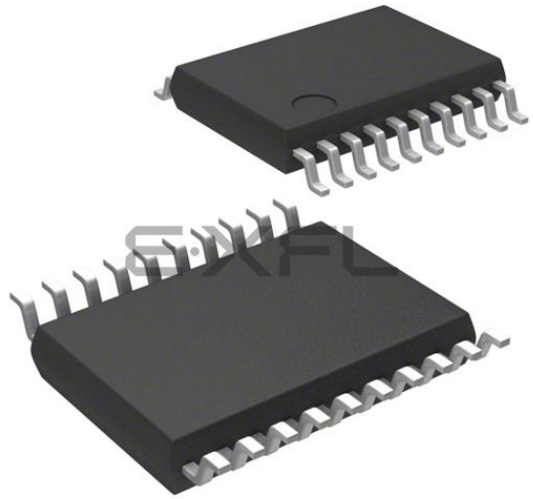

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What is "Embedded - Microcontrollers"?

"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®-M0
Core Size	32-Bit Single-Core
Speed	48MHz
Connectivity	I²C, IrDA, LINbus, SPI, UART/USART
Peripherals	DMA, I²S, POR, PWM, WDT
Number of I/O	15
Program Memory Size	16KB (16K x 8)
Program Memory Type	FLASH
EEPROM Size	-
RAM Size	4K x 8
Voltage - Supply (Vcc/Vdd)	2V ~ 3.6V
Data Converters	A/D 12x12b
Oscillator Type	Internal
Operating Temperature	-40°C ~ 85°C (TA)
Mounting Type	Surface Mount
Package / Case	20-TSSOP (0.173", 4.40mm Width)
Supplier Device Package	20-TSSOP
Purchase URL	https://www.e-xfl.com/product-detail/stmicroelectronics/stm32f031f4p6

List of tables

2 Description

The STM32F031x4/x6 microcontrollers incorporate the high-performance ARM® Cortex®-M0 32-bit RISC core operating at up to 48 MHz frequency, high-speed embedded memories (up to 32 Kbytes of Flash memory and 4 Kbytes of SRAM), and an extensive range of enhanced peripherals and I/Os. All devices offer standard communication interfaces (one I^2C, one SPI/ I^2S and one USART), one 12-bit ADC,
five 16-bit timers, one 32-bit timer and an advanced-control PWM timer.

The STM32F031x4/x6 microcontrollers operate in the -40 to +85 °C and -40 to +105 °C temperature ranges, from a 2.0 to 3.6 V power supply. A comprehensive set of power-saving modes allows the design of low-power applications.

The STM32F031x4/x6 microcontrollers include devices in six different packages ranging from 20 pins to 48 pins with a die form also available upon request. Depending on the device chosen, different sets of peripherals are included.

These features make the STM32F031x4/x6 microcontrollers suitable for a wide range of applications such as application control and user interfaces, hand-held equipment, A/V receivers and digital TV, PC peripherals, gaming and GPS platforms, industrial applications, PLCs, inverters, printers, scanners, alarm systems, video intercoms and HVACs.

Table 2. STM32F031x4/x6 family device features and peripheral counts

Peripheral		STM32F031Fx		STM32F031Ex	STM32F031Gx		STM32F031Kx		STM32F031Cx	
Flash memory (Kbyte)		16	32	32	16	32	16	32	16	32
SRAM (Kbyte)		4								
Timers	Advanced control	1 (16-bit)								
	General purpose	4 (16-bit) 1 (32-bit)								
Comm. interfaces	SPI [I^2S](1)	1 [1]								
	I^2C	1								
	USART	1								
12-bit ADC (number of channels)		1 (9 ext. + 3 int.)		1 (10 ext. + 3 int.)						
GPIOs		15		20	23		25 (on LQFP32) 27 (on UFQFPN32)		39	
Max. CPU frequency		48 MHz								
Operating voltage		2.0 to 3.6 V								
Operating temperature		Ambient operating temperature: -40°C to 85°C / -40°C to 105°C Junction temperature: -40°C to 105°C / -40°C to 125°C								
Packages		TSSOP20		WLCSP25	UFQFPN28		LQFP32 UFQFPN32		LQFP48	

1. The SPI interface can be used either in SPI mode or in I^2S audio mode.

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

3.10.1 Temperature sensor

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

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

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

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

Table 3. Temperature sensor calibration values

Calibration value name	Description	Memory address
TS_CAL1	TS ADC raw data acquired at a temperature of 30 °C (± 5 °C), V_{DDA}= 3.3 V (± 10 mV)	0x1FFF F7B8 - 0x1FFF F7B9
TS_CAL2	TS ADC raw data acquired at a temperature of 110 °C (± 5 °C), V_{DDA}= 3.3 V (± 10 mV)	0x1FFF F7C2 - 0x1FFF F7C3

3.10.2 Internal voltage reference (V_{REFINT})

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

Table 4. Internal voltage reference calibration values

Calibration value name	Description	Memory address
VREFINT_CAL	Raw data acquired at a temperature of 30 °C (± 5 °C), V_{DDA}= 3.3 V (± 10 mV)	0x1FFF F7BA - 0x1FFF F7BB

3.10.3 V_{BAT} battery voltage monitoring

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

3.11 Timers and watchdogs

The STM32F031x4/x6 devices include up to five general-purpose timers and an advanced control timer.

Table 5 compares the features of the different timers.

