal oscillator
- Internal low-power 32 kHz RO

Memories

- On-chip nonvolatile flash memory of 256 Kbytes
- On-chip RAM of 64 Kbytes or 32 Kbytes
- One-time-programmable (OTP) memory area of 1 Kbyte
- Embedded UART bootloader
- Ultra-low-power modes with or without timer and RAM retention

Security

- Flash read/write protection
- SWD disabling
- Secure bootloader
- True random number generator (RNG)
- Hardware encryption AES maximum 128-bit security coprocessor
- Hardware public key accelerator (PKA)
- CRC calculation unit
- 64-bit unique ID

System peripherals

- 1x DMA controller with eight channels supporting ADC, SPI, I2C, USART, and LPUART
- 1x SPI
- 2x SPI/I2S
- 2x I2C (SMBus/PMBus)
- 1x PDM (digital microphone interface)
- 1x LPUART

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- 1x USART (ISO 7816 smartcard mode, IrDA, SPI controller, and modbus)
- 1x independent WDG
- 1x real-time clock (RTC)
- 1x independent SysTick
- 1x 16-bit, six channel advanced timer

General-purpose inputs/outputs

- Quadrature decoder
- Up to 32 fast I/Os
- 28 of them with wake-up capability
- 31 of them 5 V tolerant

Analog peripherals

- 12-bit ADC with eight input channels, up to 16 bits with a decimation filter
- Battery monitoring
- Analog watchdog
- Analog mic I/F with PGA

Debug

- Development support
- Serial wire debug (SWD)
- Four breakpoints and two watchpoints

All packages are ECOPACK2 compliant.

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1 Introduction

This document provides information on STM32WB0xxC devices, such as description, functional overview, pin assignment and definition, electrical characteristics, packaging and ordering information.

It must be read in conjunction with the STM32WB0xxC reference manual (RM0530).

For information on the device errata with respect to the datasheet and reference manual, refer to the STM32WB0xxC errata sheet (ES0632).

For information on the Arm® Cortex®-M0+ core, refer to the Cortex-M0+ Technical Reference Manual, available from the www.arm.com website.

For information on Bluetooth®, refer to http://www.bluetooth.com website.

Note: Arm is a registered trademark of Arm Limited (or its subsidiaries) in the US and/or elsewhere.

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2 Description

The STM32WB0xxC is an ultra-low-power programmable Bluetooth® Low Energy wireless SoC solution. It embeds STMicroelectronics state-of-art 2.4 GHz RF radio IPs combining unparalleled performance with extremely long-battery lifetime. It is compliant with Bluetooth® Low Energy SIG core specification version 5.4 addressing point-to-point connectivity and Bluetooth Mesh networking and allows large-scale device networks to be established in a reliable way. The STM32WB0xxC is also suitable for 2.4 GHz proprietary radio wireless communication to address ultra-low latency applications.

The STM32WB0xxC embeds a Cortex®-M0+ microcontroller that can operate up to 64 MHz and also the BlueNRG core coprocessor (DMA based) for Bluetooth® Low Energy timing critical operations.

In addition, the STM32WB0xxC provides enhanced security hardware support by dedicated hardware functions:

True random number generator (RNG), encryption AES maximum 128-bit security coprocessor, public key accelerator (PKA), CRC calculation unit, 64-bit unique ID, flash memory read and write protection.

The STM32WB0xxC can be configured to support standalone or network processor applications. In the first configuration, the STM32WB0xxC operates as a single device in the application for managing both the application code and the Bluetooth® Low Energy stack.

The STM32WB0xxC embeds high-speed and flexible memory types: flash memory of 256 Kbytes, RAM memory of 64 Kbytes, one-time-programmable (OTP) memory area of 1 Kbyte, ROM memory of 7 Kbytes (ST reserved area).

Direct data transfer between memory and peripherals and from memory-to-memory is supported by eight DMA channels with a full flexible channel mapping by the DMAMUX peripheral.

The STM32WB0xxC embeds a 12-bit ADC, allowing measurements of up to eight external sources and up to three internal sources, including battery monitoring and a temperature sensor.

The STM32WB0xxC has a low-power RTC and one advanced 16-bit timer.

The STM32WB0xxC features standard and advanced communication interfaces:

1x SPI, 2x SPI/I2S, 1x LPUART, 1x USART supporting ISO 7816 (smartcard mode), IrDA, and modbus mode, 2x I^2C supporting SMBus/PMBus, 1x channel PDM.

The STM32WB0xxC operates in the -40 to +105°C temperature range from a 1.7 V to 3.6 V power supply. A comprehensive set of power-saving modes enables the design of low-power applications.

The STM32WB0xxC integrates a high efficiency SMPS step-down converter and an integrated PDR circuitry with a fixed threshold that generates a device reset when the V_{DD} drops under 1.65 V.

The STM32WB0xxC comes in different package versions supporting up to:

32 I/Os for the VFQFPN48 package, 20 I/Os for the VFQFPN32 package, 30 I/Os for the WLCSP49 package.

Refer to Table 1 for the list of peripherals available on each part number.

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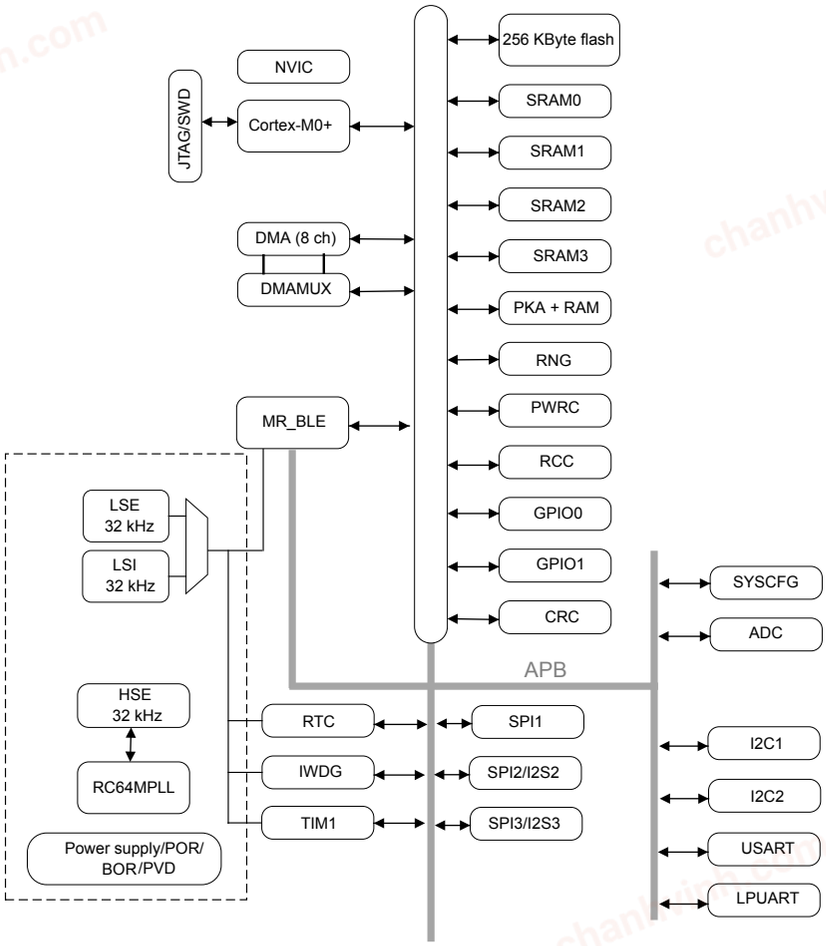
Table 1. Device features and peripheral counts

Peripherals		STM32WB06KC	STM32WB06CC	STM32WB07KC	STM32WB07CC
Flash memory (Kbytes)		256 Kbytes			
SRAM (Kbytes)	SRAM0	16 Kbytes		16 Kbytes	
	SRAM1	16 Kbytes		16 Kbytes	
	SRAM2	-		16 Kbytes	
	SRAM3	-		16 Kbytes	
Bluetooth® Low Energy		Yes			
Timers	General purpose	1 x 16-bit, 6 channel advanced timer			
	2.4 GHz proprietary radio timer low-power	32-bit			
	SysTick	1			
Real-time clock (RTC)		Yes			
Random number generator		Yes			
AES		Yes			
Public key accelerator (PKA)		Yes			
Communication interfaces	SPI/I2S	2 with I2S feature			
	I2C	1			
	USART	1			
	LPUART	1			
12-bit ADC with 1 PDM	Number of channels	8			
GPIOs		32			
Wakeup pins		28			
Maximum CPU frequency (MHz)		64			
Operating voltage		1.7 to 3.6 V			
Operating temperature		Temperature range: −40 to 105 °C			
Packages		VFQFPN32 5 x 5 mm, 0.50 mm pitch, very fine pitch quad flat no lead package			
		VFQFPN48 6 x 6 mm, 0.40 mm pitch, very fine pitch quad flat no lead package			
		WLCSP49 3.140 x 3.140 mm, 0.40 mm pitch, wafer level chip scale array package			

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

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Figure 1. **STM32WB0xxC block diagram**



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3 Functional overview

3.1 ARM Cortex–M0+ core with MPU

The STM32WB0xxC contains an ARM Cortex-M0+ microcontroller core. The Cortex-M0+ was developed to provide a low-cost platform that meets the needs of CPU implementation, with a reduced pin count and low-power consumption, while delivering outstanding computational performance and an advanced response to interrupts. The Cortex-M0+ can run from 1 MHz up to 64 MHz.

The Cortex-M0+ processor is built on a highly area and power optimized 32-bit processor core, with a 2-stage pipeline Von Neumann architecture. The processor delivers exceptional energy efficiency through a small but powerful instruction set and extensively optimized design, providing high-end processing hardware including a single-cycle multiplier.

The interrupts are handled by the Cortex-M0+ Nested Vector Interrupt Controller (NVIC). The NVIC controls specific Cortex-M0+ interrupts as well as the STM32WB0xxC peripheral interrupts. With its embedded ARM core, the STM32WB0xxC family is compatible with all ARM tools and software.

3.2 Memory protection unit (MPU)

The MPU is used to manage accesses to memory to prevent one task from accidentally corrupting the memory or resources used by any other active task. This memory area is organized into up to 8 protected areas. The protection area sizes are between 32 bytes and the whole 4 gigabytes of addressable memory.

The MPU 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 settings, based on the process to be executed.

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

3.3 Memories

3.3.1 Embedded flash memory

The flash memory controller implements the erase and program Flash memory operation. The flash controller also implements the read and write protection.

The flash memory features are:

- Memory organization:
  - 1 bank of 256 kB
  - Page size: 2 kB
  - Page number 128
- 32-bit wide data read/write
- Page erase and mass erase

The flash memory controller features are:

- Flash memory read operations
- Flash memory write operations: single data write or 4x32-bits burst write
- Flash memory erase operations
- Page write protect mechanism

3.3.2 Embedded SRAM

The STM32WB0xxC has a total of 64 kB of embedded SRAM, split into four banks as shown in the following table:

Table 2. SRAM overview

SRAM bank	Size	Address	Retained in Deepstop
SRAM0	16 kB	0x2000 0000	Always

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SRAM bank	Size	Address	Retained in Deepstop
SRAM1	16 kB	0x2000 4000	Programmable by the user
SRAM2	16 kB	0x2000 8000	Programmable by the user
SRAM3	16 kB	0x2000 C000	Programmable by the user

3.3.3 Embedded ROM

The STM32WB0xxC has a total of 7 Kbytes of embedded ROM. This area is ST reserved and contains:

- The UART bootloader from which the CPU boots after each reset (first 6 Kbytes of ROM memory)
- Some ST reserved values including the ADC trimming values (the last 1 Kbyte of ROM memory)

3.3.4 Embedded OTP

The one-time-programmable (OTP) is a memory of 1 Kbyte dedicated for user data. The OTP data cannot be erased.

The user can protect the OTP data area by writing the last word at address 0x1000 1BFC and by performing a system reset. This operation freezes the OTP memory from further unwanted write operations.

3.4 Security and safety

The STM32WB0xxC contains many security blocks for the Bluetooth® Low Energy and the host application.

It includes:

- Flash read/write protections
- As protection against potential hacker attacks, the SWD access can be disabled
- Secure bootloader
- Customer storage of the Bluetooth® Low Energy keys
- True random number generator (RNG)
- Private key accelerator (PKA) including:
  - Elliptic curve Diffie-Hellman (ECDH) public-private key pair calculation accelerator
  - Based on the Montgomery method for fast modular multiplications
  - Built-in Montgomery domain inward and outward transformations
    - AMBA® AHB lite target interface with a reduced command set
- Cyclic redundancy check calculation unit (CRC)

3.5 Boot modes

After the CPU boots, the application software has the capability to modify the memory map at address `0x0000 0000`. This modification is carried out by programming the REMAP bit in the flash memory controller.

The following memory can be remapped:

- Main flash memory
- SRAM0 memory

3.6 Radio system

3.6.1 RF subsystem

The STM32WB0xxC embeds an ultralow power radio, compliant with the Bluetooth® Low Energy specification. The Bluetooth® Low Energy features 1 Mbps and 2 Mbps transfer rates as well as long range options (125 kbps, 500 kbps), supports multiple roles simultaneously acting at the same time as a Bluetooth® Low Energy sensor and a hub device.

The Bluetooth® Low Energy protocol stack is implemented by an efficient system partitioned as follows:

- Hardware part: BlueCore handling time-critical and time consuming Bluetooth® Low Energy protocol parts
- Firmware part: Arm® Cortex®-M0+ core handling nontime critical Bluetooth® Low Energy protocol parts

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3.6.1.1 RF front-end block diagram

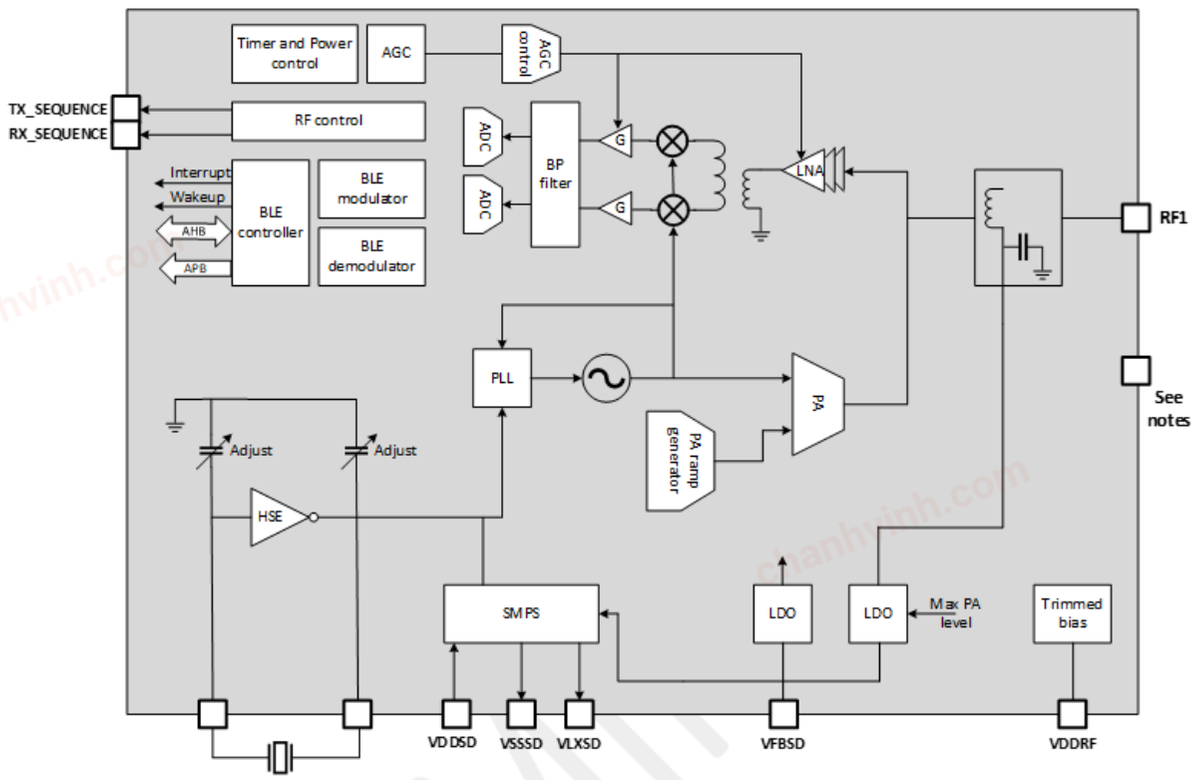
The RF front-end is based on a direct modulation of the carrier in Tx, and uses a low IF architecture in Rx mode.

Thanks to an internal transformer with RF pins, the circuit directly interfaces the antenna (single ended connection, impedance close to 50 Ω). The natural band pass behavior of the internal transformer simplifies outside circuitry aimed at harmonic filtering and out of band interferer rejection.

In transmit mode, the maximum output power is user selectable through the programmable LDO voltage of the power amplifier. A linearized, smoothed analog control offers a clean power ramp-up.

In receive mode, the automatic gain control (AGC) can reduce the gain in both the RF and IF stages, optimizing interferer rejection. Thanks to the use of complex filtering and a highly accurate I/Q architecture, high sensitivity, and excellent linearity can be achieved.

Figure 2. STM32WB0xxC RF block diagram



Note:
VFQFPN32 and VFQFPN48: VSS through exposed pad, and VSSRF pins must be connected to ground plane.
WLCSP49: V_{SSRF} pins must be connected to ground plane.

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3.6.1.2 IPDs for STM32WB06xC and STM32WB07xC

Table 3 lists the available IPD variants for the STM32WB06xC and STM32WB07xC devices.

