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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, Cap Sense, DMA, I²S, POR, PWM, WDT
Number of I/O	51
Program Memory Size	64KB (64K x 8)
Program Memory Type	FLASH
EEPROM Size	4K x 8
RAM Size	32K x 8
Voltage - Supply (Vcc/Vdd)	1.8V ~ 3.6V
Data Converters	A/D 20x12b; D/A 2x12b
Oscillator Type	Internal
Operating Temperature	-40°C ~ 85°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/stm32l151r8t6atr

2.2 Ultra-low-power device continuum

The ultra-low-power family offers a large choice of cores and features. From a proprietary 8-bit core up to the Cortex-M3, including the Cortex-M0+, the STM8Lx and STM32Lx series offer the best range of choices to meet your requirements in terms of ultra-low-power features. The STM32 Ultra-low-power series is an ideal fit for applications like gas/water meters, keyboard/mouse, or wearable devices for fitness and healthcare. Numerous built-in features like LCD drivers, dual-bank memory, low-power Run mode, op-amp, AES-128bit, DAC, crystal-less USB and many others, allow to build highly cost-optimized applications by reducing the BOM.

Note: STMicroelectronics as a reliable and long-term manufacturer ensures as much as possible the pin-to-pin compatibility between any STM8Lx and STM32Lx devices and between any of the STM32Lx and STM32Fx series. Thanks to this unprecedented scalability, your existing applications can be upgraded to respond to the latest market features and efficiency demand.

2.2.1 Performance

All families incorporate highly energy-efficient cores with both Harvard architecture and pipelined execution: advanced STM8 core for STM8L families and ARM Cortex-M3 core for STM32L family. In addition specific care for the design architecture has been taken to optimize the mA/DMIPS and mA/MHz ratios.

This allows the ultra-Low-power performance to range from 5 up to 33.3 DMIPs.

2.2.2 Shared peripherals

STM8L15xxx and STM32L1xxxx share identical peripherals which ensure a very easy migration from one family to another:

- Analog peripherals: ADC, DAC and comparators
- Digital peripherals: RTC and some communication interfaces

2.2.3 Common system strategy

To offer flexibility and optimize performance, the STM8L15xxx and STM32L1xxxx families use a common architecture:

- Common power supply range from 1.65 V to 3.6 V, (1.65 V at power down only for STM8L15xxx devices)
- Architecture optimized to reach ultra-low consumption both in low-power modes and Run mode
- Fast startup strategy from low-power modes
- Flexible system clock
- Ultra-safe reset: same reset strategy including power-on reset, power-down reset, brownout reset and programmable voltage detector.

2.2.4 Features

ST ultra-low-power continuum also lies in feature compatibility:

- More than 10 packages with pin count from 20 to 144 pins and size down to 3 x 3 mm
- Memory density ranging from 4 to 512 Kbytes

3.9 LCD (liquid crystal display)

The LCD drives up to 8 common terminals and 44 segment terminals to drive up to 320 pixels.

- Internal step-up converter to guarantee functionality and contrast control irrespective of V_{DD}. This converter can be deactivated, in which case the V_{LCD} pin is used to provide the voltage to the LCD
- Supports static, 1/2, 1/3, 1/4 and 1/8 duty
- Supports static, 1/2, 1/3 and 1/4 bias
- Phase inversion to reduce power consumption and EMI
- Up to 8 pixels can be programmed to blink
- Unneeded segments and common pins can be used as general I/O pins
- LCD RAM can be updated at any time owing to a double-buffer
- The LCD controller can operate in Stop mode
- V_{LCD} rail decoupling capability

Table 6. V_{LCD} rail decoupling

	Bias			Pin	
	1/2	1/3	1/4		
$V_{LCDrail1}$	1/2 V_{LCD}	2/3 V_{LCD}	1/2 V_{LCD}	PB2	
$V_{LCDrail2}$	NA	1/3 V_{LCD}	1/4 V_{LCD}	PB12	PE11
$V_{LCDrail3}$	NA	NA	3/4 V_{LCD}	PB0	PE12

3.10 ADC (analog-to-digital converter)

A 12-bit analog-to-digital converters is embedded into STM32L151x6/8/B-A and STM32L152x6/8/B-A devices with up to 24 external channels, performing conversions in single-shot or scan mode. In scan mode, automatic conversion is performed on a selected group of analog inputs.

The ADC can be served by the DMA controller.

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

The events generated by the general-purpose timers (TIMx) can be internally connected to the ADC start trigger and injection trigger, to allow the application to synchronize A/D conversions and timers. An injection mode allows high priority conversions to be done by interrupting a scan mode which runs in as a background task.

The ADC includes a specific low-power mode. The converter is able to operate at maximum speed even if the CPU is operating at a very low frequency and has an auto-shutdown function. The ADC's runtime and analog front-end current consumption are thus minimized whatever the MCU operating mode.

3.10.1 Temperature sensor

The temperature sensor T_{SENSE} 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, see *Table 59: Temperature sensor calibration values*.

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. 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 17: Embedded internal reference voltage*.

3.11 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.