Table 5. Timer feature comparison

Timer type	Timer	Counter resolution	Counter type	Prescaler factor	DMA request generation	Capture/compare channels	Complementary outputs
Advanced control	TIM1	16-bit	Up, down, up/down	integer from 1 to 65536	Yes	4	3
General purpose	TIM2	32-bit	Up, down, up/down	integer from 1 to 65536	Yes	4	-
	TIM3	16-bit	Up, down, up/down	integer from 1 to 65536	Yes	4	-
	TIM14	16-bit	Up	integer from 1 to 65536	No	1	-
	TIM16 TIM17	16-bit	Up	integer from 1 to 65536	Yes	1	1

3.11.1 Advanced-control timer (TIM1)

The advanced-control timer (TIM1) can be seen as a three-phase PWM multiplexed on six channels. It has complementary PWM outputs with programmable inserted dead times. It can also be seen as a complete general-purpose timer. The four independent channels can be used for:

- input capture
- output compare
- PWM generation (edge or center-aligned modes)
- one-pulse mode output

If configured as a standard 16-bit timer, it has the same features as the TIMx timer. If configured as the 16-bit PWM generator, it has full modulation capability (0-100%).

The counter can be frozen in debug mode.

Many features are shared with those of the standard timers which have the same architecture. The advanced control timer can therefore work together with the other timers via the Timer Link feature for synchronization or event chaining.

3.11.2 General-purpose timers (TIM2, 3, 14, 16, 17)

There are five synchronizable general-purpose timers embedded in the STM32F031x4/x6 devices (see *Table 5* for differences). Each general-purpose timer can be used to generate PWM outputs, or as simple time base.

Figure 5. UFQFPN32 package pinout

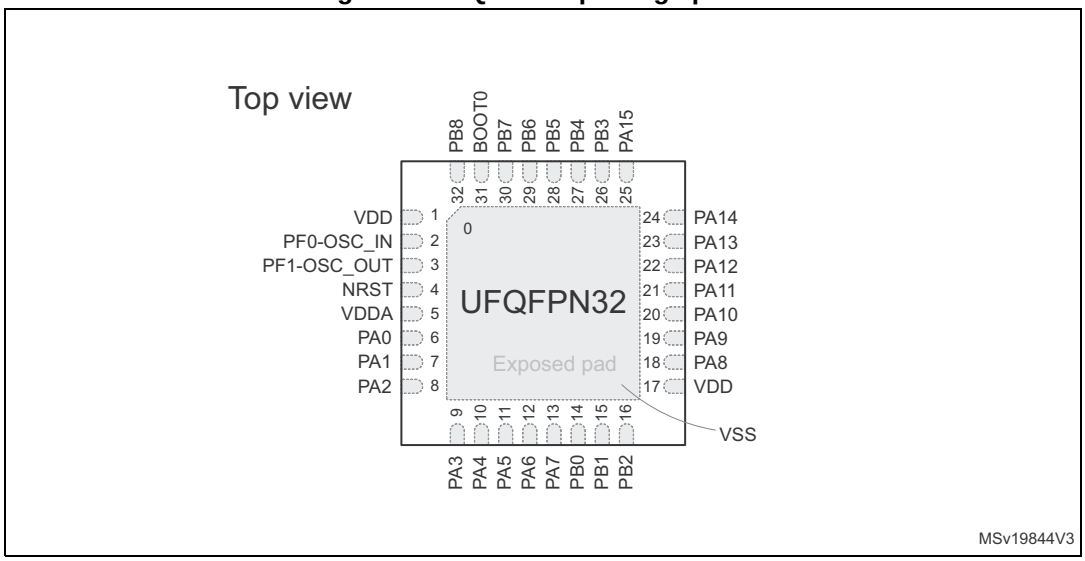


Figure 6. UFQFPN28 package pinout

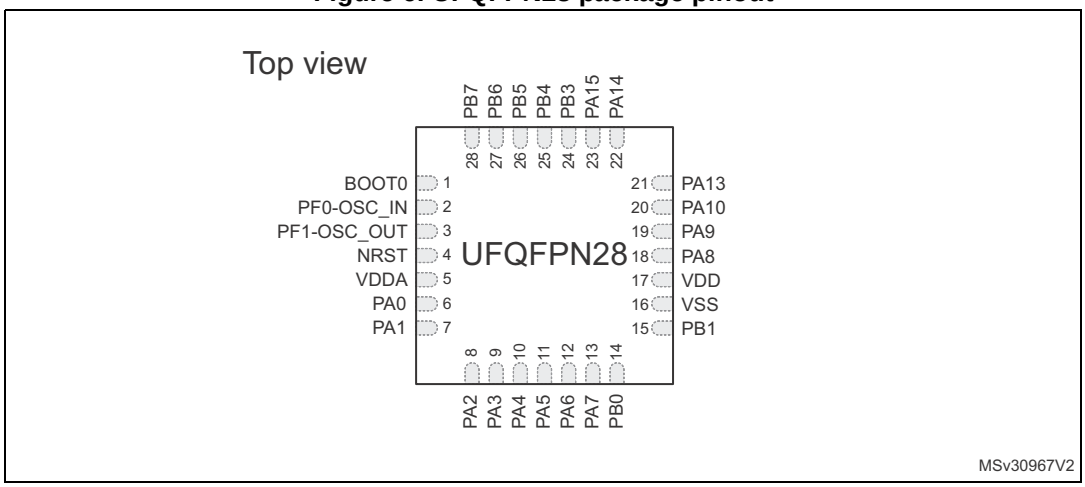
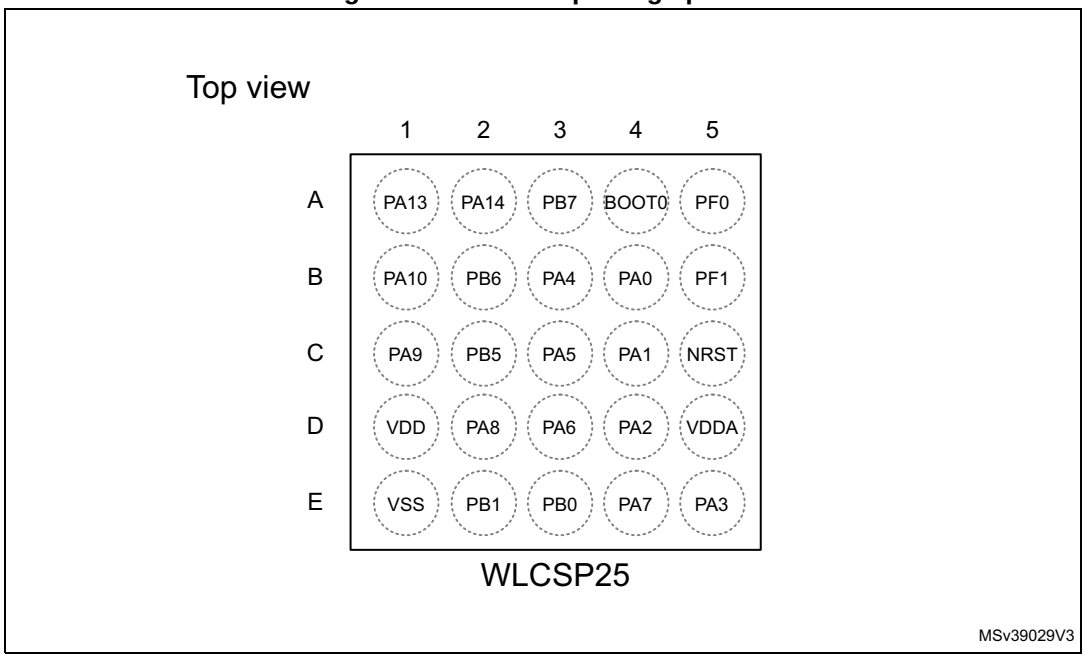