Table 3. IPDs for STM32WB0xxC

IPD	MCU package	STM32WB06xC and STM32WB07xC part number
MLPF-NRG-01D3	VFQFPN32, VFQFPN48	STM32WB06KCV, STM32WB06CCV STM32WB07KCV, STM32WB07CCV
	WLCSP49	STM32WB06CCF, STM32WB07CCF

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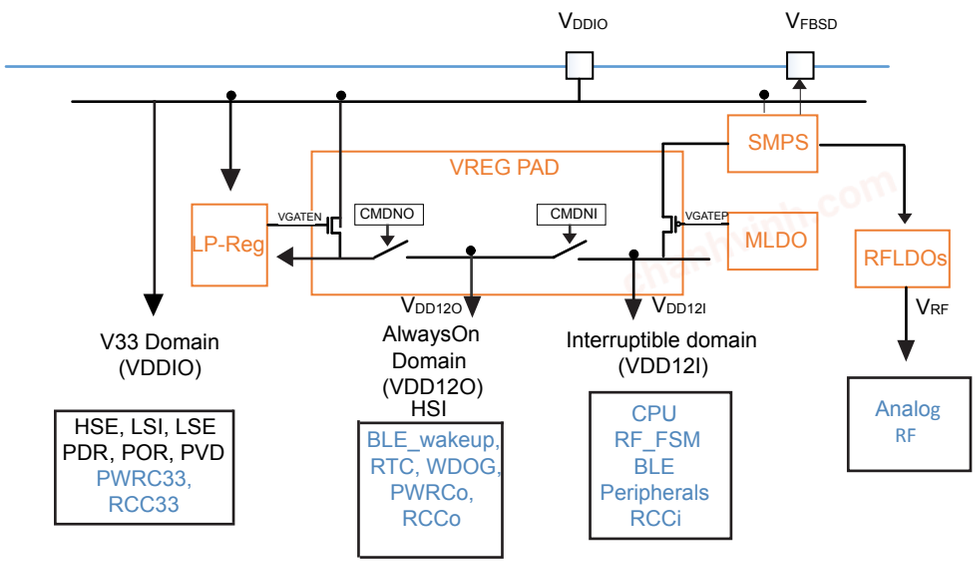
3.7 Power supply management

3.7.1 Power supply schemes

The STM32WB0xxC embeds three power domains:

- VDD33 (VDDIO or VDD):
  - the voltage range is between 1.7 V and 3.6 V
  - it supplies a part of the I/O ring, the embedded regulators and the system analog IPs as power management block and embedded oscillators
- VDD12o:
  - always-on digital power domain
  - this domain is generally supplied at 1.2 V during active phase of the device
  - this domain is supplied at 1.0 V during low power mode (Deepstop)
- VDD12i:
  - interruptible digital power domain
  - this domain is generally supplied at 1.2 V during active phase of the device
  - this domain is shut down during low-power mode (Deepstop)

Figure 3. Power supply domain overview



3.7.2 Power supply supervisor

The STM32WB0xxC device embeds several power voltage monitorings:

- Power-on-reset (POR): during the power-on, the device remains in reset mode if V_{DDIO} is below a V_{POR} threshold (typically 1.65 V)
- Power-down-reset (PDR): during power-down, the PDR puts the device under reset when the supply voltage (V_{DD}) drops below the VPDR threshold (around 20 mV below V_{POR}). The PDR feature is always enabled
- Programmable voltage detector (PVD): can be used to monitor the V_{DDIO} (against a programmed threshold) or an external analog input signal. When the feature is enabled and the PVD measures a voltage below the comparator, an interrupt is generated (if unmasked)

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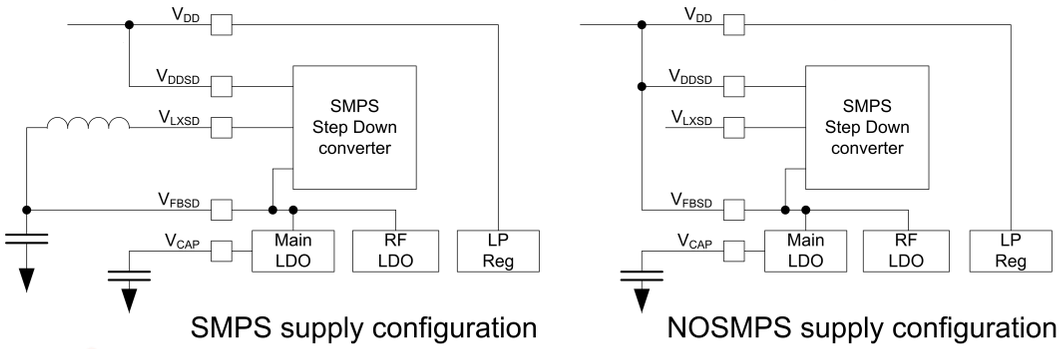
3.7.3 SMPS step-down regulator

The device integrates a step-down converter to improve low-power performance when the V_{DD} voltage is high enough. The SMPS output voltage can be programmed from 1.2 V to 1.90 V. It is internally clocked at 4 MHz or 8 MHz.

The device can be operated without the SMPS by just wiring its output to V_{DD}. This is the case for applications where the voltage is low, or where the power consumption is not critical.

Except for the configuration SMPS OFF, an L/C BOM must be present on the board and connected to the VFBSD pad.

Figure 4. Power supply configuration



3.7.4 Linear voltage regulators

The digital power supplies are provided by different regulators:

- The main LDO (MLDO):
  - it provides 1.2 V from a 1.4-3.3 V input voltage
  - it supplies both VDD12i and VDD12o when the device is active
  - it is disabled during the low power mode (Deepstop)
- Low power LDO (LPREG):
  - it stays enabled during both active and low power phases
  - it provides 1.0 V voltage
  - it is not connected to the digital domain when the device is active
  - it is connected to the VDD12o domain during low power mode (Deepstop)
- A dedicated LDO (RFLDO) to provide a 1.2 V to the analog RF block

An embedded SMPS step-down converter is available (inserted between the external power and the LDOs).

3.8 Low-power modes

Several operating modes are defined for the STM32WB0xxC:

- Run mode
- Deepstop mode
- Shutdown mode

Table 4. Relationship between the low power modes and functional blocks

Mode	Shutdown	Deepstop	Idle	Run
CPU	OFF	OFF	OFF	ON
Flash	OFF	OFF	ON	ON
RAM	OFF	ON/OFF granularity 16 Kbytes	ON/OFF	ON/OFF
Radio	OFF	OFF	ON/OFF	ON/OFF
Supply system	OFF	OFF	ON (DC-DC ON/OFF)	ON (DC-DC ON/OFF)
Register retention	OFF	ON	ON	ON

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Mode	Shutdown	Deepstop	Idle	Run
HS clock	OFF	OFF	ON	ON
LS clock	OFF	ON/OFF	ON	ON
Peripherals	OFF	OFF	ON/OFF	ON/OFF
Wake-on RTC	OFF	ON/OFF	ON/OFF	NA
Wake-on GPIOs	OFF	ON/OFF	ON/OFF	NA
Wake-on reset pin	ON	ON	ON	NA

3.8.1 Run mode

In Run mode the STM32WB0xxC is fully operational:

- All interfaces are active
- The internal power supplies are active
- The system clock and the bus clock are running
- The CPU core and the radio can be used

The power consumption may be reduced by gating the clock of the unused peripherals.

3.8.2 Deepstop mode

The Deepstop is the only low power mode of the STM32WB0xxC allowing the restart from a saved context environment and the application at wakeup to go on running.

The conditions to enter the Deepstop mode are:

- The radio is sleeping (no radio activity)
- The CPU is sleeping (WFI with SLEEPDEEP bit activated)
- No unmasked wakeup sources are active
- The low power mode selection (LPMS) bit of the power controller unit is 0 (default)

In Deepstop mode:

- The system and the bus clocks are stopped
- Only the essential digital power domain is ON and supplied at 1.0 V
- The bank RAM0 is kept in retention
- The other banks of RAM can be in retention or not, depending on the software configuration
- The low speed clock can be running or stopped, depending on the software configuration:
  - ON or OFF
  - Sourced by LSE or by LSI
- The RTC and the IWDG stay active, if enabled and the low speed clock is ON
- The I/Os pull-up and pull-down can be controlled during Deepstop mode, depending on the software configuration
- The radio wakeup block, including its timer, stays active (if enabled and the low speed clock is ON)
- Eight I/Os (PA4/ PA5/ PA6/ PA7/ PA8/ PA9/ PA10/ PA11) can be in output driving:
  - A static low or high level
  - The low speed clock
  - The RTC output

Possible wakeup sources are:

- The radio block is able to generate two events to wake up the system through its embedded wakeup timer running on a low speed clock:
  - Radio wakeup time is reached
  - CPU host wakeup time is reached
- The RTC can generate a wakeup event
- The IWDG can generate a reset event
- Up to 28 GPIOs are able to wake up the system (PA0 to PA15 and PB0 to PB11)

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At the wakeup, all the hardware resources located in the digital power domain that are OFF during the Deepstop mode, are reset. The CPU reboots. The wakeup reason is visible in the register of the power controller.

3.8.3 Shutdown mode

The Shutdown mode is the least power-consuming mode.

The conditions to enter Shutdown mode are the same conditions needed to enter Deepstop mode except that the LPMS bit of the power controller unit is 1.

In Shutdown mode, the STM32WB0xxC is in ultralow power consumption: all voltage regulators, clocks, and the RF interface are not powered. The STM32WB0xxC can enter shutdown mode by internal software sequence. The only way to exit Shutdown mode is by asserting and deasserting the RSTN pin.

In shutdown mode:

- The system is powered down as both the regulators are OFF.
- The VDDIO power domain is ON.
- All the clocks are OFF, LSI, and LSE are OFF.
- The I/Os pull-up and pull-down can be controlled during Shutdown mode, depending on the software configuration.
- The only wakeup source is a low pulse on the RSTN pin.

The exit from Shutdown is similar to a POR startup. The PDR feature can be enabled or disabled during Shutdown.

3.9 Peripheral interconnect matrix

3.9.1 System architecture

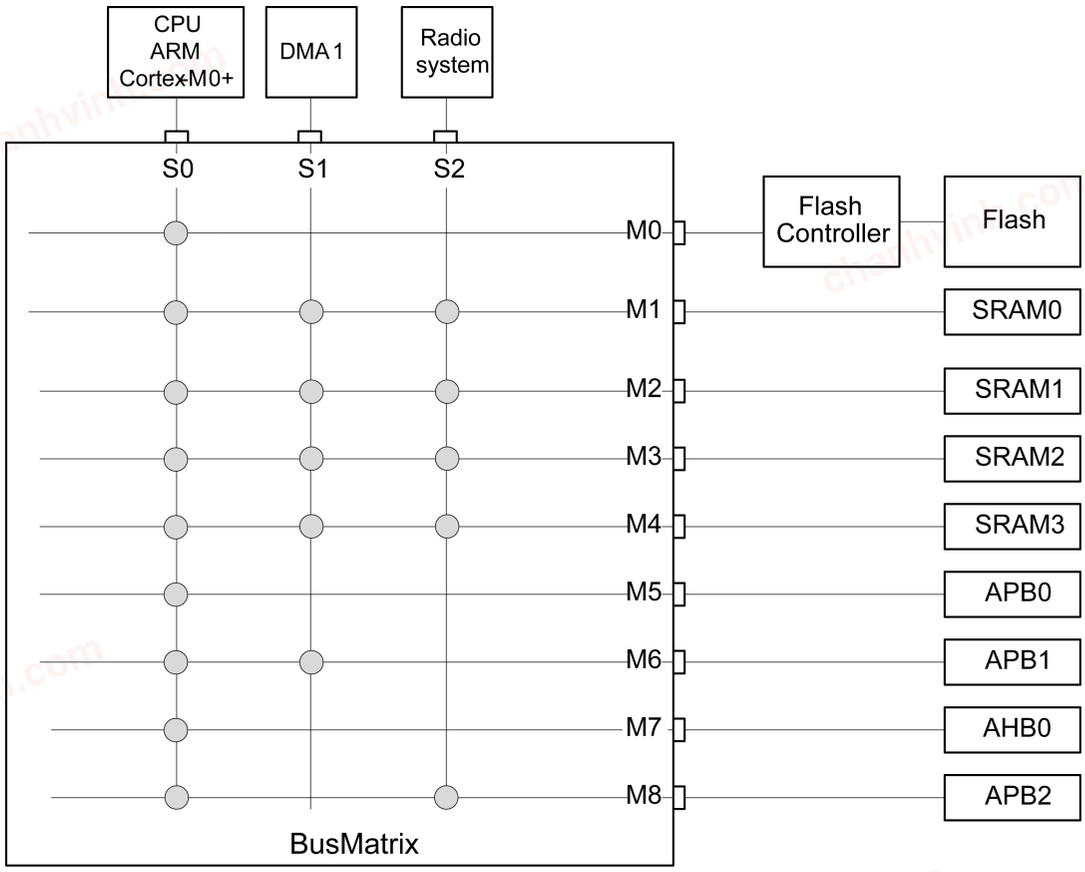
The main system consists of 32-bit multilayer AHB bus matrix that interconnects:

- Three masters:
  - CPU (Cortex®-M0+) core S-bus
  - DMA1
  - Radio system
- Nine slaves:
  - Internal Flash memory on CPU (Cortex®-M0+) S bus
  - Internal SRAM0 (16 kB)
  - Internal SRAM1 (16 kB)
  - Internal SRAM2 (16 kB)
  - Internal SRAM3 (16 kB)
  - APB0 peripherals (through an AHB to APB bridge)
  - APB1 peripherals (through an AHB to APB bridge)
  - AHB0 peripherals
  - AHBRF including AHB to APB bridge and radio peripherals (connected to APB2)

The bus matrix provides access from a master to a slave, enabling concurrent access and efficient operation even when several high-speed peripherals work simultaneously.

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Figure 5. **Bus matrix**



3.10 Reset and clock controller (RCC)

3.10.1 Reset management

The STM32WB0xxC offers two different resets:

- The PORESETn: this reset is provided by the low power management unit (LPMU) analog block and corresponds to a POR or PDR root cause. It is linked to power voltage ramp-up or ramp-down. This reset impacts all resources of the STM32WB0xxC. The exit from Shutdown mode is equivalent to a POR and thus generates a PORESETn. The PORESETn signal is active when the power supply of the device is below a threshold value or when the regulator does not provide the target voltage.

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- The PADRESETn (system reset): this reset is built through several sources:
  - PORESETn
  - Reset due to the watchdog
    The STM32WB0xxC device embeds a watchdog timer, which may be used to recover from software crashes
  - Reset due to CPU lockup
    The Cortex®-M0+ generates a lockup to indicate the core is in the lock-up state resulting from an unrecoverable exception. The lock-up reset is masked if a debugger is connected to the Cortex®-M0+
  - Software system reset
    The system reset request is generated by the debug circuitry of the Cortex®-M0+. The debugger sets the SYSRESETREQ bit of the application interrupt and reset control register (AIRCR). This system reset request through the AIRCR can also be done by the embedded software (into the hard fault handler for instance)
  - Reset from the RSTN external pin
    The RSTN pin toggles to inform that a reset has occurred

  This PADRESETn resets all resources of the STM32WB0xxC, except:
- Debug features
- Flash memory controller key management
- RTC timer
- Power controller unit
- Part of the RCC registers

The pulse generator guarantees a minimum reset pulse duration of 20 µs for each internal reset source. In case of reset from the RSTN external pad, the reset pulse is generated when the pad is asserted low.

3.10.2 Clock management

Three different clock sources may be used to drive the system clock of the STM32WB0xxC:

- HSI: high speed internal 64 MHz RC oscillator
- PLL64M: 64 MHz PLL clock
- HSE: high speed 32 MHz external crystal

The STM32WB0xxC also has a low speed clock tree used by some timers in the radio, RTC, and IWDG.

Four different clock sources can be used for this low speed clock tree:

- Low speed internal (LSI): low speed and low drift internal RC with a fixed frequency between 24 kHz and 49 kHz depending on the sample
- Low speed external (LSE) from:
  - An external crystal 32.768 kHz
  - A single-ended 32.738 kHz input signal
- A 32 kHz clock (CLK_16 MHz/512 in Figure 6. Clock tree) obtained by dividing HSI or HSE. In this case, the slow clock is not available in Deepstop low power mode
- LSI_LPMU: 32 kHz clock used by the low power management unit (LPMU) analog block.

By default, after a system reset, all low-speed sources are OFF.

Both the activation and the selection of the slow clock are relevant during the Deepstop mode and at wakeup as the slow clock generates a clock for the timers involved in wakeup event generation.

The HSI and the PLL64M clocks are provided by the same analog block called RC64MPLL. The 64 MHz clock output by this block can be:

- A nonaccurate clock when no external XO provides an input clock to this block (HSI)
- An accurate clock when the external XO provides the 32 MHz and once its internal PLL is locked (PLL64M)

This fast clock source is used to generate all the fast clocks of the device through dividers. After reset, the CLK_SYS is divided by four to provide a 16 MHz to the whole system (CPU, DMA, memories, and peripherals).

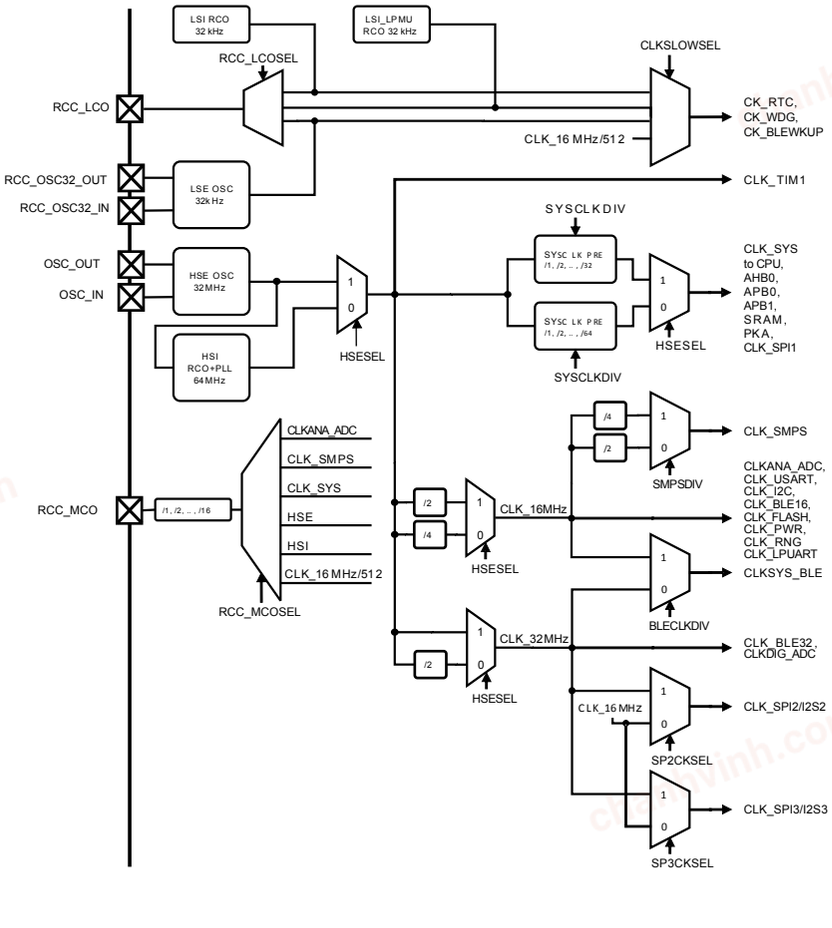
This fast clock source is also used to generate several internal fast clocks in the system:

- Always 32 MHz requested by a few peripherals like the radio

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- Always 16 MHz requested by a few peripherals like serial interfaces (to maintain fixed the baud rate while the system clock is switching from one frequency to another) or like the flash memory controller and radio (to have a fixed reference clock to manage delays)

Figure 6. Clock tree



It is possible to output some internal clocks on external pads:

- The low speed clocks can be output on the RCC_LCO I/O
- The high speed clocks can be output on the RCC_MCO I/O

This is possible by programming the associated I/O in the correct alternate function.

Most of the peripherals only use the system clock except:

- I^2C, USART, LPUART: they always use an a16 MHz clock to have a fixed reference clock for baud rate management. The goal is to allow the CPU to boost or slow down the system clock (depending on ongoing activities) without impacting a potential ongoing serial interface transfer on external I/Os
- SPI: when the I2S mode is used, the baud rate is always managed through the 16 MHz or 32 MHz clock. When modes other than the I2S run, the baud rate is managed by the system clock. This implies that its baud rate is impacted by dynamic system clock frequency changes
- RNG: in parallel to the system clock, the RNG always uses a 16 MHz clock to generate at a constant frequency the random number whatever the system clock frequency
- Flash memory controller: in parallel to the system clock, the flash memory controller always uses a 16 MHz clock to generate specific delays required by the flash memory during programming and erase operations for example
- PKA: in parallel to the system clock, the PKA uses a clock at half of the system clock frequency

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- Radio: it does not directly use the system clock for its APB/AHB interfaces, but the system clock with a potential divider (1 or 2 or 4). In parallel, the radio always uses 16 MHz and always 32 MHz for modulator, demodulator and to have a fixed reference clock to manage specific delays
- ADC: in parallel to the system clock, ADC uses a 64 MHz prescaled clock running at 16 MHz

3.11 General purpose inputs/outputs (GPIO)

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. Fast I/O toggling can be achieved thanks to their mapping on the AHB0 bus.

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.

3.11.1 Tx and Rx event alert

The STM32WB0xxC is provided with the RADIO_TX_SEQUENCE and RADIO_RX_SEQUENCE signals which alert, respectively, transmission and reception activities.

A signal can be enabled for Tx and Rx on two pins, through alternate functions:

- RADIO_TX_SEQUENCE is available on PA10 (AF2) or PB15 (AF1).
- RADIO_RX_SEQUENCE is available on PA8 (AF2) or PA11 (AF2).

The signal is high when the radio is in Tx (or Rx), low otherwise.

The signals can be used to control external antenna switching and support coexistence with other wireless technologies.

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3.12 Direct memory access (DMA)

The DMA is used in order to provide high-speed data transfer between peripherals and memory as well as memory-to-memory. Data can be quickly moved by DMA without any CPU actions. In this manner, CPU resources are free for other operations.

The DMA controller has eight channels in total. Each has an arbiter to handle the priority among DMA requests.

