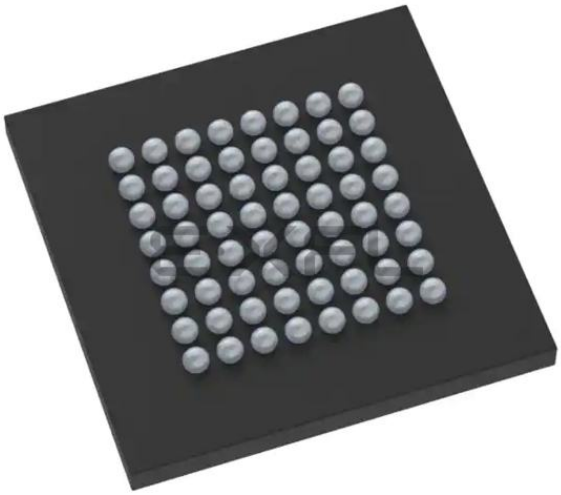

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What is "Embedded - Microcontrollers"?

"Embedded - Microcontrollers" refer to small, integrated circuits designed to perform specific tasks within larger systems. These microcontrollers are essentially compact computers on a single chip, containing a processor core, memory, and programmable input/output peripherals. They are called "embedded" because they are embedded within electronic devices to control various functions, rather than serving as standalone computers. Microcontrollers are crucial in modern electronics, providing the intelligence and control needed for a wide range of applications.

Applications of "Embedded - Microcontrollers"

Details	
Product Status	Active
Core Processor	ARM® Cortex®-M3
Core Size	32-Bit Single-Core
Speed	32MHz
Connectivity	I²C, IrDA, LINbus, SPI, UART/USART, USB
Peripherals	Brown-out Detect/Reset, DMA, I²S, LCD, POR, PWM, WDT
Number of I/O	51
Program Memory Size	384KB (384K x 8)
Program Memory Type	FLASH
EEPROM Size	12K x 8
RAM Size	48K x 8
Voltage - Supply (Vcc/Vdd)	1.8V ~ 3.6V
Data Converters	A/D 21x12b; D/A 2x12b
Oscillator Type	Internal
Operating Temperature	-40°C ~ 85°C (TA)
Mounting Type	Surface Mount
Package / Case	64-UFBGA, WLCSP
Supplier Device Package	64-WLCSP (4.54x4.91)
Purchase URL	https://www.e-xfl.com/product-detail/stmicroelectronics/stm32l162rdy6tr

List of tables

3.1 Low-power modes

The ultra-low-power STM32L162xD devices support dynamic voltage scaling to optimize its power consumption in run mode. The voltage from the internal low-drop regulator that supplies the logic can be adjusted according to the system's maximum operating frequency and the external voltage supply.

There are three power consumption ranges:

- Range 1 (V_{DD} range limited to 1.71 V - 3.6 V), with the CPU running at up to 32 MHz
- Range 2 (full V_{DD} range), with a maximum CPU frequency of 16 MHz
- Range 3 (full V_{DD} range), with a maximum CPU frequency limited to 4 MHz (generated only with the multispeed internal RC oscillator clock source)

Seven low-power modes are provided to achieve the best compromise between low-power consumption, short startup time and available wakeup sources:

- **Sleep** mode

  In Sleep mode, only the CPU is stopped. All peripherals continue to operate and can wake up the CPU when an interrupt/event occurs. Sleep mode power consumption at 16 MHz is about 1 mA with all peripherals off.

- **Low-power run** mode

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

- **Low-power sleep** mode

  This mode is achieved by entering Sleep mode with the internal voltage regulator in Low-power mode to minimize the regulator's operating current. In Low-power sleep mode, both the clock frequency and the number of enabled peripherals are limited; a typical example would be to have a timer running at 32 kHz.

  When wakeup is triggered by an event or an interrupt, the system reverts to the run mode with the regulator on.

- **Stop** mode with RTC

  Stop mode achieves the lowest power consumption while retaining the RAM and register contents and real time clock. All clocks in the V_{CORE} domain are stopped, the PLL, MSI RC, HSI RC and HSE crystal oscillators are disabled. The LSE or LSI is still running. The voltage regulator is in the low-power mode.

  The device can be woken up from Stop mode by any of the EXTI line, in 8 µs. The EXTI line source can be one of the 16 external lines. It can be the PVD output, the Comparator 1 event or Comparator 2 event (if internal reference voltage is on), it can be the RTC alarm(s), the USB wakeup, the RTC tamper events, the RTC timestamp event or the RTC wakeup.