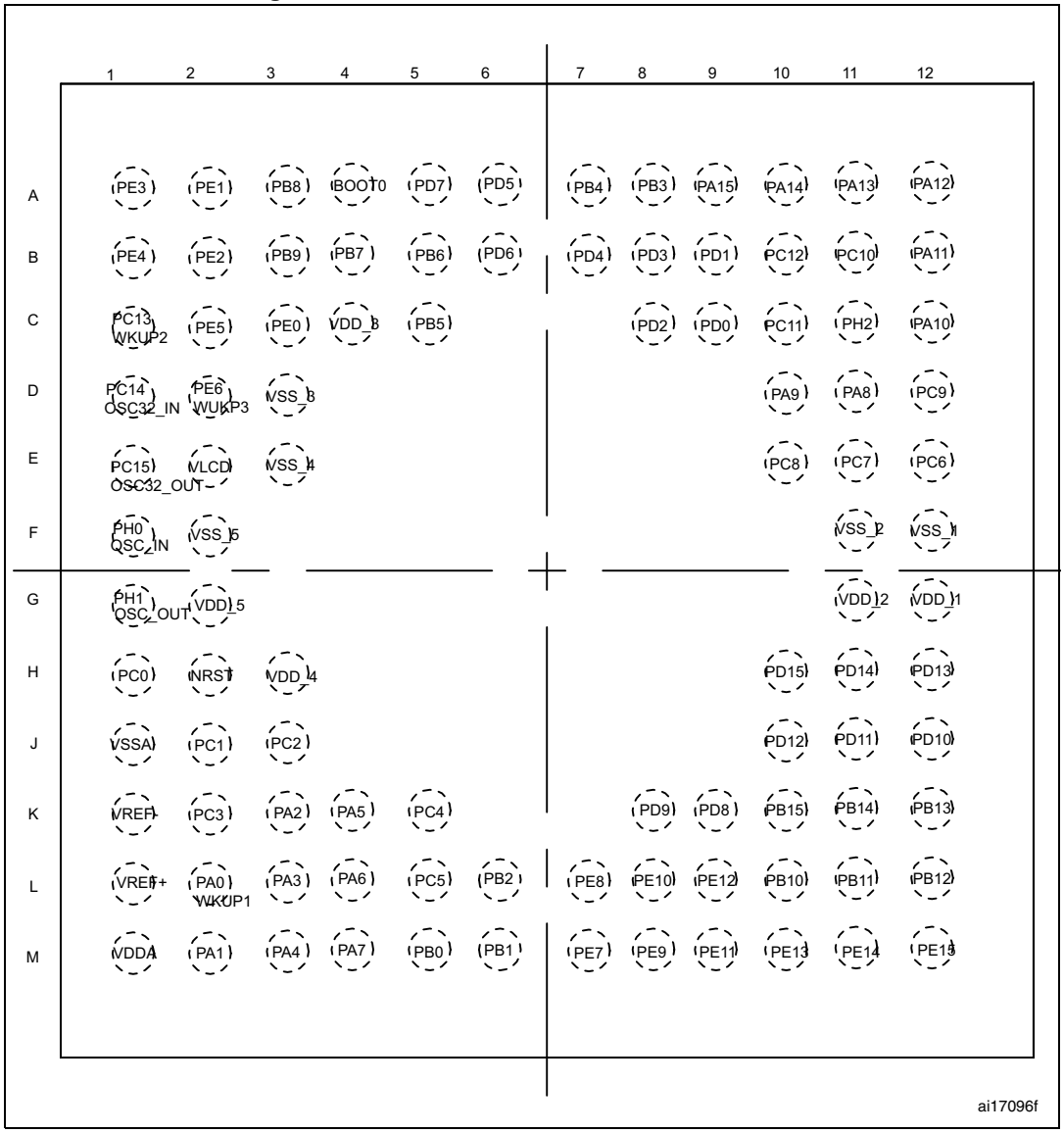
This dual digital Interface supports the following features:

- two DAC converters: one for each output channel
- 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 STM32L151x6/8/B-A and STM32L152x6/8/B-A devices. The DAC channels are triggered through the timer update outputs that are also connected to different DMA channels.

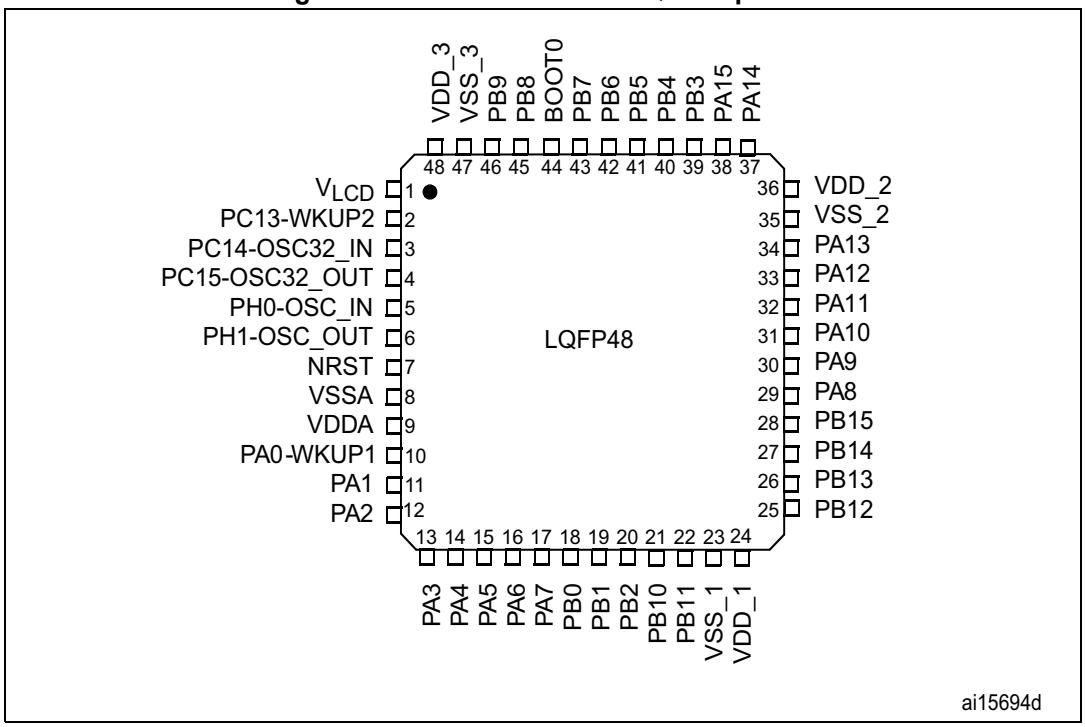
4 Pin descriptions

Figure 3. STM32L15xVxxxA UFBGA100 ballout



1. This figure shows the package top view.

Figure 7. STM32L15xCxxxA LQFP48 pinout



1. This figure shows the package top view.

Table 9. STM32L151x6/8/B-A and STM32L152x6/8/B-A pin definitions (continued)