Figure 7. WLCSP25 package pinout



1. The above figure shows the package in top view, changing from bottom view in the previous document versions.

Figure 8. TSSOP20 package pinout

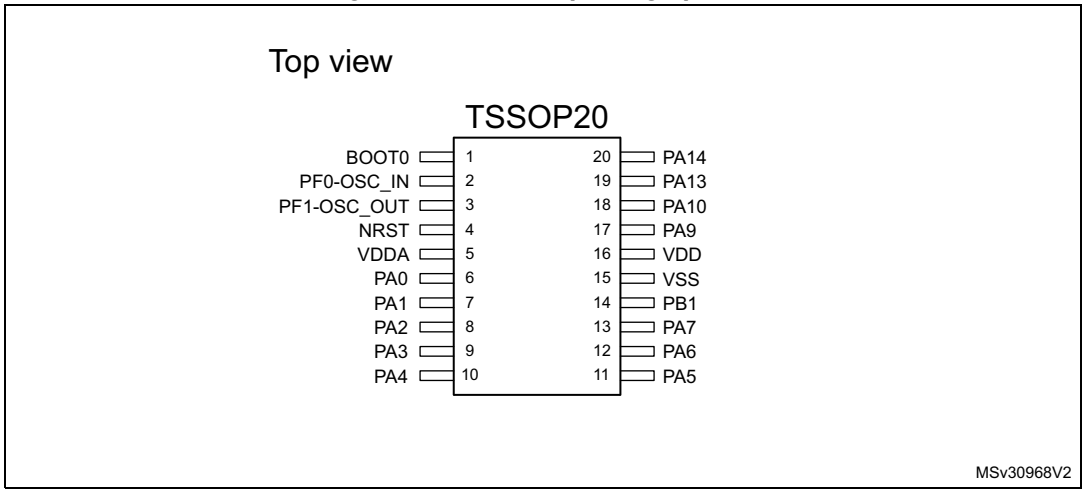


Table 11. Pin definitions (continued)

Pin number						Pin name (function upon reset)	Pin type	I/O structure	Notes	Pin functions	
LQFP48	LQFP32	UFQFPN32	UFQFPN28	WLCSP25	TSSOP20					Alternate functions	Additional functions
17	13	13	13	E4	13	PA7	I/O	TTa	-	SPI1_MOSI, I2S1_SD, TIM3_CH2, TIM14_CH1, TIM1_CH1N, TIM17_CH1, EVENTOUT	ADC_IN7
18	14	14	14	E3	-	PB0	I/O	TTa	-	TIM3_CH3, TIM1_CH2N, EVENTOUT	ADC_IN8
19	15	15	15	E2	14	PB1	I/O	TTa	-	TIM3_CH4, TIM14_CH1, TIM1_CH3N	ADC_IN9
20	-	16	-	-	-	PB2	I/O	FT	(4)	-	-
21	-	-	-	-	-	PB10	I/O	FTf	-	TIM2_CH3, I2C1_SCL	-
22	-	-	-	-	-	PB11	I/O	FTf	-	TIM2_CH4, EVENTOUT, I2C1_SDA	-
23	16	0	16	E1	15	VSS	S	-	-	Ground	
24	17	17	17	D1	16	VDD	S	-	-	Digital power supply	
25	-	-	-	-	-	PB12	I/O	FT	-	TIM1_BKIN, EVENTOUT, SPI1_NSS	-
26	-	-	-	-	-	PB13	I/O	FT	-	TIM1_CH1N, SPI1_SCK	-
27	-	-	-	-	-	PB14	I/O	FT	-	TIM1_CH2N, SPI1_MISO	-
28	-	-	-	-	-	PB15	I/O	FT	-	TIM1_CH3N, SPI1_MOSI	RTC_REFIN
29	18	18	18	D2	-	PA8	I/O	FT	-	USART1_CK, TIM1_CH1, EVENTOUT, MCO	-