Table 4. Functionalities depending on the working mode (from Run/active down to standby) (continued)

Ips	Run/Active	Sleep	Low-power Run	Low-power Sleep	Stop		Standby	
						Wakeup capability		Wakeup capability
ADC	Y	Y	--	--	--	--	--	--
DAC	Y	Y	Y	Y	Y	--	--	--
Tempsensor	Y	Y	Y	Y	Y	--	--	--
OP amp	Y	Y	Y	Y	Y	--	--	--
Comparators	Y	Y	Y	Y	Y	Y	--	--
16-bit and 32-bit Timers	Y	Y	Y	Y	--	--	--	--
IWDG	Y	Y	Y	Y	Y	Y	Y	Y
WWDG	Y	Y	Y	Y	--	--	--	--
Touch sensing	Y	Y	--	--	--	--	--	--
Systic Timer	Y	Y	Y	Y		--	--	--
GPIOs	Y	Y	Y	Y	Y	Y	--	3 pins
Wakeup time to Run mode	0 µs	0.4 µs	3 µs	46 µs	< 8 µs		58 µs	
Consumption V_{DD}=1.8 to 3.6 V (Typ)	Down to 230 µA/MHz (from Flash)	Down to 43 µA/MHz (from Flash)	Down to 11 µA	Down to 4.4 µA	0.475 µA (no RTC) V_{DD}=1.8V		0.305 µA (no RTC) V_{DD}=1.8V	
					1.1 µA (with RTC) V_{DD}=1.8V		0.82 µA (with RTC) V_{DD}=1.8V	
					0.475 µA (no RTC) V_{DD}=3.0V		0.305 µA (no RTC) V_{DD}=3.0V	
					1.35 µA (with RTC) V_{DD}=3.0V		1.15 µA (with RTC) V_{DD}=3.0V	

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

3.2 ARM® Cortex®-M3 core with MPU

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

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

from chip to chip due to process variation, the uncalibrated internal temperature sensor is suitable for applications that detect temperature changes only.

To improve the accuracy of the temperature sensor measurement, each device is individually factory-calibrated by ST. The temperature sensor factory calibration data are stored by ST in the system memory area, accessible in read-only mode. See *Table 68: Temperature sensor calibration values*.

3.11.2 Internal voltage reference (V_{REFINT})

The internal voltage reference (V_{REFINT}) provides a stable (bandgap) voltage output for the ADC and Comparators. V_{REFINT} is internally connected to the ADC_IN17 input channel. It enables accurate monitoring of the V_{DD} value (when no external voltage, VREF+, is available for ADC). The precise voltage of V_{REFINT} is individually measured for each part by ST during production test and stored in the system memory area. It is accessible in read-only mode. See *Table 14: Embedded internal reference voltage calibration values*.

3.12 DAC (digital-to-analog converter)

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

This dual digital Interface supports the following features:

- Two DAC converters: one for each output channel
- 8-bit or 12-bit monotonic output
- Left or right data alignment in 12-bit mode
- Synchronized update capability
- Noise-wave generation
- Triangular-wave generation
- Dual DAC channels, independent or simultaneous conversions
- DMA capability for each channel (including the underrun interrupt)
- External triggers for conversion
- Input reference voltage V_{REF+}

Eight DAC trigger inputs are used in the STM32L162xD devices. The DAC channels are triggered through the timer update outputs that are also connected to different DMA channels.

3.13 Operational amplifier

The STM32L162xD devices embed three operational amplifiers with external or internal follower routing capability (or even amplifier and filter capability with external components). When one operational amplifier is selected, one external ADC channel is used to enable output measurement.

The operational amplifiers feature:

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

3.14 Ultra-low-power comparators and reference voltage

The STM32L162xD devices embed two comparators sharing the same current bias and reference voltage. The reference voltage can be internal or external (coming from an I/O).

