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"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, PDR, POR, PVD, PWM, Temp Sensor, WDT
Number of I/O	55
Program Memory Size	64KB (64K x 8)
Program Memory Type	FLASH
EEPROM Size	-
RAM Size	8K x 8
Voltage - Supply (Vcc/Vdd)	2V ~ 3.6V
Data Converters	A/D 19x12b; D/A 1x12b
Oscillator Type	Internal
Operating Temperature	-40°C ~ 105°C (TA)
Mounting Type	Surface Mount
Package / Case	64-LQFP
Supplier Device Package	64-LQFP (10x10)
Purchase URL	https://www.e-xfl.com/product-detail/stmicroelectronics/stm32f051r8t7

Contents

1 Introduction 9

2 Description 10

3 Functional overview 13

3.1 ARM®-Cortex®-M0 core 13

3.2 Memories 13

3.3 Boot modes 13

3.4 Cyclic redundancy check calculation unit (CRC) 14

3.5 Power management 14

3.5.1 Power supply schemes 14

3.5.2 Power supply supervisors 14

3.5.3 Voltage regulator 14

3.5.4 Low-power modes 15

3.6 Clocks and startup 15

3.7 General-purpose inputs/outputs (GPIOs) 16

3.8 Direct memory access controller (DMA) 17

3.9 Interrupts and events 17

3.9.1 Nested vectored interrupt controller (NVIC) 17

3.9.2 Extended interrupt/event controller (EXTI) 17

3.10 Analog-to-digital converter (ADC) 17

3.10.1 Temperature sensor 18

3.10.2 Internal voltage reference (V_{REFINT}) 18

3.10.3 V_{BAT} battery voltage monitoring 19

3.11 Digital-to-analog converter (DAC) 19

3.12 Comparators (COMP) 19

3.13 Touch sensing controller (TSC) 19

3.14 Timers and watchdogs 21

3.14.1 Advanced-control timer (TIM1) 21

3.14.2 General-purpose timers (TIM2, 3, 14, 15, 16, 17) 22

3.14.3 Basic timer TIM6 22

3.14.4 Independent watchdog (IWDG) 22

3.14.5 System window watchdog (WWDG) 23

3.14.6 SysTick timer . . . 23
3.15 Real-time clock (RTC) and backup registers . . . 23
3.16 Inter-integrated circuit interface (I^2C) . . . 24
3.17 Universal synchronous/asynchronous receiver/transmitter (USART) . . . 25
3.18 Serial peripheral interface (SPI) / Inter-integrated sound interface (I^2S) . 26
3.19 High-definition multimedia interface (HDMI) - consumer electronics control (CEC) . . . 26
3.20 Serial wire debug port (SW-DP) . . . 26

4 Pinouts and pin descriptions . . . 27

5 Memory mapping . . . 39

6 Electrical characteristics . . . 42
6.1 Parameter conditions . . . 42
6.1.1 Minimum and maximum values . . . 42
6.1.2 Typical values . . . 42
6.1.3 Typical curves . . . 42
6.1.4 Loading capacitor . . . 42
6.1.5 Pin input voltage . . . 42
6.1.6 Power supply scheme . . . 43
6.1.7 Current consumption measurement . . . 44
6.2 Absolute maximum ratings . . . 45
6.3 Operating conditions . . . 47
6.3.1 General operating conditions . . . 47
6.3.2 Operating conditions at power-up / power-down . . . 47
6.3.3 Embedded reset and power control block characteristics . . . 48
6.3.4 Embedded reference voltage . . . 49
6.3.5 Supply current characteristics . . . 49
6.3.6 Wakeup time from low-power mode . . . 59
6.3.7 External clock source characteristics . . . 59
6.3.8 Internal clock source characteristics . . . 63
6.3.9 PLL characteristics . . . 66
6.3.10 Memory characteristics . . . 66
6.3.11 EMC characteristics . . . 67
6.3.12 Electrical sensitivity characteristics . . . 68
6.3.13 I/O current injection characteristics . . . 69

6.3.14 I/O port characteristics 70
6.3.15 NRST pin characteristics 75
6.3.16 12-bit ADC characteristics 76
6.3.17 DAC electrical specifications 80
6.3.18 Comparator characteristics 82
6.3.19 Temperature sensor characteristics 84
6.3.20 V_{BAT} monitoring characteristics 84
6.3.21 Timer characteristics 84
6.3.22 Communication interfaces 85

7 Package information 91
7.1 UFBGA64 package information 91
7.2 LQFP64 package information 94
7.3 LQFP48 package information 97
7.4 UFQFPN48 package information 100
7.5 WLCSP36 package information 103
7.6 LQFP32 package information 106
7.7 UFQFPN32 package information 108
7.8 Thermal characteristics 112
7.8.1 Reference document 112
7.8.2 Selecting the product temperature range 112

