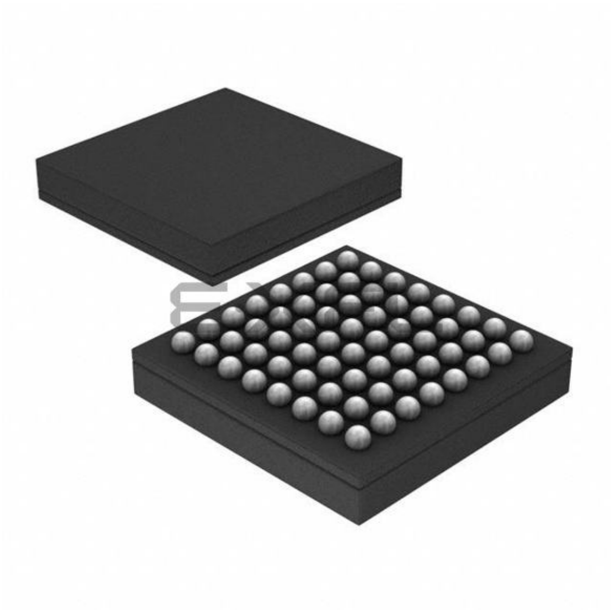

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What is "Embedded - Microcontrollers"?

"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	128KB (128K x 8)
Program Memory Type	FLASH
EEPROM Size	4K x 8
RAM Size	16K 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-TFBGA
Supplier Device Package	64-TFBGA (5x5)
Purchase URL	https://www.e-xfl.com/product-detail/stmicroelectronics/stm32l151rbh6ttr

1 Introduction

This datasheet provides the ordering information and mechanical device characteristics of the STM32L151x6/8/B-A and STM32L152x6/8/B-A ultra-low-power ARM® Cortex®-M3 based microcontrollers product line.

The ultra-low-power STM32L151x6/8/B-A and STM32L152x6/8/B-A microcontroller family includes devices in 3 different package types: from 48 to 100 pins. Depending on the device chosen, different sets of peripherals are included, the description below gives an overview of the complete range of peripherals proposed in this family.

These features make the ultra-low-power STM32L151x6/8/B-A and STM32L152x6/8/B-A microcontroller family suitable for a wide range of applications:

- Medical and handheld equipment
- Application control and user interface
- PC peripherals, gaming, GPS and sport equipment
- Alarm systems, Wired and wireless sensors, Video intercom
- Utility metering

This STM32L151x6/8/B-A and STM32L152x6/8/B-A datasheet should be read in conjunction with the STM32L1xxxx reference manual (RM0038). The document "Getting started with STM32L1xxxx hardware development" AN3216 gives a hardware implementation overview.

Both documents are available from the STMicroelectronics website *www.st.com*.

For information on the ARM® Cortex®-M3 core please refer to the Cortex®-M3 Technical Reference Manual, available from the ARM website.

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

Caution: This datasheet does not apply to:

– STM32L15xx6/8/B

covered by a separate datasheet.

Table 3. Functionalities depending on the operating power supply range (continued)

Operating power supply range	Functionalities depending on the operating power supply range			
	DAC and ADC operation	USB	Dynamic voltage scaling range	I/O operation
V_{DD} = 2.0 to 2.4 V	Conversion time up to 500 Ksps	Functional(2)	Range 1, Range 2 or Range 3	Full speed operation
V_{DD} = 2.4 to 3.6 V	Conversion time up to 1 Msps	Functional(2)	Range 1, Range 2 or Range 3	Full speed operation

1. CPU frequency changes from initial to final must respect "F_{CPU} initial < 4*F_{CPU} final" to limit V_{CORE} drop due to current consumption peak when frequency increases. It must also respect 5 µs delay between two changes. For example to switch from 4.2 MHz to 32 MHz, you can switch from 4.2 MHz to 16 MHz, wait 5 µs, then switch from 16 MHz to 32 MHz.
2. Should be USB-compliant from I/O voltage standpoint, the minimum V_{DD} is 3.0 V.

Table 4. CPU frequency range depending on dynamic voltage scaling

CPU frequency range	Dynamic voltage scaling range
16 MHz to 32 MHz (1ws) 32 kHz to 16 MHz (0ws)	Range 1
8 MHz to 16 MHz (1ws) 32 kHz to 8 MHz (0ws)	Range 2
2.1 MHz to 4.2 MHz (1ws) 32 kHz to 2.1 MHz (0ws)	Range 3

3.4 Clock management

The clock controller distributes the clocks coming from different oscillators to the core and the peripherals. It also manages clock gating for low-power modes and ensures clock robustness. It features:

- **Clock prescaler**: to get the best trade-off between speed and current consumption, the clock frequency to the CPU and peripherals can be adjusted by a programmable prescaler
- **Safe clock switching**: clock sources can be changed safely on the fly in run mode through a configuration register.
- **Clock management**: to reduce power consumption, the clock controller can stop the clock to the core, individual peripherals or memory.
- **Master clock source**: three different clock sources can be used to drive the master clock:
  - 1-24 MHz high-speed external crystal (HSE), that can supply a PLL
  - 16 MHz high-speed internal RC oscillator (HSI), trimmable by software, that can supply a PLL
  - Multispeed internal RC oscillator (MSI), trimmable by software, able to generate 7 frequencies (65.5 kHz, 131 kHz, 262 kHz, 524 kHz, 1.05 MHz, 2.1 MHz, 4.2 MHz) with a consumption proportional to speed, down to 750 nA typical. When a 32.768 kHz clock source is available in the system (LSE), the MSI frequency can be trimmed by software down to a ±0.5% accuracy.
- **Auxiliary clock source**: two ultra-low-power clock sources that can be used to drive the LCD controller and the real-time clock:
  - 32.768 kHz low-speed external crystal (LSE)
  - 37 kHz low-speed internal RC (LSI), also used to drive the independent watchdog. The LSI clock can be measured using the high-speed internal RC oscillator for greater precision.
- **RTC and LCD clock sources:** the LSI, LSE or HSE sources can be chosen to clock the RTC and the LCD, whatever the system clock.
- **USB clock source:** the embedded PLL has a dedicated 48 MHz clock output to supply the USB interface.
- **Startup clock:** after reset, the microcontroller restarts by default with an internal 2.1 MHz clock (MSI). The prescaler ratio and clock source can be changed by the application program as soon as the code execution starts.
- **Clock security system (CSS):** this feature can be enabled by software. If a HSE clock failure occurs, the master clock is automatically switched to HSI and a software interrupt is generated if enabled.
- **Clock-out capability (MCO: microcontroller clock output):** it outputs one of the internal clocks for external use by the application.

