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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	38
Program Memory Size	32KB (32K x 8)
Program Memory Type	FLASH
EEPROM Size	-
RAM Size	4K x 8
Voltage - Supply (Vcc/Vdd)	1.65V ~ 3.6V
Data Converters	A/D 10x12b
Oscillator Type	Internal
Operating Temperature	-40°C ~ 85°C (TA)
Mounting Type	Surface Mount
Package / Case	48-LQFP
Supplier Device Package	48-LQFP (7x7)
Purchase URL	https://www.e-xfl.com/product-detail/stmicroelectronics/stm32f038c6t6

List of figures

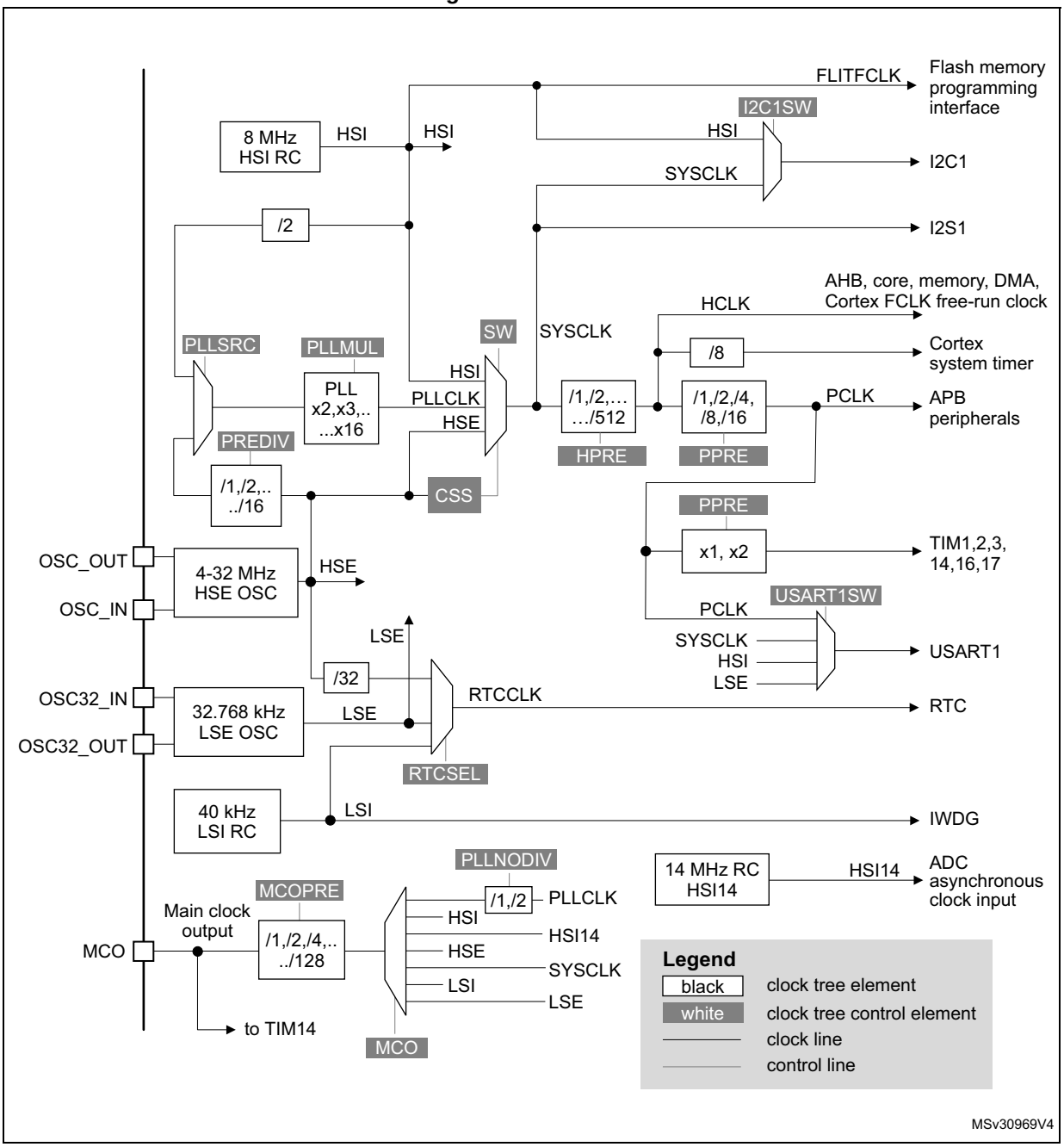
Note: The RTC, the IWDG, and the corresponding clock sources are not stopped by entering Stop mode.