8 Ordering information 115

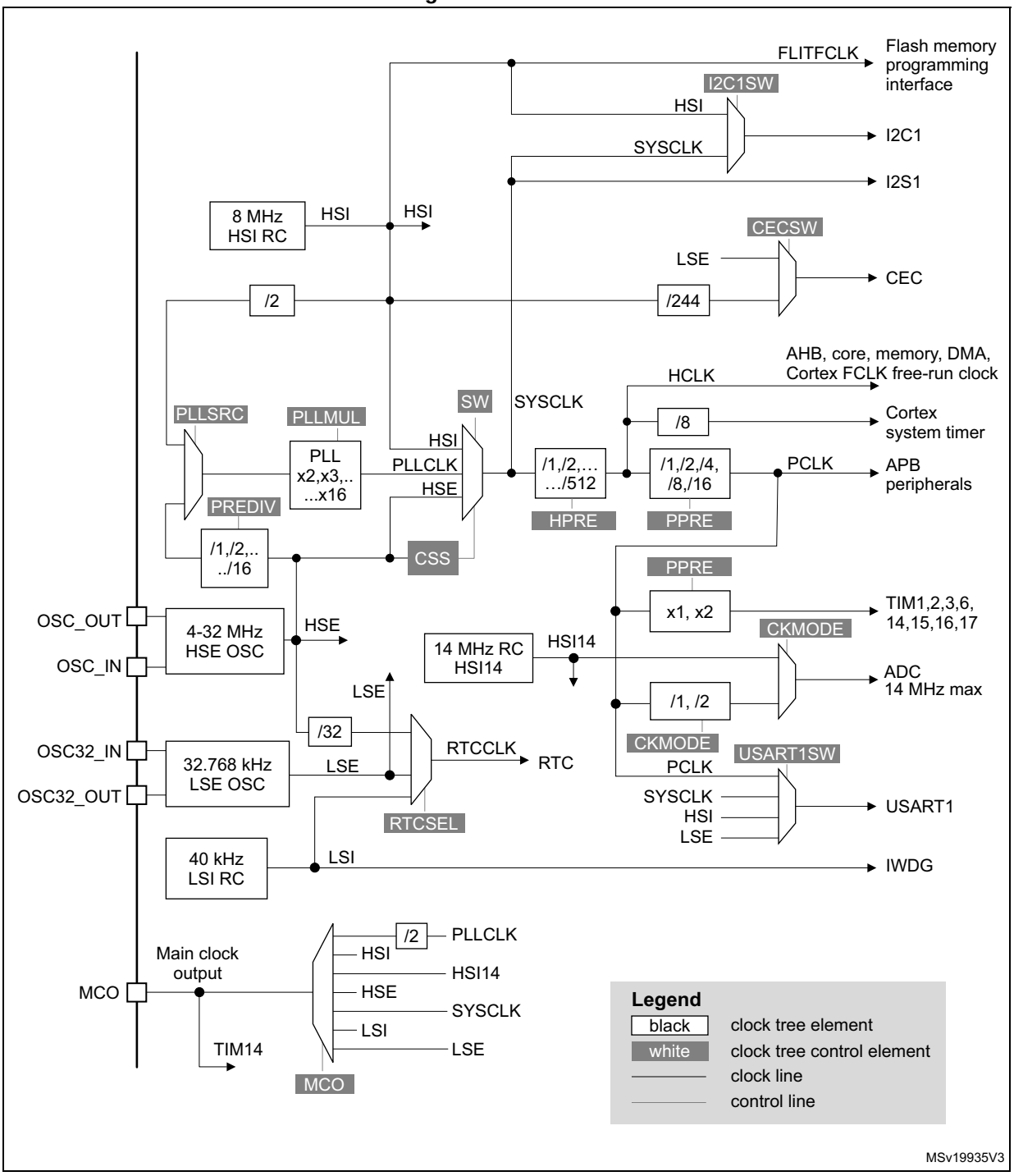
9 Revision history 116

Table 48. I/O static characteristics . . . 70
Table 49. Output voltage characteristics . . . 73
Table 50. I/O AC characteristics . . . 74
Table 51. NRST pin characteristics . . . 75
Table 52. ADC characteristics . . . 76
Table 53. R_{AIN} max for f_{ADC} = 14 MHz . . . 77
Table 54. ADC accuracy . . . 78
Table 55. DAC characteristics . . . 80
Table 56. Comparator characteristics . . . 82
Table 57. TS characteristics . . . 84
Table 58. V_{BAT} monitoring characteristics . . . 84
Table 59. TIMx characteristics . . . 84
Table 60. IWDG min/max timeout period at 40 kHz (LSI) . . . 85
Table 61. WWDG min/max timeout value at 48 MHz (PCLK) . . . 85
Table 62. I^2C analog filter characteristics . . . 86
Table 63. SPI characteristics . . . 86
Table 64. I^2S characteristics . . . 88
Table 65. UFBGA64 package mechanical data . . . 91
Table 66. UFBGA64 recommended PCB design rules . . . 92
Table 67. LQFP64 package mechanical data . . . 94
Table 68. LQFP48 package mechanical data . . . 98
Table 69. UFQFPN48 package mechanical data . . . 101
Table 70. WLCSP36 package mechanical data . . . 103
Table 71. WLCSP36 recommended PCB design rules . . . 104
Table 72. LQFP32 package mechanical data . . . 107
Table 73. UFQFPN32 package mechanical data . . . 110
Table 74. Package thermal characteristics . . . 112
Table 75. Ordering information scheme . . . 115
Table 76. Document revision history . . . 116