Several prescalers allow the configuration of the AHB frequency, the high-speed APB (APB2) and the low-speed APB (APB1) domains. The maximum frequency of the AHB and the APB domains is 32 MHz. See *Figure 2* for details on the clock tree.

3.5 Low-power real-time clock and backup registers

The real-time clock (RTC) is an independent BCD timer/counter. Dedicated registers contain the sub-second, second, minute, hour (12/24 hour), week day, date, month, year, in BCD (binary-coded decimal) format. Correction for 28, 29 (leap year), 30, and 31 day of the month are made automatically. The RTC provides two programmable alarms and programmable periodic interrupts with wakeup from Stop and Standby modes.

The programmable wakeup time ranges from 120 µs to 36 hours.

The RTC can be calibrated with an external 512 Hz output, and a digital compensation circuit helps reduce drift due to crystal deviation. The RTC can also be automatically corrected with a 50/60Hz stable power line.

The RTC calendar can be updated on the fly down to sub second precision, which enables network system synchronization. A time stamp can record an external event occurrence, and generates an interrupt.

There are twenty 32-bit backup registers provided to store 80 bytes of user application data. They are cleared in case of tamper detection. Three pins can be used to detect tamper events. A change on one of these pins can reset backup register and generate an interrupt. To prevent false tamper event, like ESD event, these three tamper inputs can be digitally filtered.

3.6 GPIOs (general-purpose inputs/outputs)

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, and can be individually remapped using dedicated AFIO registers. All GPIOs are high current capable. The alternate function configuration of I/Os can be locked if needed following a specific sequence in order to avoid spurious writing to the I/O registers. The I/O controller is connected to the AHB with a toggling speed of up to 16 MHz.

External interrupt/event controller (EXTI)

The external interrupt/event controller consists of 23 edge detector lines used to generate interrupt/event requests. Each line can be individually configured to select the trigger event (rising edge, falling edge, both) and can be masked independently. A pending register maintains the status of the interrupt requests. The EXTI can detect an external line with a pulse width shorter than the Internal APB2 clock period. Up to 83 GPIOs can be connected to the 16 external interrupt lines. The 7 other lines are connected to RTC, PVD, USB or Comparator events.

Table 7. Timer feature comparison

Timer	Counter resolution	Counter type	Prescaler factor	DMA request generation	Capture/compare channels	Complementary outputs
TIM2, TIM3, TIM4	16-bit	Up, down, up/down	Any integer between 1 and 65536	Yes	4	No
TIM9	16-bit	Up, down, up/down	Any integer between 1 and 65536	No	2	No
TIM10, TIM11	16-bit	Up	Any integer between 1 and 65536	No	1	No
TIM6, TIM7	16-bit	Up	Any integer between 1 and 65536	Yes	0	No

3.17 CRC (cyclic redundancy check) calculation unit

The CRC (cyclic redundancy check) calculation unit is used to get a CRC code from a 32-bit data word and a fixed generator polynomial.

Among other applications, CRC-based techniques are used to verify data transmission or storage integrity. In the scope of the EN/IEC 60335-1 standard, they offer a means of verifying the Flash memory integrity. The CRC calculation unit helps compute a signature of the software during runtime, to be compared with a reference signature generated at link-time and stored at a given memory location.

3.18 Development support

Serial wire JTAG debug port (SWJ-DP)

The ARM SWJ-DP interface is embedded, and is a combined JTAG and serial wire debug port that enables either a serial wire debug or a JTAG probe to be connected to the target. The JTAG JTMS and JTCK pins are shared with SWDAT and SWCLK, respectively, and a specific sequence on the JTMS pin is used to switch between JTAG-DP and SW-DP.

The JTAG port can be permanently disabled with a JTAG fuse.

Embedded Trace Macrocell™

The ARM Embedded Trace Macrocell provides a greater visibility of the instruction and data flow inside the CPU core by streaming compressed data at a very high rate from the STM32L151x6/8/B-A and STM32L152x6/8/B-A device through a small number of ETM pins to an external hardware trace port analyzer (TPA) device. The TPA is connected to a host computer using USB, Ethernet, or any other high-speed channel. Real-time instruction and data flow activity can be recorded and then formatted for display on the host computer running debugger software. TPA hardware is commercially available from common development tool vendors. It operates with third party debugger software tools.