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

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

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

3.15 System configuration controller and routing interface

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

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

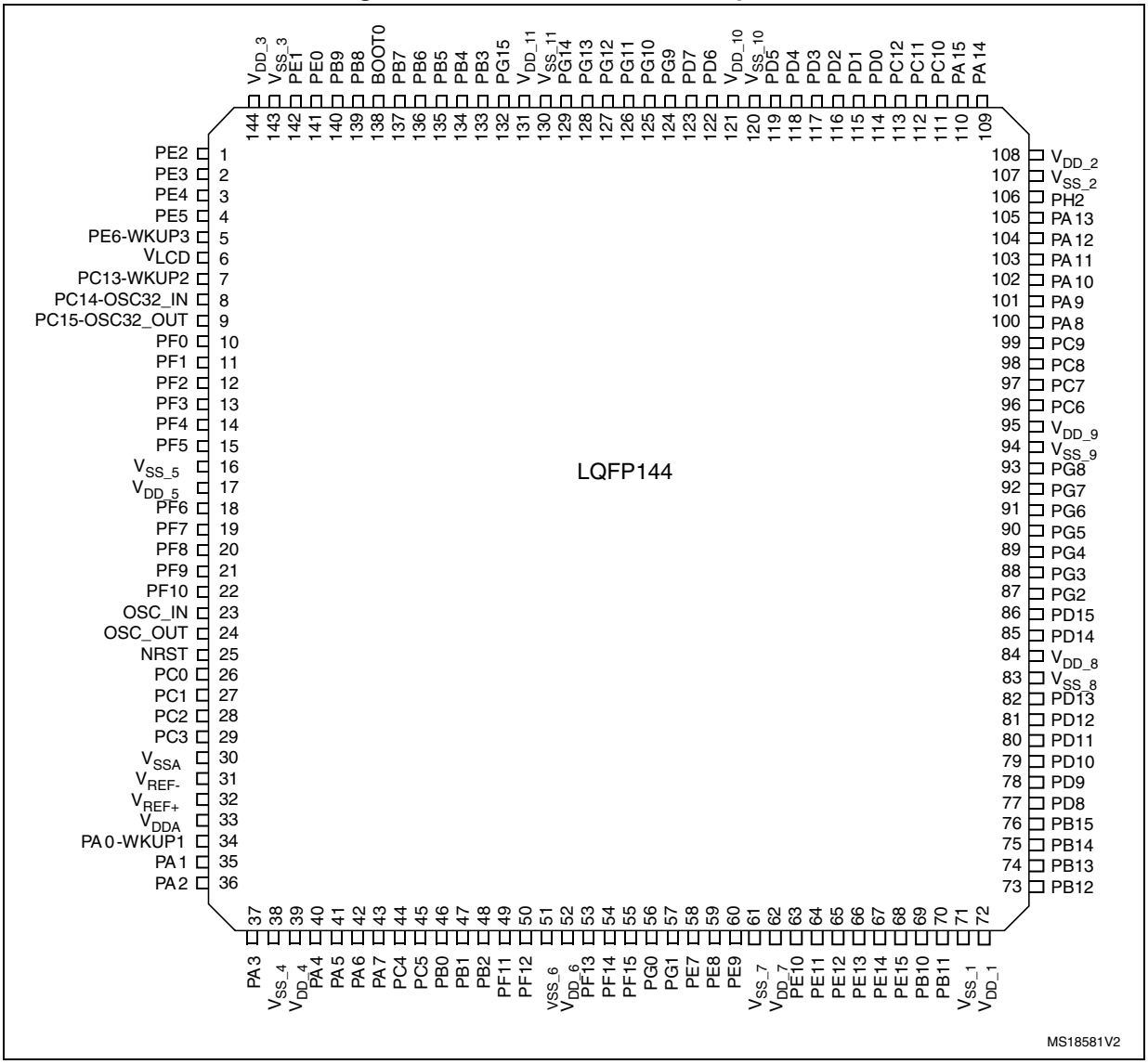
3.16 Touch sensing

The STM32L162xD devices provide a simple solution for adding capacitive sensing functionality to any application. These devices offer up to 34 capacitive sensing channels distributed over 11 analog I/O groups. Both software and timer capacitive sensing acquisition modes are supported.

Capacitive sensing technology is able to detect the presence of a finger near a sensor which is protected from direct touch by a dielectric (glass, plastic...). The capacitive variation introduced by the finger (or any conductive object) is measured using a proven implementation based on a surface charge transfer acquisition principle. It consists of charging the sensor capacitance and then transferring a part of the accumulated charges into a sampling capacitor until the voltage across this capacitor has reached a specific threshold. The capacitive sensing acquisition only requires few external components to operate. This acquisition is managed directly by the GPIOs, timers and analog I/O groups (see *Section 3.15: System configuration controller and routing interface*).

4 Pin descriptions

Figure 3. STM32L162ZD LQFP144 pinout



1. This figure shows the package top view.

Table 6. Legend/abbreviations used in the pinout table (continued)

Name		Abbreviation	Definition
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	