DMA main features are:

- Eight independently configurable channels (requests)
- Each of the eight channels is connected to dedicated hardware DMA requests, software trigger is also supported on each channel. This configuration is done by software
- Priorities among requests from channels of DMA are software programmable (four levels consisting of very high, high, medium, low) or hardware in case of equality (request 1 has priority over request 2, and so on)
- Independent source and destination transfer size (byte, half word, word), emulating packing and unpacking. Source/destination addresses must be aligned on the data size
- Support for circular buffer management
- Three event flags (DMA half transfer, DMA transfer complete and DMA transfer error) logically ORed together in a single interrupt request for each channel
- Memory-to-memory transfer (RAM only)
- Peripheral-to-memory and memory-to-peripheral, and peripheral-to-peripheral transfers
- Access to SRAMs and APB1 peripherals as source and destination
- Programmable number of data to be transferred: up to 65536

3.13 Interrupts and events

3.13.1 Nested vectored interrupt controller (NVIC)

The interrupts are handled by the Cortex®-M0+ nested vector interrupt controller (NVIC). NVIC controls specific Cortex®-M0+ interrupts as well as the STM32WB0xxC peripheral interrupts.

The NVIC benefits are the following:

- Nested vectored interrupt controller that is an integral part of the Arm® Cortex®-M0+
- A tightly coupled interrupt controller provides low interrupt latency
- Control system exceptions and peripheral interrupts
- NVIC supports 32 vectored interrupts
- Four programmable interrupt priority levels with hardware priority level masking
- Software interrupt generation using the Arm® exceptions SVCall and PendSV
- Support for NMI
- Arm® Cortex® M0+ vector table offset register VTOR implemented

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

3.14 Analog digital converter (ADC)

The STM32WB0xxC embeds a 12-bit ADC. The ADC consists of a 12-bit successive approximation analog-to-digital converter (SAR) with 2 x 8 multiplexed channels allowing measurements of up to eight external sources and up to two internal sources.

The ADC main features are:

- Conversion frequency is up to 1 Msps
- Three input voltage ranges are supported (0 - 1.2 V, 0 - 2.4 V, 0 - 3.6 V)
- Up to eight analog single-ended channels or four analog differential inputs or a mix of both
- Temperature sensor conversion
- Battery level conversion up to 3.6 V
- ADC continuous or single mode conversion is possible
- ADC down-sampler for multi-purpose applications to improve analog performance while off-loading the CPU (ratio adjustable from 1 to 128)
- A watchdog feature to inform when data is outside thresholds

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- DMA capability
- Interrupt sources with flags.

3.14.1 Digital MEMS microphone interface

The digital MEMS microphone interface aims to interconnect with an external digital MEMS microphone. The STM32WB0xxC can configure two GPIOs as a PDM interface. The PDM_CLK provides the clock output signal, programmable in frequency, to the microphone, while the PDM_DATA receives the PDM output data from the microphone. The decimation filter and the digital control resources are used to handle the PDM data stream.

3.14.2 Analog microphone interface

The analog microphone interface is dedicated to the analog microphone signal. The input audio signal is amplified with a programmable gain amplifier (PGA) from 0 dB to 30 dB, then the data stream is sampled by ADC and processed through the decimation filter.

3.14.3 Temperature sensor

The temperature sensor (TS) generates a voltage that varies linearly with temperature. The temperature sensor is internally connected to the ADC input channel, which is used to convert the sensor output voltage into a digital value.

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

3.15 True random number generator (RNG)

An RNG, or random number generator, is based on continuous analog noise and provides a 16-bit value to the host upon being read. The minimum period is 1.25 µs, which corresponds to 20 RNG clock cycles between two consecutive random numbers.

3.16 Timers and watchdog

The STM32WB0xxC includes one advanced 16-bit timer, one watchdog timer, and a SysTick timer.

3.16.1 Advanced control timer (TIM1)

The advanced-control timer can be considered as a three-phase PWM multiplexed on six channels. The six channels have complementary PWM outputs with programmable inserted dead-times.

They can also be used as general-purpose timers for:

- Input capture (except channels 5 and 6)
- Output compare
- PWM generation (edge and center-aligned mode)
- One-pulse mode output

3.16.2 Independent watchdog (IWDG)

The independent watchdog is based on a 12-bit downcounter and 8-bit prescaler. It is clocked from the LS clock and it can operate in Deepstop mode. It can also be used as a watchdog to reset the device when a problem occurs.

3.16.3 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

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3.17 Real-time clock (RTC), tamper and backup registers

3.17.1 Real-time clock (RTC)

The RTC is an independent BCD timer/counter. The RTC provides a time of day/clock/calendar with programmable alarm interrupt. RTC includes also a periodic programmable wakeup flag with interrupt capability. The RTC provides an automatic wakeup to manage all low power modes.

Two 32-bit registers contain seconds, minutes, hours (12- or 24-hour format), day (day of week), date (day of month), month, and year, expressed in binary coded decimal format (BCD). The sub-second value is also available in binary format. Compensations for 28-, 29- (leap year), 30-, and 31-day months are performed automatically. Daylight saving time compensation can also be performed. Additional 32-bit registers contain the programmable alarm sub seconds, seconds, minutes, hours, day, and date.

A digital calibration circuit with 0.95 ppm resolution is available to compensate for quartz crystal inaccuracy. After power-on reset, all RTC registers are protected against possible parasitic write accesses. As long as the supply voltage remains in the operating range, the RTC never stops, regardless of the device status (Run mode, low power mode or under system reset). The RTC counter does not freeze when CPU is halted by a debugger.

3.18 Inter-integrated circuit interface (I2C)

The STM32WB0xxC embeds two I2Cs. The I^2C bus interface handles communications between the microcontroller and the serial I^2C bus. It controls all I^2C bus-specific sequencing, protocol, arbitration, and timing.

The I2C peripheral supports:

- I^2C bus specification and user manual rev. 5 compatibilities:
  - Target and controller modes
  - Multicontroller capability
  - Standard mode (Sm), with a bitrate up to 100 Kbit/s
  - Fast mode (Fm), with a bitrate up to 400 Kbit/s
  - Fast mode plus (Fm+), with a bitrate up to 1 Mbit/s and 20 mA output driver I/Os
  - 7-bit and 10-bit addressing mode
  - Multiple 7-bit target addresses (two addresses, 1 with configurable mask)
  - All 7-bit address acknowledge mode
  - General call
  - Programmable setup and hold times
  - Easy to use event management
  - Optional clock stretching
  - Software reset
- System management bus (SMBus) specification rev 2.0 compatibility:
  - Hardware PEC (Packet Error Checking) generation and verification with ACK control
  - Address resolution protocol (ARP) support
  - Host and device support
  - SMBus alert
  - Timeouts and idle condition detection
- Power system management protocol (PMBus™) specification Rev. 1.1 compatibility
- Independent clock: a choice of independent clock sources allowing the I^2C communication speed to be independent from the PCLK reprogramming
- Programmable analog and digital noise filters
- 1-byte buffer with DMA capability

3.19 Universal synchronous/asynchronous receiver transmitter (USART/UART)

USART offers flexible full-duplex data exchange with external equipment requiring an industry standard NRZ asynchronous serial data format. USART is able to communicate with a speed up to 2 Mbit/s. Furthermore, USART is able to detect and automatically set its own baud rate, based on the reception of a single character.

The USART peripheral supports:

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- Synchronous one-way communication
- Half-duplex single wire communication
- Local interconnection network (LIN) master/slave capability
- Smart card mode, ISO 7816 compliant protocol
- IrDA (infrared data association) SIR ENDEC specifications
- Modem operations (CTS/RTS)
- RS485 driver enable
- Multiprocessor communications
- SPI-like communication capability

High speed data communication is possible by using DMA (direct memory access) for multibuffer configuration.

3.19.1 Embedded UART bootloader

The STM32WB0xxC has a preprogrammed bootloader supporting the UART protocol with automatic baud rate detection. The main features of the embedded bootloader are:

- Auto baud rate detection up to 1 Mbps
- Flash mass erase, section erase
- Flash programming
- Flash readout protection enable/disable

The preprogrammed bootloader is an application, which is stored in the STM32WB0xxC internal ROM at manufacturing time by STMicroelectronics. This application allows upgrading the flash device with a user application using a serial communication channel (UART).

The bootloader is activated by hardware by forcing PA10 high during hardware reset, otherwise, application residing in flash is launched.

3.20 LPUART

LPUART is a UART which allows bidirectional UART communications. It supports half-duplex single wire communications and modem operations (CTS/RTS). It also supports multiprocessor communications. DMA (direct memory access) can be used for data transmission/reception.

3.21 Serial peripheral interface (SPI)

The STM32WB0xxC has three SPI interfaces (SPI1, SPI2, SPI3) allowing communication up to 32 Mbit/s in both controller and target modes. The SPI peripheral supports:

- Controller or target operation
- Multimaster support
- Full-duplex synchronous transfers on three lines
- Half-duplex synchronous transfer on two lines (with bidirectional data line)
- Simplex synchronous transfers on two lines (with unidirectional data line)
- Serial communication with external devices
- NSS management by hardware or software for both controller and target: dynamic change of controller/target operations
- SPI Motorola support
- SPI TI mode support
- Hardware CRC features for reliable communication

All SPI interfaces can be served by the DMA controller.

3.21.1 Inter-IC sound (I2S)

The STM32WB0xxC SPI interfaces: SPI2 and SPI3 support the I2S protocol. The I2S interface can operate in target or controller mode with half-duplex communication. It can address four different audio standards:

- Philips I2S standard
- MSB-justified standards (left-justified)
- LSB-justified standards (right-justified)

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- Phase-change memory standard.

The I2S interfaces DMA capability for transmission and reception.

3.22 Development support

3.22.1 Serial wire debug port

The STM32WB0xxC embeds an Arm SWD interface that allows interactive debugging and programming of the device. The interface is composed of only two pins: DEBUG_SWDIO and DEBUG_SWCLK. The enhanced debugging features for developers allow up to four breakpoints and up to two watchpoints.

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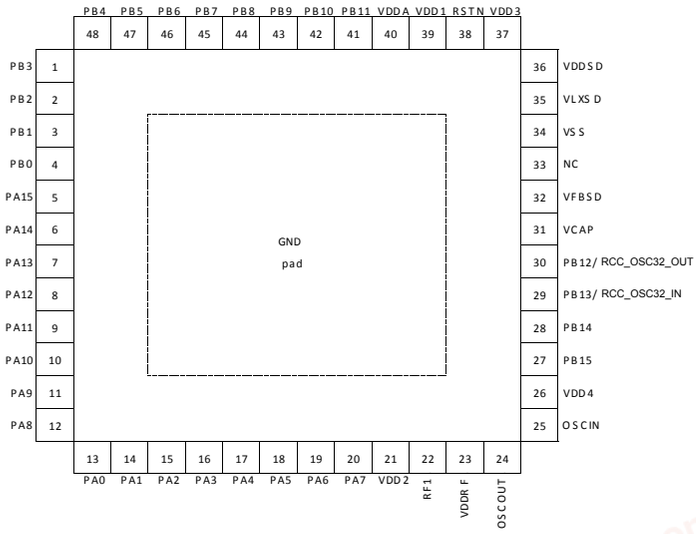
4 Pinouts/ballouts, pin description, and alternate functions

4.1 Pinout/ballout schematics

The STM32WB0xxC comes in three package versions: VFQFPN48 offering 32 GPIOs, WLCSP49 offering 30 GPIOs and VFQFPN32 offering 20 GPIOs.

Figure 7. VFQFPN48 pinout

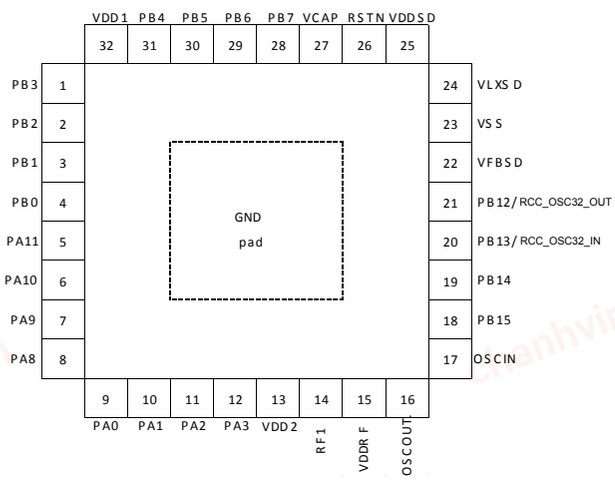
Package top view



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Figure 8. VFQFPN32 pinout

Package top view

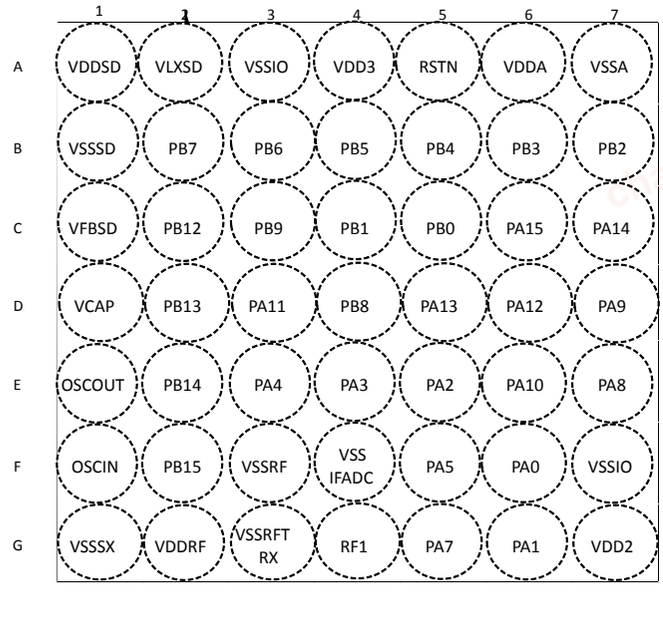


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Figure 9. WLCSP49 pinout

Package top view



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4.2 Pin description

Table 5. 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	A	Analog-only input
	I	Input-only pin
	I/O	Input/output pin
	O	Output-only pin
	S	Supply pin
I/O structure	DDR	DDR 1.5 V or 1.2 V I/O for DDR3, DDR3L, LPDDR2/LPDDR3, DDR4, and LPDDR4 interfaces
	DSI	1.2 V I/O for DSI interface
	FT	5 V-tolerant I/O
	FTP	5 V-tolerant I/O with fixed pull-down
	FTPD	5 V-tolerant I/O with fixed programmable pull-down
	FTU	5 V-tolerant I/O with fixed pull-up
	RF	RF I/O
	TC	3.6 V-capable I/O with ESS diode connected to V_{DD}
	TT	3.6 V-tolerant I/O
	TTa	3.6 V-tolerant I/O with internal clamping to V_{DDA}
	B	Dedicated BOOT0 pin
	POR	External power on reset pin with embedded weak pull-up resistor, powered from V_{DDA}
	RST	Bidirectional reset pin with embedded weak pull-up resistor
	Options for TT and FT I/Os(1)	
	_a	I/O with analog switch function supplied by V_{DDA}
	_c	USB Type-C® power delivery capable I/O
	_d	USB Type-C® power delivery dead battery function I/O
	_e	I/O with switchable diode to V_{DD}
	_f	I2C Fm+ capable I/O
	_h	High-speed low-voltage I/O
	_l	I/O with LCD function supplied by V_{LCD}

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Name		Abbreviation	Definition
I/O structure		_p	I/O with differential clock capability CLKP/CLKN
		_s	I/O supplied only by V_{DDIO2}
		_t	Tamper I/O
		_u	I/O with USB function, supplied by V_{DDUSB}
		_v	Very high-speed I/O
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	

1. *The related I/O structures in the table below are a concatenation of various options. Examples: FT_hat, FT_fs, FT_u, TT_a.*

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Table 6. **STM32WB0xxC pin/ball definition**

Pin number			Pin name (function after reset)	Pin type	I/O structure	Alternate functions	Additional functions
VFQFPN32	VFQFPN48	WLCSP49					
1	1	B6	PB3	I/O	FT_a	USART_CTS, LPUART_TX, TIM1_CH4	ADC_VINP0,PWR_WKUP3
2	2	B7	PB2	I/O	FT_a	USART_RTS_DE, PDM_DATA, TIM1_CH3	ADC_VINM0, PWR_WKUP2
3	3	C4	PB1	I/O	FT_a	SPI1_NSS, PDM_CLK, TIM1_ETR	ADC_VINP1, PWR_WKUP1
4	4	C5	PB0	I/O	FT_a	USART_RX, LPUART_RTS_DE, TIM1_CH2N	ADC_VINM1, PWR_WKUP0
-	5	C6	PA15	I/O	FT_a	I2C2_SMBA, SPI1_MOSI, TIM1_BKIN2	ADC_VINP2, PWR_WKUP27
-	6	C7	PA14	I/O	FT_a	I2C2_SDA, SPI1_MISO, TIM1_BKIN	ADC_VINM2, PWR_WKUP26
-	7	D5	PA13	I/O	FT_a	I2C2_SCL, SPI1_SCK, SPI2_MISO, TIM1_ETR	ADC_VINP3, PWR_WKUP25
-	8	D6	PA12	I/O	FT_a	I2C1_SMBA, SPI1_NSS, SPI2_MOSI,TIM1_CH1, I2S2_SD	ADC_VINM3, PWR_WKUP24
5	9	D3	PA11	I/O	FT	RCC_MCO, SPI1_NSS, RADIO_RX_SEQUENCE, SPI3_MOSI, I2S3_SD	PWR_WKUP11, GPIO in Deepstop, RTC_OUT
6	10	E6	PA10	I/O	FT	RCC_LCO, SPI1_MISO, RADIO_TX_SEQUENCE, I2S3_MCK	BOOT, PWR_WKUP10, GPIO in Deepstop, RCC_LCO
7	11	D7	PA9	I/O	FT	USART_TX, SPI1_SCK, RTC_OUT, SPI3_NSS, TIM1_CH4, I2S3_WS	PWR_WKUP9, GPIO in Deepstop, RCC_LCO
8	12	E7	PA8	I/O	FT	USART_RX, SPI1_MOSI, RADIO_RX_SEQUENCE, SPI3_MISO, TIM1_CH3	PWR_WKUP8, GPIO in Deepstop, RTC_OUT
9	13	F6	PA0	I/O	FT_f	I2C1_SCL, USART_CTS, TIM1_CH3, I2S2_MCK	PWR_WKUP12
10	14	G6	PA1	I/O	FT_f	I2C1_SDA, SPI2_MISO, USART_TX, TIM1_CH4	PWR_WKUP13
11	15	E5	PA2	I/O	FT	DEBUG_SWDIO, USART_CK, TIM_BKIN, I2S3_MCK	PWR_WKUP14
12	16	E4	PA3	I/O	FT	DEBUG_SWCLK, USART_RTS_DE, TIM_BKIN2, SPI3_SCK, I2S3_SCK	PWR_WKUP15
-	17	E3	PA4	I/O	FT	RCC_LCO, SPI2_NSS, LPUART_TX, TIM1_CH1, I2S2_WS	PWR_WKUP16, GPIO in Deepstop, RCC_LCO
-	18	F5	PA5	I/O	FT	RCC_MCO, SPI2_SCK, LPUART_RX, TIM1_CH2, I2S2_SCK	PWR_WKUP17, GPIO in Deepstop, RCC_LCO
-	19	-	PA6	I/O	FT	LPUART_CTS, SPI2_MOSI, SPI2_NSS, TIM1_CH1, I2S2_SD, I2S2_WS	PWR_WKUP18, GPIO in Deepstop, RCC_LCO