Pins					Pin name	Pin type(1)	I/O structure	Main function(2) (after reset)	Pins functions	
LQFP100	LQFP64	TFBGA64	UFBGA100	LQFP48 or UFQFPN48					Alternate functions	Additional functions
35	26	F5	M5	18	PB0	I/O	TC	PB0	TIM3_CH3/ LCD_SEG5	ADC_IN8/ COMP1_INP/ VREF_OUT /VLCDRAIL3
36	27	G5	M6	19	PB1	I/O	FT	PB1	TIM3_CH4/ LCD_SEG6	ADC_IN9/ COMP1_INP/ VREF_OUT
37	28	G6	L6	20	PB2	I/O	FT	PB2/ BOOT1	BOOT1	VLCDRAIL1
38	-	-	M7	-	PE7	I/O	TC	PE7	-	ADC_IN22/ COMP1_INP
39	-	-	L7	-	PE8	I/O	TC	PE8	-	ADC_IN23/ COMP1_INP
40	-	-	M8	-	PE9	I/O	TC	PE9	TIM2_CH1_ETR	ADC_IN24/ COMP1_INP
41	-	-	L8	-	PE10	I/O	TC	PE10	TIM2_CH2	ADC_IN25/ COMP1_INP
42	-	-	M9	-	PE11	I/O	FT	PE11	TIM2_CH3	VLCDRAIL2
43	-	-	L9	-	PE12	I/O	FT	PE12	TIM2_CH4/ SPI1_NSS	VLCDRAIL3
44	-	-	M10	-	PE13	I/O	FT	PE13	SPI1_SCK	-
45	-	-	M11	-	PE14	I/O	FT	PE14	SPI1_MISO	-
46	-	-	M12	-	PE15	I/O	FT	PE15	SPI1_MOSI	-
47	29	G7	L10	21	PB10	I/O	FT	PB10	I2C2_SCL/USART3_TX /TIM2_CH3/ LCD_SEG10	-
48	30	H7	L11	22	PB11	I/O	FT	PB11	I2C2_SDA/USART3_RX /TIM2_CH4/ LCD_SEG11	-
49	31	D6	F12	23	V_{SS_1}	S	-	V_{SS_1}	-	-
50	32	E6	G12	24	V_{DD_1}	S	-	V_{DD_1}	-	-

Table 9. STM32L151x6/8/B-A and STM32L152x6/8/B-A pin definitions (continued)

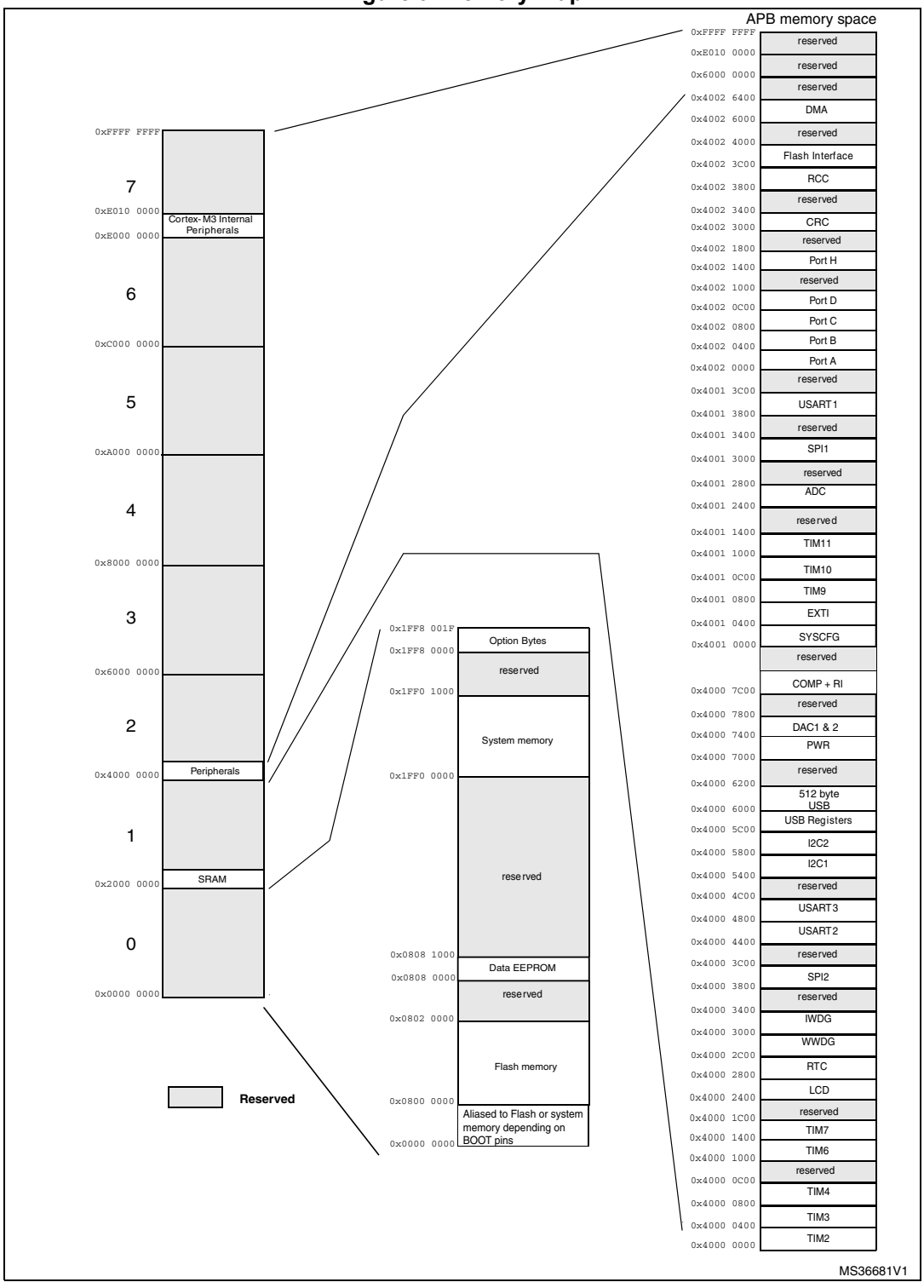
Pins					Pin name	Pin type[1]	I/O structure	Main function[2] (after reset)	Pins functions	
LQFP100	LQFP64	TFBGA64	UFBGA100	LQFP48 or UFQFPN48					Alternate functions	Additional functions
98	-	-	A2	-	PE1	I/O	FT	PE1	LCD_SEG37/ TIM11_CH1	-
99	63	D4	D3	47	V_{SS_3}	S	-	V_{SS_3}	-	-
100	64	E4	C4	48	V_{DD_3}	S	-	V_{DD_3}	-	-