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 10. Alternate function input/output

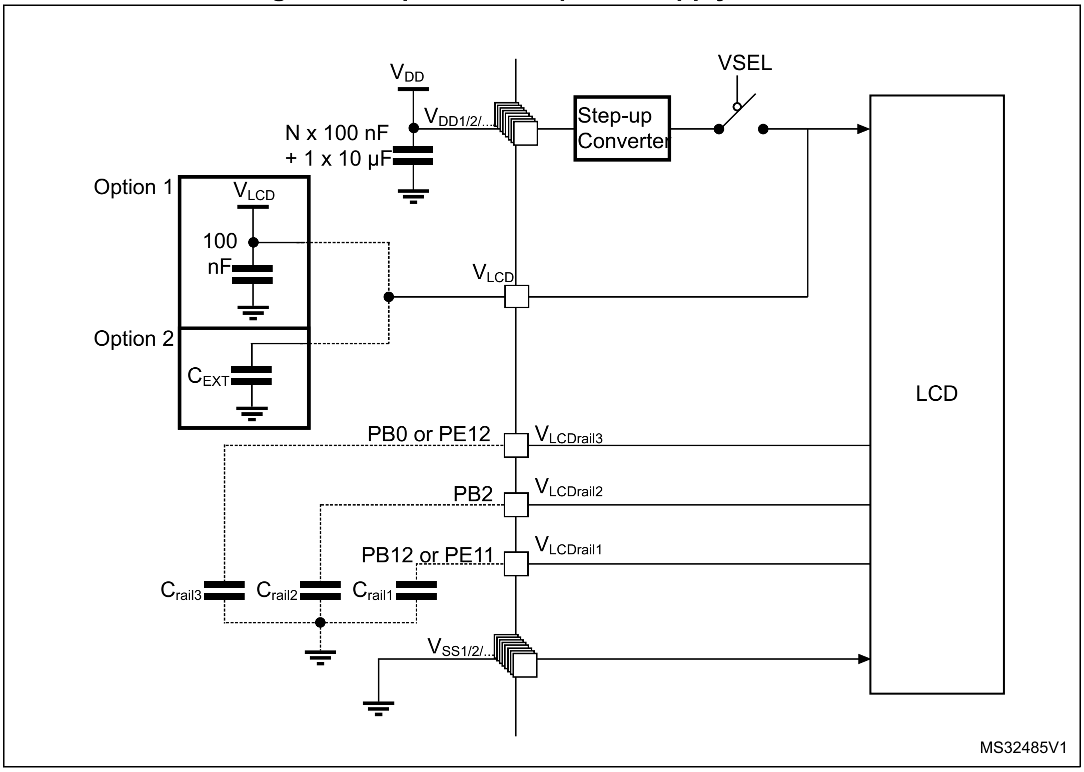
Port name	Digital alternate function number														
	AFIO0	AFIO1	AFIO2	AFIO3	AFIO4	AFIO5	AFOI6	AFIO7	AFIO8	AFIO9	AFIO11	AFIO12	AFIO13	AFIO14	AFIO15
	Alternate function														
	SYSTEM	TIM2	TIM3/4	TIM9/10/11	I2C1/2	SPI1/2	N/A	USART 1/2/3	N/A	N/A	LCD	N/A	N/A	RI	SYSTEM
BOOT0	BOOT0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NRST	NRST	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PA0-WKUP1	-	TIM2_CH1_ETR	-	-	-	-	-	USART2_CTS	-	-	-	-	-	TIMx_IC1	EVENTOUT
PA1	-	TIM2_CH2	-	-	-	-	-	USART2_RTS	-	-	[SEG0]	-	-	TIMx_IC2	EVENTOUT
PA2	-	TIM2_CH3	-	TIM9_CH1	-	-	-	USART2_TX	-	-	[SEG1]	-	-	TIMx_IC3	EVENTOUT
PA3	-	TIM2_CH4	-	TIM9_CH2	-	-	-	USART2_RX	-	-	[SEG2]	-	-	TIMx_IC4	EVENTOUT
PA4	-	-	-	-	-	SPI1_NSS	-	USART2_CK	-	-	-	-	-	TIMx_IC1	EVENTOUT
PA5	-	TIM2_CH1_ETR	-	-	-	SPI1_SCK	-	-	-	-	-	-	-	TIMx_IC2	EVENTOUT
PA6	-	-	TIM3_CH1	TIM10_CH1	-	SPI1_MISO	-	-	-	-	[SEG3]	-	-	TIMx_IC3	EVENTOUT
PA7	-	-	TIM3_CH2	TIM11_CH1	-	SPI1_MOSI	-	-	-	-	[SEG4]	-	-	TIMx_IC4	EVENTOUT
PA8	MCO	-	-	-	-	-	-	USART1_CK	-	-	[COM0]	-	-	TIMx_IC1	EVENTOUT
PA9	-	-	-	-	-	-	-	USART1_TX	-	-	[COM1]	-	-	TIMx_IC2	EVENTOUT
PA10	-	-	-	-	-	-	-	USART1_RX	-	-	[COM2]	-	-	TIMx_IC3	EVENTOUT
PA11	-	-	-	-	-	SPI1_MISO	-	USART1_CTS	-	-	-	-	-	TIMx_IC4	EVENTOUT
PA12	-	-	-	-	-	SPI1_MOSI	-	USART1_RTS	-	-	-	-	-	TIMx_IC1	EVENTOUT
PA13	JTMS-SWDIO	-	-	-	-	-	-	-	-	-	-	-	-	TIMx_IC2	EVENTOUT
PA14	JTCK-SWCLK	-	-	-	-	-	-	-	-	-	-	-	-	TIMx_IC3	EVENTOUT
PA15	JTDI	TIM2_CH1_ETR	-	-	-	SPI1_NSS	-	-	-	-	SEG17	-	-	TIMx_IC4	EVENTOUT
PB0	-	-	TIM3_CH3	-	-	-	-	-	-	-	[SEG5]	-	-	-	EVENTOUT
PB1	-	-	TIM3_CH4	-	-	-	-	-	-	-	[SEG6]	-	-	-	EVENTOUT
PB2	BOOT1	-	-	-	-	-	-	-	-	-	-	-	-	-	EVENTOUT
PB3	JTDO	TIM2_CH2	-	-	-	SPI1_SCK	-	-	-	-	[SEG7]	-	-	-	EVENTOUT