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Pin number			Pin name (function after reset)	Pin type	I/O structure	Alternate functions	Additional functions
VFQFPN32	VFQFPN48	WLCSP49					
-	20	G5	PA7	I/O	FT	LPUART_RTS_DE, SPI2_MISO, SPI2_SCK, TIM1_CH2, I2S2_SCK	PWR_WKUP19, GPIO in Deepstop, RTC_OUT
13	21	G7	VDD2	S	-	-	1.7-3.6 battery voltage input
14	22	G4	RF1	I/O	RF	-	RF input/output. Impedance 50 Ω
15	23	G2	VDDRF	S	-	-	1.7-3.6 battery voltage input
16	24	E1	OSCOUT	I/O	RF	-	32 MHz crystal
17	25	F1	OSCIN	I/O	RF	-	32 MHz crystal
-	26	-	VDD4	S	-	-	1.7-3.6 battery voltage input
18	27	F2	PB15	I/O	FT	I2C1_SMBA, RADIO_TX_SEQUENCE, RCC_MCO, TIM1_CH4N, USART_TX	-
19	28	E2	PB14	I/O	FT_a	SPI1_MOSI, I2C2_SDA, TIM1_ETR, TIM1_CH3N, USART_RX	PWR_PVD_IN
20	29	D2	PB13	I/O	FT	SPI1_MISO, I2C2_SCL, PDM_CLK, TIM1_BKIN2, TIM1_CH4	RCC_OSC32_OUT
21	30	C2	PB12	I/O	FT	SPI1_SCK, RCC_LCO, PDM_DATA, TIM1_BKIN, TIM1_CH3	RCC_OSC32_IN
27	31	D1	VCAP	S	-	-	1.2 Vdigital core
22	32	C1	VFBSD	S	-	-	SMPS output
-	33	-	NC	S	-	-	-
23	34	B1	VSSSD	S	-	-	SMPS Ground
24	35	A2	VLXSD	S	-	-	SMPS input/output
25	36	A1	VDDSD	S	-	-	1.7-3.6 battery voltage input
-	37	A4	VDD3	S	-	-	1.7-3.6 battery voltage input
26	38	A5	RSTN	I/O	RST	-	Reset pin
32	39	-	VDD1	S	-	-	1.7-3.6 battery voltage input
-	40	A6	VDDA	S	-	-	1.2 V analog ADC core
-	41	-	PB11	I/O	FT	SPI1_SCK, SPI2_NSS, I2C1_SCL, TIM1_CH1, TIM1_CH4N, I2S2_WS	PWR_WKUP23
-	42	-	PB10	I/O	FT	SPI1_NSS, SPI2_SCK, I2C1_SDA, TIM1_CH2, TIM1_CH3N, I2S2_SCK	PWR_WKUP22
-	43	C3	PB9	I/O	FT	USART_TX, LPUART_CTS, TIM1_CH1N, TIM1_CH2N, I2S2_MCK	PWR_WKUP21

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Pin number			Pin name (function after reset)	Pin type	I/O structure	Alternate functions	Additional functions
VFQFPN32	VFQFPN48	WLCSP49					
-	44	D4	PB8	I/O	FT	USART_CK, LPUART_RX, TIM1_CH4, TIM1_CH1N	PWR_WKUP20
28	45	B2	PB7	I/O	FT_f	I2C2_SDA, SPI2_SCK, LPUART_RX, TIM1_CH2, I2S2_SCK	PWR_WKUP7
29	46	B3	PB6	I/O	FT_f	I2C2_SCL, SPI2_NSS, LPUART_TX, TIM1_CH1, I2S2_WS	PWR_WKUP6
30	47	B4	PB5	I/O	TT	LPUART_RX, SPI2_MOSI, PDM_CLK, I2S2_SD	PGA_VBIAS_MIC(1), PWR_WKUP5
48	31	B5	PB4	I/O	FT	LPUART_TX, SPI2_MISO, PDM_DATA	PGA_VIN, PWR_WKUP4
-	-	A7	VSSA	S	-	-	Ground analog ADC core
-	-	A3	VSSIO	S	-	-	Ground I/O
-	-	F7	VSSIO	S	-	-	Ground I/O
-	-	F4	VSSIFADC	S	-	-	Ground analog RF
-	-	G1	VSSSX	S	-	-	Ground analog RF
-	-	G3	VSSRFTRX	S	-	-	Ground analog RF
-	-	F3	VSSRF	S	-	-	Ground analog RF
Exposed pad	Exposed pad	-	GND	S	-	-	Ground

1. *This pin is not 5 V tolerant.*

4.3 Alternate functions

Table 7. Alternate function port A

Port		AF0	AF1	AF2	AF3	AF4	AF5	AF6	AF7
		I2C1/I2C2/SYS_AF LPUART/ USART	SPI1/SPI2/ SYS_AF/ USART/I2S2	SPI1/SPI2/RTC USART/ TIM/ I2S2	SPI2/ SPI3 LPUART/ I2S2/ I2S3	TIM1	SYS_AF	-	SYS_AF
Port A	PA0	I2C1_SCL	USART_CTS	I2S2_MCK	-	TIM1_CH3	-	-	-
	PA1	I2C1_SDA	SPI2_MISO	USART_TX	-	TIM1_CH4	-	-	-
	PA2	DEBUG_SWDIO	USART_CK	TIM_BKIN	I2S3_MCK	-	DEBUG_SWDIO	-	DEBUG_SWDIO
	PA3	DEBUG_SWCLK	USART_RTS_DE	TIM_BKIN2	SPI3_SCK/I2S3_SCK	-	DEBUG_SWCLK	-	DEBUG_SWCLK
	PA4	RCC_LCO	SPI2_NSS/I2S2_WS	-	LPUART_TX	TIM1_CH1	-	-	-
	PA5	RCC_MCO	SPI2_SCK/I2S2_SCK	-	LPUART_RX	TIM1_CH2	-	-	-

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Port		AF0	AF1	AF2	AF3	AF4	AF5	AF6	AF7
		I2C1/I2C2/SYS_AF LPUART/ USART	SPI1/SPI2/ SYS_AF/ USART/I2S2	SPI1/SPI2/RTC USART/ TIM/ I2S2	SPI2/ SPI3 LPUART/ I2S2/ I2S3	TIM1	SYS_AF	-	SYS_AF
Port A	PA6	LPUART_CTS	SPI2_MOSI/I2S2_SD	-	SPI2_NSS/I2S2_WS	TIM1_CH1	-	-	-
	PA7	LPUART_RTS_DE	SPI2_MISO	-	SPI2_SCK/I2S2_SCK	TIM1_CH2	-	-	-
	PA8	USART_RX	SPI1_MOSI	RADIO_RX_SEQUENCE	SPI3_MISO	TIM1_CH3	-	-	-
	PA9	USART_TX	SPI1_SCK	RTC_OUT	SPI3_NSS/I2S3_WS	TIM1_CH4	-	-	-
	PA10	RCC_LCO	SPI1_MISO	RADIO_TX_SEQUENCE	I2S3_MCK	-	-	-	-
	PA11	RCC_MCO	SPI1_NSS	RADIO_RX_SEQUENCE	SPI3_MOSI/I2S3_SD	-	-	-	-
	PA12	I2C1_SMBA	DEBUG_SWDIO	SPI1_NSS	SPI2_MOSI/I2S2_SD	TIM1_CH1	-	-	-
	PA13	I2C2_SCL	DEBUG_SWCLK	SPI1_SCK	SPI2_MISO	TIM1_ETR	-	-	-
	PA14	I2C2_SDA	-	SPI1_MISO	-	TIM1_BKIN	-	-	-
	PA15	I2C2_SMBA	-	SPI1_MOSI	-	TIM1_BKIN2	-	-	-

Table 8. Alternate function port B

Port		AF0	AF1	AF2	AF3	AF4	AF5	AF6	AF7
		SPI1/I2C2 USART/LPUART	PDM/SYS_AF/I2C2 LPUART/SPI2/I2S2	SPI2/I2C1/PDM TIM1/SYS_AF/ I2S2	TIM1/PDM LPUART	TIM1	-	-	USART
Port B	PB0	USART_RX	LPUART_RTS_DE	-	TIM1_CH2N	-	-	-	-
	PB1	SPI1_NSS	PDM_CLK	-	TIM1_ETR	-	-	-	-
	PB2	USART_RTS_DE	PDM_DATA	-	TIM1_CH3	-	-	-	-
	PB3	USART_CTS	LPUART_TX	-	TIM1_CH4	-	-	-	-
	PB4	LPUART_TX	SPI2_MISO	-	PDM_DATA	-	-	-	-
	PB5	LPUART_RX	SPI2_MOSI/I2S2_SD	-	PDM_CLK	-	-	-	-
	PB6	I2C2_SCL	SPI2_NSS/I2S2_WS	-	LPUART_TX	TIM1_CH1	-	-	-
	PB7	I2C2_SDA	SPI2_SCK/IS2S_SCK	-	LPUART_RX	TIM1_CH2	-	-	-
	PB8	USART_CK	LPUART_RX	-	TIM1_CH4	TIM1_CH1N	-	-	-
	PB9	USART_TX	LPUART_CTS	I2S2_MCK	TIM1_CH1N	TIM1_CH2N	-	-	-
	PB10	SPI1_NSS	SPI2_SCK/I2S2_SCKK	I2C1_SDA	TIM1_CH2	TIM1_CH3N	-	-	-
	PB11	SPI1_SCK	SPI2_NSS/I2S2_WS	I2C1_SCL	TIM1_CH1	TIM1_CH4N	-	-	-
	PB12	SPI1_SCK	RCC_LCO	PDM_DATA	TIM1_BKIN	TIM1_CH3	-	-	-
	PB13	SPI1_MISO	I2C2_SCL	PDM_CLK	TIM1_BKIN2	TIM1_CH4	-	-	-

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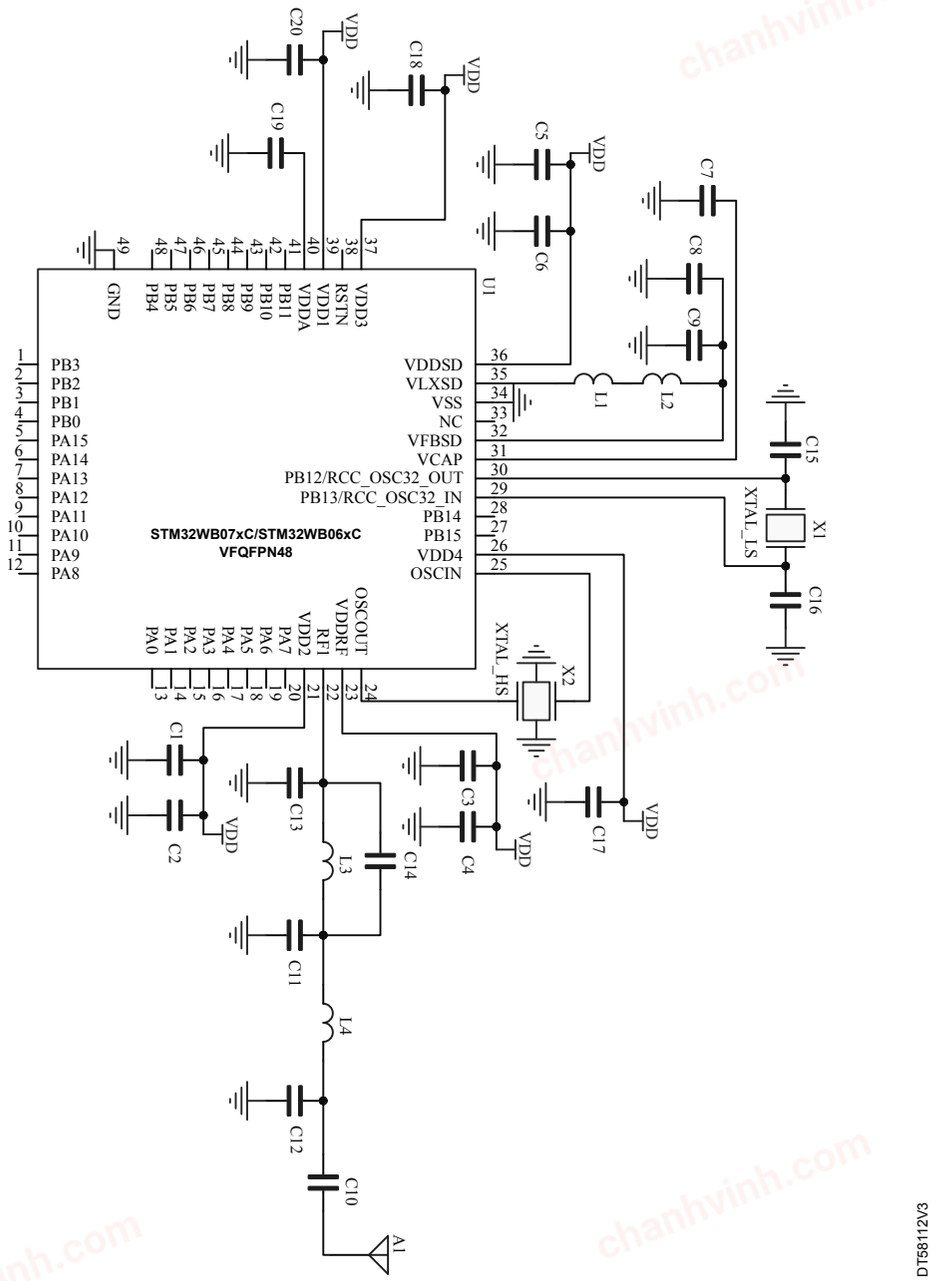
Port		AF0	AF1	AF2	AF3	AF4	AF5	AF6	AF7
		SPI1/I2C2 USART/LPUART	PDM/SYS_AF/I2C2 LPUART/SPI2/I2S2	SPI2/I2C1/PDM TIM1/SYS_AF/ I2S2	TIM1/PDM LPUART	TIM1	-	-	USART
Port B	PB14	SPI1_MOSI	I2C2_SDA	TIM1_ETR	TIM1_CH3N	-	-	-	USART_RX
	PB15	I2C1_SMBA	RADIO_TX_SEQUENCE	RCC_MCO	TIM1_CH4N	-	-	-	USART_TX

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5 Application circuits

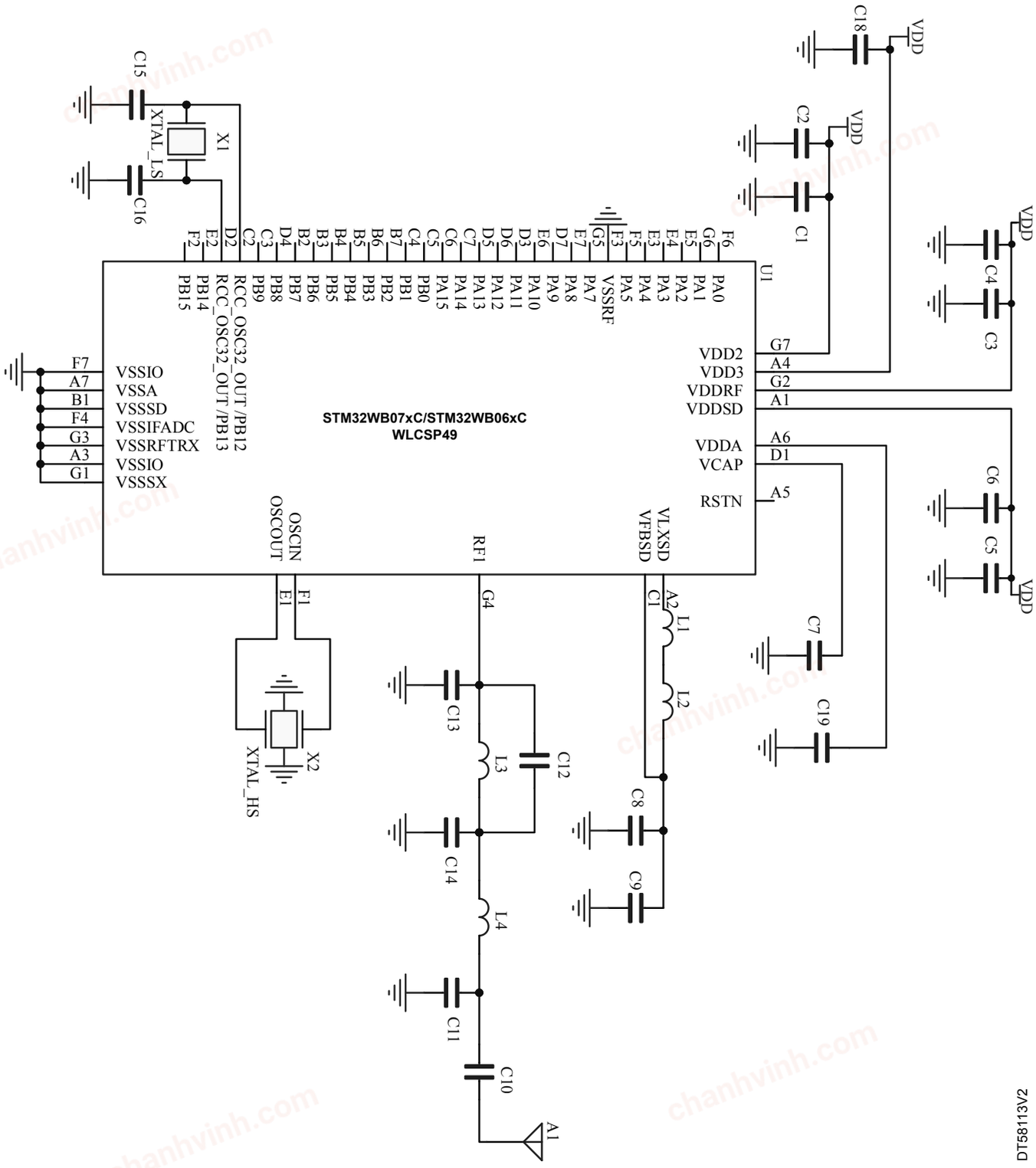
The schematics below are purely indicative.