Alternate functions

Table 8. Alternate function input/output

Port name	Digital alternate function number									..			..		
	AFIO0	AFIO1	AFIO2	AFIO3	AFIO4	AFIO5	AFIO6	AFIO7	AFIO8	..	AFIO11	AFIO12	..	AFIO14	AFIO15
	Alternate function														
	SYSTEM	TIM2	TIM3/4/5	TIM9/ 10/11	I2C1/2	SPI1/2	SPI3	USART1/2/3	UART4/5		LCD	FSMC/ SDIO		CPRI	SYSTEM
BOOT0	BOOT0	-	-	-	-	-	-	-	-		-	-		-	EVENT OUT
NRST	NRST	-	-	-	-	-	-	-	-		-	-		-	-
PA0-WKUP1	-	TIM2_CH1_ETR	TIM5_CH1	-	-	-	-	USART2_CTS	-		-	-		TIMx_IC1	EVENT OUT
PA1	-	TIM2_CH2	TIM5_CH2	-	-	-	-	USART2_RTS	-		SEG0	-		TIMx_IC2	EVENT OUT
PA2	-	TIM2_CH3	TIM5_CH3	TIM9_CH1	-	-	-	USART2_TX	-		SEG1	-		TIMx_IC3	EVENT OUT
PA3	-	TIM2_CH4	TIM5_CH4	TIM9_CH2	-	-	-	USART2_RX	-		SEG2	-		TIMx_IC4	EVENT OUT
PA4	-	-	-	-	-	SPI1_NSS	SPI3_NSS I2S3_WS	USART2_CK	-		-	-		TIMx_IC1	EVENT OUT
PA5	-	TIM2_CH1_ETR	-	-	-	SPI1_SCK	-	-	-		-	-		TIMx_IC2	EVENT OUT
PA6	-	-	TIM3_CH1	TIM10_ CH1	-	SPI1_MISO	-	-	-		SEG3	-		TIMx_IC3	EVENT OUT
PA7	-	-	TIM3_CH2	TIM11_ CH1	-	SPI1_MOSI	-	-	-		SEG4	-		TIMx_IC4	EVENT OUT
PA8	MCO	-	-	-	-	-	-	USART1_CK	-		COM0	-		TIMx_IC1	EVENT OUT
PA9	-	-	-	-	-	-	-	USART1_TX	-		COM1	-		TIMx_IC2	EVENT OUT
PA10	-	-	-	-	-	-	-	USART1_RX	-		COM2	-		TIMx_IC3	EVENT OUT
PA11	-	-	-	-	-	SPI1_MISO		USART1_CTS	-		-	-		TIMx_IC4	EVENT OUT

Table 8. Alternate function input/output (continued)

Port name	Digital alternate function number									..			..		
	AFIO0	AFIO1	AFIO2	AFIO3	AFIO4	AFIO5	AFIO6	AFIO7	AFIO8		AFIO11	AFIO12		AFIO14	AFIO15
	Alternate function														
	SYSTEM	TIM2	TIM3/4/5	TIM9/ 10/11	I2C1/2	SPI1/2	SPI3	USART1/2/3	UART4/5		LCD	FSMC/ SDIO		CPRI	SYSTEM
PD8	-	-	-	-	-	-	-	USART3_TX	-		SEG28	D13/DA13		TIMx_IC1	EVENT OUT
PD9	-	-	-	-	-	-	-	USART3_RX	-		SEG29	D14/DA14		TIMx_IC2	EVENT OUT
PD10	-	-	-	-	-	-	-	USART3_CK	-		SEG30	D15/DA15		TIMx_IC3	EVENT OUT
PD11	-	-	-	-	-	-	-	USART3_CTS	-		SEG31	A16		TIMx_IC4	EVENT OUT
PD12	-	-	TIM4_CH1	-	-	-	-	USART3_RTS	-		SEG32	A17		TIMx_IC1	EVENT OUT
PD13	-	-	TIM4_CH2	-	-	-	-	-	-		SEG33	A18		TIMx_IC2	EVENT OUT
PD14	-	-	TIM4_CH3	-	-	-	-	-	-		SEG34	D0/DA0		TIMx_IC3	EVENT OUT
PD15	-	-	TIM4_CH4	-	-	-	-	-	-		SEG35	D1/DA1		TIMx_IC4	EVENT OUT
PE0	-	-	TIM4_ETR	TIM10_CH1	-	-	-	-	-		SEG36	NBL0		TIMx_IC1	EVENT OUT
PE1	-	-	-	TIM11_CH1	-	-	-	-	-		SEG37	NBL1		TIMx_IC2	EVENT OUT
PE2	TRACECK	-	TIM3_ETR	-	-	-	-	-	-		SEG 38	A23		TIMx_IC3	EVENT OUT
PE3	TRACED0	-	TIM3_CH1	-	-	-	-	-	-		SEG 39	A19		TIMx_IC4	EVENT OUT
PE4	TRACED1	-	TIM3_CH2	-	-	-	-	-	-		-	A20		TIMx_IC1	EVENT OUT
PE5	TRACED2	-	-	TIM9_CH1	-	-	-	-	-		-	A21		TIMx_IC2	EVENT OUT
PE6-WKUP3	TRACED3	-	-	TIM9_CH2	-	-	-	-	-		-	-		TIMx_IC3	EVENT OUT

6 Electrical characteristics

6.1 Parameter conditions

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

6.1.1 Minimum and maximum values

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

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

6.1.2 Typical values

Unless otherwise specified, typical data are based on T_A = 25 °C, V_{DD} = 3.6 V (for the 1.65 V ≤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 9*.

6.1.5 Pin input voltage

The input voltage measurement on a pin of the device is described in *Figure 10*.