1. I = input, O = output, S = supply.
2. Function availability depends on the chosen device. For devices having reduced peripheral counts, it is always the lower number of peripheral that is included. For example, if a device has only one SPI and two USARTs, they will be called SPI1 and USART1 & USART2, respectively. Refer to *Table 2 on page 11*.
3. Applicable to STM32L152xxxxA devices only. In STM32L151xxxxA devices, this pin should be connected to V_{DD}.
4. The PC14 and PC15 I/Os are only configured as OSC32_IN/OSC32_OUT when the LSE oscillator is on (by setting the LSEON bit in the RCC_CSR register). The LSE oscillator pins OSC32_IN/OSC32_OUT can be used as general-purpose PC14/PC15 I/Os, respectively, when the LSE oscillator is off (after reset, the LSE oscillator is off). The LSE has priority over the GPIO function. For more details, refer to Using the OSC32_IN/OSC32_OUT pins as GPIO PC14/PC15 port pins section in the STM32L1xxxx reference manual (RM0038).
5. The PH0 and PH1 I/Os are only configured as OSC_IN/OSC_OUT when the HSE oscillator is on (by setting the HSEON bit in the RCC_CR register). The HSE oscillator pins OSC_IN/OSC_OUT can be used as general-purpose PH0/PH1 I/Os, respectively, when the HSE oscillator is off (after reset, the HSE oscillator is off). The HSE has priority over the GPIO function.
6. Unlike in the LQFP64 package, there is no PC3 in the TFBGA64 package. The V_{REF+} functionality is provided instead.

5 Memory mapping

The memory map is shown in the following figure.

Figure 9. Memory map



6.1.6 Power supply scheme

Figure 12. Power supply scheme

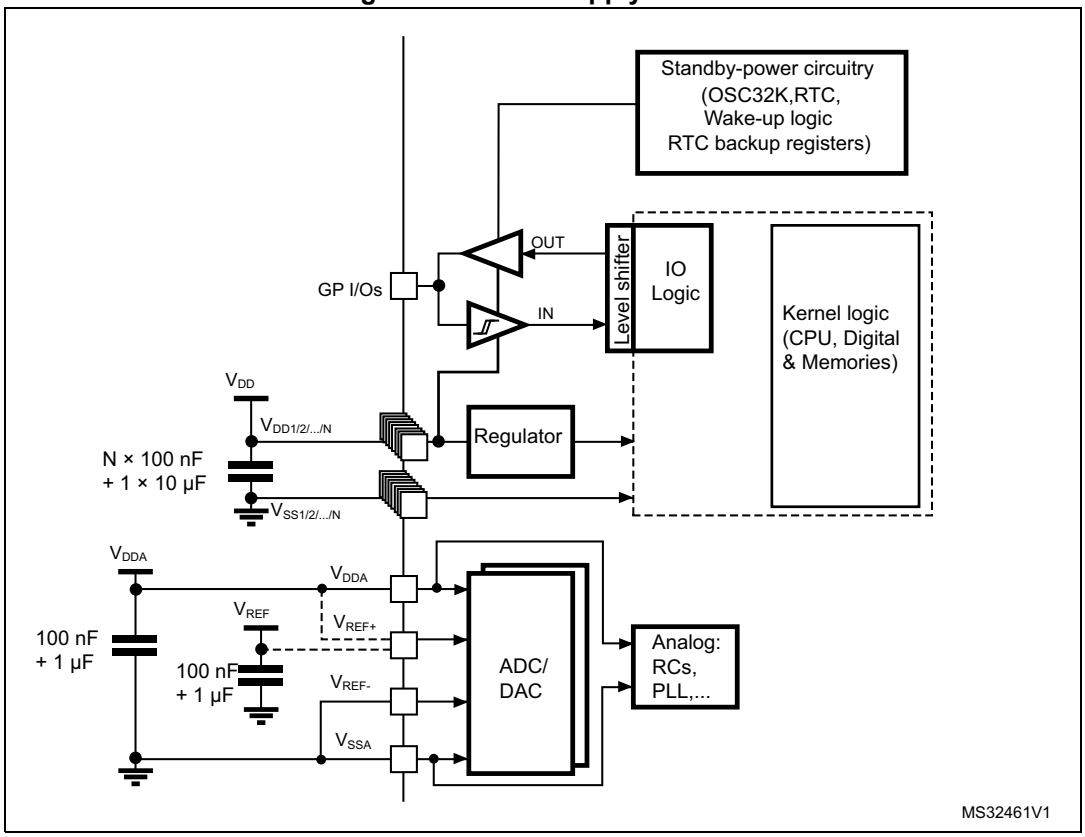


Table 22. Current consumption in Low-power sleep mode

Symbol	Parameter	Conditions			Typ	Max (1)	Unit
I_{DD} (LP Sleep)	Supply current in Low-power sleep mode	All peripherals OFF, V_{DD} from 1.65 V to 3.6 V	MSI clock, 65 kHz f_{HCLK} = 32 kHz Flash OFF	T_A = -40 °C to 25 °C	5.5	-	µA
			MSI clock, 65 kHz f_{HCLK} = 32 kHz Flash ON	T_A = -40 °C to 25 °C	15	16	
				T_A = 85 °C	20	23	
				T_A = 105 °C	24	26	
			MSI clock, 65 kHz f_{HCLK} = 65 kHz, Flash ON	T_A = -40 °C to 25 °C	15	16	
				T_A = 85 °C	20.5	23	
				T_A = 105 °C	25.4	27	
			MSI clock, 131 kHz f_{HCLK} = 131 kHz, Flash ON	T_A = -40 °C to 25 °C	18	20	
				T_A = 55 °C	21	22	
				T_A = 85 °C	23	27	
				T_A = 105 °C	28	31	
		TIM9 and USART1 enabled, Flash ON, V_{DD} from 1.65 V to 3.6 V	MSI clock, 65 kHz f_{HCLK} = 32 kHz	T_A = -40 °C to 25 °C	15	16	
				T_A = 85 °C	20	22	
				T_A = 105 °C	24	26	
			MSI clock, 65 kHz f_{HCLK} = 65 kHz	T_A = -40 °C to 25 °C	15	16	
				T_A = 85 °C	20.5	23	
				T_A = 105 °C	25.4	27	
			MSI clock, 131 kHz f_{HCLK} = 131 kHz	T_A = -40 °C to 25 °C	18	20	
				T_A = 55 °C	21	22	
				T_A = 85 °C	23	27	
				T_A = 105 °C	28	30	
I_{DD} Max (LP Sleep)	Max allowed current in Low-power Sleep mode	V_{DD} from 1.65 V to 3.6 V	-	-	-	200	