Figure 10. Application circuit: DC-DC converter, VFQFPN48 package



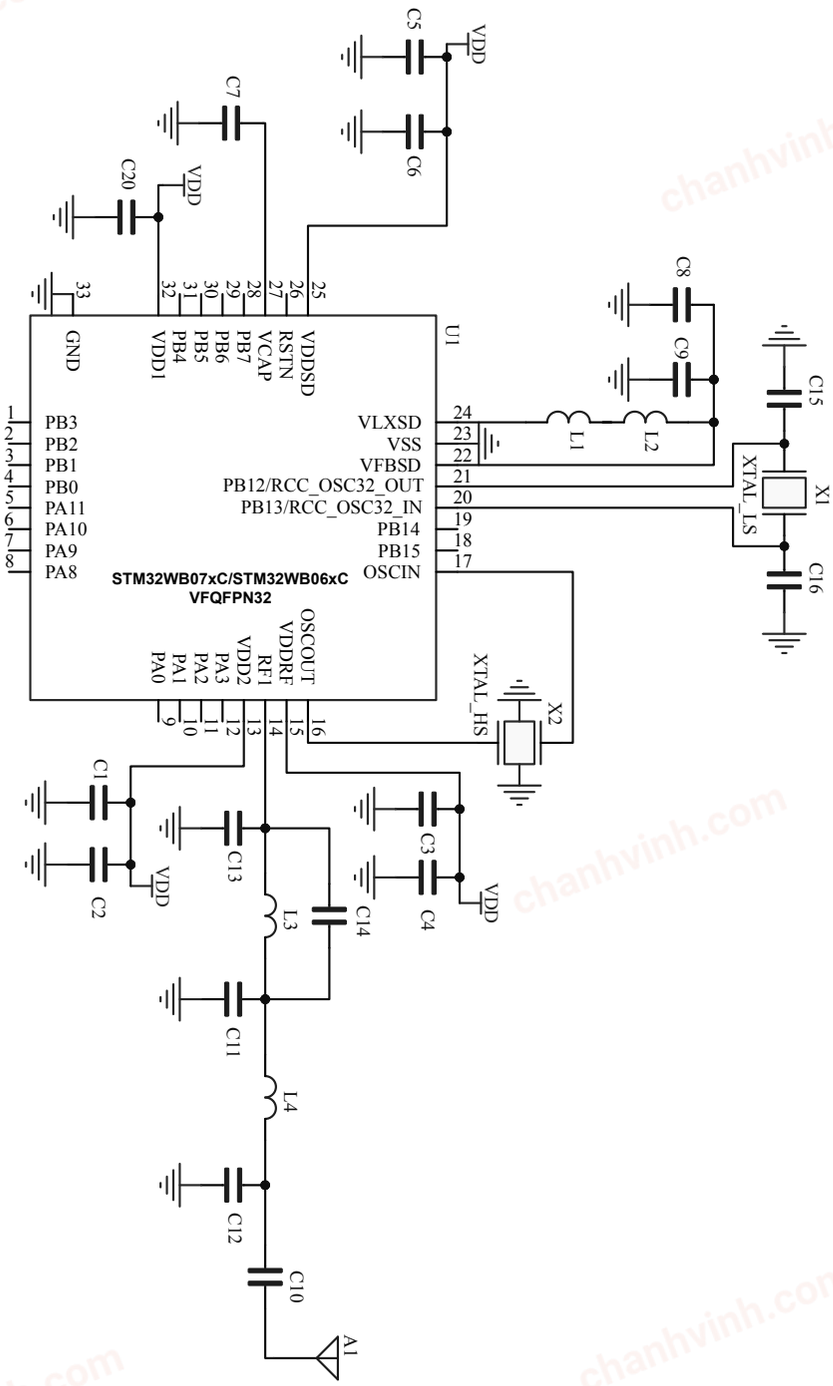
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Figure 11. **Application circuit: DC-DC converter, WLCSP49 package**



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Figure 12. **Application circuit: DC-DC converter, VFQFPN32 package**



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Table 9. Application circuit external components

Component	Description
C1	Decoupling capacitor
C2	Decoupling capacitor
C3	Decoupling capacitor
C4	Decoupling capacitor
C5	Decoupling capacitor
C6	Decoupling capacitor
C7	Decoupling capacitor
C8	DC-DC converter output capacitor
C9	DC-DC converter output inductor
C10	DC block capacitor
C11	RF matching capacitor
C12	RF matching capacitor
C13	RF matching capacitor
C14	RF matching capacitor
C15	32 kHz crystal loading capacitor
C16	32 kHz crystal loading capacitor
C17	Decoupling capacitor
C18	Decoupling capacitor
C19	Decoupling capacitor
C20	Decoupling capacitor
L1	DC-DC converter output inductor
L2	DC-DC converter filtering inductor
L3	RF matching inductor
L4	RF matching inductor
X1	Low speed crystal
X2	High speed crystal
U1	STM32WB06xC/STM32WB07xC

Note: In order to make the board DC–DC OFF, the inductance L1 must be removed and the supply voltage must be applied to the VFBSD pin.

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6 Electrical characteristics

6.1 Parameter conditions

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

6.1.1 Minimum and maximum values

Unless otherwise specified the minimum and maximum values are guaranteed in the worst conditions of junction temperature, supply voltage and frequencies by tests in production on 100 % of the devices with an junction temperature at T_J = 25 °C and T_J = T_{Jmax} (given by the selected temperature range).

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

6.1.2 Typical values

Unless otherwise specified, typical data are based on T_J = 25 °C, V_{DD} = 3.3 V (for the 1.62 V ≤ V_{DD} ≤ 3.6 V voltage range). They are given only as design guidelines and are not tested.

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

6.1.3 Typical curves

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

6.1.4 Loading capacitor

The loading conditions used for pin parameter measurement are shown in Figure 13.

6.1.5 Pin input voltage

The input voltage measurement on a pin of the device is described in Figure 14.

Figure 13. Pin loading conditions

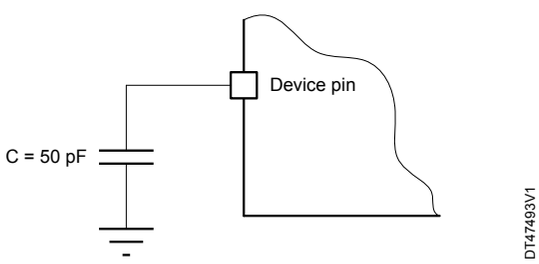
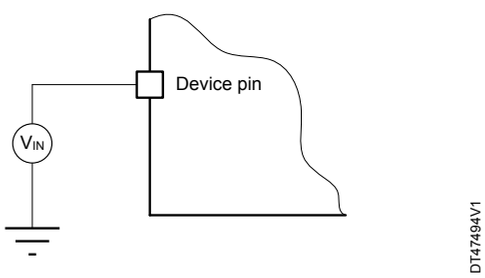


Figure 14. Pin input voltage



6.2 Absolute maximum ratings

Stresses above the absolute maximum ratings listed in the tables below, 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 10. Voltage characteristics

Symbol	Ratings	Min.	Max.	Unit
VDD1, VDD2, VDD3, VDD4, VDDRF, VDDSD	DC-DC converter supply voltage input and output	-0.3	+3.9	V
VCAP, VDDA	DC voltage on linear voltage regulator	-0.3	+1.32	

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Symbol	Ratings	Min.	Max.	Unit
FXTALOUT, FXTALIN	DC Voltage on HSE	-0.3	+1.32	V
PA0 to PA15, PB0 to PB4, PB6 to PB15	DC voltage on digital input/output pins	-0.3	+3.9	
VLXSD, VFBSD	DC voltage on analog pins			
RCC_OSC32_OUT/PB12, RCC_OSC32_IN/PB13, PB5	DC voltage on XTAL pins and PGA_VBIAS_MIC	-0.3	+3.6	
RF1	DC voltage on RF pin		+1.4	-
$\lvert\Delta V_{DD}\rvert$	Variations between different V_{DDX} power pins of the same domain	-	50	mV

Note: All the main power and ground pins must always be connected to the external power supply, in the permitted range.

Table 11. Current characteristics

Symbol	Ratings	Max.	Unit
ΣIV_{DD}	Total current into sum of all VDD power lines (source)	130	mA
ΣIV_{GND}	Total current out of sum of all ground lines (sink)	130	
$IV_{DD(PIN)}$	Maximum current into each VDD power pin (source)	100	
$IV_{GND(PIN)}$	Maximum current out of each ground pin (sink)	100	
$I_{IO(PIN)}$	Output current sunk by any I/O and control pin	20	
	Output current sourced by any I/O and control pin	20	
$\Sigma I_{IO(PIN)}$	Total output current sunk by sum of all I/Os and control pins	100	
	Total output current sourced by sum of all I/Os and control pins	100	

Table 12. Thermal characteristics

Symbol	Ratings	Value	Unit
T_{STG}	Storage temperature range	-40 to -125	°C
T_J	Maximum junction temperature	125	

6.3 Operating conditions

6.3.1 General operating conditions

Table 13. General operating conditions

Symbol	Parameter	Conditions	Min.	Max.	Unit
f_{HCLK}	Internal AHB clock frequency	-	1	64	MHz
f_{PCLK0}	Internal APB0 clock	-	1	64	
f_{PCLK1}	Internal APB1 clock frequency	-	1	64	
f_{PCLK2}	Internal APB2 clock frequency	-	16	32	
V_{DD}	Standard operating voltage	-	1.7	3.6	V
V_{FBSMPS}	SMPS feedback voltage	-	1.4	3.6	
V_{DDRF}	Minimum RF voltage	-	1.7	3.6	

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Symbol	Parameter	Conditions	Min.	Max.	Unit
V_{IN}	I/O input voltage	-	-0.3	VDD+0.3	V
P_D	Power dissipation at T_A=105 °C(1)	VFQFPN48 package	-	30	mW
		VFQFPN32 package			
T_A	Ambient temperature	Maximum power dissipation	-40	105	°C
T_J	Junction temperature range	-	-40	105	-

1. *T_A cannot exceed the T_J max.*

6.3.2 Summary of main performance

Table 14. Main performance SMPS ON

Symbol	Parameter	Test conditions	Typ. VDD = 1.8 V	Typ. VDD = 3.3 V	Unit
I_{CORE}	Core current consumption	Shutdown	8	19	nA
		Deepstop, no timer, wakeup GPIO, RAM0 retained	0.44	0.46	µA
		Deepstop, no timer, wakeup GPIO, all RAM retained	0.62	0.64	
		Deepstop (32 kHz LSI), RAM0 retained	0.94	1.06	
		Deepstop (32 kHz LSI), all RAMs retained	1.12	1.24	
		Deepstop (32 kHz LSE), RAM0 retained	0.64	0.75	
		Deepstop (32 kHz LSE), all RAM retained	0.83	0.94	
		CPU in Run (64 MHz). Dhrystone, clock source PLL64	-	2719	uA
		CPU in Run (32 MHz). Dhrystone, clock source PLL64	-	2188	
		CPU in WFI (64 MHz), all peripherals off, clock source PLL64	-	1708	
		CPU in WFI (16 MHz), all peripherals off, clock source direct HSE	-	1092	
		Radio Rx at sensitivity level	-	3350	
		Radio Tx 0 dBm output power	-	4300	
$I_{DYNAMIC}$	Dynamic current	Computed value: (CPU 64 MHz Dhrystone - CPU 32 MHz Dhrystone) / 32	-	16.5	µA/MHz

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Table 15. Main performance SMPS bypassed

Symbol	Parameter	Test conditions	Typ. VDD = 1.8 V	Typ. VDD = 3.3 V	Unit
I_{CORE}	Core current consumption	Shutdown	8	19	nA
		Deepstop, no timer, wakeup GPIO, RAM0 retained	0.44	0.46	µA
		Deepstop, no timer, wakeup GPIO, all RAM retained	0.62	0.64	
		Deepstop (32 kHz LSI), RAM0 retained	0.94	1.06	
		Deepstop (32 kHz LSI), all RAMs retained	1.12	1.24	
		Deepstop (32 kHz LSE), RAM0 retained	0.64	0.75	
		Deepstop (32 kHz LSE), all RAM retained	0.83	0.94	
		CPU in Run (64 MHz). Dhrystone, clock source PLL64	-	4482	
		CPU in WFI (64 MHz), all peripherals off, clock source PLL64	-	2230	
		CPU in WFI (16 MHz), all peripherals off, clock source direct HSE	-	757	
		Radio Rx at sensitivity level	-	6700	
		Radio Tx 0 dBm output power	-	8900	

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Table 16. **Peripheral current consumption at VDD = 3.3 V, sysclk at 32 MHz, SMPS on**

Parameter	Test conditions	Typ.	Unit
ADC	-	80	µA
DMA	-	39	
GPIOA	-	2	
GPIOB	-	2	
I2C1	-	40	
I2C2	-	39	
I2S2	Peripheral clock at 32 MHz	46	
I2S3	Peripheral clock at 32 MHz	47	
IWDG	-	11	
LPUART	-	52	
PVD	-	0.8	
PKA	-	50	
RNG	-	64	
RTC	-	14	
SPI1	-	35	
SPI2	Peripheral clock at 16 MHz	40	
SPI3	Peripheral clock at 16 MHz	42	
SysTick	-	8	
TIM1	-	248	
USART	-	81	
SYSCFG	-	33	
THSENS	-	301	
CRC	-	9	

6.3.3 RF general characteristics

All performance data are referred to a 50 Ω antenna connector, via reference design.

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Table 17. Bluetooth Low Energy RF general characteristics

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
F_{RANGE}	Frequency range(1)	-	2400	-	2483.5	MHz
RF_{CH}	RF channel center frequency(1)	-	2402	-	2480	
PLL_{RES}	RF channel spacing(1)	-	-	2	-	MHz
ΔF	Frequency deviation(1)	-	-	250	-	kHz
Δf1	Frequency deviation average(1)	-	450	-	550	kHz
C_{Fdev}	Center frequency deviation(1)	During the packet and including both initial frequency offset and drift	-	-	±150	kHz
Δfa	Frequency deviation Δf2 (average) / Δf1 (average)(1)	-	0.80	-	-	-
R_{gfsk}	On-air data rate(1)	-	1	-	2	Mbps
STacc	Symbol time accuracy(1)	-	-	-	±50	ppm
MOD	Modulation scheme	-	GFSK			-
BT	Bandwidth-bit period product	-	-	0.5	-	-
Mindex	Modulation index(1)	-	0.45	0.5	0.55	-
PMAX	Maximum output	At antenna connector, VSMPS = 1.9 V, LDO code	-	+8	-	dBm
PMIN	Minimum output	At antenna connector	-	-20	-	dBm
PRFC	RF power accuracy	@ 27 °C	-	±1.5	-	dB
		All temperatures	-	±2.5	-	

1. *Tested according to Bluetooth SIG radio frequency physical layer (RF PHY) test suite (not tested in production).*

6.3.4 RF transmitter characteristics

All performance data are referred to a 50 Ω antenna connector, via reference design.

Table 18. Bluetooth Low Energy RF transmitter characteristics at 1 Mbps not coded

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
P_{BW1M}	6 dB bandwidth for modulated carrier	Using resolution bandwidth of 100 kHz	500	-	-	kHz
P_{RF1}, 1 Ms/s	In-band emission at ±2 MHz(1)	Using resolution bandwidth of 100 kHz and average detector	-	-	-20	dBm
P_{RF2}, 1 Ms/s	In-band emission at ±[3+n]MHz, where n=0,1,2..(1)	Using resolution bandwidth of 100 kHz and average detector	-	-	-30	dBm
PS_{PUR}	Spurious emission	Harmonics included. Using resolution bandwidth of 1 MHz and average detector	-	-	-41	dBm
$Freq_{drift}$	Frequency drift(1)	Integration interval #n – integration interval #0, where n=2,3,4..k	-50	-	+50	kHz
$IFreq_{drift}$	Initial carrier frequency drift(1)	Integration interval #1 – integration interval #0	-23	-	+23	kHz
$Int_{Freqdrift}$	Intermediate carrier frequency drift(1)	Integration interval #n – integration interval #(n-5), where n=6,7,8..k	-20	-	+20	kHz
Drift Rate max	Maximum drift rate(1)	Between any two 10-bit groups separated by 50 µs	-20	-	+20	kHz/50 µs
Z_{RF1}	Optimum RF load (impedance at RF1 pin)	@ 2440 MHz	-	40	-	Ω

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1. *Tested according to Bluetooth SIG radio frequency physical layer (RF PHY) test suite (not tested in production).*

Table 19. Bluetooth Low Energy RF transmitter characteristics at 2 Mbps not coded

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
P_{BW1M}	6 dB bandwidth for modulated carrier	Using resolution bandwidth of 100 kHz	670	-	-	kHz
P_{RF1}, 2 Ms/s	In-band emission at ±4 MHz(1)	Using resolution bandwidth of 100 kHz and average detector	-	-	-20	dBm
P_{RF2}, 2 Ms/s	In-band emission at±5 MHz(1)	Using resolution bandwidth of 100 kHz and average detector	-	-	-20	dBm
P_{RF3}, 2 Ms/s	In-band emission at ±[6+n]MHz, where n=0,1,2..(1)	Using resolution bandwidth of 100 kHz and average detector	-	-	-30	dBm
P_{SPUR}	Spurious emission	Harmonics included. Using resolution bandwidth of 1 MHz and average detector	-	-	-41	dBm
$Freq_{drift}$	Frequency drift(1)	Integration interval #n – integration interval #0, where n=2,3,4..k	-50	-	+50	kHz
$IFreq_{drift}$	Initial carrier frequency drift(1)	Integration interval #1 – integration interval #0	-23	-	+23	kHz
$IntFreq_{drift}$	Intermediate carrier frequency drift(1)	Integration interval #n – integration interval #(n-5), where n=6,7,8..k	-20	-	+20	kHz
$DriftRate_{max}$	Maximum drift rate(1)	Between any two 20-bit groups separated by 50 µs	-20	-	+20	kHz/50µs
Z_{RF1}	Optimum RF load (impedance at RF1 pin)	@ 2440 MHz	-	40	-	Ω

1. *Tested according to Bluetooth SIG radio frequency physical layer (RF PHY) test suite (not tested in production).*

Table 20. Bluetooth Low Energy RF transmitter characteristics at 1 Mbps LE coded (S=8)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
P_{BW}	6 dB bandwidth for modulated carrier	Using resolution bandwidth of 100 kHz	500	-	-	kHz
$P_{RF1, LE\ coded}$	In-band emission at ±2 MHz(1)	Using resolution bandwidth of 100 kHz and average detector	-	-	-20	dBm
$P_{RF2, LE\ coded}$	In-band emission at ±[3+n] MHz, where n=0,1,2..(1)	Using resolution bandwidth of 100 kHz and average detector	-	-	-30	dBm
PS_{PUR}	Spurious emission	Harmonics included. Using resolution bandwidth of 1 MHz and average detector	-	-	-41	dBm
$Freq_{drift}$	Frequency drift(1)	Integration interval #n – integration interval #0, where n=1,2,3..k	-50	-	+50	kHz
$IFreq_{drift}$	Initial carrier frequency drift(1)	Integration interval #3 – integration interval #0	-19.2	-	+19.2	kHz
$IntFreq_{drift}$	Intermediate carrier frequency drift(1)	Integration interval #n – integration interval #(n-3), where n=7,8,9..k	-19.2	-	+19.2	kHz
$DriftRate_{max}$	Maximum drift rate(1)	Between any two 16-bit groups separated by 48 µs	-19.2	-	+19.2	kHz/48 µs
Z_{RF1}	Optimum RF load (Impedance at RF1 pin)	@ 2440 MHz	-	40	-	Ω

1. *Tested according to Bluetooth SIG radio frequency physical layer (RF PHY) test suite (not tested in production).*

6.3.5 RF receiver characteristics

All performance data are referred to a 50 Ω antenna connector, via reference design.