List of figures

Figure 1. Block diagram . . . 12
Figure 2. Clock tree . . . 16
Figure 3. LQFP64 package pinout . . . 27
Figure 4. UFBGA64 package pinout . . . 28
Figure 5. LQFP48 package pinout . . . 28
Figure 6. UFQFPN48 package pinout . . . 29
Figure 7. WLCSP36 package pinout . . . 29
Figure 8. LQFP32 package pinout . . . 30
Figure 9. UFQFPN32 package pinout . . . 30
Figure 10. STM32F051x8 memory map . . . 39
Figure 11. Pin loading conditions . . . 42
Figure 12. Pin input voltage . . . 42
Figure 13. Power supply scheme . . . 43
Figure 14. Current consumption measurement scheme . . . 44
Figure 15. High-speed external clock source AC timing diagram . . . 60
Figure 16. Low-speed external clock source AC timing diagram . . . 60
Figure 17. Typical application with an 8 MHz crystal . . . 62
Figure 18. Typical application with a 32.768 kHz crystal . . . 63
Figure 19. HSI oscillator accuracy characterization results for soldered parts . . . 64
Figure 20. HSI14 oscillator accuracy characterization results . . . 65
Figure 21. TC and TTa I/O input characteristics . . . 72
Figure 22. Five volt tolerant (FT and FTf) I/O input characteristics . . . 72
Figure 23. I/O AC characteristics definition . . . 75
Figure 24. Recommended NRST pin protection . . . 76
Figure 25. ADC accuracy characteristics . . . 79
Figure 26. Typical connection diagram using the ADC . . . 79
Figure 27. 12-bit buffered / non-buffered DAC . . . 81
Figure 28. Maximum V_{REFINT} scaler startup time from power down . . . 83
Figure 29. SPI timing diagram - slave mode and CPHA = 0 . . . 87
Figure 30. SPI timing diagram - slave mode and CPHA = 1 . . . 87
Figure 31. SPI timing diagram - master mode . . . 88
Figure 32. I^2S slave timing diagram (Philips protocol) . . . 89
Figure 33. I^2S master timing diagram (Philips protocol) . . . 90
Figure 34. UFBGA64 package outline . . . 91
Figure 35. Recommended footprint for UFBGA64 package . . . 92
Figure 36. UFBGA64 package marking example . . . 93
Figure 37. LQFP64 package outline . . . 94
Figure 38. Recommended footprint for LQFP64 package . . . 95
Figure 39. LQFP64 package marking example . . . 96
Figure 40. LQFP48 package outline . . . 97
Figure 41. Recommended footprint for LQFP48 package . . . 98
Figure 42. LQFP48 package marking example . . . 99
Figure 43. UFQFPN48 package outline . . . 100
Figure 44. Recommended footprint for UFQFPN48 package . . . 101
Figure 45. UFQFPN48 package marking example . . . 102
Figure 46. WLCSP36 package outline . . . 103
Figure 47. Recommended pad footprint for WLCSP36 package . . . 104
Figure 48. WLCSP36 package marking example . . . 105

Figure 2. Clock tree



3.7 General-purpose inputs/outputs (GPIOs)

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.

sensor, voltage reference, VBAT voltage measurement) channels and performs conversions in single-shot or scan modes. In scan mode, automatic conversion is performed on a selected group of analog inputs.

The ADC can be served by the DMA controller.

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

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 and comparators. V_{REFINT} is internally connected to the ADC_IN17 input channel. The precise voltage of V_{REFINT} is individually measured for each part by ST during production test and stored in the system memory area. It is accessible in read-only mode.

Table 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

can be used either as a watchdog to reset the device when a problem occurs, or as a free running timer for application timeout management. It is hardware or software configurable through the option bytes. The counter can be frozen in debug mode.

3.14.5 System window watchdog (WWDG)

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

3.14.6 SysTick timer

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

- a 24-bit down counter
- autoreload capability
- maskable system interrupt generation when the counter reaches 0
- programmable clock source (HCLK or HCLK/8)

3.15 Real-time clock (RTC) and backup registers

The RTC and the five backup registers are supplied through a switch that takes power either on V_{DD} supply when present or through the V_{BAT} pin. The backup registers are five 32-bit registers used to store 20 bytes of user application data when V_{DD} power is not present. They are not reset by a system or power reset, or at wake up from Standby mode.

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

- calendar with subseconds, seconds, minutes, hours (12 or 24 format), week day, date, month, year, in BCD (binary-coded decimal) format
- automatic correction for 28, 29 (leap year), 30, and 31 day of the month
- programmable alarm with wake up from Stop and Standby mode capability
- on-the-fly correction from 1 to 32767 RTC clock pulses. This can be used to synchronize the RTC with a master clock
- digital calibration circuit with 1 ppm resolution, to compensate for quartz crystal inaccuracy
- two anti-tamper detection pins with programmable filter. The MCU can be woken up from Stop and Standby modes on tamper event detection
- timestamp feature which can be used to save the calendar content. This function can be triggered by an event on the timestamp pin, or by a tamper event. The MCU can be woken up from Stop and Standby modes on timestamp event detection
- reference clock detection: a more precise second source clock (50 or 60 Hz) can be used to enhance the calendar precision