Table 10. Alternate function input/output (continued)

Port name	Digital alternate function number														
	AFIO0	AFIO1	AFIO2	AFIO3	AFIO4	AFIO5	AFOI6	AFIO7	AFIO8	AFIO9	AFIO11	AFIO 12	AFIO 13	AFIO14	AFIO15
	Alternate function														
	SYSTEM	TIM2	TIM3/4	TIM9/10/11	I2C1/2	SPI1/2	N/A	USART 1/2/3	N/A	N/A	LCD	N/A	N/A	RI	SYSTEM
PD10	-	-	-	-	-	-	-	USART3_CK	-	-	-	-	-	TIMx_IC3	EVENTOUT
PD11	-	-	-	-	-	-	-	USART3_CTS	-	-	-	-	-	TIMx_IC4	EVENTOUT
PD12	-	-	TIM4_CH1	-	-	-	-	USART3_RTS	-	-	-	-	-	TIMx_IC1	EVENTOUT
PD13	-	-	TIM4_CH2	-	-	-	-	-	-	-	-	-	-	TIMx_IC2	EVENTOUT
PD14	-	-	TIM4_CH3	-	-	-	-	-	-	-	-	-	-	TIMx_IC3	EVENTOUT
PD15	-	-	TIM4_CH4	-	-	-	-	-	-	-	-	-	-	TIMx_IC4	EVENTOUT
PE0	-	-	TIM4_ETR	TIM10_CH1	-	-	-	-	-	-	-	-	-	TIMx_IC1	EVENTOUT
PE1	-	-		TIM11_CH1	-	-	-	-	-	-	-	-	-	TIMx_IC2	EVENTOUT
PE2	TRACECK	-	TIM3_ETR	-	-	-	-	-	-	-	-	-	-	TIMx_IC3	EVENTOUT
PE3	TRACED0	-	TIM3_CH1	-	-	-	-	-	-	-	-	-	-	TIMx_IC4	EVENTOUT
PE4	TRACED1	-	TIM3_CH2	-	-	-	-	-	-	-	-	-	-	TIMx_IC1	EVENTOUT
PE5	TRACED2	-	-	TIM9_CH1*	-	-	-	-	-	-	-	-	-	TIMx_IC2	EVENTOUT
PE6	TRACED3	-	-	TIM9_CH2*	-	-	-	-	-	-	-	-	-	TIMx_IC3	EVENTOUT
PE7	-	-	-	-	-	-	-	-	-	-	-	-	-	TIMx_IC4	EVENTOUT
PE8	-	-	-	-	-	-	-	-	-	-	-	-	-	TIMx_IC1	EVENTOUT
PE9	-	TIM2_CH1_ETR	-	-	-	-	-	-	-	-	-	-	-	TIMx_IC2	EVENTOUT
PE10	-	TIM2_CH2	-	-	-	-	-	-	-	-	-	-	-	TIMx_IC3	EVENTOUT
PE11	-	TIM2_CH3	-	-	-	-	-	-	-	-	-	-	-	TIMx_IC4	EVENTOUT
PE12	-	TIM2_CH4	-	-	-	SPI1_NSS	-	-	-	-	-	-	-	TIMx_IC1	EVENTOUT
PE13	-	-	-	-	-	SPI1_SCK	-	-	-	-	-	-	-	TIMx_IC2	EVENTOUT
PE14	-	-	-	-	-	SPI1_MISO	-	-	-	-	-	-	-	TIMx_IC3	EVENTOUT
PE15	-	-	-	-	-	SPI1_MOSI	-	-	-	-	-	-	-	TIMx_IC4	EVENTOUT
PH0-OSC_IN	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

6.1.7 Optional LCD power supply scheme

Figure 13. Optional LCD power supply scheme



1. Option 1: LCD power supply is provided by a dedicated VLCD supply source, VSEL switch is open.
2. Option 2: LCD power supply is provided by the internal step-up converter, VSEL switch is closed, an external capacitance is needed for correct behavior of this converter.