Figure 9. Pin loading conditions

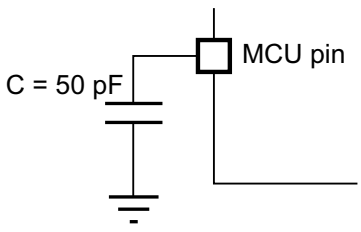


Figure 10. Pin input voltage

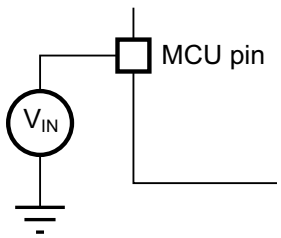


Table 21. Typical and maximum current consumptions in Stop mode (continued)

Symbol	Parameter	Conditions		Typ	Max(1)	Unit
I_{DD} (Stop)	Supply current in Stop mode (RTC disabled)	Regulator in LP mode, HSI and HSE OFF, independent watchdog and LSI enabled	T_A = -40°C to 25°C	1.6	2.2	µA
		Regulator in LP mode, LSI, HSI and HSE OFF (no independent watchdog)	T_A = -40°C to 25°C	0.475	1	
			T_A = 55°C	0.915	3	
			T_A= 85°C	3.35	9	
			T_A = 105°C	10.0	22(5)	
I_{DD} (WU from Stop)	Supply current during wakeup from Stop mode	MSI = 4.2 MHz	T_A = -40°C to 25°C	2	-	mA
		MSI = 1.05 MHz		1.45	-	
		MSI = 65 kHz(6)		1.45	-	

1. Guaranteed by characterization results, unless otherwise specified.
2. LCD enabled with external VLCD, static duty, division ratio = 256, all pixels active, no LCD connected.
3. LCD enabled with external VLCD, 1/8 duty, 1/3 bias, division ratio = 64, all pixels active, no LCD connected.
4. Based on characterization done with a 32.768 kHz crystal (MC306-G-06Q-32.768, manufacturer JFVNY) with two 6.8 pF loading capacitors.
5. Guaranteed by test in production.
6. When MSI = 64 kHz, the RMS current is measured over the first 15 µs following the wakeup event. For the remaining part of the wakeup period, the current corresponds the Run mode current.

Table 24. Low-power mode wakeup timings

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

1. Guaranteed by characterization, unless otherwise specified

6.3.6 External clock source characteristics

High-speed external user clock generated from an external source

In bypass mode the HSE oscillator is switched off and the input pin is a standard GPIO.The external clock signal has to respect the I/O characteristics in *Section 6.3.13*. However, the recommended clock input waveform is shown in *Figure 14*.

Table 25. High-speed external user clock characteristics(1)

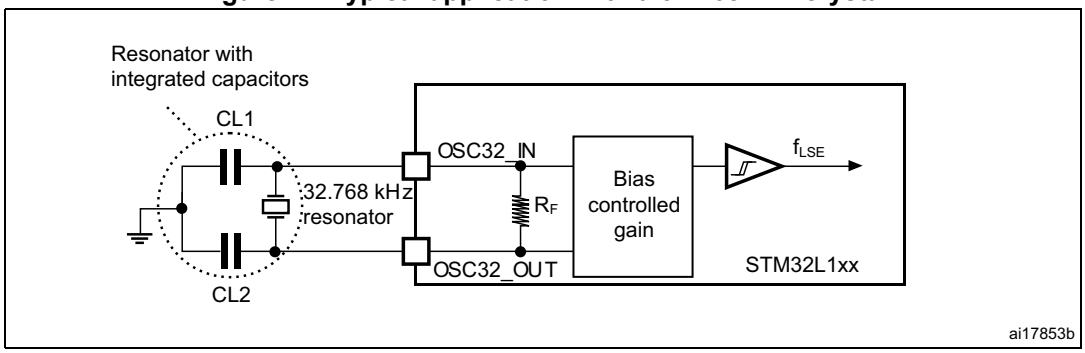
Symbol	Parameter	Conditions	Min	Typ	Max	Unit
f_{HSE_ext}	User external clock source frequency	CSS is on or PLL is used	1	8	32	MHz
		CSS is off, PLL not used	0	8	32	MHz

4. $t_{SU(LSE)}$ is the startup time measured from the moment it is enabled (by software) to a stabilized 32.768 kHz oscillation is reached. This value is measured for a standard crystal resonator and it can vary significantly with the crystal manufacturer.

Note: For C_{L1} and C_{L2}, it is recommended to use high-quality ceramic capacitors in the 5 pF to 15 pF range selected to match the requirements of the crystal or resonator (see Figure 17). C_{L1} and C_{L2}, are usually the same size. The crystal manufacturer typically specifies a load capacitance which is the series combination of C_{L1} and C_{L2}.
Load capacitance C_L has the following formula: $C_L = C_{L1} \times C_{L2} / (C_{L1} + C_{L2}) + C_{stray}$ where C_{stray} is the pin capacitance and board or trace PCB-related capacitance. Typically, it is between 2 pF and 7 pF.