4 Pinouts and pin descriptions

Figure 3. LQFP64 package pinout

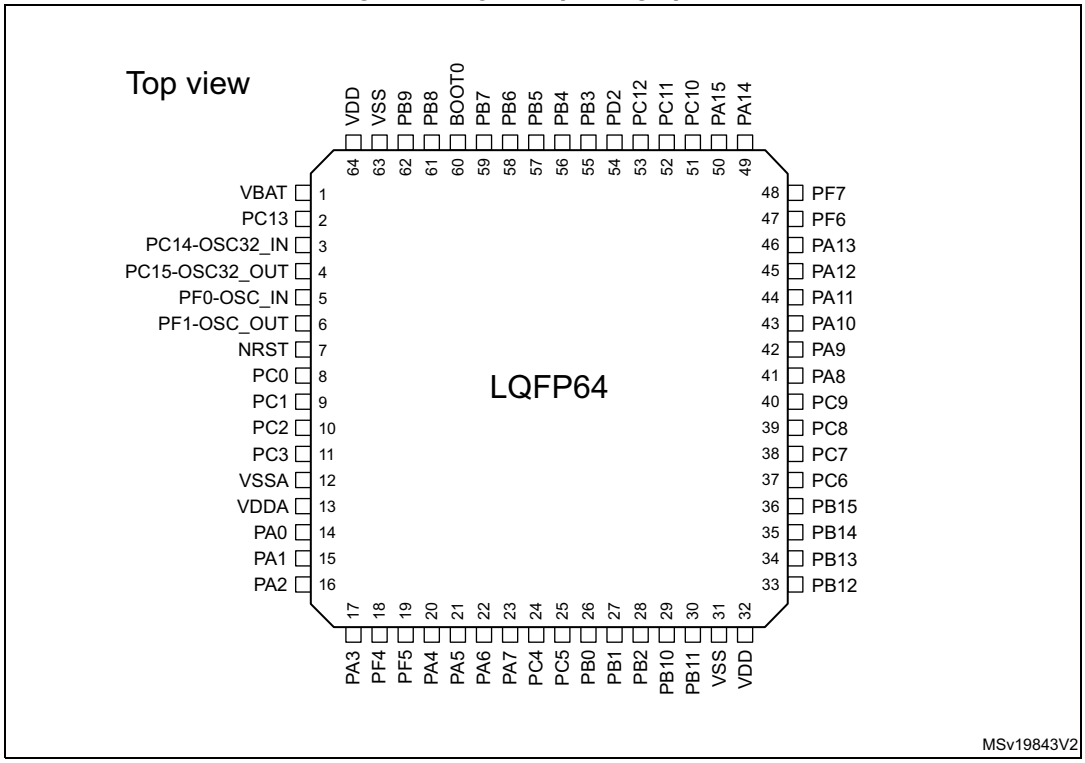


Figure 8. LQFP32 package pinout

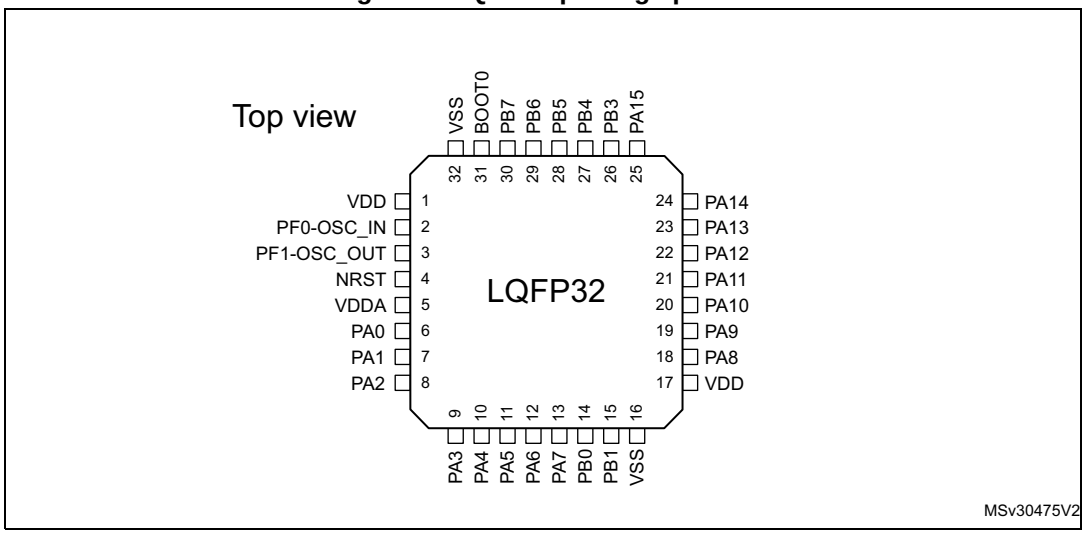


Figure 9. UFQFPN32 package pinout

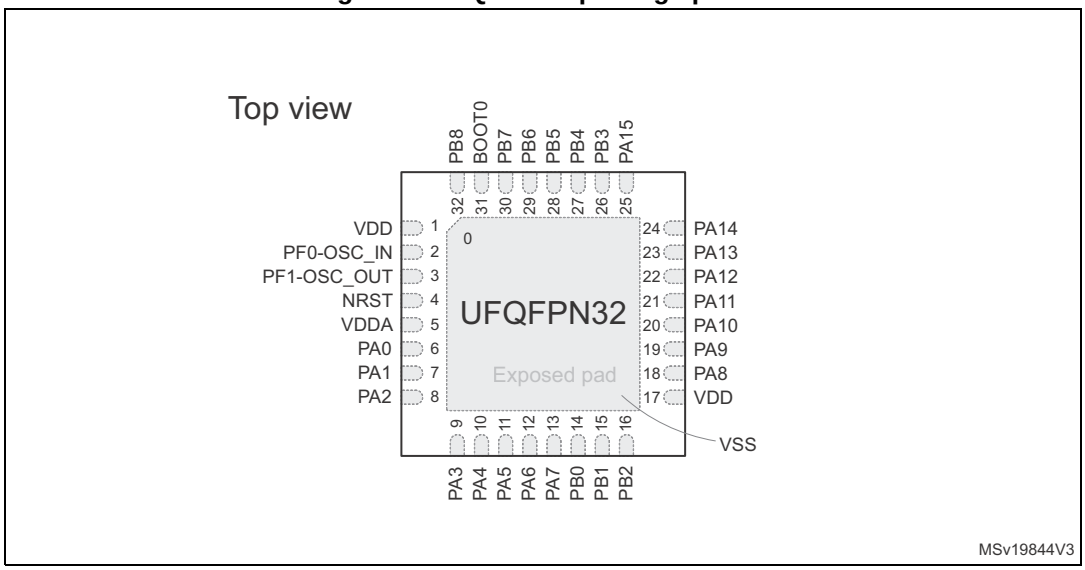


Table 13. Pin definitions (continued)