6.1.8 Current consumption measurement

Figure 14. Current consumption measurement scheme

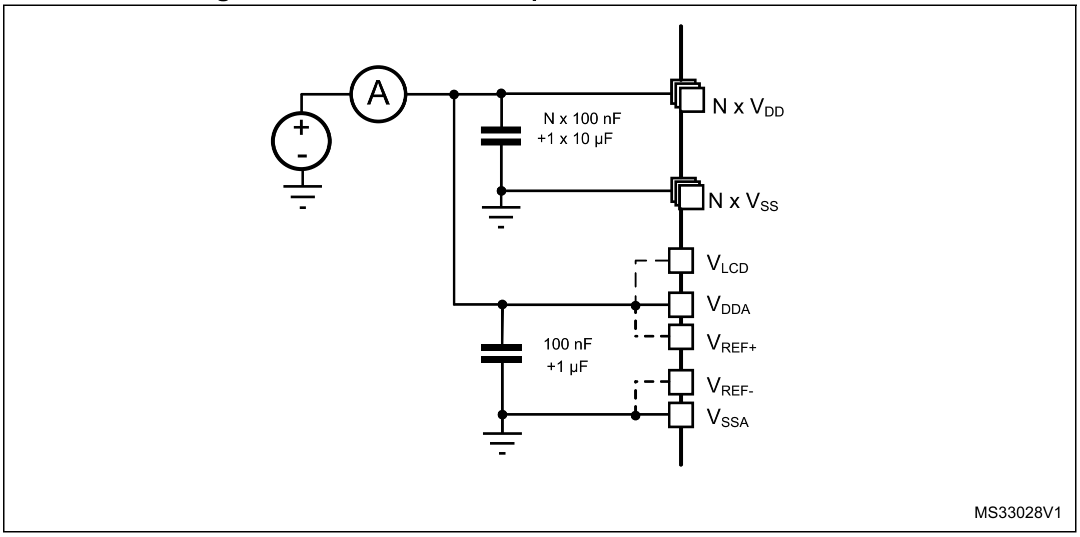


Table 15. Embedded reset and power control block characteristics (continued)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{BOR0}	Brown-out reset threshold 0	Falling edge	1.67	1.7	1.74	V
		Rising edge	1.69	1.76	1.8	
V_{BOR1}	Brown-out reset threshold 1	Falling edge	1.87	1.93	1.97	
		Rising edge	1.96	2.03	2.07	
V_{BOR2}	Brown-out reset threshold 2	Falling edge	2.22	2.30	2.35	
		Rising edge	2.31	2.41	2.44	
V_{BOR3}	Brown-out reset threshold 3	Falling edge	2.45	2.55	2.60	
		Rising edge	2.54	2.66	2.7	
V_{BOR4}	Brown-out reset threshold 4	Falling edge	2.68	2.8	2.85	
		Rising edge	2.78	2.9	2.95	
V_{PVD0}	Programmable voltage detector threshold 0	Falling edge	1.8	1.85	1.88	V
		Rising edge	1.88	1.94	1.99	
V_{PVD1}	PVD threshold 1	Falling edge	1.98	2.04	2.09	
		Rising edge	2.08	2.14	2.18	
V_{PVD2}	PVD threshold 2	Falling edge	2.20	2.24	2.28	
		Rising edge	2.28	2.34	2.38	
V_{PVD3}	PVD threshold 3	Falling edge	2.39	2.44	2.48	
		Rising edge	2.47	2.54	2.58	
V_{PVD4}	PVD threshold 4	Falling edge	2.57	2.64	2.69	
		Rising edge	2.68	2.74	2.79	
V_{PVD5}	PVD threshold 5	Falling edge	2.77	2.83	2.88	
		Rising edge	2.87	2.94	2.99	
V_{PVD6}	PVD threshold 6	Falling edge	2.97	3.05	3.09	
		Rising edge	3.08	3.15	3.20	
V_{hyst}	Hysteresis voltage	BOR0 threshold	-	40	-	mV
		All BOR and PVD thresholds excepting BOR0	-	100	-	

1. Guaranteed by characterization.
2. Valid for device version without BOR at power up. Please see option "D" in Ordering information scheme for more details.

Table 20. Current consumption in Sleep mode

Symbol	Parameter	Conditions		f_{HCLK}	Typ	Max(1)	Unit
I_{DD} (Sleep)	Supply current in Sleep mode, Flash OFF	$f_{HSE} = f_{HCLK}$ up to 16 MHz included, $f_{HSE} = f_{HCLK}/2$ above 16 MHz (PLL ON)(2)	Range 3, V_{CORE}=1.2 V VOS[1:0] = 11	1 MHz	50	155	µA
				2 MHz	78.5	235	
				4 MHz	140	370(3)	
			Range 2, V_{CORE}=1.5 V VOS[1:0] = 10	4 MHz	165	375	
				8 MHz	310	530	
				16 MHz	590	1000	
			Range 1, V_{CORE}=1.8 V VOS[1:0] = 01	8 MHz	350	615	
				16 MHz	680	1200	
				32 MHz	1600	2350	
		HSI clock source (16 MHz)	Range 2, V_{CORE}=1.5 V VOS[1:0] = 10	16 MHz	640	970	
			Range 1, V_{CORE}=1.8 V VOS[1:0] = 01	32 MHz	1600	2350	
		MSI clock, 65 kHz	Range 3, V_{CORE}=1.2 V VOS[1:0] = 11	65 kHz	19	60	
		MSI clock, 524 kHz		524 kHz	33	90	
		MSI clock, 4.2 MHz		4.2 MHz	145	210	
	Supply current in Sleep mode, Flash ON	$f_{HSE} = f_{HCLK}$ up to 16 MHz included, $f_{HSE} = f_{HCLK}/2$ above 16 MHz (PLL ON)(2)	Range 3, V_{CORE}=1.2 V VOS[1:0] = 11	1 MHz	60.5	145	µA
				2 MHz	89.5	225	
				4 MHz	150	360	
			Range 2, V_{CORE}=1.5 V VOS[1:0] = 10	4 MHz	180	370	
				8 MHz	320	490	
				16 MHz	605	895	
			Range 1, V_{CORE}=1.8 V VOS[1:0] = 01	8 MHz	380	565	
				16 MHz	695	1070	
				32 MHz	1600	2200	
		HSI clock source (16 MHz)	Range 2, V_{CORE}=1.5 V VOS[1:0] = 10	16 MHz	650	970	
			Range 1, V_{CORE}=1.8 V VOS[1:0] = 01	32 MHz	1600	2320	
		MSI clock, 65 kHz	Range 3, V_{CORE}=1.2V VOS[1:0] = 11	65 kHz	29.5	65	
		MSI clock, 524 kHz		524 kHz	44	80	
		MSI clock, 4.2 MHz		4.2 MHz	155	220	

1. Guaranteed by characterization results, unless otherwise specified.
2. Oscillator bypassed (HSEBYP = 1 in RCC_CR register)
3. Guaranteed by test in production.