1. Guaranteed by characterization results, unless otherwise specified.

To complete these trials, ESD stress can be applied directly on the device, over the range of specification values. When unexpected behavior is detected, the software can be hardened to prevent unrecoverable errors occurring (see application note AN1015).

Electromagnetic Interference (EMI)

The electromagnetic field emitted by the device are monitored while a simple application is executed (toggling 2 LEDs through the I/O ports). This emission test is compliant with IEC 61967-2 standard which specifies the test board and the pin loading.

Table 39. EMI characteristics

Symbol	Parameter	Conditions	Monitored frequency band	Max vs. frequency range			Unit
				4 MHz voltage Range 3	16 MHz voltage Range 2	32 MHz voltage Range 1	
S_{EMI}	Peak level	V_{DD} = 3.3 V, T_A = 25 °C, LQFP100 package compliant with IEC 61967-2	0.1 to 30 MHz	-16	-7	-3	dBµV
			30 to 130 MHz	-12	2	12	
			130 MHz to 1GHz	-11	0	8	
			SAE EMI Level	1	1.5	2	-

6.3.11 Electrical sensitivity characteristics

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

Electrostatic discharge (ESD)

Electrostatic discharges (a positive then a negative pulse separated by 1 second) are applied to the pins of each sample according to each pin combination. The sample size depends on the number of supply pins in the device (3 parts × (n+1) supply pins). This test conforms to the JESD22-A114, ANSI/ESD STM5.3.1 standard.

Table 40. 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	C4	500	V

1. Guaranteed by characterization results.

6.3.13 I/O port characteristics

General input/output characteristics

Unless otherwise specified, the parameters given in *Table 43* are derived from tests performed under conditions summarized in *Table 14*. All I/Os are CMOS and TTL compliant.

Table 43. I/O static characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{IL}	Input low level voltage	TC and FT I/O	-	-	0.3 V_{DD}(1)(2)	V
		BOOT0	-		0.14 V_{DD}(2)	
V_{IH}	Input high level voltage	TC I/O	0.45 V_{DD}+0.38(2)	-	-	
		FT I/O	0.39 V_{DD}+0.59(2)	-	-	
		BOOT0	0.15 V_{DD}+0.56(2)	-	-	
V_{hys}	I/O Schmitt trigger voltage hysteresis(2)	TC and FT I/O	-	10% V_{DD}(3)	-	
		BOOT0	-	0.01	-	
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	
		$V_{SS} \le V_{IN} \le V_{DD}$ TC and FT I/O	-	-	±50	
		FT I/O $V_{DD} \le V_{IN} \le 5V$	-	-	±10	uA
R_{PU}	Weak pull-up equivalent resistor(5)(1)	$V_{IN} = V_{SS}$	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. Guaranteed by design.
3. With a minimum of 200 mV.
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. This PMOS/NMOS contribution to the series resistance is minimal (~10% order).

6.3.16 Communication interfaces

I^2C interface characteristics

The STM32L151x6/8/B-A and STM32L152x6/8/B-A product line I^2C interface meets the requirements of the standard I^2C communication protocol with the following restrictions: SDA and SCL are not “true” open-drain I/O pins. When configured as open-drain, the PMOS connected between the I/O pin and V_{DD} is disabled, but is still present.

The I^2C characteristics are described in *Table 48*. Refer also to *Section 6.3.12: I/O current injection characteristics* for more details on the input/output alternate function characteristics (SDA and SCL).

Table 48. I^2C characteristics

Symbol	Parameter	Standard mode I^2C(1)(2)		Fast mode I^2C(1)(2)		Unit
		Min	Max	Min	Max	
$t_{w(SCLL)}$	SCL clock low time	4.7	-	1.3	-	µs
$t_{w(SCLH)}$	SCL clock high time	4.0	-	0.6	-	
$t_{su(SDA)}$	SDA setup time	250	-	100	-	ns
$t_{h(SDA)}$	SDA data hold time	-	3450(3)	-	900(3)	
$t_{r(SDA)}$ $t_{r(SCL)}$	SDA and SCL rise time	-	1000	-	300	
$t_{f(SDA)}$ $t_{f(SCL)}$	SDA and SCL fall time	-	300	-	300	
$t_{h(STA)}$	Start condition hold time	4.0	-	0.6	-	µs
$t_{su(STA)}$	Repeated Start condition setup time	4.7	-	0.6	-	
$t_{su(STO)}$	Stop condition setup time	4.0	-	0.6	-	µs
$t_{w(STO:STA)}$	Stop to Start condition time (bus free)	4.7	-	1.3	-	µs
C_b	Capacitive load for each bus line	-	400	-	400	pF
t_{SP}	Pulse width of spikes that are suppressed by the analog filter	0	50(4)	0	50(4)	ns

1. Guaranteed by design.
2. f_{PCLK1} must be at least 2 MHz to achieve standard mode I²C frequencies. It must be at least 4 MHz to achieve fast mode I²C frequencies. It must be a multiple of 10 MHz to reach the 400 kHz maximum I²C fast mode clock.
3. The maximum Data hold time has only to be met if the interface does not stretch the low period of SCL signal.
4. The minimum width of the spikes filtered by the analog filter is above $t_{SP(max)}$.

6.3.17 12-bit ADC characteristics

Unless otherwise specified, the parameters given in *Table 55* are guaranteed by design.