3.6 Clocks and startup

System clock selection is performed on startup, however the internal RC 8 MHz oscillator is selected as default CPU clock on reset. An external 4-32 MHz clock can be selected, in which case it is monitored for failure. If failure is detected, the system automatically switches back to the internal RC oscillator. A software interrupt is generated if enabled. Similarly, full interrupt management of the PLL clock entry is available when necessary (for example on failure of an indirectly used external crystal, resonator or oscillator).

Several prescalers allow the application to configure the frequency of the AHB and the APB domains. The maximum frequency of the AHB and the APB domains is 48 MHz.

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.

The I/O configuration can be locked if needed following a specific sequence in order to avoid spurious writing to the I/Os registers.

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.

4 Pinouts and pin description

Figure 3. LQFP48 package pinout

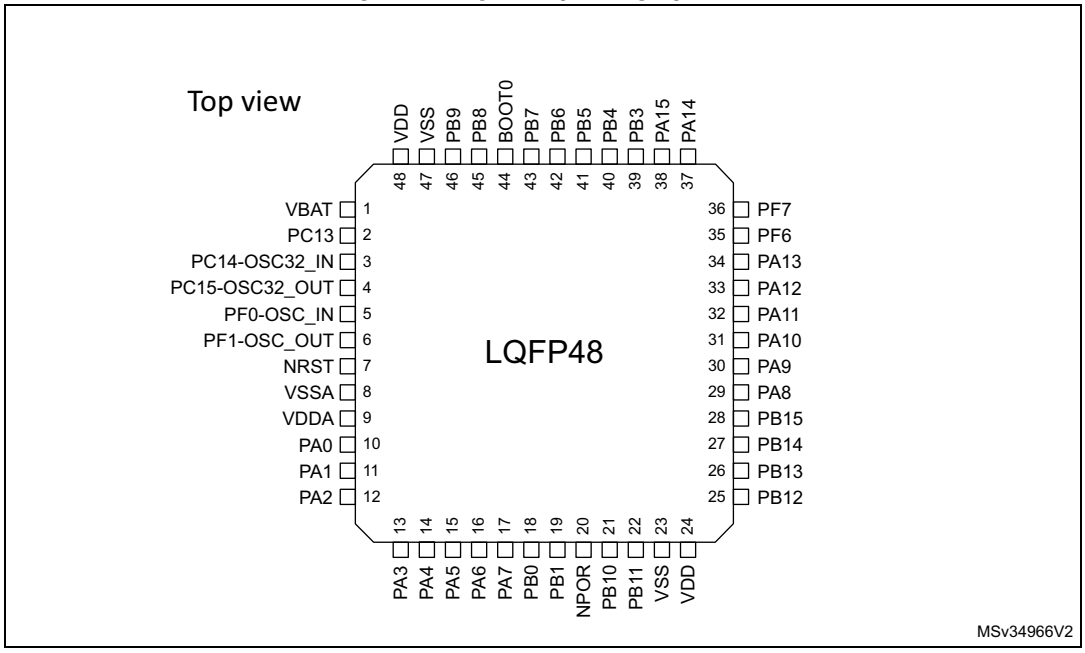


Figure 4. UFQFPN32 package pinout

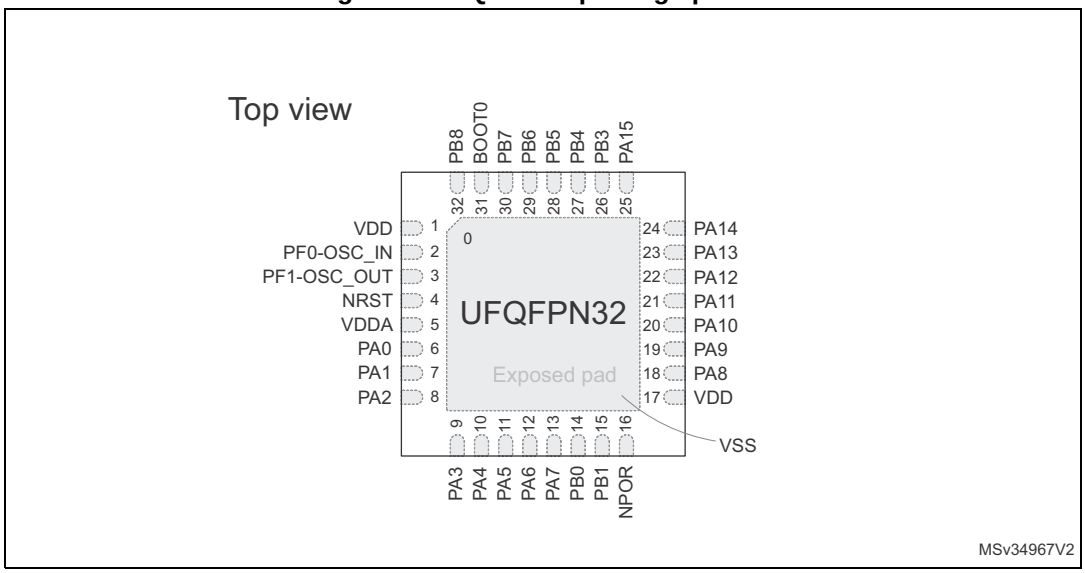


Table 11. Pin definitions (continued)

Pin number					Pin name (function upon reset)	Pin type	I/O structure	Notes	Pin functions	
LQFP48	UFQFPN32	UFQFPN28	WLCSP25	TSSOP20					Alternate functions	Additional functions
30	19	19	C1	17	PA9	I/O	FTf	-	USART1_TX, TIM1_CH2, I2C1_SCL	-