Table 25. Peripheral current consumption[1] (continued)

Peripheral		Typical consumption, V_{DD} = 3.0 V, T_A = 25 °C				Unit
		Range 1, V_{CORE}= 1.8 V VOS[1:0] = 01	Range 2, V_{CORE}= 1.5 V VOS[1:0] = 10	Range 3, V_{CORE}= 1.2 V VOS[1:0] = 11	Low-power sleep and run	
I_{DD} (RTC)		0.4				µA
I_{DD} (LCD)		3.1				
I_{DD} (ADC)[4]		1450				
I_{DD} (DAC)[5]		340				
I_{DD} (COMP1)		0.16				
I_{DD} (COMP2)	Slow mode	2				
	Fast mode	5				
I_{DD} (PVD / BOR)[6]		2.6				
I_{DD} (IWDG)		0.25				

1. Data based on differential I_{DD} measurement between all peripherals OFF an one peripheral with clock enabled, in the following conditions: f_{HCLK} = 32 MHz (Range 1), f_{HCLK} = 16 MHz (Range 2), f_{HCLK} = 4 MHz (Range 3), f_{HCLK} = 64kHz (Low-power run/sleep), $f_{APB1} = f_{HCLK}$, $f_{APB2} = f_{HCLK}$, default prescaler value for each peripheral. The CPU is in Sleep mode in both cases. No I/O pins toggling.
2. HSI oscillator is OFF for this measure.
3. In low-power sleep and run mode, the Flash memory must always be in power-down mode.
4. Data based on a differential I_{DD} measurement between ADC in reset configuration and continuous ADC conversion (HSI consumption not included).
5. Data based on a differential I_{DD} measurement between DAC in reset configuration and continuous DAC conversion of V_{DD}/2. DAC is in buffered mode, output is left floating.
6. Including supply current of internal reference voltage.

6.3.5 Wakeup time from Low-power mode

The wakeup times given in the following table are measured with the MSI RC oscillator. The clock source used to wake up the device depends on the current operating mode:

- Sleep mode: the clock source is the clock that was set before entering Sleep mode
- Stop mode: the clock source is the MSI oscillator in the range configured before entering Stop mode
- Standby mode: the clock source is the MSI oscillator running at 2.1 MHz

All timings are derived from tests performed under ambient temperature and V_{DD} supply voltage conditions summarized in *Table 14*.

Low-speed external user clock generated from an external source

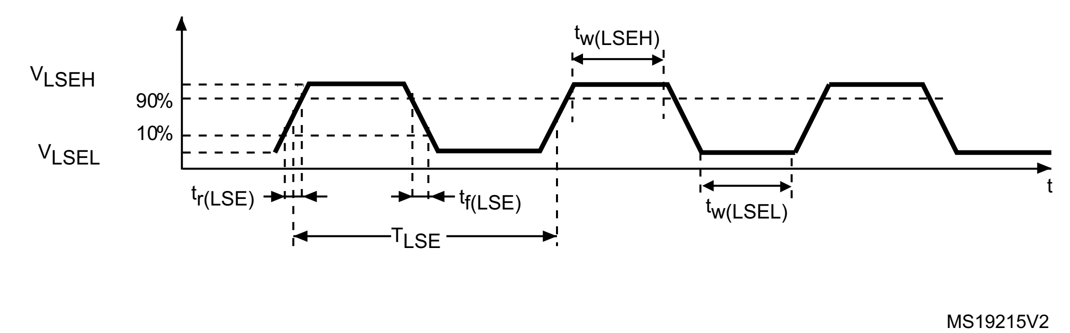
The characteristics given in the following table result from tests performed using a low-speed external clock source, and under ambient temperature and supply voltage conditions summarized in Table 14.

Table 28. Low-speed external user clock characteristics(1)

Symbol	Parameter	Min	Typ	Max	Unit
f_{LSE_ext}	User external clock source frequency	1	32.768	1000	kHz
V_{LSEH}	OSC32_IN input pin high level voltage	$0.7V_{DD}$	-	V_{DD}	-
V_{LSEL}	OSC32_IN input pin low level voltage	V_{SS}	-	$0.3V_{DD}$	-
$t_{w(LSEH)}$ $t_{w(LSEL)}$	OSC32_IN high or low time	465	-	-	ns
$t_{r(LSE)}$ $t_{f(LSE)}$	OSC32_IN rise or fall time	-	-	10	ns
$C_{IN(LSE)}$	OSC32_IN input capacitance	-	0.6	-	pF

1. Guaranteed by design.

Figure 16. 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 1 to 24 MHz crystal/ceramic resonator oscillator. All the information given in this paragraph are based on characterization results obtained with typical external components specified in Table 29. 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 29. HSE oscillator characteristics(1)(2)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
f_{OSC_IN}	Oscillator frequency	-	1		24	MHz
R_F	Feedback resistor	-		200	-	kΩ

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 44*.

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 ΣI_{VDD} (see *Table 12*).
- 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 ΣI_{VSS} (see *Table 12*).

Output voltage levels

Unless otherwise specified, the parameters given in *Table 44* are derived from tests performed under ambient temperature and V_{DD} supply voltage conditions summarized in *Table 14*. All I/Os are CMOS and TTL compliant.

Table 44. 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} (3)(2)	Output high level voltage for an I/O pin		V_{DD}-0.4	-	
V_{OL} (1)(4)	Output low level voltage for an I/O pin	I_{IO} = 4 mA 1.65 V < V_{DD} < 2.7 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} = 15 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 12* 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 12* and the sum of I_{IO} (I/O ports and control pins) must not exceed I_{VDD}.
4. Guaranteed by characterization results.

6.3.18 DAC electrical specifications

Data guaranteed by design, unless otherwise specified.