Pin number						Pin name (function upon reset)	Pin type	I/O structure	Notes	Pin functions	
LQFP64	UFBGA64	LQFP48/UFQFPN48	WLCSP36	LQFP32	UFQFPN32					Alternate functions	Additional functions
58	D3	42	C4	29	29	PB6	I/O	FTf	-	I2C1_SCL, USART1_TX, TIM16_CH1N, TSC_G5_IO3	-
59	C3	43	A4	30	30	PB7	I/O	FTf	-	I2C1_SDA, USART1_RX, TIM17_CH1N, TSC_G5_IO4	-
60	B4	44	B4	31	31	BOOT0	I	B	-	Boot memory selection	
61	B3	45	-	-	32	PB8	I/O	FTf	(4)(5)	I2C1_SCL, CEC, TIM16_CH1, TSC_SYNC	-
62	A3	46	-	-	-	PB9	I/O	FTf	(5)	I2C1_SDA, IR_OUT, TIM17_CH1, EVENTOUT	-
63	D5	47	D6	32	0	VSS	S	-	-	Ground	
64	E5	48	A5	1	1	VDD	S	-	-	Digital power supply	

1. PC13, PC14 and PC15 are supplied through the power switch. Since the switch only sinks a limited amount of current (3 mA), the use of GPIOs PC13 to PC15 in output mode is limited:
   - The speed should not exceed 2 MHz with a maximum load of 30 pF.
   - These GPIOs must not be used as current sources (e.g. to drive an LED).
2. After the first RTC domain power-up, PC13, PC14 and PC15 operate as GPIOs. Their function then depends on the content of the RTC registers which are not reset by the main reset. For details on how to manage these GPIOs, refer to the RTC domain and RTC register descriptions in the reference manual.
3. Distinct VSSA pin is only available on packages with 48 and more pins. For all other packages, the pin number corresponds to the VSS pin to which VSSA pad of the silicon die is connected.
4. On the LQFP32 package, PB2 and PB8 must be set to defined levels by software, as their corresponding pads on the silicon die are left unconnected. Apply the same recommendations as for unconnected pins.
5. On the WLCSP36 package, PB8, PB9, PB10, PB11, PB12, PB13, PB14 and PB15 must be set to defined levels by software, as their corresponding pads on the silicon die are left unconnected. Apply the same recommendations as for unconnected pins.
6. After reset, these pins are configured as SWDIO and SWCLK alternate functions, and the internal pull-up on the SWDIO pin and the internal pull-down on the SWCLK pin are activated.

Table 16. STM32F051xx peripheral register boundary addresses (continued)

Bus	Boundary address	Size	Peripheral
APB	0x4000 7C00 - 0x4000 7FFF	1 KB	Reserved
	0x4000 7800 - 0x4000 7BFF	1 KB	CEC
	0x4000 7400 - 0x4000 77FF	1 KB	DAC
	0x4000 7000 - 0x4000 73FF	1 KB	PWR
	0x4000 5C00 - 0x4000 6FFF	5 KB	Reserved
	0x4000 5800 - 0x4000 5BFF	1 KB	I2C2
	0x4000 5400 - 0x4000 57FF	1 KB	I2C1
	0x4000 4800 - 0x4000 53FF	3 KB	Reserved
	0x4000 4400 - 0x4000 47FF	1 KB	USART2
	0x4000 3C00 - 0x4000 43FF	2 KB	Reserved
	0x4000 3800 - 0x4000 3BFF	1 KB	SPI2
	0x4000 3400 - 0x4000 37FF	1 KB	Reserved
	0x4000 3000 - 0x4000 33FF	1 KB	IWDG
	0x4000 2C00 - 0x4000 2FFF	1 KB	WWDG
	0x4000 2800 - 0x4000 2BFF	1 KB	RTC
	0x4000 2400 - 0x4000 27FF	1 KB	Reserved
	0x4000 2000 - 0x4000 23FF	1 KB	TIM14
	0x4000 1400 - 0x4000 1FFF	3 KB	Reserved
	0x4000 1000 - 0x4000 13FF	1 KB	TIM6
	0x4000 0800 - 0x4000 0FFF	2 KB	Reserved
	0x4000 0400 - 0x4000 07FF	1 KB	TIM3
	0x4000 0000 - 0x4000 03FF	1 KB	TIM2

6 Electrical characteristics

6.1 Parameter conditions

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

6.1.1 Minimum and maximum values

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

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

6.1.2 Typical values

Unless otherwise specified, typical data are based on T_A = 25 °C, V_{DD} = V_{DDA} = 3.3 V. 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 11*.

6.1.5 Pin input voltage

The input voltage measurement on a pin of the device is described in *Figure 12*.