31	20	20	B1	18	PA10	I/O	FTf	-	USART1_RX, TIM1_CH3, TIM17_BKIN, I2C1_SDA	-
32	21	-	-	-	PA11	I/O	FT	-	USART1_CTS, TIM1_CH4, EVENTOUT	-
33	22	-	-	-	PA12	I/O	FT	-	USART1_RTS, TIM1_ETR, EVENTOUT	-
34	23	21	A1	19	PA13 (SWDIO)	I/O	FT	(5)	IR_OUT, SWDIO	-
35	-	-	-	-	PF6	I/O	FTf	-	I2C1_SCL	-
36	-	-	-	-	PF7	I/O	FTf	-	I2C1_SDA	-
37	24	22	A2	20	PA14 (SWCLK)	I/O	FT	(5)	USART1_TX, SWCLK	-
38	25	23	-	-	PA15	I/O	FT	(6)	SPI1_NSS, I2S1_WS, TIM2_CH_ETR, EVENTOUT, USART1_RX	-
39	26	24	-	-	PB3	I/O	FT	(6)	SPI1_SCK, I2S1_CK, TIM2_CH2, EVENTOUT	-
40	27	25	-	-	PB4	I/O	FT	(6)	SPI1_MISO, I2S1_MCK, TIM3_CH1, EVENTOUT	-

Table 16. Current characteristics

Symbol	Ratings	Max.	Unit
ΣI_{VDD}	Total current into sum of all VDD power lines (source)(1)	120	mA
ΣI_{VSS}	Total current out of sum of all VSS ground lines (sink)(1)	-120	
$I_{VDD(PIN)}$	Maximum current into each VDD power pin (source)(1)	100	
$I_{VSS(PIN)}$	Maximum current out of each VSS ground pin (sink)(1)	-100	
$I_{IO(PIN)}$	Output current sunk by any I/O and control pin	25	
	Output current source by any I/O and control pin	-25	
$\Sigma I_{IO(PIN)}$	Total output current sunk by sum of all I/Os and control pins(2)	80	
	Total output current sourced by sum of all I/Os and control pins(2)	-80	
$I_{INJ(PIN)}$(3)	Injected current on POR, B, FT and FTf pins	-5/+0(4)	
	Injected current on TC and RST pin	± 5	
	Injected current on TTa pins(5)	± 5	
$\Sigma I_{INJ(PIN)}$	Total injected current (sum of all I/O and control pins)(6)	± 25	