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

Figure 17. Typical application with a 32.768 kHz crystal



6.3.14 I/O port characteristics

General input/output characteristics

Unless otherwise specified, the parameters given in *Table 55* are derived from tests performed under the conditions summarized in *Table 12*. All I/Os are CMOS and TTL compliant.

Table 49. I/O static characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{IL}	Input low level voltage	-	-	-	$0.3V_{DD}$ (1)	V
V_{IH}	Input high level voltage	Standard I/O	0.7 V_{DD}	-	-	
		FT I/O		-	-	
		BOOT0 I/O		-	-	
V_{hys}	I/O Schmitt trigger voltage hysteresis(2)	Standard I/O	-	10% V_{DD}(3)	-	
I_{lkg}	Input leakage current(4)	$V_{SS} \le V_{IN} \le V_{DD}$ I/Os with LCD	-	-	±50	nA
		$V_{SS} \le V_{IN} \le V_{DD}$ I/Os with analog switches	-	-	±50	
		$V_{SS} \le V_{IN} \le V_{DD}$ I/Os with analog switches and LCD	-	-	±50	
		$V_{SS} \le V_{IN} \le V_{DD}$ I/Os with USB	-	-	±250	
		$V_{SS} \le V_{IN} \le V_{DD}$ Standard I/Os	-	-	±50	
		FT I/O $V_{DD} \le V_{IN} \le 5V$	-	-	±10	uA
R_{PU}	Weak pull-up equivalent resistor(1)(5)	$V_{IN} = V_{SS}$	30	45	60	kΩ
R_{PD}	Weak pull-down equivalent resistor(5)	$V_{IN} = V_{DD}$	30	45	60	kΩ
C_{IO}	I/O pin capacitance	-	-	5	-	pF

1. Guaranteed by test in production
2. Hysteresis voltage between Schmitt trigger switching levels. Guaranteed by characterization results.
3. With a minimum of 200 mV. Guaranteed by characterization results.
4. The max. value may be exceeded if negative current is injected on adjacent pins.
5. Pull-up and pull-down resistors are designed with a true resistance in series with a switchable PMOS/NMOS.

Output driving current

The GPIOs (general purpose input/outputs) can sink or source up to ±8 mA, and sink or source up to ±20 mA with the non-standard V_{OL}/V_{OH} specifications given in *Table 50*.

In the user application, the number of I/O pins which can drive current must be limited to respect the absolute maximum rating specified in *Section 6.2*:

- The sum of the currents sourced by all the I/Os on $V_{DD,}$ plus the maximum Run consumption of the MCU sourced on $V_{DD,}$ cannot exceed the absolute maximum rating $I_{VDD(\Sigma)}$ (see *Table 10*).
- The sum of the currents sunk by all the I/Os on V_{SS} plus the maximum Run consumption of the MCU sunk on V_{SS} cannot exceed the absolute maximum rating $I_{VSS(\Sigma)}$ (see *Table 10*).

Output voltage levels

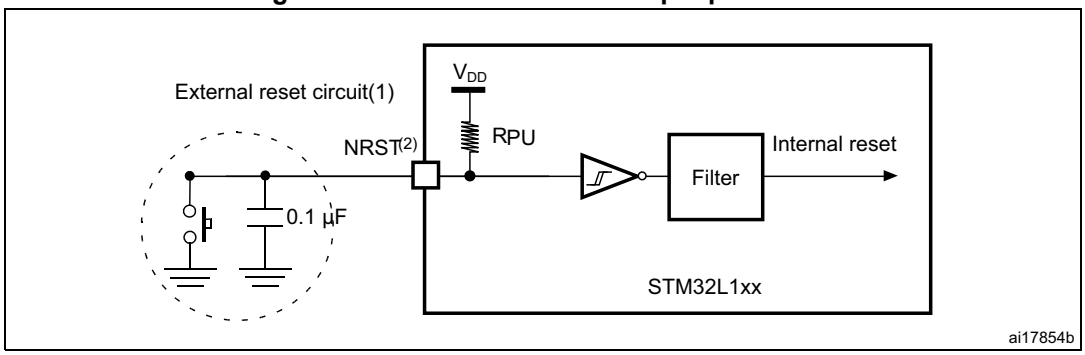
Unless otherwise specified, the parameters given in *Table 50* are derived from tests performed under the conditions summarized in *Table 12*. All I/Os are CMOS and TTL compliant.

Table 50. Output voltage characteristics

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

1. The I_{IO} current sunk by the device must always respect the absolute maximum rating specified in *Table 10* and the sum of I_{IO} (I/O ports and control pins) must not exceed I_{VSS}.
2. Guaranteed by test in production.
3. The I_{IO} current sourced by the device must always respect the absolute maximum rating specified in *Table 10* and the sum of I_{IO} (I/O ports and control pins) must not exceed I_{VDD}.
4. Guaranteed by characterization results.