Table 12. Alternate functions selected through GPIOA_AFR registers for port A

Pin name	AF0	AF1	AF2	AF3	AF4	AF5	AF6	AF7
PA0	-	USART1_CTS	TIM2_CH1_ ETR	-	-	-	-	-
PA1	EVENTOUT	USART1_RTS	TIM2_CH2	-	-	-	-	-
PA2	-	USART1_TX	TIM2_CH3	-	-	-	-	-
PA3	-	USART1_RX	TIM2_CH4	-	-	-	-	-
PA4	SPI1_NSS, I2S1_WS	USART1_CK	-	-	TIM14_CH1	-	-	-
PA5	SPI1_SCK, I2S1_CK	-	TIM2_CH1_ ETR	-	-	-	-	-
PA6	SPI1_MISO, I2S1_MCK	TIM3_CH1	TIM1_BKIN	-	-	TIM16_CH1	EVENTOUT	-
PA7	SPI1_MOSI, I2S1_SD	TIM3_CH2	TIM1_CH1N	-	TIM14_CH1	TIM17_CH1	EVENTOUT	-
PA8	MCO	USART1_CK	TIM1_CH1	EVENTOUT	-	-	-	-
PA9	-	USART1_TX	TIM1_CH2	-	I2C1_SCL	-	-	-
PA10	TIM17_BKIN	USART1_RX	TIM1_CH3	-	I2C1_SDA	-	-	-
PA11	EVENTOUT	USART1_CTS	TIM1_CH4	-	-	-	-	-
PA12	EVENTOUT	USART1_RTS	TIM1_ETR	-	-	-	-	-
PA13	SWDIO	IR_OUT	-	-	-	-	-	-
PA14	SWCLK	USART1_TX	-	-	-	-	-	-
PA15	SPI1_NSS, I2S1_WS	USART1_RX	TIM2_CH1_ ETR	EVENTOUT	-	-	-	-

Table 23. Typical and maximum current consumption from V_{DD} at 3.6 V (continued)

Symbol	Parameter	Conditions	f_{HCLK}	All peripherals enabled				All peripherals disabled				Unit
				Typ	Max @ T_A(1)			Typ	Max @ T_A(1)			
					25 °C	85 °C	105 °C		25 °C	85 °C	105 °C	
I_{DD}	Supply current in Sleep mode	HSE bypass, PLL on	48 MHz	10.7	11.7(2)	11.9	12.5(2)	2.4	2.6(2)	2.7	2.9(2)	mA
			32 MHz	7.1	7.8	8.1	8.2	1.6	1.7	1.9	1.9	
			24 MHz	5.5	6.3	6.4	6.4	1.3	1.4	1.5	1.5	
		HSE bypass, PLL off	8 MHz	1.8	2.0	2.0	2.1	0.4	0.4	0.5	0.5	
			1 MHz	0.2	0.5	0.5	0.5	0.1	0.1	0.1	0.1	
		HSI clock, PLL on	48 MHz	10.8	11.9	12.1	12.6	2.4	2.7	2.7	2.9	
			32 MHz	7.3	8.0	8.4	8.5	1.7	1.9	1.9	2.0	
			24 MHz	5.5	6.2	6.5	6.5	1.3	1.5	1.5	1.6	
		HSI clock, PLL off	8 MHz	1.9	2.2	2.3	2.4	0.5	0.5	0.5	0.6	

1. Data based on characterization results, not tested in production unless otherwise specified.
2. Data based on characterization results and tested in production (using one common test limit for sum of I_{DD} and I_{DDA}).

Table 24. Typical and maximum current consumption from the V_{DDA} supply

Symbol	Parameter	Conditions (1)	f_{HCLK}	V_{DDA} = 2.4 V				V_{DDA} = 3.6 V				Unit
				Typ	Max @ T_A(2)			Typ	Max @ T_A(2)			
					25 °C	85 °C	105 °C		25 °C	85 °C	105 °C	
I_{DDA}	Supply current in Run or Sleep mode, code executing from Flash memory or RAM	HSE bypass, PLL on	48 MHz	150	170(3)	178	182(3)	164	183(3)	195	198(3)	µA
			32 MHz	104	121	126	128	113	129	135	138	
			24 MHz	82	96	100	103	88	102	106	108	
		HSE bypass, PLL off	8 MHz	2.0	2.7	3.1	3.3	3.5	3.8	4.1	4.4	
			1 MHz	2.0	2.7	3.1	3.3	3.5	3.8	4.1	4.4	
		HSI clock, PLL on	48 MHz	220	240	248	252	244	263	275	278	
			32 MHz	174	191	196	198	193	209	215	218	
			24 MHz	152	167	173	174	168	183	190	192	
		HSI clock, PLL off	8 MHz	72	79	82	83	83.5	91	94	95	

1. Current consumption from the V_{DDA} supply is independent of whether the digital peripherals are enabled or disabled, being in Run or Sleep mode or executing from Flash memory or RAM. Furthermore, when the PLL is off, I_{DDA} is independent of clock frequencies.
2. Data based on characterization results, not tested in production unless otherwise specified.
3. Data based on characterization results and tested in production (using one common test limit for sum of I_{DD} and I_{DDA}).

trigger circuits used to discriminate the input value. Unless this specific configuration is required by the application, this supply current consumption can be avoided by configuring these I/Os in analog mode. This is notably the case of ADC input pins which should be configured as analog inputs.