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Table 21. Bluetooth® Low Energy RF receiver characteristics at 1 Msym/s uncoded

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
RX_{SENS}	Sensitivity	PER < 30.8%	-	-97	-	dBm
P_{SAT}	Saturation	PER < 30.8%	-	8	-	dBm
Z_{RF1}	Optimum RF source (impedance at RF1 pin)	@ 2440 MHz	-	40	-	Ω
RF selectivity with Bluetooth® Low Energy equal modulation on interfering signal						
$C/I_{CO\text{-}channel}$	Co-channel interference $f_{RX} = f_{interference}$	Wanted signal = -67 dBm, PER < 30.8%	-	8	-	dBc
$C/I_{1\ MHz}$	Adjacent interference $f_{interference} = f_{RX} \pm 1$ MHz	Wanted signal = -67 dBm, PER < 30.8%	-	-1	-	dBc
$C/I_{2\ MHz}$	Adjacent interference $f_{interference} = f_{RX} \pm 2$ MHz	Wanted signal = -67 dBm, PER < 30.8%	-	-35	-	dBc
$C/I_{3\ MHz}$	Adjacent interference $f_{interference} = f_{RX} \pm (3+n)$ MHz [n = 0,1,2…]	Wanted signal = -67 dBm, PER < 30.8%	-	-47	-	dBc
C/I_{Image}	Image frequency interference $f_{interference} = f_{image}$	Wanted signal = -67 dBm, PER < 30.8%	-	-25	-	dBc
$C/I_{Image\pm1\ MHz}$	Adjacent channel-to-image frequency $f_{interference} = f_{image} \pm 1$ MHz	Wanted signal= -67 dBm, PER < 30.8%	-	-25	-	dBc
Out of band blocking (interfering signal CW)						
C/I_{Block}	Interfering signal frequency 30 MHz – 2000 MHz	Wanted signal = -67 dBm, PER < 30.8%, measurement resolution 10 MHz	-	5	-	dB
C/I_{Block}	Interfering signal frequency 2003 MHz – 2399 MHz	Wanted signal = -67 dBm, PER < 30.8%, measurement resolution 3 MHz	-	-5	-	dB
C/I_{Block}	Interfering signal frequency 2484 MHz – 2997 MHz	Wanted signal = -67 dBm, PER < 30.8%, measurement resolution 3 MHz	-	-5	-	dB
C/I_{Block}	Interfering signal frequency 3000 MHz – 12.75 GHz	Wanted signal = -67 dBm, PER < 30.8%, measurement resolution 25 MHz	-	10	-	dB
Intermodulation characteristics (CW signal at f_1, Bluetooth® Low Energy interfering signal at f_2)						
P_IM(3)	Input power of IM interferer at 3 and 6 MHz distance from the wanted signal	Wanted signal = -64 dBm, PER < 30.8%	-	-27	-	dBm
P_IM(-3)	Input power of IM interferer at -3 and -6 MHz distance from the wanted signal	Wanted signal = -64 dBm, PER < 30.8%	-	-40	-	dBm
P_IM(4)	Input power of IM interferer at ±4 and ±8 MHz distance from the wanted signal	Wanted signal= -64 dBm, PER < 30.8%	-	-32	-	dBm
P_IM(5)	Input power of IM interferer at ±5 and ±10 MHz distance from the wanted signal	Wanted signal = -64 dBm, PER < 30.8%	-	-32	-	dBm

Table 22. Bluetooth® Low Energy RF receiver characteristics at 2 Msym/s uncoded

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
RX_{SENS}	Sensitivity	PER < 30.8%	-	-94	-	dBm
P_{SAT}	Saturation	PER < 30.8%	-	8	-	dBm
Z_{RF1}	Optimum RF source (impedance at RF1 pin)	@ 2440 MHz	-	40	-	Ω

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Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
RF selectivity with Bluetooth® Low Energy equal modulation on interfering signal						
$C/I_{CO\text{-}channel}$	Co-channel interference $f_{RX} = f_{interference}$	Wanted signal= -67 dBm, PER < 30.8%	-	8	-	dBc
$C/I_{2\ MHz}$	Adjacent interference $f_{interference} = f_{RX} \pm 2$ MHz	Wanted signal = -67 dBm, PER < 30.8%	-	-14	-	dBc
$C/I_{4\ MHz}$	Adjacent interference $f_{interference} = f_{RX} \pm 4$ MHz	Wanted signal = -67 dBm, PER < 30.8%	-	-41	-	dBc
$C/I_{6\ MHz}$	Adjacent interference $f_{interference} = f_{RX} \pm (6+2n)$ MHz [n = 0,1,2…]	Wanted signal = -67 dBm, PER < 30.8%	-	-45	-	dBc
C/I_{Image}	Image frequency interference $f_{interference} = f_{image\text{-}2M}$	Wanted signal = -67 dBm, PER < 30.8%	-	-25	-	dBc
$C/I_{Image\pm1\ MHz}$	Adjacent channel-to-image frequency $f_{interference} = f_{image\text{-}2M} \pm 2$ MHz	Wanted signal= -67 dBm, PER < 30.8%	- -	-14	-	dBc
Out of band blocking (interfering signal CW)						
C/I_{Block}	Interfering signal frequency 30 MHz – 2000 MHz	Wanted signal= -67 dBm, PER < 30.8%, measurement resolution 10 MHz	-	5	-	dB
C/I_{Block}	Interfering signal frequency 2003 MHz – 2399 MHz	Wanted signal= -67 dBm, PER < 30.8%, measurement resolution 3 MHz	-	-5	-	dB
C/I_{Block}	Interfering signal frequency 2484 MHz – 2997 MHz	Wanted signal= -67 dBm, PER < 30.8%, measurement resolution 3 MHz	-	-5	-	dB
C/I_{Block}	Interfering signal frequency 3000 MHz – 12.75 GHz	Wanted signal= -67 dBm, PER < 30.8%, measurement resolution 25 MHz	-	10	-	dB
Intermodulation characteristics (CW signal at f_1, Bluetooth® Low Energy interfering signal at f_2)						
P_IM(6)	Input power of IM interferer at 6 and 12 MHz distance from the wanted signal	Wanted signal= -64 dBm, PER < 30.8%	-	-27	-	dBm
P_IM(-6)	Input power of IM interferer at -6 and -12 MHz distance from the wanted signal	Wanted signal= -64 dBm, PER < 30.8%	-	-30	-	dBm
P_IM(8)	Input power of IM interferer at ±8 and ±16 MHz distance from the wanted signal	Wanted signal= -64 dBm, PER < 30.8%	-	-30	-	dBm
P_IM(10)	Input power of IM interferer at ±10 and ±20 MHz distance from the wanted signal	Wanted signal= -64 dBm, PER < 30.8%	-	-28	-	dBm

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Table 23. Bluetooth® Low Energy RF receiver characteristics at 1 Msym/s LE coded (S=2)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
RX_{SENS}	Sensitivity	PER < 30.8%	-	-100	-	dBm
P_{SAT}	Saturation	PER < 30.8%		8	-	dBm
Z_{RF1}	Optimum RF source (impedance at RF1 pin)	@ 2440 MHz		40	-	Ω
RF selectivity with Bluetooth® Low Energy equal modulation on interfering signal						-
C/I_{CO}-channel	Co-channel interference $f_{RX} = f_{interference}$	Wanted signal = -79 dBm, PER < 30.8%	-	2	-	dBc
$C/I_{1\ MHz}$	Adjacent interference $f_{interference} = f_{RX} \pm 1$ MHz	Wanted signal = -79 dBm, PER < 30.8%		-5	-	dBc
$C/I_{2\ MHz}$	Adjacent interference $f_{interference} = f_{RX} \pm 2$ MHz	Wanted signal = -79 dBm, PER < 30.8%		-38	-	dBc
$C/I_{3\ MHz}$	Adjacent interference $f_{interference} = f_{RX} \pm (3+n)$ MHz [n = 0,1,2…]	Wanted signal = -79 dBm, PER < 30.8%		-50	-	dBc
C/I_{Image}	Image frequency interference $f_{interference} = f_{image}$	Wanted signal = -79 dBm, PER < 30.8%		-30	-	dBc
$C/I_{Image\pm1\ MHz}$	Adjacent channel-to-image frequency $f_{interference} = f_{image} \pm 1$ MHz	Wanted signal = -79 dBm, PER < 30.8%		-34	-	dBc

Table 24. Bluetooth® Low Energy RF receiver characteristics at 1 Msym/s LE coded (S=8)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
RX_{SENS}	Sensitivity	PER < 30.8%	-	-104	-	dBm
P_{SAT}	Saturation	PER < 30.8%		8	-	dBm
Z_{RF1}	Optimum RF source (impedance at RF1 pin)	@ 2440 MHz		40	-	Ω
RF selectivity with Bluetooth® Low Energy equal modulation on interfering signal						-
$C/I_{CO\text{-}channel}$	Co-channel interference $f_{RX} = f_{interference}$	Wanted signal = -79 dBm, PER < 30.8%	-	1	-	dBc
$C/I_{1\ MHz}$	Adjacent interference $f_{interference} = f_{RX} \pm 1$ MHz	Wanted signal = -79 dBm, PER < 30.8%		-4	-	dBc
$C/I_{2\ MHz}$	Adjacent interference $f_{interference} = f_{RX} \pm 2$ MHz	Wanted signal = -79 dBm, PER < 30.8%		-39	-	dBc
$C/I_{3\ MHz}$	Adjacent interference $f_{interference} = f_{RX} \pm (3+n)$ MHz [n = 0,1,2…]	Wanted signal = -79 dBm, PER < 30.8%		-53	-	dBc
C/I_{Image}	Image frequency interference $f_{interference} = f_{image}$	Wanted signal = -79 dBm, PER < 30.8%		-33	-	dBc
$C/I_{Image} \pm 1$ MHz	Adjacent channel-to-image frequency $f_{interference} = f_{image} \pm 1$ MHz	Wanted signal = -79 dBm, PER < 30.8%		-32	-	dBc

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6.3.6 Embedded reset and power control block characteristics

Table 25. Embedded reset and power control block characteristics

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
TRSTTEMPO	Reset temporization after PDR is detected	VDD rising	-	-	500	us
VPDR	Power-down reset threshold	-	-	1.63	-	V
VPVD0	PVD0 threshold	PVD0 threshold at the falling edge of VDDIO	-	2.05	-	
VPVD1	PVD1 threshold	PVD1 threshold at the falling edge of VDDIO	-	2.21	-	
VPVD2	PVD2 threshold	PVD2 threshold at the falling edge of VDDIO	-	2.36	-	
VPVD3	PVD3 threshold	PVD3 threshold at the falling edge of VDDIO	-	2.53	-	
VPVD4	PVD4 threshold	PVD4 threshold at the falling edge of VDDIO	-	2.64	-	
VPVD5	PVD5 threshold	PVD5 threshold at the falling edge of VDDIO	-	2.82	-	
VPVD6	PVD6 threshold	PVD6 threshold at the falling edge of VDDIO	-	2.91	-	
VPVD7	PVD threshold for VIN_PVD	PVD7 threshold (VBGP) at the falling edge of VIN_PVD	-	1.2	-	

6.3.7 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 MCU is put under the following conditions:

- All I/O pins are in analog input mode
- All peripherals are disabled except when explicitly mentioned
- The flash memory access time is adjusted with the minimum wait state number
- When the peripherals are enabled $f_{PCLK} = f_{HCLK}$

Table 26. Current consumption

Symbol	Parameter	Conditions	Typ.			Unit
			25°C	85 °C	105 °C	
I_{DD}(Run)	Supply current in Run mode	f_{HCLK} = 64 MHz All peripherals disabled	2.40	2.49	2.54	mA
		f_{HCLK} = 32 MHz All peripherals disabled	1.98	2.03	2.08	
		f_{HCLK} = 16 MHz All peripherals disabled	1.62	1.67	1.71	
I_{DD}(Deepstop)	Supply current in Deepstop(1)	Timer OFF	0.65	6.73	15.73	µA
		Timer source LSI	1.25	7.41	16.46	
		Timer source LSI RTC ON	1.30	7.56	16.70	
		Timer source LSI IWDG ON	1.27	7.47	16.55	
		Timer source LSI RTC and IWDG ON	1.33	7.61	16.79	

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Symbol	Parameter	Conditions	Typ.			Unit
			25°C	85 °C	105 °C	
I_{DD}(Deepstop)	Supply current in Deepstop(1)	Timer source LSE	1.00	7.16	16.22	µA
		Timer source LSE RTC ON	1.06	7.31	16.45	
		Timer source LSE IWDG ON	1.02	7.22	16.30	
		Timer source LSE RTC and IWDG ON	1.07	7.36	16.54	
I_{DD}(Shutdown)	Supply current in Shutdown	-	0.02	0.46	1.36	
I_{DD}(RST)	Current under reset condition	-	1.34	1.45	1.55	mA

1. *The current consumption in Deepstop is measured considering the entire SRAM retained.*

6.3.8 Wakeup time from low power modes

The wakeup times reported are the latency between the event and the execution of the instruction. The device goes to low-power mode after WFI (wait for interrupt) instructions.

Table 27. Low power mode wakeup timing

Symbol	Parameter	Conditions	Typ.	Unit
$T_{WUDEEPSTOP}$	Wakeup time from Deepstop mode to Run mode	Wakeup from GPIO VDD = 3.3 V flash memory	110	µs

6.3.9 External clock source characteristics

6.3.9.1 High speed crystal requirements

The high speed external oscillator must be supplied with an external 32 MHz crystal that is specified for a 6 to 8 pF loading capacitor. The STM32WB0xxC includes internal programmable capacitances that can be used to tune the crystal frequency to compensate the PCB parasitic one. These internal load capacitors are made by a fixed one, in parallel with a 6-bit binary weighted capacitor bank. Thanks to the low CL step size (LSB is typically 0.07 pF), very fine crystal tuning is possible. With a typical XTAL sensitivity of -14 ppm/pF, it is possible to trim a 32 MHz crystal, with a resolution of 1 ppm.

The requirements for the external 32 MHz crystal are reported in the table below.

Table 28. HSE crystal requirements

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
f_{NOM}	Oscillator frequency	-	-	32	-	MHz
f_{TOL}	Frequency tolerance	Includes initial accuracy, stability over temperature, aging, and frequency pulling due to incorrect load capacitance	-	-	±50	ppm
ESR	Equivalent series resistance	-	-	-	100	Ω
P_D	Drive level	-	-	-	100	µW
CL	HSE crystal load capacitance	27°C, typical corner GMCONF = 3	5 (1)	7(2)	9.2(3)	pF
CLstep	HSE crystal load capacitance LSB value	27 °C, GMCONF = 3 XOTUNE code between 32 and 33	-	0.07	-	pF

1. *XOTUNE programmed at minimum code = 0*
2. *XOTUNE programmed at center code = 32*

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3. *XOTUNE programmed at maximum code = 63*

6.3.9.2 *Low speed crystal requirements*

A low speed clock can be supplied with an external 32.768 kHz crystal oscillator. Requirements for the external 32.768 kHz crystal are reported in the table below.

Table 29. LSE crystal requirements

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
f_{NOM}	Nominal frequency	-	-	32.768	-	kHz
ESR	Equivalent series resistance	-	-	-	90	kΩ
P_D	Drive level	-	-	-	0.1	µW
$G_{mcritmax}$	Maximum critical crystal g_m	LSEDRV[1:0] = 00 Low drive capability	-	-	0.50	µA/V
		LSEDRV[1:0] = 01 Medium low drive capability	-	-	0.75	
		LSEDRV[1:0] = 10 Medium high drive capability	-	-	1.70	
		LSEDRV[1:0] = 11 High drive capability	-	-	2.70	

6.3.10 Internal clock source characteristics

6.3.10.1 *High speed ring oscillator characteristics*

Table 30. HSI oscillator characteristics

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
f_{NOM}	Nominal frequency	-	-	64	-	MHz

6.3.10.2 *Low speed ring oscillator characteristics*

Table 31. LSI oscillator characteristics

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
f_{NOM}	Nominal frequency	-	-	33	-	kHz
$\Delta F_{RO_\Delta T}/F_{RO}$	Frequency spread vs. temperature	Standard deviation	-	140	-	ppm/°C

6.3.11 PLL characteristics

Characteristics measured over recommended operating conditions unless otherwise specified.

Table 32. PLL characteristics

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
PN_{SYNTH}	RF carrier phase noise	At ±1 MHz offset from carrier (measured at 2.4 GHz)	-	-110	-	dBc/Hz

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Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
PN_{SYNTH}	RF carrier phase noise	At 2.4 GHz ±3 MHz offset from carrier (measured at 2.4 GHz)	-	-114	-	dBc/Hz
		At 2.4 GHz±6 MHz offset from carrier (measured at 2.4 GHz)	-	-128	-	dBc/Hz
		At ±25 MHz offset from carrier	-	-135	-	dBc/Hz
$LOCK_{TIMETX}$	PLL lock time to TX	With calibration @2.5 ppm	-	150	-	µs
$LOCK_{TIMERX}$	PLL lock time to RX	With calibration @2.5 ppm	-	110	-	µs
$LOCK_{TIMERXTX}$	PLL lock time RX to TX	Without calibration @2.5 ppm	-	47	-	µs
$LOCK_{TIMETXRX}$	PLL lock time TX to RX	Without calibration @2.5 ppm	-	32	-	µs

6.3.12 Flash memory characteristics

The characteristics below are specified by design - not tested in production.

Table 33. Flash memory characteristics

Symbol	Parameter	Test conditions	Typ.	Max.	Unit
t_{prog}	32-bit programming time	-	20	40	µs
t_{prog_burst}	4x32-bit burst programming time	-	4x20	4x40	
t_{ERASE}	Page (2 kbytes) erase time	-	20	40	ms
t_{ME}	Mass erase time	-	20	40	
I_{DD}	Average consumption from VDD	Write mode	3	-	mA
		Erase mode	3	-	
		Mass erase	5	-	

Table 34. Flash memory endurance and data retention

Symbol	Parameter	Test conditions	Min.	Unit
N_{END}	Endurance	T_A = -40 to +105 °C	10	kcycles
t_{RET}	Data retention	T_A = 105 °C	10	Years

6.3.13 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 x (n + 1) supply pins). This test conforms to the ANSI/JEDEC standard.

Table 35. ESD absolute maximum ratings

Symbol	Parameter	Conditions	Class	Max.(1)	Unit
$V_{ESD(HBM)}$	Electrostatic discharge voltage (human body model)	Conforming to ANSI/ESDA/JEDEC JS-001	2	2000	V
$V_{ESD(CBM)}$	Electrostatic discharge voltage (charge device model)	Conforming to ANSI/ESDA/STM5.3.1 JS-002	C2a	500	

1. *Guaranteed by design.*

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6.3.14 I/O port characteristics

Unless otherwise specified, the parameters given in the tables below are derived from tests performed under the conditions summarized in General operating conditions. All I/Os are designed as CMOS-compliant.

The characteristics below are guaranteed by characterization.

Table 36. I/O static characteristics

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
V_{IL}	I/O input low level voltage	1.62 V < VDD < 3.6 V	-	-	0.3 x VDD	V
V_{IH}	I/O input high level voltage		0.7 x VDD	-	-	
I_{lkg}	Input leakage current	0 <= VIN <= Max(VDDx)(1)	-	-	+/-100	nA
		Max(VDDx)(1) <= VIN <= Max(VDDx)(1) +1 V	-	-	650	
		Max(VDDx)(1) + 1 V < VIN <= 5.5 V	-	-	200	
R_{PU}	Pull-up resistor	VIN = GND	25	40	55	kΩ
R_{PD}	Pull-down resistor	VIN = VDD	25	40	55	
C_{IO}	I/O pin capacitance	-	-	5	-	pF

1. *Max(VDDx) is the maximum value among all the I/O supplies.*

All I/Os are CMOS-compliant (no software configuration required).

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 that can drive current must be limited to respect the absolute maximum rating specified.

- The sum of currents sourced by all I/Os on VDD, plus the maximum consumption of MCU sourced on VDD, cannot exceed the absolute maximum rating ΣIVDD
- The sum of currents sunk by all I/Os on VSS, plus the maximum consumption of the MCU sunk on GND, cannot exceed the absolute maximum rating ΣIVGND

The characteristics below are guaranteed by characterization.

Table 37. Output voltage characteristics

Symbol	Parameter	Conditions	Min.	Max.	Unit
V_{OL}	Output low level voltage for I/O pin	CMOS port(1) |IIO| = 8 mA VDD ≥ 2.7 V	-	0.4	V
V_{OH}	Output high level voltage for I/O pin		VDD -0.4	-	
V_{OL}	Output low level voltage for I/O pin	|IIO| = 20 mA VDD ≥ 2.7 V	-	1.3	
V_{OH}	Output high level voltage for I/O pin		VDD -1.3	-	
V_{OL}	Output low level voltage for I/O pin	|IIO| = 4 mA VDD ≥ 1.62 V	-	0.4	
V_{OH}	Output high level voltage for I/O pin		VDD-0.45	-	

1. *CMOS outputs are compatible with JEDEC standards JESD36 and JESD52.*

6.3.15 RSTN pin characteristics

The RSTN pin input driver uses CMOS technology. It is connected to a permanent pull-up resistor, RPU.

Unless otherwise specified, the parameters given in the table below are derived from tests performed under the ambient temperature and supply voltage conditions summarized in General operating conditions.

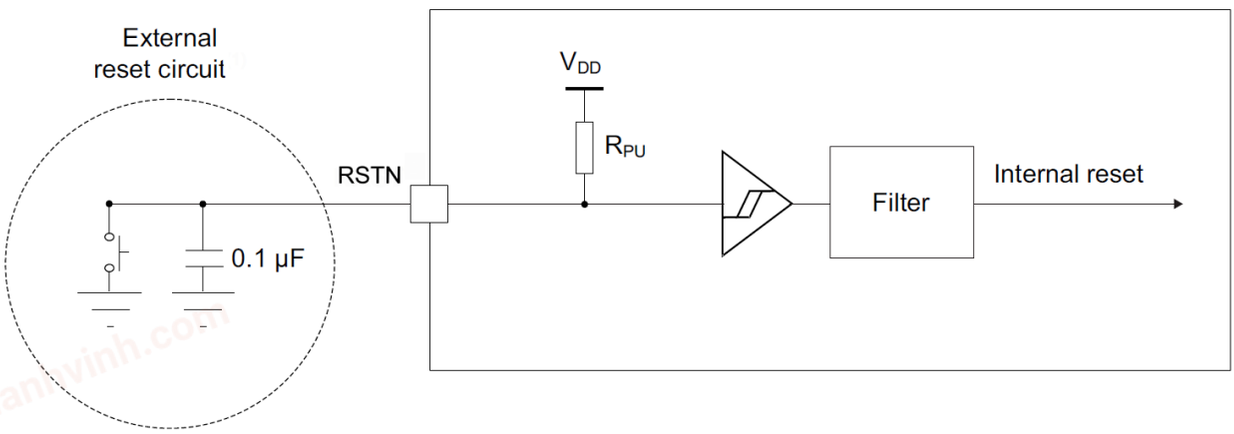
The characteristics below are specified by design - not tested in production.