Table 54. ADC clock frequency

Symbol	Parameter	Conditions			Min	Max	Unit
f_{ADC}	ADC clock frequency	Voltage Range 1 & 2	2.4 V ≤V_{DDA} ≤3.6 V	V_{REF+} = V_{DDA}	0.480	16	MHz
				V_{REF+} < V_{DDA} V_{REF+} > 2.4 V		8	
				V_{REF+} < V_{DDA} V_{REF+} ≤2.4 V		4	
			1.8 V ≤V_{DDA} ≤2.4 V	V_{REF+} = V_{DDA}		8	
				V_{REF+} < V_{DDA}		4	
		Voltage Range 3				4	

Table 55. ADC characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{DDA}	Power supply	-	1.8	-	3.6	V
V_{REF+}	Positive reference voltage	2.4 V ≤V_{DDA} ≤3.6 V V_{REF+} must be below or equal to V_{DDA}	1.8(1)	-	V_{DDA}	V
V_{REF-}	Negative reference voltage	-	-	V_{SSA}	-	V
I_{VDDA}	Current on the V_{DDA} input pin	-	-	1000	1450	µA
I_{VREF}(2)	Current on the V_{REF} input pin	Peak	-	400	700	µA
		Average	-		450	µA
V_{AIN}	Conversion voltage range(3)	-	0(4)	-	V_{REF+}	V
f_S	12-bit sampling rate	Direct channels	-	-	1	Msps
		Multiplexed channels	-	-	0.76	
	10-bit sampling rate	Direct channels	-	-	1.07	Msps
		Multiplexed channels	-	-	0.8	
	8-bit sampling rate	Direct channels	-	-	1.23	Msps
		Multiplexed channels	-	-	0.89	
	6-bit sampling rate	Direct channels	-	-	1.45	Msps
		Multiplexed channels	-	-	1	

Table 56. ADC accuracy(1)(2)

Symbol	Parameter	Test conditions	Min(3)	Typ	Max(3)	Unit
ET	Total unadjusted error	$2.4\ V \le V_{DDA} \le 3.6\ V$ $2.4\ V \le V_{REF+} \le 3.6\ V$ $f_{ADC} = 8\ MHz$, $R_{AIN} = 50\ \Omega$ $T_A = -40$ to $105\ °C$	-	2.5	4	LSB
EO	Offset error		-	1	2	
EG	Gain error		-	1.5	3.5	
ED	Differential linearity error		-	1	2	
EL	Integral linearity error		-	2	3	
ENOB	Effective number of bits	$2.4\ V \le V_{DDA} \le 3.6\ V$ $V_{DDA} = V_{REF+}$ $f_{ADC} = 16\ MHz$, $R_{AIN} = 50\ \Omega$ $T_A = -40$ to $105\ °C$ F_{input} =10 kHz	9.5	10	-	bits
SINAD	Signal-to-noise and distortion ratio		59	62	-	dB
SNR	Signal-to-noise ratio		60	62	-	
THD	Total harmonic distortion		-	-72	-69	
ENOB	Effective number of bits	$1.8\ V \le V_{DDA} \le 2.4\ V$ $V_{DDA} = V_{REF+}$ $f_{ADC} = 8\ MHz$ or $4\ MHz$, $R_{AIN} = 50\ \Omega$ $T_A = -40$ to $105\ °C$ F_{input} =10 kHz	9.5	10	-	bits
SINAD	Signal-to-noise and distortion ratio		59	62	-	dB
SNR	Signal-to-noise ratio		60	62	-	
THD	Total harmonic distortion		-	-72	-69	
ET	Total unadjusted error	$2.4\ V \le V_{DDA} \le 3.6\ V$ $1.8\ V \le V_{REF+} \le 2.4\ V$ $f_{ADC} = 4\ MHz$, $R_{AIN} = 50\ \Omega$ $T_A = -40$ to $105\ °C$	-	4	6.5	LSB
EO	Offset error		-	1.5	3.5	
EG	Gain error		-	3.5	6	
ED	Differential linearity error		-	1	2	
EL	Integral linearity error		-	2.5	3.5	
ET	Total unadjusted error	$1.8\ V \le V_{DDA} \le 2.4\ V$ $1.8\ V \le V_{REF+} \le 2.4\ V$ $f_{ADC} = 4\ MHz$, $R_{AIN} = 50\ \Omega$ $T_A = -40$ to $105\ °C$	-	2	3	LSB
EO	Offset error		-	1	1.5	
EG	Gain error		-	1.5	2.5	
ED	Differential linearity error		-	1	2	
EL	Integral linearity error		-	2	3	

1. ADC DC accuracy values are measured after internal calibration.
2. ADC accuracy vs. negative injection current: Injecting a negative current on any analog input pins should be avoided as this significantly reduces the accuracy of the conversion being performed on another analog input. It is recommended to add a Schottky diode (pin to ground) to analog pins which may potentially inject negative currents.
   Any positive injection current within the limits specified for $I_{INJ(PIN)}$ and $\Sigma I_{INJ(PIN)}$ in *Section 6.3.12* does not affect the ADC accuracy.
3. Guaranteed by characterization results.