1. All main power (VDD, VDDA) and ground (VSS, VSSA) pins must always be connected to the external power supply, in the permitted range.
2. This current consumption must be correctly distributed over all I/Os and control pins. The total output current must not be sunk/sourced between two consecutive power supply pins referring to high pin count QFP packages.
3. A positive injection is induced by $V_{IN} > V_{DDIOx}$ while a negative injection is induced by $V_{IN} < V_{SS}$. $I_{INJ(PIN)}$ must never be exceeded. Refer to *Table 15: Voltage characteristics* for the maximum allowed input voltage values.
4. Positive injection is not possible on these I/Os and does not occur for input voltages lower than the specified maximum value.
5. On these I/Os, a positive injection is induced by $V_{IN} > V_{DDA}$. Negative injection disturbs the analog performance of the device. See note (2) below *Table 51: ADC accuracy*.
6. When several inputs are submitted to a current injection, the maximum $\Sigma I_{INJ(PIN)}$ is the absolute sum of the positive and negative injected currents (instantaneous values).

Table 17. Thermal characteristics

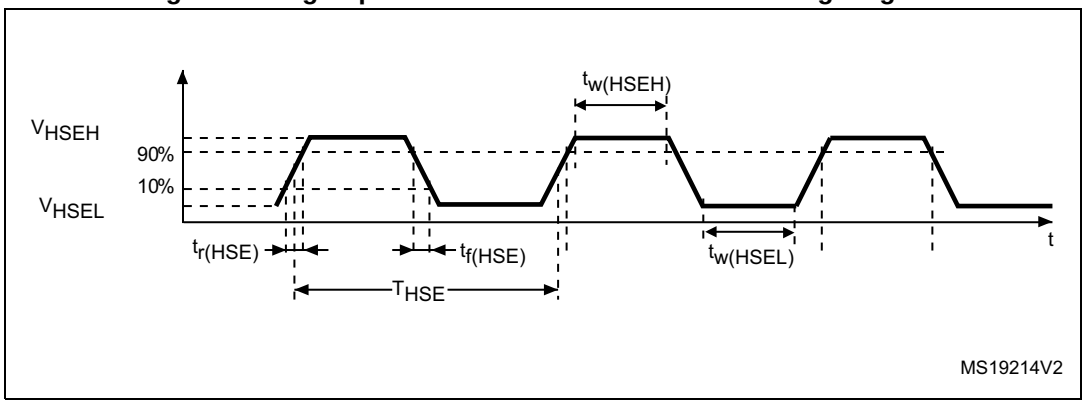
Symbol	Ratings	Value	Unit
T_{STG}	Storage temperature range	–65 to +150	°C
T_J	Maximum junction temperature	150	°C

Table 21. Typical and maximum current consumption from V_{DD} supply at V_{DD} = 1.8 V