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Table 38. RSTN pin characteristics

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit.
$V_{IL(RSTN)}$	RSTN input low level voltage	-	-	-	0.3 x VDD	V
$V_{IH(RSTN)}$	RSTN input high level voltage	-	0.7 x VDD	-	-	
$V_{hys(RSTN)}$	RSTN Schmitt trigger voltage hysteresis	-	-	200	-	mV
RPU	Weak pull-up equivalent resistor	VIN=GND	25	40	55	kΩ

Figure 15. Recommended RSTN pin protection



(1) The external reset circuit protects the device against parasitic resets
(2) The user must ensure that the level on the RSTN pin can go below the VIL(RSTN) max. level specified in the table, otherwise the reset will not be considered by the device.
Note: The external capacitor on RSTN must be placed as close as possible to the device.

Note: The external reset circuit protects the device against parasitic resets.
The user must ensure that the level on the RSTN pin can go below the V_{IL}(RSTN) max. level specified in the table, otherwise the reset is not considered by the device. The external capacitor on RSTN must be placed as close as possible to the device.

6.3.16 ADC characteristics

Table 39. ADC characteristics (HSI must be set to PLL mode)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Units
Ch_diff_num	Number of channels for differential mode	VFQFPN48, WLCSP49	-	-	4	-
Ch_se_num	Number of channels for single ended mode	VFQFPN48, WLCSP49	-	-	8	-
$IBAT_{ADCBIAS}$	ADC biasing consumption at battery	Biasing blocks turned on	-	145	-	µA
$IBAT_{ADCACTIVE}$	ADC active consumption at battery	ADC activated in differential mode	-	185	-	µA
VDDA	Analog supply voltage	-	1.2	-	1.32	V
R_{AIN}	Input impedance	In DC	-	250	-	kΩ
R_{in}	Internal access resistance	VBOOST is enabled for VDD < 2.7 V	-	-	550	Ω
C_{in}	Input sampling capacitor	-	-	4	-	pF
T_s	Sampling period	Default configuration	-	1	-	µs

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Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Units
T_{sw}	Sampling time	Default configuration	-	125	-	ns
DR	Output data rate	-	-	200	-	k samples/s
$FRMT_{output}$	Output data format	-	-	16	-	bits
TL	Latency time	200 kSps	-	5	-	µs
$T_{STARTUP}$	Start-up time	From ADC enable to conversion start	-	-	1	µs
DNL	Differential non-linearity	-	-	±0.7	-	LSB
INL	Integral non-linearity	-	-	±1	-	LSB
SNR Diff	Signal to noise ratio	Differential input @1 kHz, -1 dBFs, Fs = 1 MHz with DF	-	72	-	dB
STHD Diff	Signal to THD ratio (10 harmonics)	Differential input @1 kHz, -1 dBFs, Fs = 1 MHz with DF	-	75	-	dB
ENOB Diff	Effective number of bits	Differential input @1 kHz, -1 dBFs, Fs = 1 MHz with DF	-	11.5	-	bits
SNR SE	Signal-to-noise ratio	Single ended @1 kHz, -1 dBFs, Fs = 1 MHz with DF	-	70	-	dB
STHD SE	Signal-to THD ratio (10 harmonics)	Single ended @1 kHz, -1 dBFs, Fs = 1 MHz with DF	-	70	-	dB
ENOB SE	Effective number of bits	Single ended @1 kHz, -1 dBFs, Fs = 1 MHz with DF	-	11	-	bits
-	ADC_ERR_1V7	Absolute error when used for battery measurements at 1.7 V, 2.4 V, 3.0 V, 3.6 V	-	13	-	mV
-	ADC_ERR_2V4		-	0	-	
-	ADC_ERR_3V0		-	-9	-	
-	ADC_ERR_3V6		-	-22	-	

6.3.17 Temperature sensor characteristics

Table 40. Temperature sensor characteristics

Symbol	Parameter	Min.	Typ.	Max.	Unit
T_{rERR}	Error in temperature	-	±4	-	°C
T_{SLOPE}	Average temperature coefficient	-	8	-	LSB/°C
T_{ICC}	Current consumption	-	415	-	µA
T_{TS-OUT}	Output code at 30 °C (+/-5 °C)	-	2533	-	LSB

6.3.18 Timer characteristics

The characteristics below are guaranteed by design.

Table 41. TIM1 characteristics

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$t_{res(TIM)}$	Timer resolution time	$f_{TIMxCLK}$ = 64 MHz	-	15.625	-	ns
R_{esTIM}	Timer resolution	-	-	16	-	bit
$t_{COUNTER}$	16-bit counter clock period	$f_{TIMxCLK}$ = 64 MHz	0.015625	-	1024	µs

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Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
t_{MAX_COUNT}	Maximum possible count time	$f_{TIMxCLK}$= 64	-	-	67.10	s

Table 42. IWDG min./max. timeout period at 32 kHz (LSE)

Prescaler divider	PR[2:0] bits	Min. timeout RL[11:0] = 0x000	Max. timeout RL[11:0] = 0xFFF	Unit
/4	0	0.125	512	ms
/8	1	0.250	1024	
/16	2	0.500	2048	
/32	3	1.0	4096	
/64	4	2.0	8192	
/128	5	4.0	16384	
/256	6 or 7	8.0	32768	

6.3.19 I²C interface characteristics

The I²C interface meets the timing requirements of the I²C-Bus specifications and user manual rev. 03 for:

- Standard-mode (Sm): bit rate up to 100 kbit/s
- Fast-mode (Fm): bit rate up to 400 kbit/s
- Fast-mode plus (Fm+): bit rate up to 1 Mbit/s

SDA and SCL I/O requirements are met with the following restrictions: SDA and SCL I/O pins are not “true” open-drain. When configured as open-drain, the PMOS connected between the I/O pin and VDD is disabled, but is still present. The 20 mA output drive requirement in fast-mode plus is supported partially.

This limits the maximum load C_{load} supported in fast-mode plus, given by these formulas:

- $t_r(SDA/SCL) = 0.8473 \times R_p \times C_{load}$
- $R_p(min.) = [V_{DD} - V_{OL}(max)] / I_{OL}(max)$

where R_p is the I²C lines pull-up.

All I²C SDA and SCL I/Os embed an analog filter.

The characteristics below are guaranteed by design.

Table 43. I²C analog filter characteristics

Symbol	Parameter	Min.	Max.	Unit
tAF	Maximum pulse width of spikes that are suppressed by the analog filter	50	110	ns

6.3.20 SPI characteristics

The parameters for SPI are derived from tests performed according to f_{PCLKx} frequency and supply voltage conditions.

- Output speed is set to OSPEEDRy[1:0] = 11
- Capacitive load C = 30 pF
- Measurement points are done at CMOS levels: 0.5 x V_{DD}

The characteristics below are specified by design - not tested in production.

Table 44. SPI characteristics

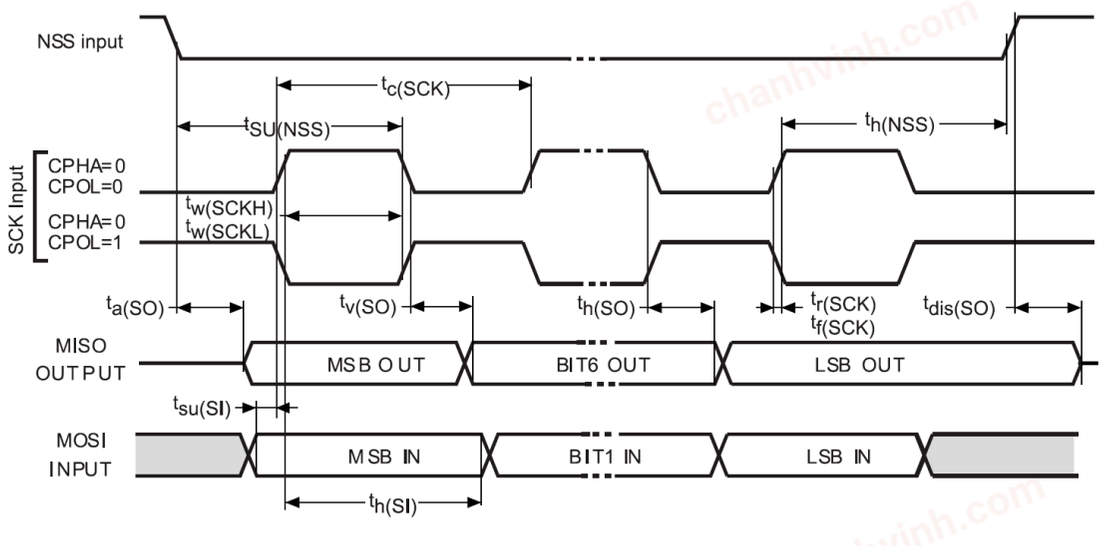
Symbol	Parameter	Conditions	Min.	Typ.	Max.	Units
f_{SCK}	SPI clock frequency	Controller mode	-	-	32	MHz

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Symbol	Parameter	Conditions	Min.	Typ.	Max.	Units
f_{SCK}	SPI clock frequency	Target mode	-	-	32(1)	MHz
tsu(NSS)	NSS setup time	-	4 / f_{PCLK}	-	-	-
th(NSS)	NSS hold time	-	2 / f_{PCLK}	-	-	-
tw(SCKH)	SCK high and low time	Controller mode	1 / f_{PCLK} - 1.5	1 / f_{PCLK}	1 / f_{PCLK}+1	ns
tw(SCKL)			1 / f_{PCLK}- 1.5	1 / f_{PCLK}	1 / f_{PCLK}+1	
tsu(MI)	Data input set-up time	Controller mode	1	-	-	
tsu(SI)	Data input set-up time	Target mode	1	-	-	
th(MI)	Data input hold time	Controller mode	3	-	-	
th(SI)	Data input hold time	Target mode	1	-	-	
$t_{a(SO)}$	Data output access time	Target mode	5	-	40	
$t_{dis(SO)}$	Data output disable time	Target mode	5	-	38	
$t_{v(MO)}$	Data output valid time	Controller mode	-	2	8	
$t_{v(SO)}$		Target mode	-	12	39	
$t_{h(MO)}$	Data output hold time	Controller mode	2	-	-	
$t_{h(SO)}$		Target mode	4	-		

1. *The maximum frequency in target transmitter mode is determined by the sum of tv(SO) and tsu(MI), which has to fit SCK low or high phase preceding the SCK sampling edge. This value can be achieved when the SPI communicates with a controller having tsu(MI) = 0 while duty(SCK) = 50 %.*

Figure 16. SPI timing diagram - target mode and CPHA = 0



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Figure 17. **SPI timing diagram - target mode and CPHA = 1**

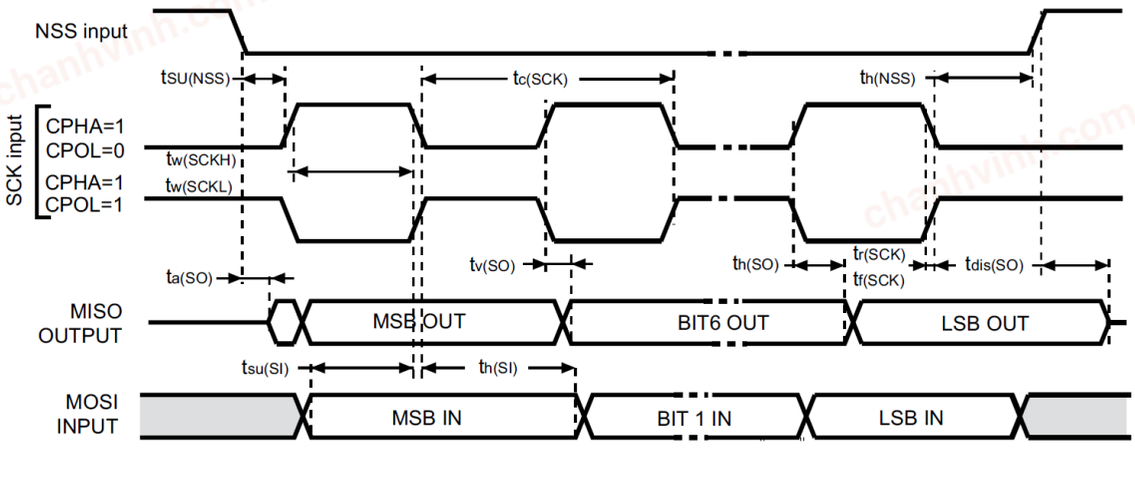
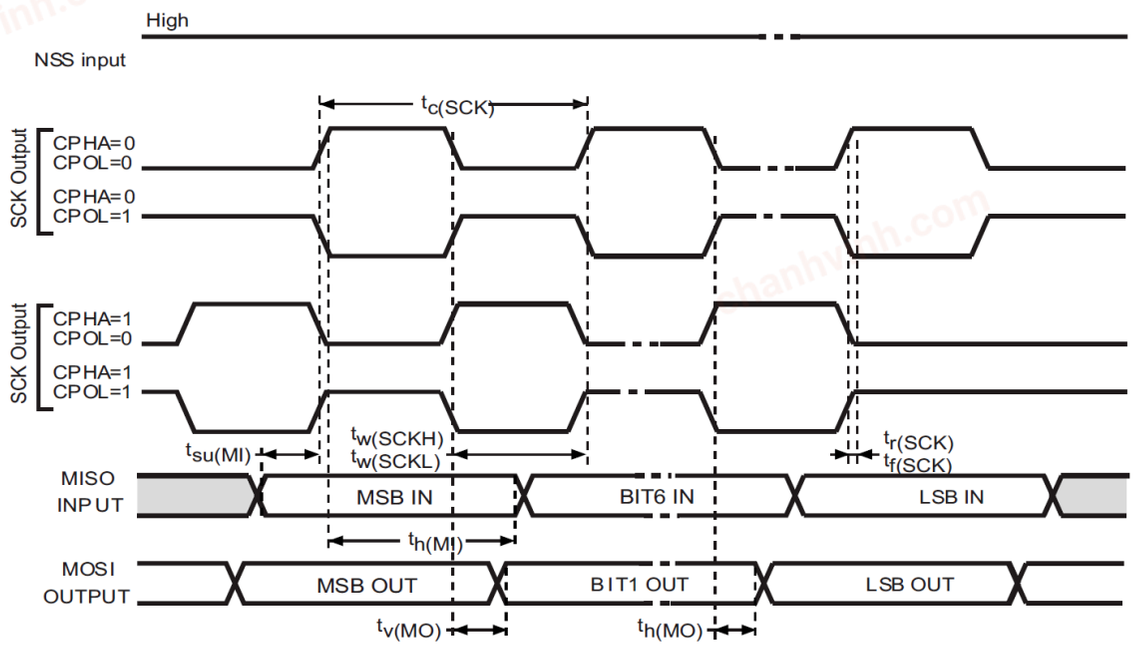


Figure 18. **SPI timing diagram - controller mode**



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7 Package information

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK packages, depending on their level of environmental compliance. ECOPACK specifications, grade definitions and product status are available at: www.st.com. ECOPACK is an ST trademark.

7.1 Device marking

Refer to technical note "Reference device marking schematics for STM32 microcontrollers and microprocessors" (TN1433) available on www.st.com, for the location of pin 1 / ball A1 as well as the location and orientation of the marking areas versus pin 1 / ball A1.

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

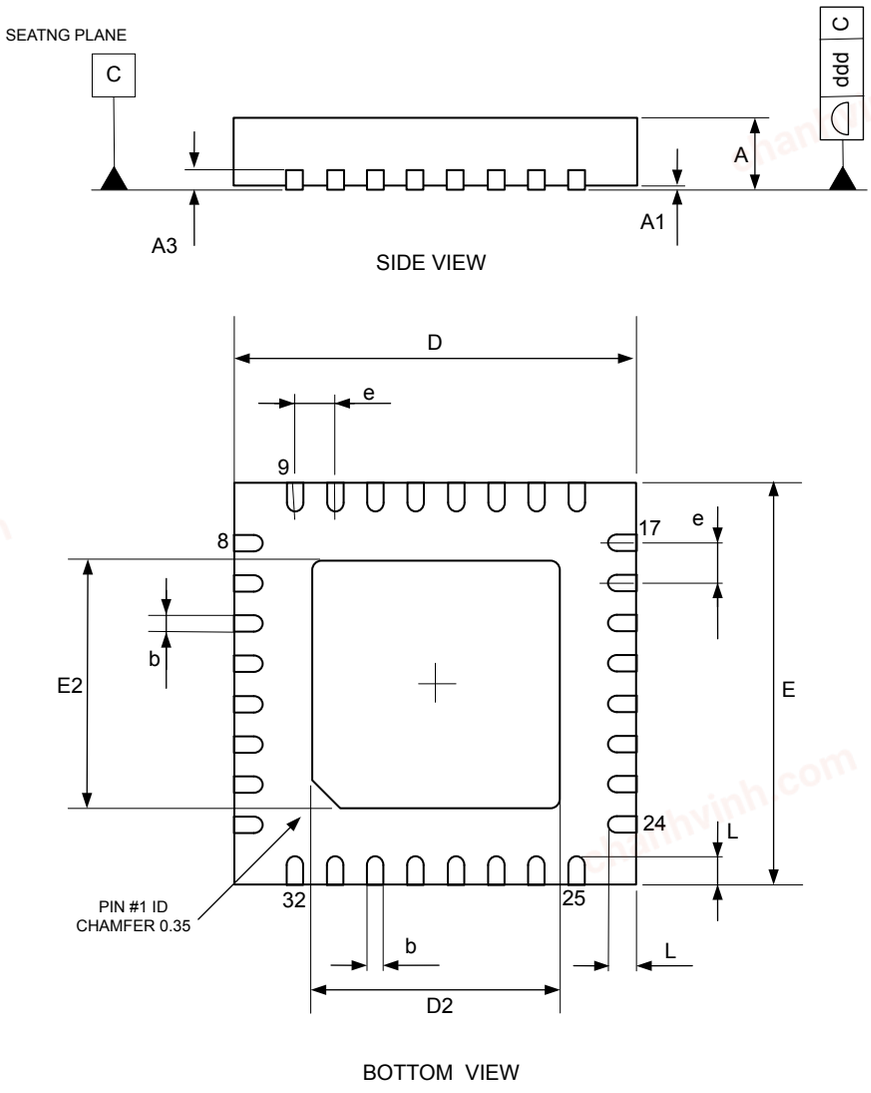
A WLCSP simplified marking example (if any) is provided in the corresponding package information subsection.

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7.2 VFQFPN32 package information (42)

This VFQFPN is a 32 lead, 5 x 5 mm, 0.50 mm pitch, very fine pitch quad flat no lead package.