Figure 27. Recommended NRST pin protection



1. The reset network protects the device against parasitic resets.
2. The user must ensure that the level on the NRST pin can go below the $V_{IL(NRST)}$ max level specified in *Table 52*. Otherwise the reset will not be taken into account by the device.

6.3.16 TIM timer characteristics

The parameters given in the *Table 53* are guaranteed by design.

Refer to *Section 6.3.14: I/O port characteristics* for details on the input/output ction characteristics (output compare, input capture, external clock, PWM output).

Table 53. TIMx(1) characteristics

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

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

6.3.18 SDIO characteristics

Table 61. SDIO characteristics(1)

Symbol	Parameter	Conditions	Min	Max	Unit
f_{PP}	Clock frequency in data transfer mode	CL ≤30 pF	0	24	MHz
$t_{W(CKL)}$	Clock low time, f_{PP} = 24 MHz	CL ≤30 pF	20(2)	-	ns
$t_{W(CKH)}$	Clock high time, f_{PP} = 24 MHz	CL ≤30 pF	18(2)	-	
t_r	Clock rise time, f_{PP} = 24 MHz	CL ≤30 pF	-	5	
t_f	Clock fall time, f_{PP} = 24 MHz	CL ≤30 pF	-	5	
CMD, D inputs (referenced to CK) in SD default mode					
-			From 2.8 to 3.6 V	-	-
t_{ISU}	Input setup time, f_{PP} = 24 MHz	CL ≤30 pF	2	-	ns
t_{IH}	Input hold time, f_{PP} = 24 MHz	CL ≤30 pF	1.6	-	
CMD, D outputs (referenced to CK) in SD default mode					
t_{OVD}	Output valid default time, f_{PP} = 24 MHz	CL ≤30 pF	0	14	ns
t_{OHD}	Output hold default time, f_{PP} = 24 MHz	CL ≤30 pF	0	-	

1. Guaranteed by characterization results.
2. Values measured with a threshold level equal to $V_{DD}/2$.

Figure 35. SDIO timings

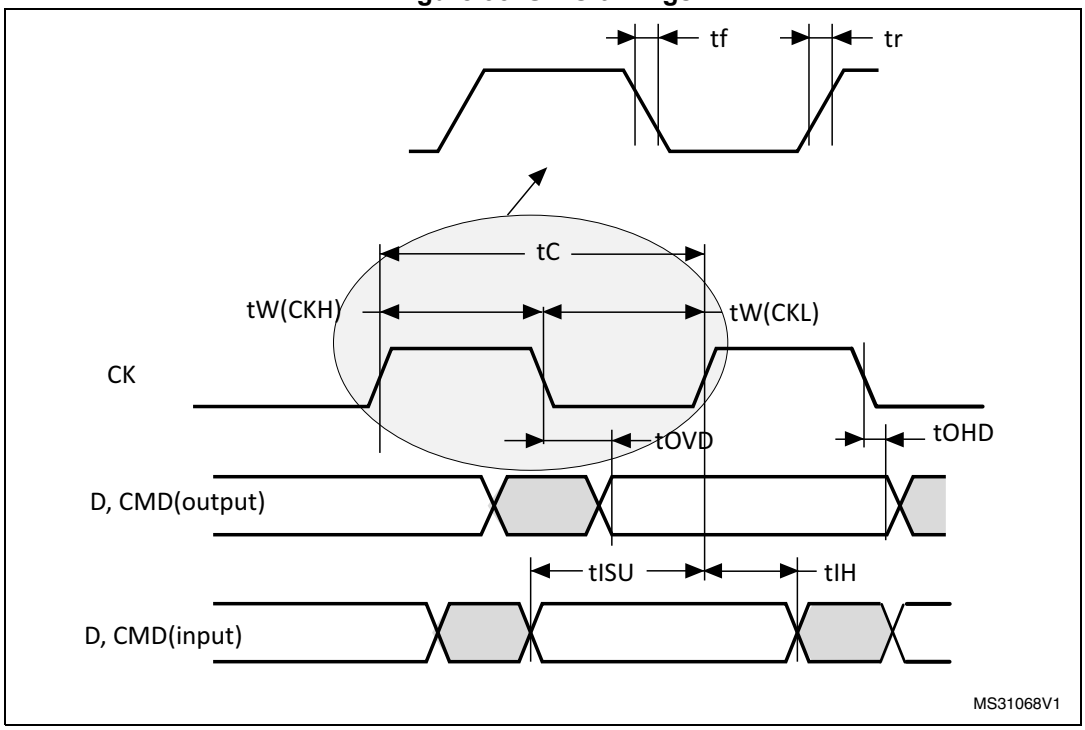
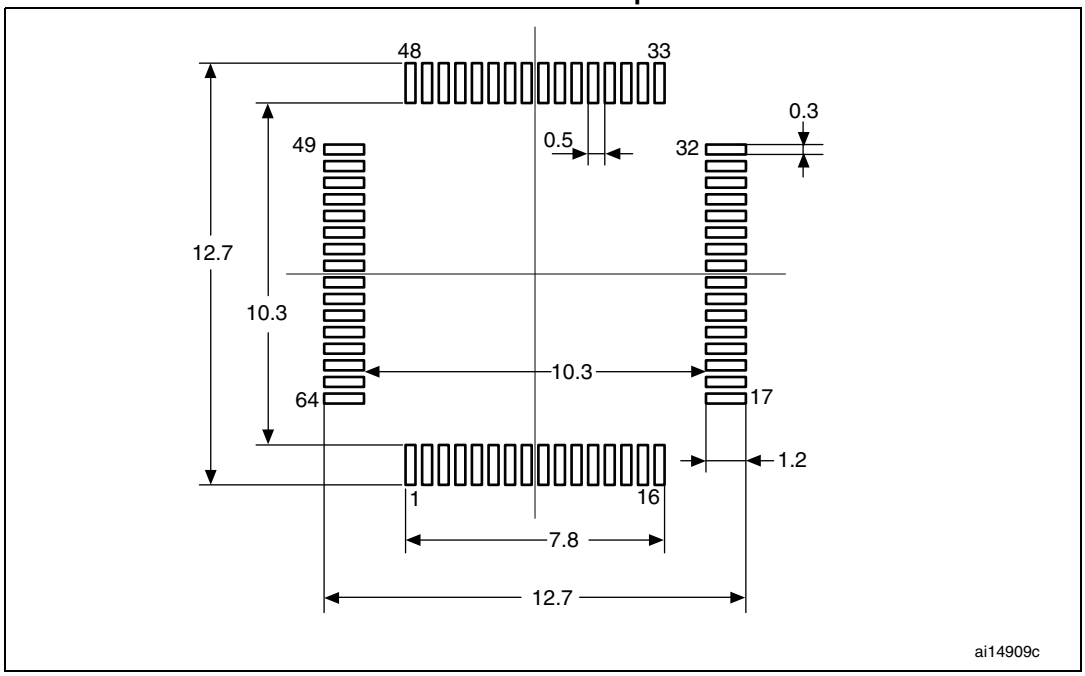