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

I/O dynamic current consumption

In addition to the internal peripheral current consumption measured previously (see *Table 29: Peripheral current consumption*), the I/Os used by an application also contribute to the current consumption. When an I/O pin switches, it uses the current from the I/O supply voltage to supply the I/O pin circuitry and to charge/discharge the capacitive load (internal or external) connected to the pin:

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

where

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

V_{DDIOx} is the I/O supply voltage

f_{SW} is the I/O switching frequency

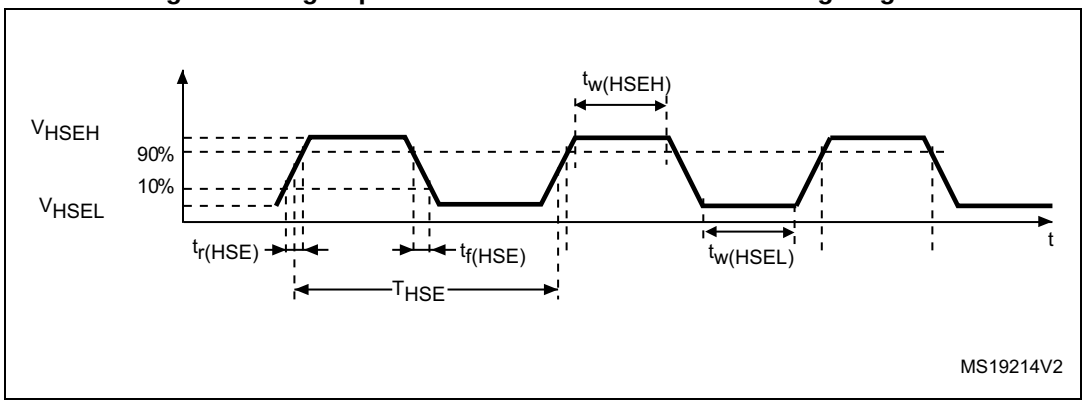
C is the total capacitance seen by the I/O pin: $C = C_{INT} + C_{EXT} + C_S$

C_S is the PCB board capacitance including the pad pin.

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

1. Guaranteed by design, not tested in production.

Figure 14. High-speed external clock source AC timing diagram



Low-speed external user clock generated from an external source

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

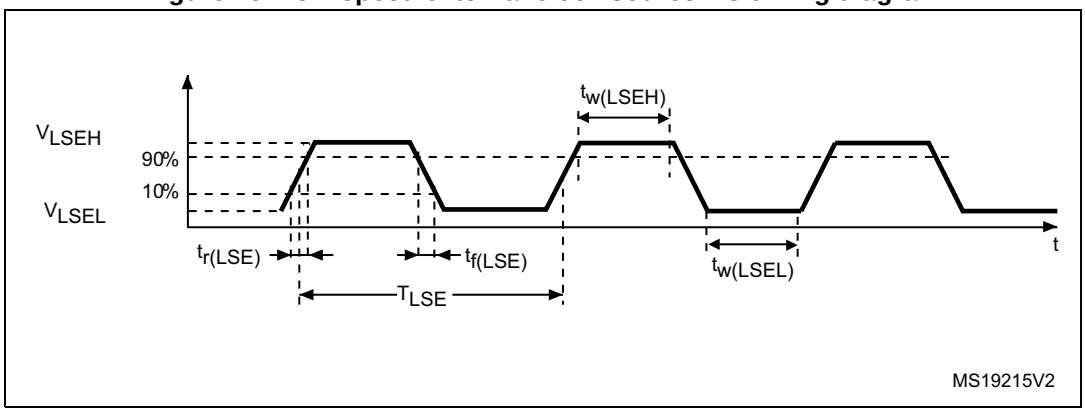
The external clock signal has to respect the I/O characteristics in *Section 6.3.14*. However, the recommended clock input waveform is shown in *Figure 15*.

Table 32. Low-speed external user clock characteristics

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

1. Guaranteed by design, not tested in production.

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



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

The high-speed external (HSE) clock can be supplied with a 4 to 32 MHz crystal/ceramic resonator oscillator. All the information given in this paragraph are based on design simulation results obtained with typical external components specified in *Table 33*. In the application, the resonator and the load capacitors have to be placed as close as possible to the oscillator pins in order to minimize output distortion and startup stabilization time. Refer to the crystal resonator manufacturer for more details on the resonator characteristics (frequency, package, accuracy).

Table 33. HSE oscillator characteristics

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

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

For C_{L1} and C_{L2}, it is recommended to use high-quality external ceramic capacitors in the 5 pF to 20 pF range (Typ.), designed for high-frequency applications, and selected to match the requirements of the crystal or resonator (see *Figure 16*). C_{L1} and C_{L2} are usually the same size. The crystal manufacturer typically specifies a load capacitance which is the series combination of C_{L1} and C_{L2}. PCB and MCU pin capacitance must be included (10 pF can be used as a rough estimate of the combined pin and board capacitance) when sizing C_{L1} and C_{L2}.

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

Low-speed internal (LSI) RC oscillator

Table 37. LSI oscillator characteristics(1)

Symbol	Parameter	Min	Typ	Max	Unit
f_{LSI}	Frequency	30	40	50	kHz
$t_{su(LSI)}$(2)	LSI oscillator startup time	-	-	85	µs
$I_{DDA(LSI)}$(2)	LSI oscillator power consumption	-	0.75	1.2	µA

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

6.3.9 PLL characteristics

The parameters given in *Table 38* are derived from tests performed under ambient temperature and supply voltage conditions summarized in *Table 18: General operating conditions*.

Table 38. PLL characteristics

Symbol	Parameter	Value			Unit
		Min	Typ	Max	
f_{PLL_IN}	PLL input clock(1)	1(2)	8.0	24(2)	MHz
	PLL input clock duty cycle	40(2)	-	60(2)	%
f_{PLL_OUT}	PLL multiplier output clock	16(2)	-	48	MHz
t_{LOCK}	PLL lock time	-	-	200(2)	µs
$Jitter_{PLL}$	Cycle-to-cycle jitter	-	-	300(2)	ps

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

6.3.10 Memory characteristics

Flash memory

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

Table 39. Flash memory characteristics

Symbol	Parameter	Conditions	Min	Typ	Max(1)	Unit
t_{prog}	16-bit programming time	T_A = - 40 to +105 °C	40	53.5	60	µs
t_{ERASE}	Page (1 KB) erase time	T_A = - 40 to +105 °C	20	-	40	ms
t_{ME}	Mass erase time	T_A = - 40 to +105 °C	20	-	40	ms
I_{DD}	Supply current	Write mode	-	-	10	mA
		Erase mode	-	-	12	mA

1. Guaranteed by design, not tested in production.

Table 58. I²C analog filter characteristics(1)

Symbol	Parameter	Min	Max	Unit
t_{AF}	Maximum width of spikes that are suppressed by the analog filter	50(2)	260(3)	ns

1. Guaranteed by design, not tested in production.
2. Spikes with widths below $t_{AF(min)}$ are filtered.
3. Spikes with widths above $t_{AF(max)}$ are not filtered

SPI/I²S characteristics

Unless otherwise specified, the parameters given in *Table 59* for SPI or in *Table 60* for I²S are derived from tests performed under the ambient temperature, f_{PCLKx} frequency and supply voltage conditions summarized in *Table 18: General operating conditions*.