Figure 11. Pin loading conditions

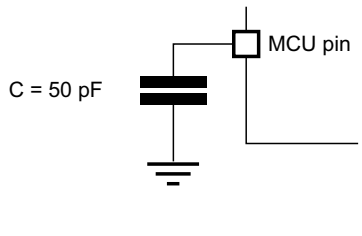
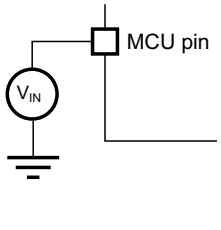
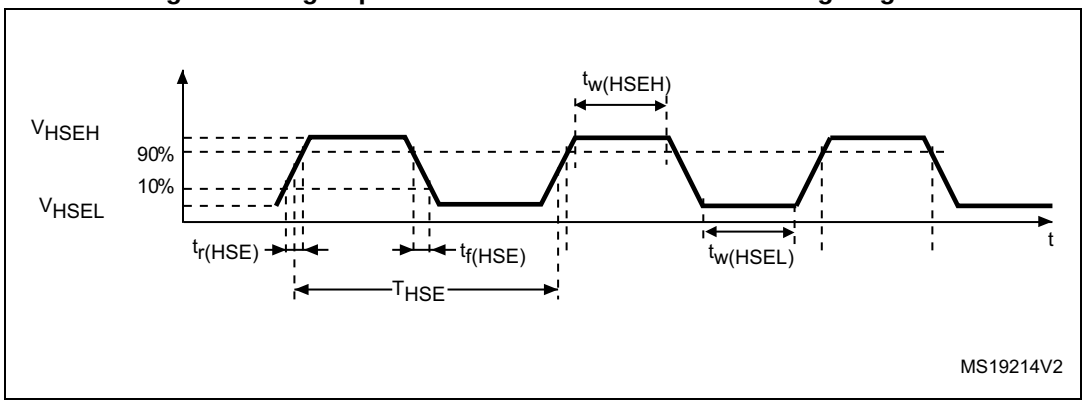


Figure 12. Pin input voltage



1. Guaranteed by design, not tested in production.

Figure 15. 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 16*.

Table 34. 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 16. Low-speed external clock source AC timing diagram

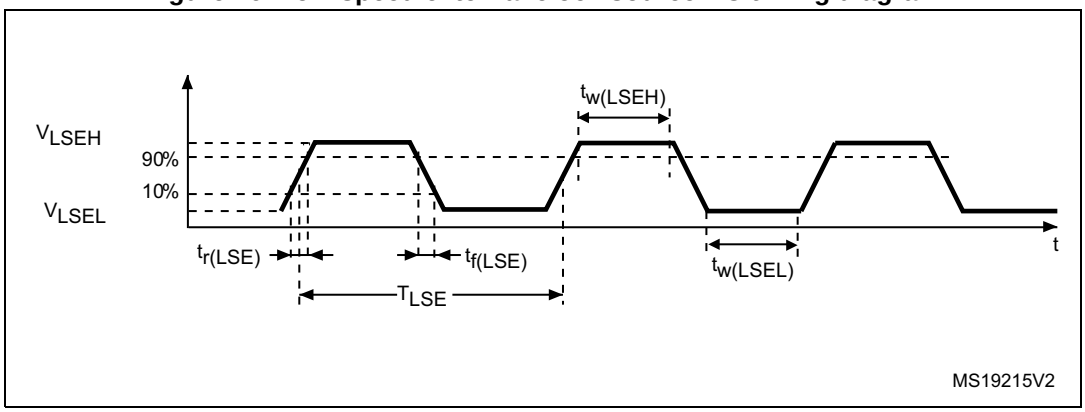


Table 45. ESD absolute maximum ratings

Symbol	Ratings	Conditions	Packages	Class	Maximum value(1)	Unit
$V_{ESD(HBM)}$	Electrostatic discharge voltage (human body model)	T_A = +25 °C, conforming to JESD22-A114	All	2	2000	V
$V_{ESD(CDM)}$	Electrostatic discharge voltage (charge device model)	T_A = +25 °C, conforming to ANSI/ESD STM5.3.1	All	C3	250	V

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

Static latch-up

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

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

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

Table 46. Electrical sensitivities

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

6.3.13 I/O current injection characteristics

As a general rule, current injection to the I/O pins, due to external voltage below V_{SS} or above V_{DDIOx} (for standard, 3.3 V-capable I/O pins) should be avoided during normal product operation. However, in order to give an indication of the robustness of the microcontroller in cases when abnormal injection accidentally happens, susceptibility tests are performed on a sample basis during device characterization.

Functional susceptibility to I/O current injection

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

The failure is indicated by an out of range parameter: ADC error above a certain limit (higher than 5 LSB TUE), out of conventional limits of induced leakage current on adjacent pins (out of the -5 µA/+0 µA range) or other functional failure (for example reset occurrence or oscillator frequency deviation).

The characterization results are given in *Table 47*.

Negative induced leakage current is caused by negative injection and positive induced leakage current is caused by positive injection.

Input/output AC characteristics

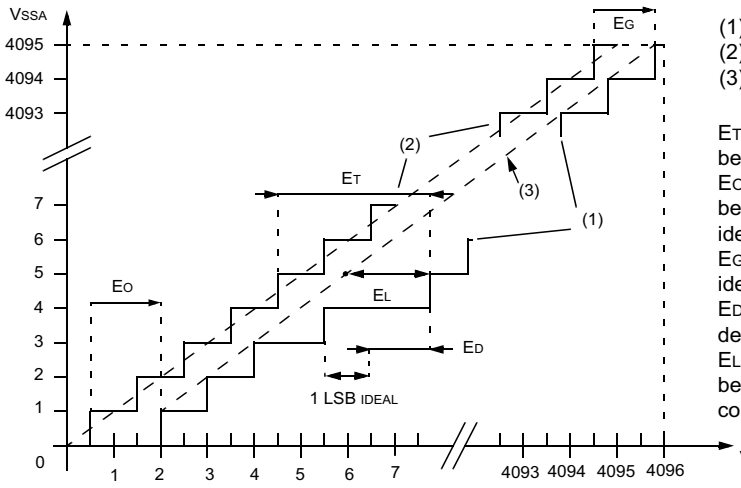
The definition and values of input/output AC characteristics are given in *Figure 23* and *Table 50*, respectively. Unless otherwise specified, the parameters given are derived from tests performed under the ambient temperature and supply voltage conditions summarized in *Table 20: General operating conditions*.