Figure 26. ADC accuracy characteristics

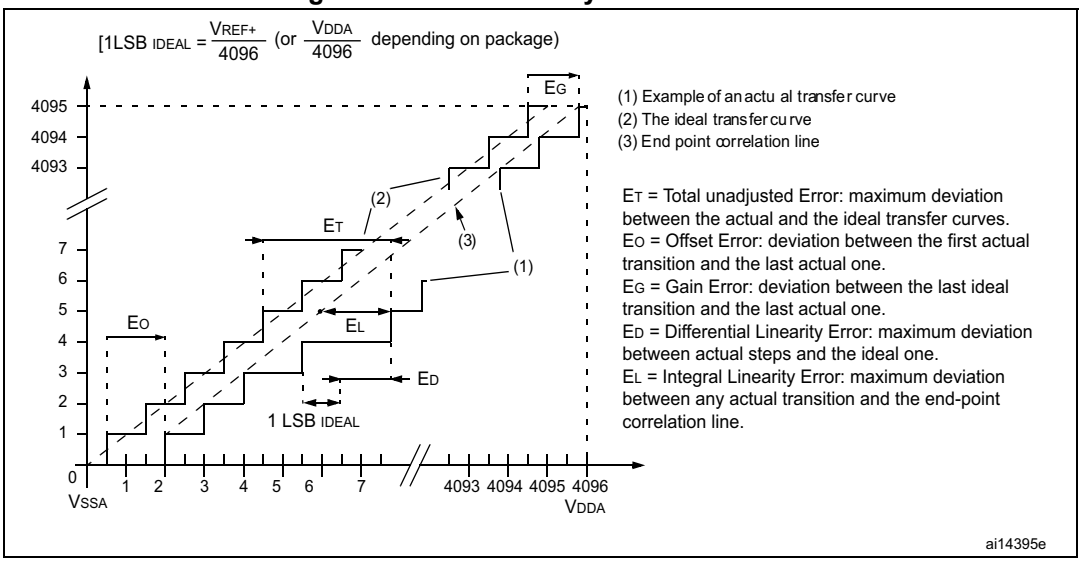
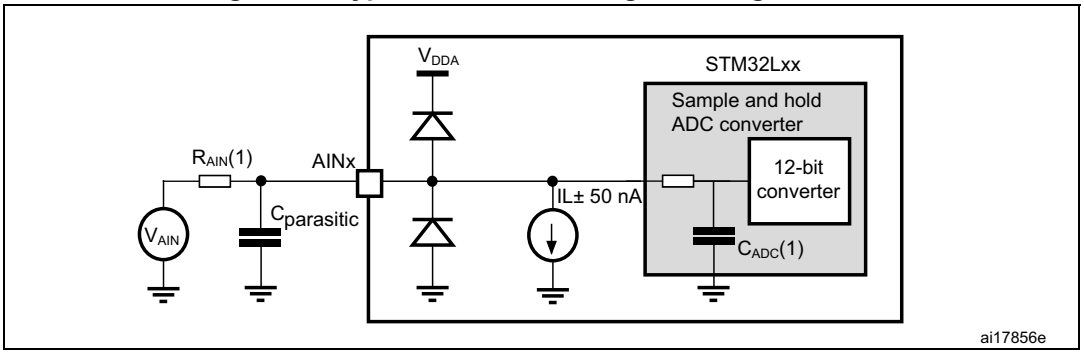


Figure 27. Typical connection diagram using the ADC



1. Refer to *Table 57: Maximum source impedance RAIN max* for the value of R_{AIN} and *Table 55: ADC characteristics* for the value of CADC
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.

Table 62. Comparator 2 characteristics

Symbol	Parameter	Conditions	Min	Typ	Max(1)	Unit
V_{DDA}	Analog supply voltage	-	1.65	-	3.6	V
V_{IN}	Comparator 2 input voltage range	-	0	-	V_{DDA}	V
t_{START}	Comparator startup time	Fast mode	-	15	20	µs
		Slow mode	-	20	25	
$t_{d\ slow}$	Propagation delay(2) in slow mode	1.65 V ≤V_{DDA} ≤2.7 V	-	1.8	3.5	
		2.7 V ≤V_{DDA} ≤3.6 V	-	2.5	6	
$t_{d\ fast}$	Propagation delay(2) in fast mode	1.65 V ≤V_{DDA} ≤2.7 V	-	0.8	2	
		2.7 V ≤V_{DDA} ≤3.6 V	-	1.2	4	
V_{offset}	Comparator offset error	-	-	±4	±20	mV
dThreshold/ dt	Threshold voltage temperature coefficient	V_{DDA} = 3.3V T_A = 0 to 50 °C V- = V_{REFINT}, 3/4 V_{REFINT}, 1/2 V_{REFINT}, 1/4 V_{REFINT}	-	15	100	ppm /°C
I_{COMP2}	Current consumption(3)	Fast mode	-	3.5	5	µA
		Slow mode	-	0.5	2	

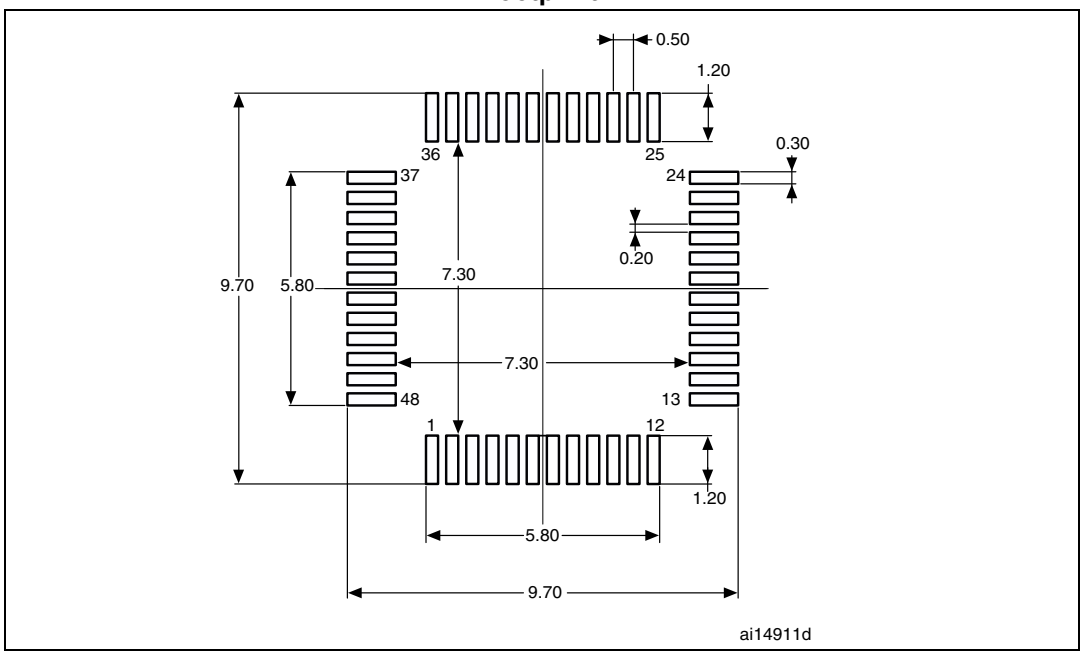
1. Guaranteed by characterization results.
2. The delay is characterized for 100 mV input step with 10 mV overdrive on the inverting input, the non-inverting input set to the reference.
3. Comparator consumption only. Internal reference voltage (necessary for comparator operation) is not included.