Refer to *Section 6.3.14: I/O port characteristics* for more details on the input/output alternate function characteristics (NSS, SCK, MOSI, MISO for SPI and WS, CK, SD for I²S).

Table 59. SPI characteristics(1)

Symbol	Parameter	Conditions	Min	Max	Unit
f_{SCK} $1/t_{c(SCK)}$	SPI clock frequency	Master mode	-	18	MHz
		Slave mode	-	18	
$t_{r(SCK)}$ $t_{f(SCK)}$	SPI clock rise and fall time	Capacitive load: C = 15 pF	-	6	ns
$t_{su(NSS)}$	NSS setup time	Slave mode	4Tpclk	-	ns
$t_{h(NSS)}$	NSS hold time	Slave mode	2Tpclk + 10	-	
$t_{w(SCKH)}$ $t_{w(SCKL)}$	SCK high and low time	Master mode, f_{PCLK} = 36 MHz, presc = 4	Tpclk/2 -2	Tpclk/2 + 1	
$t_{su(MI)}$ $t_{su(SI)}$	Data input setup time	Master mode	4	-	
		Slave mode	5	-	
$t_{h(MI)}$	Data input hold time	Master mode	4	-	
$t_{h(SI)}$		Slave mode	5	-	
$t_{a(SO)}$(2)	Data output access time	Slave mode, f_{PCLK} = 20 MHz	0	3Tpclk	
$t_{dis(SO)}$(3)	Data output disable time	Slave mode	0	18	
$t_{v(SO)}$	Data output valid time	Slave mode (after enable edge)	-	22.5	
$t_{v(MO)}$	Data output valid time	Master mode (after enable edge)	-	6	
$t_{h(SO)}$	Data output hold time	Slave mode (after enable edge)	11.5	-	
$t_{h(MO)}$		Master mode (after enable edge)	2	-	
DuCy(SCK)	SPI slave input clock duty cycle	Slave mode	25	75	%

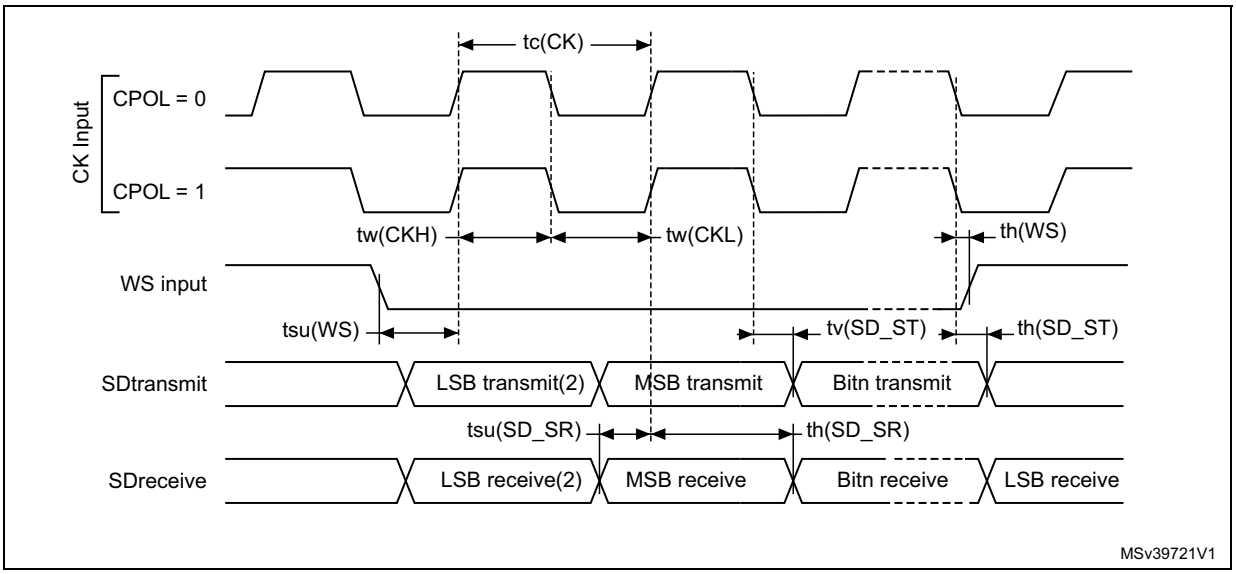
1. Data based on characterization results, not tested in production.
2. Min time is for the minimum time to drive the output and the max time is for the maximum time to validate the data.
3. Min time is for the minimum time to invalidate the output and the max time is for the maximum time to put the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

Table 60. I²S characteristics(1) (continued)

Symbol	Parameter	Conditions	Min	Max	Unit
$t_{su(SD\_MR)}$	Data input setup time	Master receiver	6	-	ns
$t_{su(SD\_SR)}$		Slave receiver	2	-	
$t_{h(SD\_MR)}$(2)	Data input hold time	Master receiver	4	-	
$t_{h(SD\_SR)}$(2)		Slave receiver	0.5	-	
$t_{v(SD\_MT)}$(2)	Data output valid time	Master transmitter	-	4	
$t_{v(SD\_ST)}$(2)		Slave transmitter	-	20	
$t_{h(SD\_MT)}$	Data output hold time	Master transmitter	0	-	
$t_{h(SD\_ST)}$		Slave transmitter	13	-	