Table 50. I/O AC characteristics(1)(2)

OSPEEDRy [1:0] value(1)	Symbol	Parameter	Conditions	Min	Max	Unit
x0	$f_{max(IO)out}$	Maximum frequency(3)	C_L = 50 pF	-	2	MHz
	$t_{f(IO)out}$	Output fall time		-	125	ns
	$t_{r(IO)out}$	Output rise time		-	125	
01	$f_{max(IO)out}$	Maximum frequency(3)	C_L = 50 pF	-	10	MHz
	$t_{f(IO)out}$	Output fall time		-	25	ns
	$t_{r(IO)out}$	Output rise time		-	25	
11	$f_{max(IO)out}$	Maximum frequency(3)	C_L = 30 pF, $V_{DDIOx} \geq$ 2.7 V	-	50	MHz
			C_L = 50 pF, $V_{DDIOx} \geq$ 2.7 V	-	30	
			C_L = 50 pF, V_{DDIOx} < 2.7 V	-	20	
	$t_{f(IO)out}$	Output fall time	C_L = 30 pF, $V_{DDIOx} \geq$ 2.7 V	-	5	ns
			C_L = 50 pF, $V_{DDIOx} \geq$ 2.7 V	-	8	
			C_L = 50 pF, V_{DDIOx} < 2.7 V	-	12	
	$t_{r(IO)out}$	Output rise time	C_L = 30 pF, $V_{DDIOx} \geq$ 2.7 V	-	5	
			C_L = 50 pF, $V_{DDIOx} \geq$ 2.7 V	-	8	
			C_L = 50 pF, V_{DDIOx} < 2.7 V	-	12	
Fm+ configuration (4)	$f_{max(IO)out}$	Maximum frequency(3)	C_L = 50 pF	-	2	MHz
	$t_{f(IO)out}$	Output fall time		-	12	ns
	$t_{r(IO)out}$	Output rise time		-	34	
-	t_{EXTIpw}	Pulse width of external signals detected by the EXTI controller	-	10	-	ns

1. The I/O speed is configured using the OSPEEDRx[1:0] bits. Refer to the STM32F0xxxx RM0091 reference manual for a description of GPIO Port configuration register.
2. Guaranteed by design, not tested in production.
3. The maximum frequency is defined in *Figure 23*.
4. When Fm+ configuration is set, the I/O speed control is bypassed. Refer to the STM32F0xxxx reference manual RM0091 for a detailed description of Fm+ I/O configuration.

Figure 25. ADC accuracy characteristics

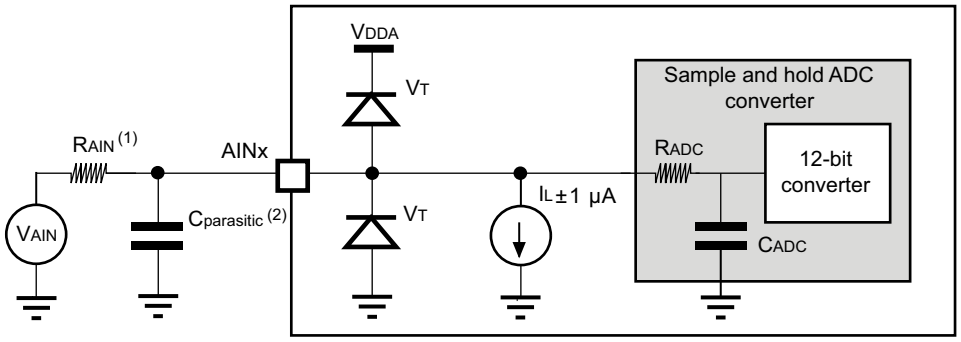


(1) Example of an actual transfer curve
(2) The ideal transfer curve
(3) End point correlation line

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

MS19880V2

Figure 26. Typical connection diagram using the ADC



MS33900V2

1. Refer to *Table 52: ADC characteristics* for the values of R_{AIN}, R_{ADC} and C_{ADC}.
2. $C_{parasitic}$ represents the capacitance of the PCB (dependent on soldering and PCB layout quality) plus the pad capacitance (roughly 7 pF). A high $C_{parasitic}$ value will downgrade conversion accuracy. To remedy this, f_{ADC} should be reduced.