Table 75. LQFP64, 10 x 10 mm 64-pin low-profile quad flat package mechanical data (continued)

Symbol	millimeters			inches[1]		
	Min	Typ	Max	Min	Typ	Max
E3	-	7.500	-	-	0.2953	-
e	-	0.500	-	-	0.0197	-
K	0°	3.5°	7°	0°	3.5°	7°
L	0.450	0.600	0.750	0.0177	0.0236	0.0295
L1	-	1.000	-	-	0.0394	-
ccc	-	-	0.080	-	-	0.0031

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

Figure 47. LQFP64, 10 x 10 mm, 64-pin low-profile quad flat package recommended footprint



1. Dimensions are in millimeters.

Table 81. Document revision history (continued)

Date	Revision	Changes
13-June-2014	5 (continued)	Added V_{DD}= 1.71 to 1.8 V operating power supply range in *Table 2: Functionalities depending on the operating power supply range* Updated “SDA data hold time” and “SDA and SCL rise time” values and added “Pulse width of spikes that are suppressed by the analog filter” row in *Table 54: I2C characteristics*. Added Input Voltage in *Table 12: General operating conditions*. Modified t_{LOCK} values in *Table 32: PLL characteristics*. Updated *Table 49: I/O static characteristics*. Updated conditions in *Table 50: Output voltage characteristics*. Removed minimum values for f_S in *Table 63: ADC characteristics*. Updated *Figure 37: Typical connection diagram using the ADC*. Updated *Table 68: Temperature sensor calibration values*. Removed figures “Power supply and reference decoupling (V_{REF+} not connected to V_{DDA}) and “Power supply and reference decoupling(V_{REF+} connected to V_{DDA}).Removed note 4 in *Table 69: Temperature sensor characteristics*. Updated *Table 66: DAC characteristics* Added *Table 50: UFBGA132, 7 x 7 mm, 132-ball ultra thin, fine-pitch ball grid array package recommended footprint*.. Updated the conditions in *Table 24: Low-power mode wakeup timings*. Removed ambiguity of “ambient temperature” in the electrical characteristics description.
23-Oct-2014	6	Updated *Section 3.19: Communication interfaces* putting I2S characteristics inside. Updated DMIPS features in cover page and *Section 2: Description*. Updated max temperature at 105°C instead of 85°C in the whole datasheet. Updated current consumption in *Table 18: Current consumption in Sleep mode*. Updated *Table 23: Peripheral current consumption* with new measured current values. Updated *Table 65: Maximum source impedance RAIN max* adding note 2.
06-Feb-2015	7	Updated *Section 7: Package information* with new package device marking. Updated *Figure 8: Memory map*.