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

Figure 29. I²S slave timing diagram (Philips protocol)



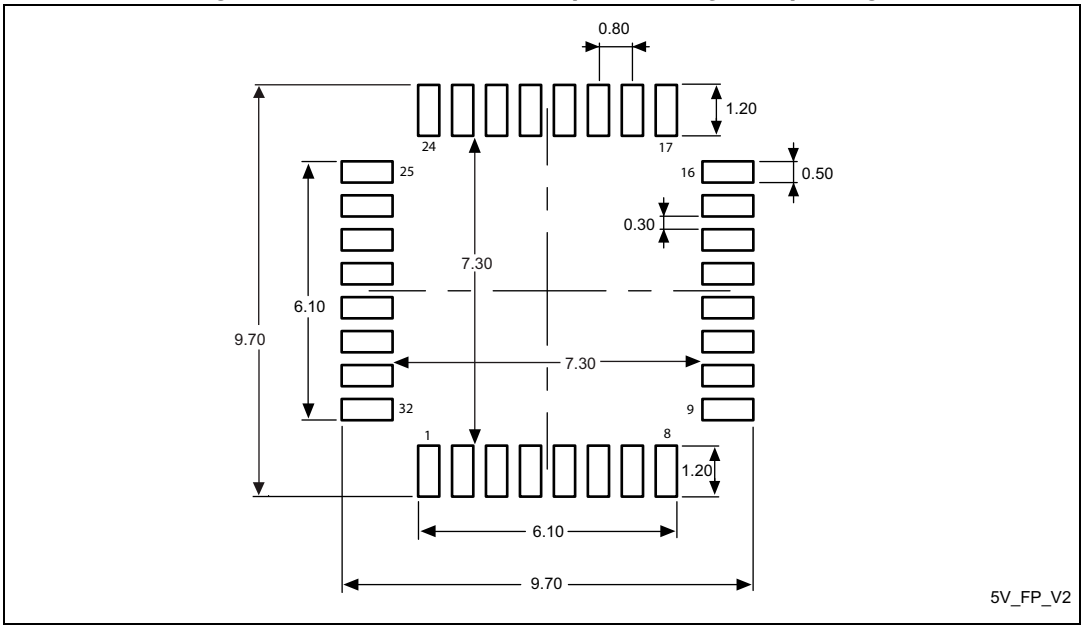
1. Measurement points are done at CMOS levels: 0.3 × V_{DDIOx} and 0.7 × V_{DDIOx}.
2. LSB transmit/receive of the previously transmitted byte. No LSB transmit/receive is sent before the first byte.

Table 62. LQFP32 package mechanical data

Symbol	millimeters			inches[1]		
	Min	Typ	Max	Min	Typ	Max
A	-	-	1.600	-	-	0.0630
A1	0.050	-	0.150	0.0020	-	0.0059
A2	1.350	1.400	1.450	0.0531	0.0551	0.0571
b	0.300	0.370	0.450	0.0118	0.0146	0.0177
c	0.090	-	0.200	0.0035	-	0.0079
D	8.800	9.000	9.200	0.3465	0.3543	0.3622
D1	6.800	7.000	7.200	0.2677	0.2756	0.2835
D3	-	5.600	-	-	0.2205	-
E	8.800	9.000	9.200	0.3465	0.3543	0.3622
E1	6.800	7.000	7.200	0.2677	0.2756	0.2835
E3	-	5.600	-	-	0.2205	-
e	-	0.800	-	-	0.0315	-
L	0.450	0.600	0.750	0.0177	0.0236	0.0295
L1	-	1.000	-	-	0.0394	-
k	0°	3.5°	7°	0°	3.5°	7°
ccc	-	-	0.100	-	-	0.0039

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

Figure 35. Recommended footprint for LQFP32 package



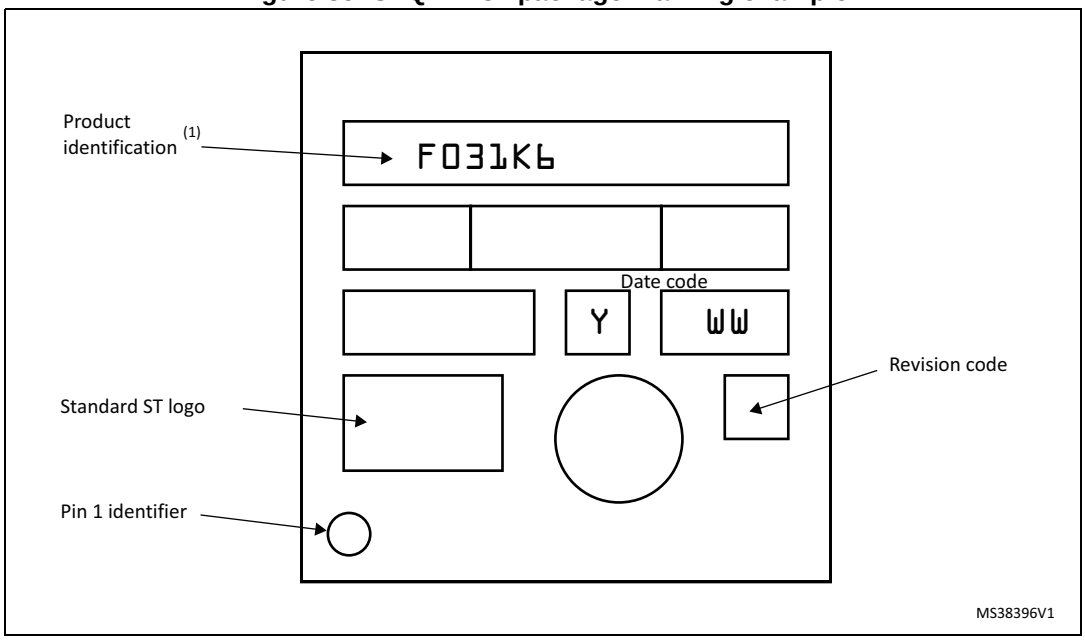
1. Dimensions are expressed in millimeters.