Table 58. DAC characteristics

Symbol	Parameter	Conditions		Min	Typ	Max	Unit
V_{DDA}	Analog supply voltage	-		1.8	-	3.6	V
V_{REF+}	Reference supply voltage	V_{REF+} must always be below V_{DDA}		1.8	-	3.6	V
V_{REF-}	Lower reference voltage	-		V_{SSA}			V
$I_{DDVREF+}$(1)	Current consumption on V_{REF+} supply $V_{REF+} = 3.3$ V	No load, middle code (0x800)		-	130	220	µA
		No load, worst code (0x000)		-	220	350	µA
I_{DDA}(1)	Current consumption on V_{DDA} supply $V_{DDA} = 3.3$ V	No load, middle code (0x800)		-	210	320	µA
		No load, worst code (0xF1C)		-	320	520	µA
R_L	Resistive load	DAC output buffer ON	Connected to V_{SSA}	5	-	-	kΩ
			Connected to V_{DDA}	25	-	-	
C_L	Capacitive load	DAC output buffer ON		-	-	50	pF
R_O	Output impedance	DAC output buffer OFF		12	16	20	kΩ
V_{DAC_OUT}	Voltage on DAC_OUT output	DAC output buffer ON		0.2	-	$V_{DDA} - 0.2$	V
		DAC output buffer OFF		0.5	-	$V_{REF+} -$ 1LSB	mV
DNL(1)	Differential non linearity(2)	$C_L \leq 50$ pF, $R_L \geq 5$ kΩ DAC output buffer ON		-	1.5	3	LSB
		No R_L, $C_L \leq 50$ pF DAC output buffer OFF		-	1.5	3	
INL(1)	Integral non linearity(3)	$C_L \leq 50$ pF, $R_L \geq 5$ kΩ DAC output buffer ON		-	2	4	
		No R_L, $C_L \leq 50$ pF DAC output buffer OFF		-	2	4	
Offset(1)	Offset error at code 0x800 (4)	$C_L \leq 50$ pF, $R_L \geq 5$ kΩ DAC output buffer ON		-	±10	±25	
		No R_L, $C_L \leq 50$ pF DAC output buffer OFF		-	±5	±8	
Offset1(1)	Offset error at code 0x001(5)	No R_L, $C_L \leq 50$ pF DAC output buffer OFF		-	±1.5	±5	

6.3.20 Comparator

Table 61. Comparator 1 characteristics

Symbol	Parameter	Conditions	Min[1]	Typ	Max[1]	Unit
V_{DDA}	Analog supply voltage	-	1.65		3.6	V
R_{400K}	R_{400K} value	-	-	400	-	kΩ
R_{10K}	R_{10K} value	-	-	10	-	kΩ
V_{IN}	Comparator 1 input voltage range	-	0.6	-	V_{DDA}	V
t_{START}	Comparator startup time	-	-	7	10	µs
td	Propagation delay[2]	-	-	3	10	µs
Voffset	Comparator offset	-	-	±3	±10	mV
$d_{Voffset}/dt$	Comparator offset variation in worst voltage stress conditions	V_{DDA} = 3.6 V V_{IN+} = 0 V V_{IN-} = V_{REFINT} T_A = 25 °C	0	1.5	10	mV/1000 h
I_{COMP1}	Current consumption[3]	-	-	160	260	nA

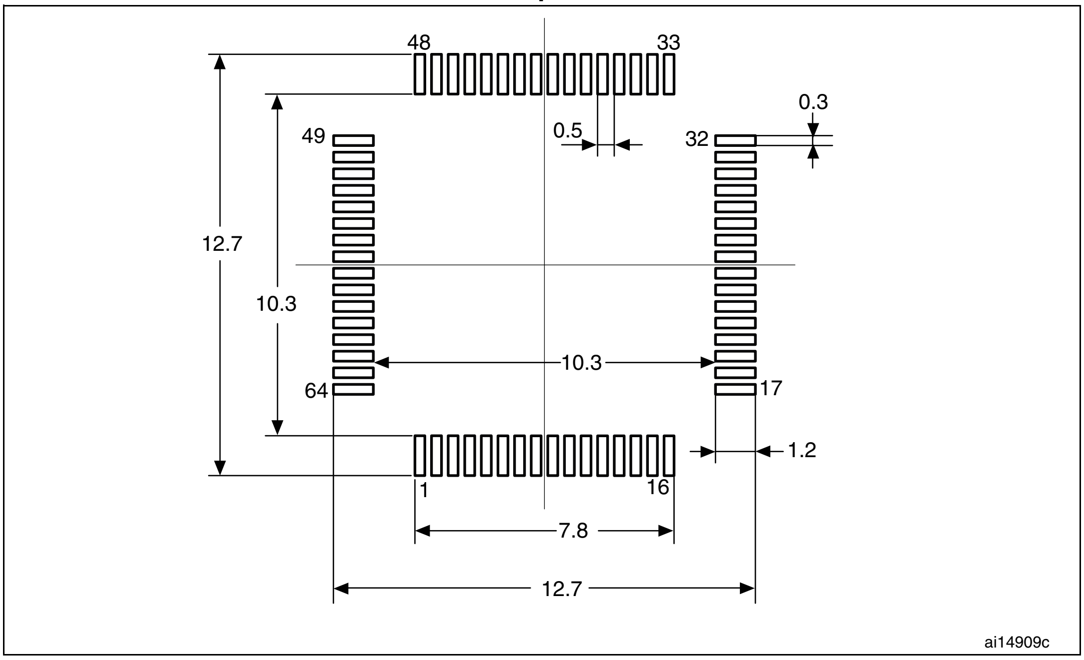
1. Guaranteed by characterization results.
2. The delay is characterized for 100 mV input step with 10 mV overdrive on the inverting input, the non-inverting input set to the reference.
3. Comparator consumption only. Internal reference voltage not included.