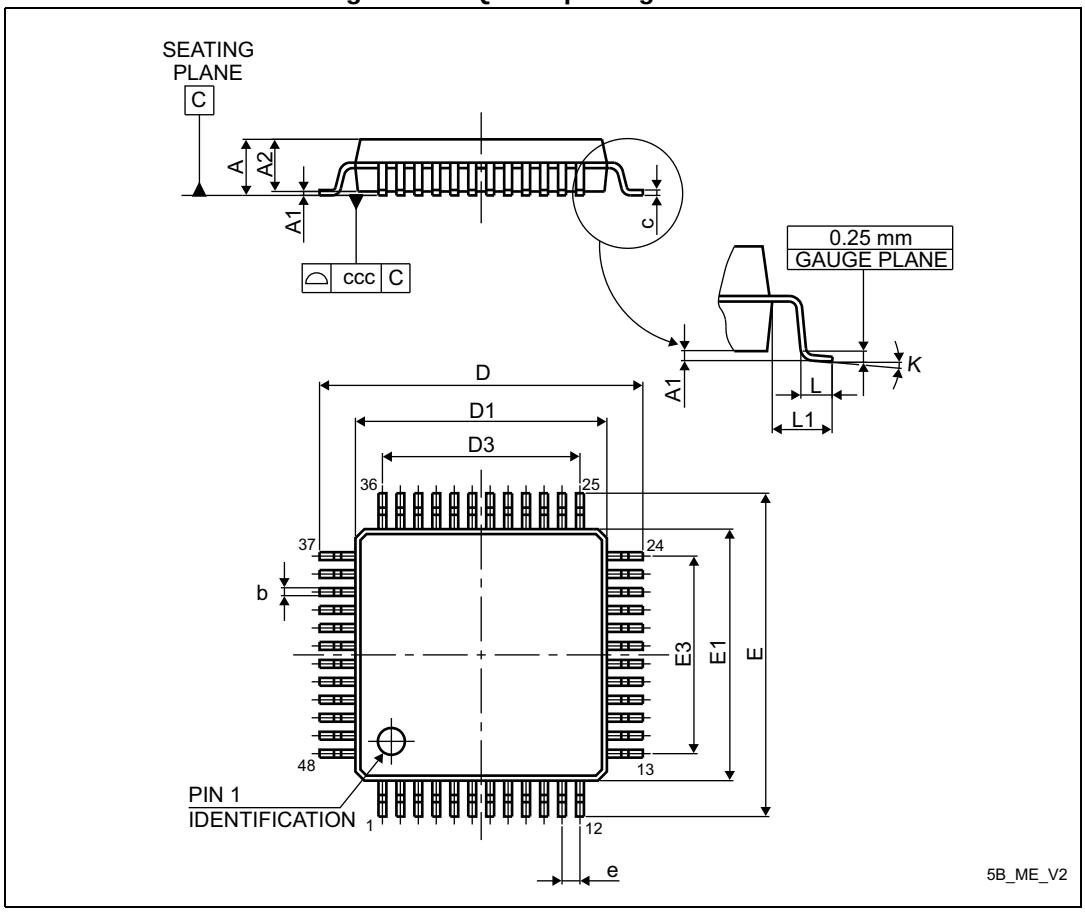
General PCB design guidelines

Power supply decoupling should be performed as shown in *Figure 13: Power supply scheme*. The 10 nF capacitor should be ceramic (good quality) and it should be placed as close as possible to the chip.

7.3 LQFP48 package information

LQFP48 is a 48-pin, 7 x 7 mm low-profile quad flat package.

Figure 40. LQFP48 package outline



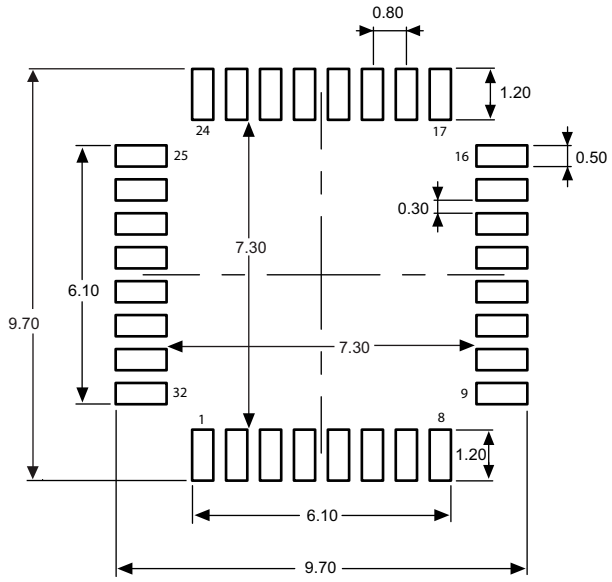
1. Drawing is not to scale.

Table 72. 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 50. Recommended footprint for LQFP32 package



1. Dimensions are expressed in millimeters.

Table 76. Document revision history (continued)

Date	Revision	Changes
13-Jan-2014	4 (continued)	Added “Negative induced leakage current is caused by negative injection and positive induced leakage current is caused by positive injection” in *Section Functional susceptibility to I/O current injection.* Replaced reference "JESD22-C101" with "ANSI/ESD STM5.3.1" in *Table : ESD absolute maximum ratings*. Merged *Table: Typical and maximum VDD consumption in Stop and Standby modes* and *Table: Typical and maximum VDDA consumption in Stop and Standby modes* into *Table: Typical and maximum current consumption in Stop and Standby modes.* Updated: – *Table: Temperature sensor calibration values,* – *Table: Internal voltage reference calibration values,* – *Table: Current characteristics,* – *Table: General operating conditions,* – *Table: Typical and maximum current consumption from the VDDA supply,* – *Table: Low-power mode wakeup timings,* – *Table: I/O current injection susceptibility,* – *Table: I/O static characteristics,* – *Table: Output voltage characteristics,* – *Table: NRST pin characteristics,* – *Table: I^2C analog filter characteristics,* – *Figure: Power supply scheme,* – *Figure: TC and TTa I/O input characteristics,* – *Figure: Five volt tolerant (FT and FTf) I/O input characteristics,* – *Figure: I/O AC characteristics definition,* – *Figure: ADC accuracy characteristics,* – *Figure: Typical connection diagram using the ADC,* – *Figure: LQFP64 – 10 x 10 mm 64 pin low-profile quad flat package outline,* – *Figure: LQFP64 recommended footprint,* – *Figure: LQFP48 – 7 x 7 mm, 48 pin low-profile quad flat package outline,* – *Figure: LQFP48 recommended footprint,* – *Figure: LQFP32 – 7 x 7 mm 32-pin low-profile quad flat package outline,* – *Figure: LQFP32 recommended footprint,* – *Figure: UFQFPN48 – 7 x 7 mm, 0.5 mm pitch, package outline.*