Device marking

The following figure gives an example of topside marking orientation versus pin 1 identifier location.

Other optional marking or inset/upset marks, which identify the parts throughout supply chain operations, are not indicated below.

Figure 39. UFQFPN32 package marking example



1. Parts marked as "ES", "E" or accompanied by an Engineering Sample notification letter, are not yet qualified and therefore not yet ready to be used in production and any consequences deriving from such usage will not be at ST charge. In no event, ST will be liable for any customer usage of these engineering samples in production. ST Quality has to be contacted prior to any decision to use these Engineering Samples to run qualification activity.

Table 65. WLCSP25 package mechanical data (continued)

Symbol	millimeters			inches[1]		
	Min	Typ	Max	Min	Typ	Max
aaa	-	0.100	-	-	0.0039	-
bbb	-	0.100	-	-	0.0039	-
ccc	-	0.100	-	-	0.0039	-
ddd	-	0.050	-	-	0.0020	-
eee	-	0.050	-	-	0.0020	-

1. Values in inches are converted from mm and rounded to 4 decimal digits.
2. Back side coating.
3. Dimension is measured at the maximum bump diameter parallel to primary datum Z.
4. Primary datum Z and seating plane are defined by the spherical crowns of the bump.

Figure 44. Recommended footprint for WLCSP25 package

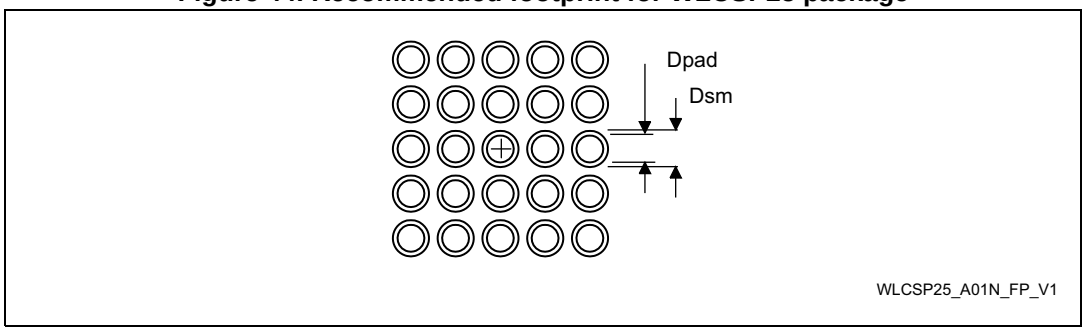


Table 66. WLCSP25 recommended PCB design rules

Dimension	Recommended values
Pitch	0.4 mm
Dpad	0.225 mm
Dsm	0.290 mm typ. (depends on the soldermask registration tolerance)
Stencil opening	0.250 mm
Stencil thickness	0.100 mm

9 Revision history

Table 70. Document revision history

Date	Revision	Changes
13-Jan-2014	1	Initial release.
11-Jul-2014	2	Changed the document status to Datasheet - production data. Updated the following: – *Table: STM32F031x4/6 family device features and peripheral counts,* – *Figure: Clock tree*, – *Figure: Power supply scheme*, – *Table: Peripheral current consumption*. Replaced *Table Typical current consumption in Run mode, code with data processing running from Flash* and *Table Typical current consumption in Sleep mode, code running from Flash or RAM* with *Table: Typical current consumption, code executing from Flash, running from HSE 8 MHz crystal.* Added the LQFP32 package: updates in *Section: Description, Section: Pinouts and pin description* and *Section: Package information.*
28-Aug-2015	3	**Updated:** – *Figure 9: STM32F031x6 memory map* – AF1 alternate functions for PA0, PA1, PA2, PA3 and PA4 in *Table 12: Alternate functions selected through GPIOA_AFR registers for port A* – the footnote for V_{IN} max value in *Table 15: Voltage characteristics* – the footnote for max V_{IN} in *Table 18: General operating conditions* – *Table 22: Embedded internal reference voltage* with the addition of t_{START} parameter – *Table 50: ADC characteristics* – *Table 53: TS characteristics*: removed the min. value for t_{START} parameter – the typical value for R parameter in *Table 54: VBAT monitoring characteristics* – the structure of *Section 7: Package information*. **Added:** – *Figure 33: LQFP48 marking example (package top view), Figure 36: LQFP32 marking example (package top view), Figure 39: UFQFPN32 marking example (package top view), Figure 42: UFQFPN28 marking example (package top view), Figure 48: TSSOP20 marking example (package top view)*

Table 70. Document revision history (continued)

Date	Revision	Changes
16-Dec-2015	4 (continued)	– *Section 6.3.16: 12-bit ADC characteristics* - changed introductory sentence – *Table 60: I^2S characteristics*: table reorganized, $t_{v(SD\_ST)}$ max value updated ***Section 7: Package information*:** – *Figure 41: Recommended footprint for UFQFPN28 package* updated ***Section 8: Part numbering*:** – added tray packing to options
06-Jan-2017	5	***Section 6: Electrical characteristics*:** – *Table 34: LSE oscillator characteristics (f_{LSE} = 32.768 kHz)* - information on configuring different drive capabilities removed. See the corresponding reference manual. – *Table 22: Embedded internal reference voltage* - V_{REFINT} values – *Figure 26: SPI timing diagram - slave mode and CPHA = 0* and *Figure 27: SPI timing diagram - slave mode and CPHA = 1* enhanced and corrected ***Section 8: Ordering information*:** – The name of the section changed from the previous “Part numbering”