Table 65. LQFP64 10 x 10 mm, 64-pin low-profile quad flat package mechanical data (continued)

Symbol	millimeters			inches[1]		
	Min	Typ	Max	Typ	Min	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 34. LQFP64 10 x 10 mm, 64-pin low-profile quad flat package recommended footprint

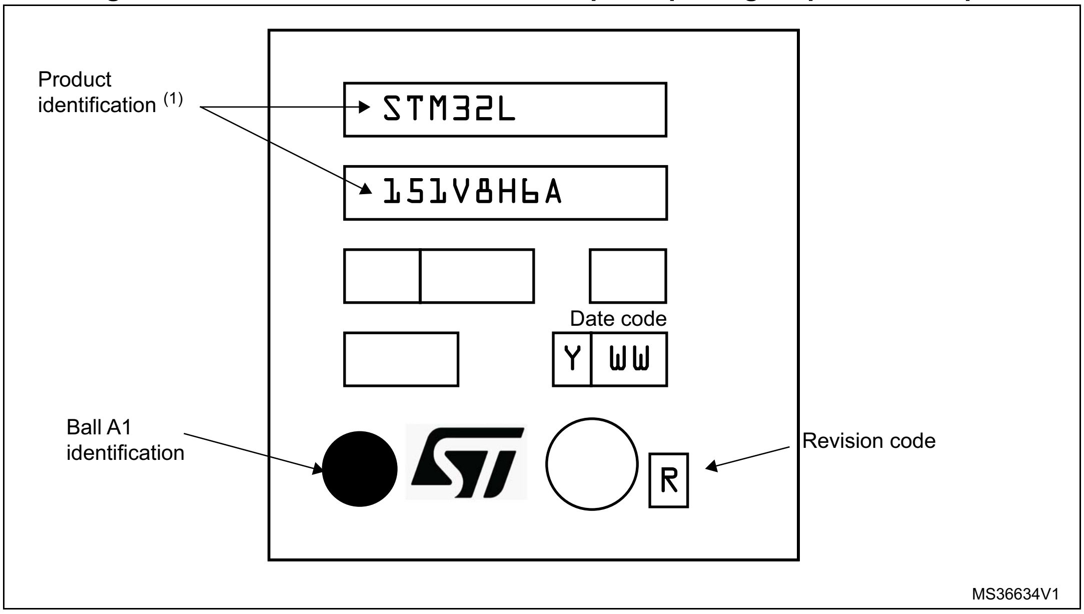


1. Dimensions are in millimeters.

UFBGA100 device marking

The following figure gives an example of topside marking orientation versus ball A1 identifier location.

Figure 44. UFBGA100 7 x 7 mm, 0.5 mm pitch, package top view example

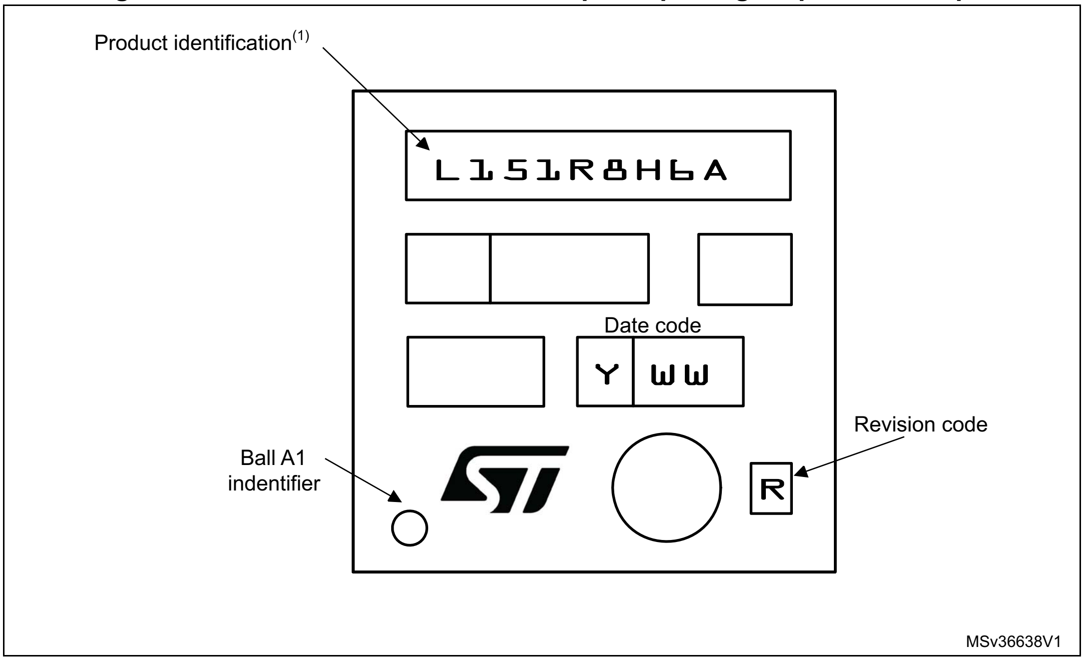


1. Parts marked as “ES”, “E” or accompanied by an Engineering Sample notification letter, are not yet qualified and therefore not yet ready to be used in production and any consequences deriving from such usage will not be at ST charge. In no event, ST will be liable for any customer usage of these engineering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

TFBGA64 device marking

The following figure gives an example of topside marking orientation versus ball A1 identifier location.

Figure 47. TFBGA64 5 x 5 mm, 0.5 mm pitch, 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.