Table 64. LQPF100 14 x 14 mm, 100-pin low-profile quad flat package mechanical data

Symbol	millimeters			inches[1]		
	Min	Typ	Max	Min	Typ	Max
A	-	-	1.600	-	-	0.0630
A1	0.050	-	0.150	0.0020	-	0.0059
A2	1.350	1.400	1.450	0.0531	0.0551	0.0571
b	0.170	0.220	0.270	0.0067	0.0087	0.0106
c	0.090	-	0.200	0.0035	-	0.0079
D	15.800	16.000	16.200	0.6220	0.6299	0.6378
D1	13.800	14.000	14.200	0.5433	0.5512	0.5591
D3	-	12.000	-	-	0.4724	-
E	15.800	16.000	16.200	0.6220	0.6299	0.6378
E1	13.800	14.000	14.200	0.5433	0.5512	0.5591
E3	-	12.000	-	-	0.4724	-
e	-	0.500	-	-	0.0197	-
L	0.450	0.600	0.750	0.0177	0.0236	0.0295
L1	-	1.000	-	-	0.0394	-
k	0.0°	3.5°	7.0°	0.0°	3.5°	7.0°
ccc	-	-	0.080	-	-	0.0031

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

Figure 37. LQFP48 7 x 7 mm, 48-pin low-profile quad flat package recommended footprint

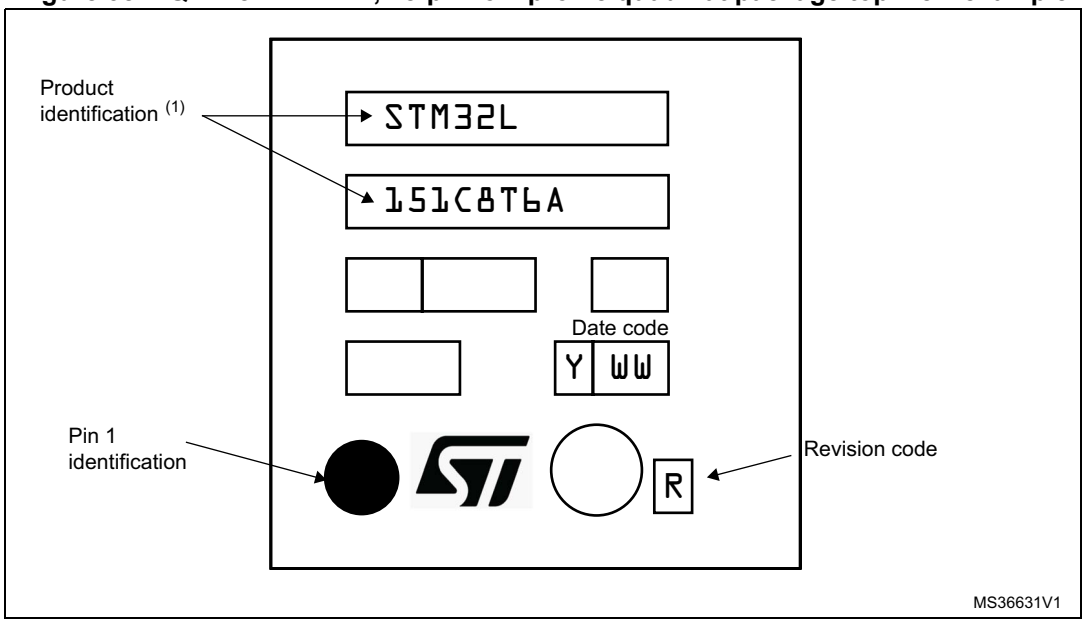


1. Dimensions are in millimeters.

LQFP48 device marking

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

Figure 38. LQFP48 7 x 7 mm, 48-pin low-profile quad flat package top view 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 70. TFBGA64 5 x 5 mm, 0.5 mm pitch, thin fine-pitch ball grid array package mechanical data (continued)

Symbol	millimeters			inches[1]		
	Min	Typ	Max	Min	Typ	Max
ddd	-	-	0.080	-	-	0.0031
eee	-	-	0.15	-	-	0.0059
fff	-	-	0.05	-	-	0.002

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

Figure 46. TFBGA64, 5 x 5 mm, 0.5 mm pitch, thin fine-pitch ball grid array package recommended footprint

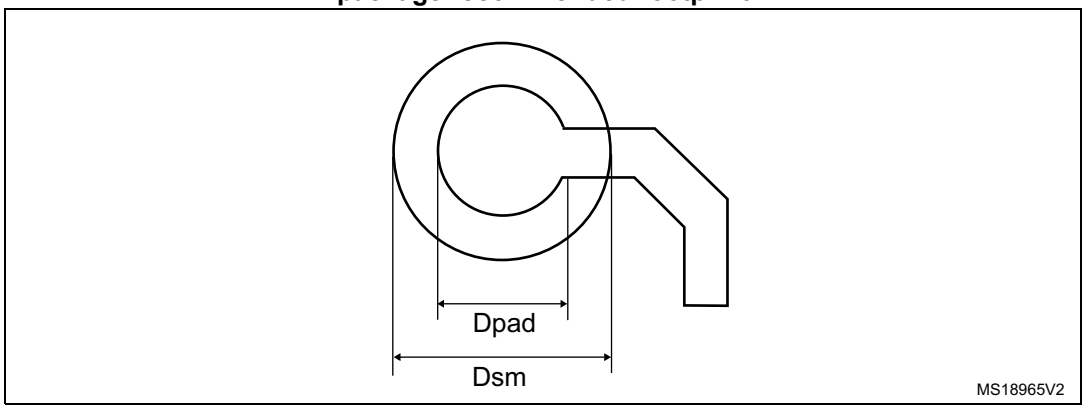


Table 71. TFBGA64 5 x 5 mm, 0.5 mm pitch, recommended PCB design rules

Dimension	Recommended values
Pitch	0.5
Dpad	0.27 mm
Dsm	0.35 mm typ. (depends on the soldermask registration tolerance)
Solder paste	0.27 mm aperture diameter.