Figure 19. VFQFPN32 - Outline



1. *Drawing is not to scale.*
2. *Package outline exclusive of any mold flashes dimensions and metal burrs.*
3. *Details of terminal 1 are optional but must be located on the top surface of the package by using either a mold or marked features.*

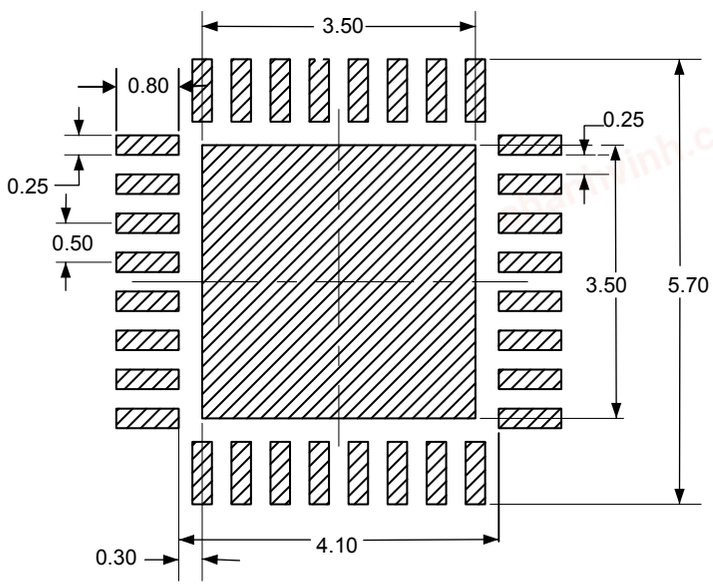
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Table 45. **VFQFPN32 - Mechanical data**

Symbol	Millimetres			Inches[1]		
	Min	Typ	Max	Min	Typ	Max
A[2]	0.80	0.90	1.00	0.0315	0.0354	0.0394
A1	0	-	0.05	0	-	0.0020
A3	-	0.20	-	-	0.008	-
b	0.18	0.25	0.30	0.0070	0.0098	0.0118
D	4.90	5.00	5.10	0.1929	0.19	0.2008
E	4.90	5.00	5.10	0.1929	0.19	0.2008
D2	3.60	3.70	3.80	0.1417	0.1457	0.1496
E2	3.60	3.70	3.80	0.1417	0.1457	0.1496
e	-	0.50	-	-	0.0197	-
L	0.30	0.40	0.50	0.0118	0.0157	0.0197
ddd	-	-	0.05	-	-	0.0020

1. *Values in inches are converted from mm and rounded to 3 decimal digits.*
2. *VFQFPN stands for thermally Enhanced very thin fine pitch quad flat package No lead . Very thin profile 0.80 < A ≤ 1.00 mm.*

Figure 20. **VFQFPN32 - Footprint example**

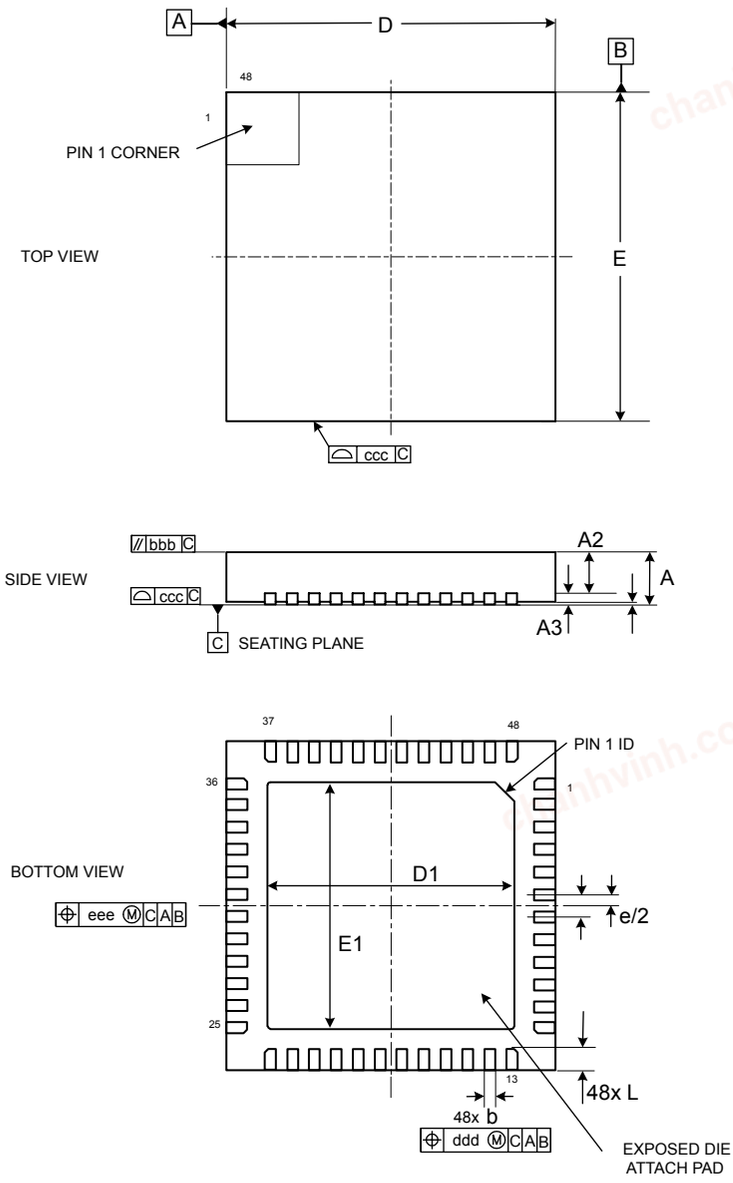


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7.3 VFQFPN48 package information

This VFQFPN is a 48 lead, 6 x 6 mm, 0.40 mm pitch, very fine pitch quad flat no lead package.

Figure 21. VFQFPN48 - Outline



A0BE_D_VFQFPN48_ME_V1

1. *Drawing is not to scale.*
2. *Dimension and tolerances conform to ASME Y14.5M.*
3. *Coplanarity applies to leads , corner leads and die attach pad.*

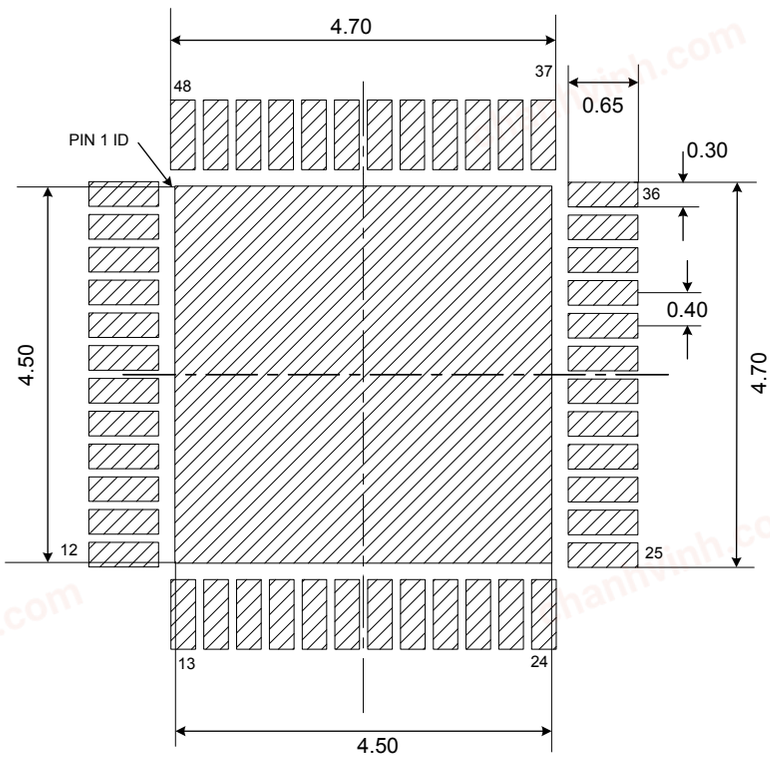
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Table 46. **VFQFPN48 - Mechanical data**

Symbol	Millimetres			Inches[1]		
	Min	Typ	Max	Min	Typ	Max
A	0.80	0.85	0.90	0.0315	0.0335	0.0354
A1	0	0.035	0.05	0	0.0014	0.0020
A2	-	0.65	0.67	-	0.0256	0.0264
A3		0.203 Ref			0.0080 Ref	
b	0.15	0.20	0.25	0.006	0.0080	0.0098
D		6.00 BSC			0.2362 BSC	
D1	4.30	4.40	4.50	0.1693	0.1732	0.1772
E		6.00 BSC			0.2362 BSC	
E1	4.30	4.40	4.50	0.1693	0.1732	0.1772
e	-	0.40 BSC	-	-	0.0157 BSC	-
L	0.40	0.45	0.50	0.0157	0.0177	0.0197
aaa		0.10			0.0039	
bbb		0.10			0.0039	
ccc		0.08			0.0031	
ddd		0.10			0.0039	

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

Figure 22. **VFQFPN48- Footprint example**

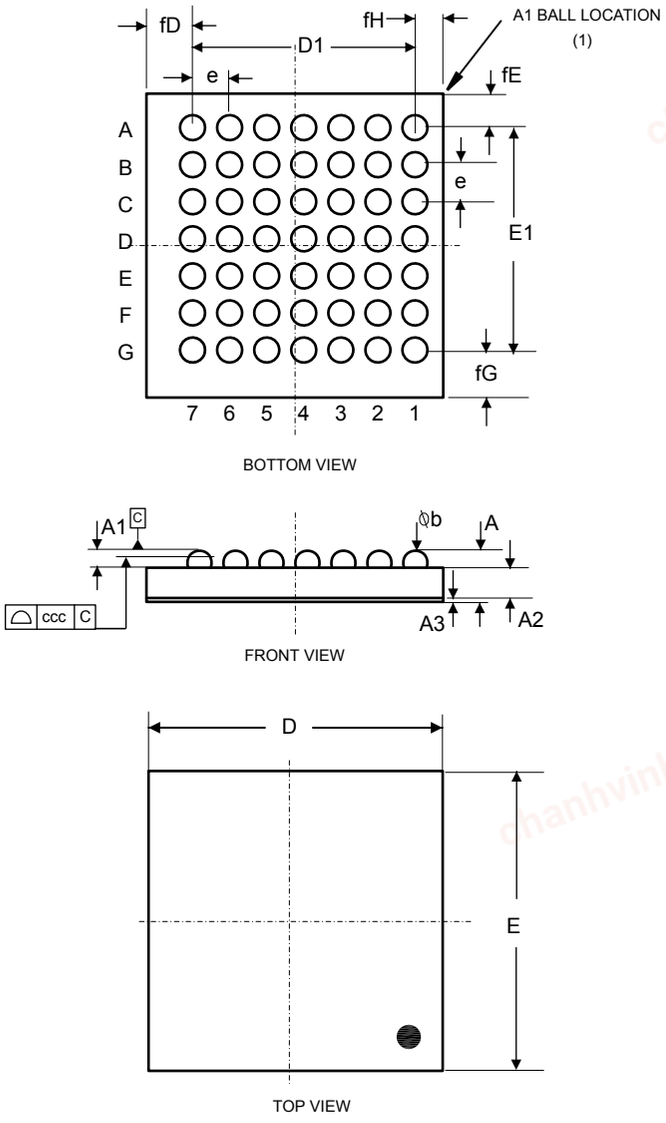


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7.4 WLCSP49 package information(01C1)

This WLCSP is a 49-ball, 3.140 x 3.140 mm, 0.40 mm pitch, wafer level chip scale array package.

Figure 23. WLCSP49 - Outline



01C1_WLCSP49_ME_V1

1. *The terminal A1 on the bumps side is identified by a distinguishing feature (for instance by a circular "clear area" - typically 0.1 mm diameter) and/or a missing bump.*
   The terminal A1 on the backside of the product is identified by a distinguishing feature (for instance by a circular "clear area" - typically 0.5 mm diameter).
2. *Drawing is not to scale.*

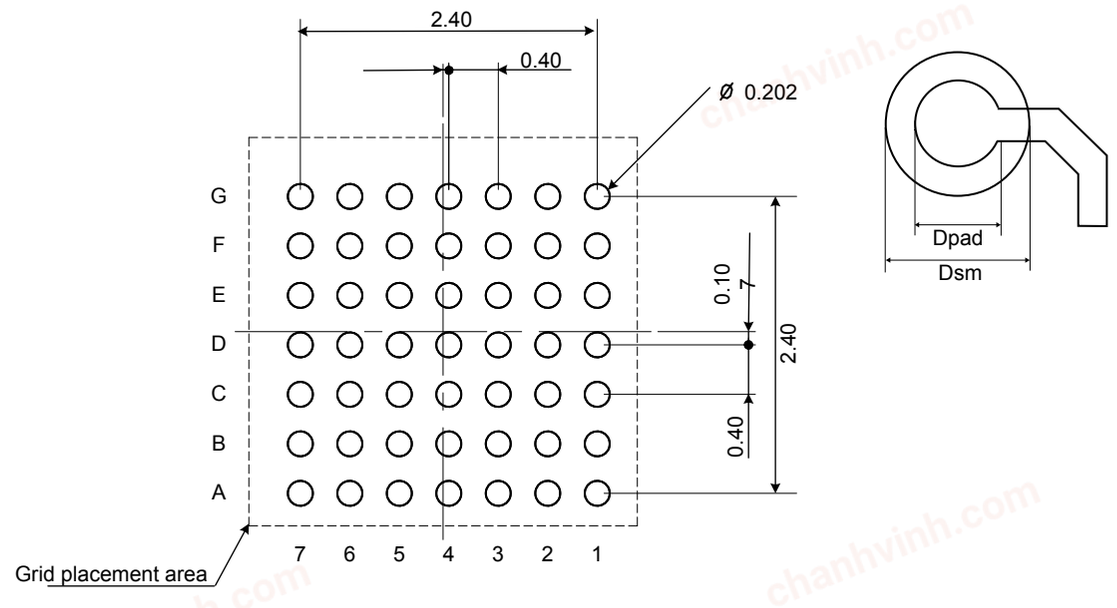
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Table 47. **WLCSP49 - Mechanical data**

Symbol	millimeters			inches[1]		
	Min	Typ	Max	Min	Typ	Max
A	-	-	0.420	-	-	0.0165
A1	0.135	-	-	0.0053	-	-
A2	-	0.225	-	-	0.0088	-
A3	-	0.025	-	-	0.0010	-
b	0.214	0.218	0.222	0.0084	0.0085	0.0087
D	-	3.140	-	-	0.1236	-
D1	-	2.400	-	-	0.0945	-
E	-	3.140	-	-	0.1236	-
E1	-	2.400	-	-	0.0945	-
e	-	0.40	-	-	0.0157	-
fD	-	0.416	-	-	0.0164	-
fE	-	0.263	-	-	0.0103	-
fG	-	0.477	-	-	0.0188	-
fH	-	0.324	-	-	0.0127	-
aaa	-	0.023	-	-	0.0009	-

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

Figure 24. **WLCSP49 - Footprint example**



1. *Dimensions are expressed in millimeters.*

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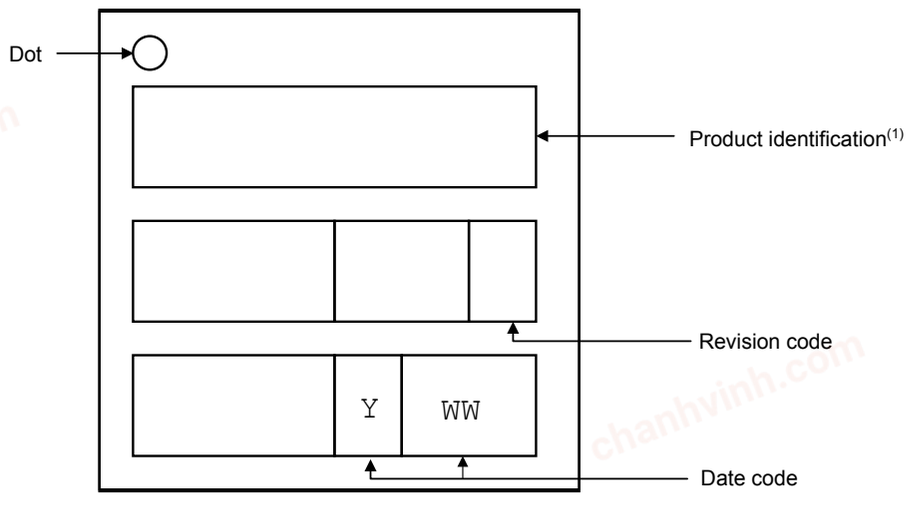
Table 48. **WLCSP49 - Example of PCB design rules**

Dimension	Values
Pitch	0.4 mm
Dpad	0,225 mm
Dsm	0.290 mm typ. (depends on soldermask registration tolerance)
Stencil opening	0.250 mm
Stencil thickness	0.100 mm

7.4.1 Device marking for WLCSP49

The following figure gives an example of topside marking versus ball A1 position identifier location.
The printed markings may differ depending on the supply chain.
Other optional marking or inset/upset marks, which depend on supply chain operations, are not indicated below.

Figure 25. **WLCSP49 marking example**



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

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7.5 Thermal characteristics

The maximum chip junction temperature ($T_{Jmax.}$) must never exceed the values in general operating conditions.

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

$$T_J\text{max.} = T_A\text{max.} + (PD\text{max} \times \theta JA) \quad (1)$$

where:

- T_A max. is the maximum ambient temperature in °C
- ΘJA is the package junction-to-ambient thermal resistance, in °C/W
- PD max. is the sum of PINT max. and PI/O max. (PD max. = PINT max. + PI/O max.)
- PINT max. is the product of IDD and VDD, expressed in Watt. This is the maximum chip internal power

PI/O max represents the maximum power dissipation on output pins:

- PI/O max. = Σ (VOL × IOL) + Σ ((VDD – VOH) × IOH)

taking into account the actual VOL / IOL and VOH / IOH of the I/Os at low and high level in the applications.

Note: When the SMPS is used, a portion of the power consumption is dissipated into the external inductor, therefore reducing the chip power dissipation. This portion depends mainly on the inductor ESR characteristics.

Note: As the radiated RF power is quite low (< 4 mW), it is not necessary to remove it from the chip power consumption.

Note: RF characteristics (such as: sensitivity, Tx power, consumption) are provided up to 85 °C.

Table 49. Package thermal characteristics

Symbol	Parameter	Value	Unit
ΘJA	Thermal resistance junction-ambient VFQFPN48 – 6 mm x 6 mm	25.1	°C/W
	Thermal resistance junction-ambient VFQFPN32 - 5 mm x 5 mm	26.9	
	Thermal resistance junction-ambient WLCSP49 – 0.4 mm pitch	-	

7.5.1 Reference documents

- JESD51-2 Integrated Circuits Thermal Test Method Environment Conditions - Natural Convection (Still Air) available on www.jedec.org.
- For information on thermal management, refer to application note *"Guidelines for thermal management on STM32 applications" (AN5036)* available on www.st.com.

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8 Ordering information

Example: STM32 WB 07 K C V 6 TR TR

Device family

STM32 = Arm®-based 32-bit microcontroller

Product type

WB = wireless Bluetooth

Device subfamily

07 = full set of features (64 KB RAM)

06 = full set of features (32 KB RAM)

Pin count

K = 32 pins

C = 48 pins

Flash memory size

C = 256 Kbytes

Package

F = WLCSP ECOPACK2

V = VFQFPN ECOPACK2

Temperature range

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

7 = industrial temperature range, –40 to 105 °C

Packing

TR = tape and reel

Note: For a list of available options (such as speed and package) or for further information on any aspect of this device, contact your nearest ST sales office.

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Important security notice

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- While robust security testing may be done, no level of certification can absolutely guarantee protections against all attacks, including, for example, against advanced attacks which have not been tested for, against new or unidentified forms of attack, or against any form of attack when using an ST product outside of its specification or intended use, or in conjunction with other components or software which are used by customer to create their end product or application. ST is not responsible for resistance against such attacks. As such, regardless of the incorporated security features and/or any information or support that may be provided by ST, each customer is solely responsible for determining if the level of attacks tested for meets their needs, both in relation to the ST product alone and when incorporated into a customer end product or application.
- All security features of ST products (inclusive of any hardware, software, documentation, and the like), including but not limited to any enhanced security features added by ST, are provided on an "AS IS" BASIS. AS SUCH, TO THE EXTENT PERMITTED BY APPLICABLE LAW, ST DISCLAIMS ALL WARRANTIES, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO THE IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE, unless the applicable written and signed contract terms specifically provide otherwise.

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Revision history

Table 50. **Document revision history**

Date	Revision	Changes
13-Jun-2024	1	Initial release.
04-Sep-2024	2	Updated VFQFPN32 package information
26-Sep-2024	3	Updated: • Table 6. STM32WB0xxC pin/ball definition • Table 7. Alternate function port A • Table 8. Alternate function port B

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