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 Run mode, code executing from Flash memory	External clock (HSE bypass)	48 MHz	18.2	19.7	20.1	20.3	11.2	11.7	12.1	12.4	mA
			32 MHz	12.4	13.1	13.4	13.6	7.6	8.2	8.3	8.6	
			24 MHz	9.8	10.4	10.6	10.7	6.1	6.6	6.7	6.8	
			8 MHz	3.3	3.7	3.8	3.8	2.2	2.4	2.5	2.6	
			1 MHz	0.7	0.8	0.9	1.0	0.5	0.6	0.7	0.7	
		Internal clock (HSI)	48 MHz	18.5	20.0	20.4	20.6	11.6	12.1	12.4	12.8	
			32 MHz	12.7	13.4	13.6	14.0	7.9	8.5	8.7	9.0	
			24 MHz	10.0	10.6	10.8	10.9	6.2	6.7	6.8	6.9	
			8 MHz	3.4	3.8	3.9	4.0	2.3	2.5	2.6	2.6	
	Supply current in Run mode, code executing from RAM	External clock (HSE bypass)	48 MHz	17.2	18.7	19.1	19.3	10.2	10.6	11.1	11.4	
			32 MHz	11.4	12.2	12.4	12.7	6.7	7.2	7.4	7.6	
			24 MHz	8.9	9.4	9.6	9.7	5.1	5.5	5.7	5.7	
			8 MHz	2.8	3.2	3.3	3.3	1.7	2.0	2.0	2.1	
			1 MHz	0.3	0.5	0.5	0.5	0.2	0.3	0.3	0.3	
		Internal clock (HSI)	48 MHz	17.5	19.0	19.4	19.6	10.4	10.8	11.2	11.6	
			32 MHz	11.7	12.4	12.7	12.9	6.9	7.4	7.6	7.8	
			24 MHz	9.1	9.6	9.8	9.9	5.2	5.6	5.7	5.8	
			8 MHz	3.0	3.3	3.4	3.5	1.7	2.0	2.1	2.1	
	Supply current in Sleep mode	External clock (HSE bypass)	48 MHz	10.4	11.7	12.0	12.3	2.4	2.6	2.7	2.8	
			32 MHz	6.9	7.6	7.8	8.1	1.5	1.7	1.8	1.9	
			24 MHz	5.4	5.9	6.1	6.2	1.2	1.3	1.4	1.5	
			8 MHz	1.7	2.2	2.3	2.4	0.4	0.4	0.5	0.5	
			1 MHz	0.3	0.3	0.4	0.4	0.1	0.1	0.2	0.2	
		Internal clock (HSI)	48 MHz	10.6	11.8	12.1	12.4	2.4	2.7	2.7	2.8	
			32 MHz	7.2	7.9	8.1	8.3	1.6	1.8	1.9	2.0	
			24 MHz	5.5	6.1	6.3	6.4	1.3	1.4	1.5	1.5	
			8 MHz	1.9	2.4	2.5	2.6	0.5	0.5	0.5	0.6	

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

Figure 13. 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.

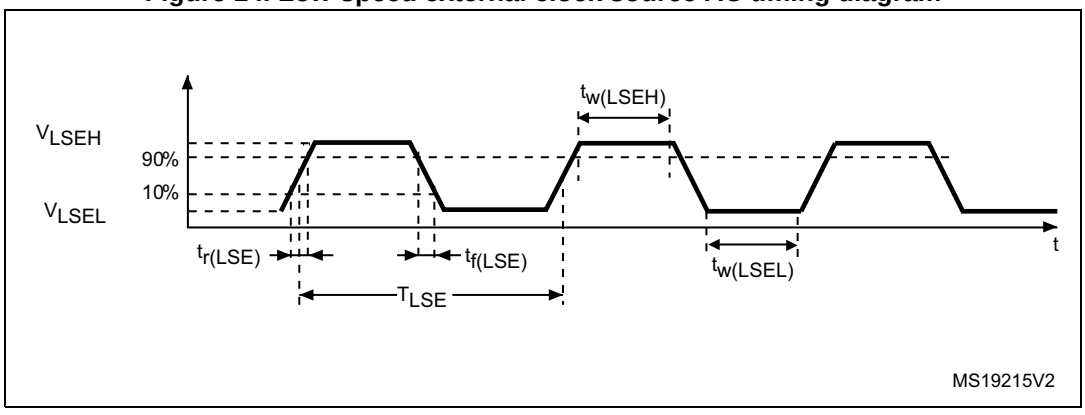
The external clock signal has to respect the I/O characteristics in *Section 6.3.13*. However, the recommended clock input waveform is shown in *Figure 14*.

Table 30. 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 14. 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 31*. 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 31. 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} = 1.8 V, Rm = 30 Ω, CL = 10 pF@8 MHz	-	0.4	-	
		V_{DD} = 1.8 V, Rm = 45 Ω, CL = 10 pF@8 MHz	-	0.5	-	
		V_{DD} = 1.8 V, Rm = 30 Ω, CL = 5 pF@32 MHz	-	0.8	-	
		V_{DD} = 1.8 V, Rm = 30 Ω, CL = 10 pF@32 MHz	-	1	-	
		V_{DD} = 1.8 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 15*). 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.

Table 41. 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 42. Electrical sensitivities

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

6.3.12 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 43*.

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

Table 49. ADC characteristics (continued)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$W_{LATENCY}$(2)(4)	ADC_DR register ready latency	ADC clock = HSI14	1.5 ADC cycles + 2 f_{PCLK} cycles	-	1.5 ADC cycles + 3 f_{PCLK} cycles	-
		ADC clock = PCLK/2	-	4.5	-	f_{PCLK} cycle
		ADC clock = PCLK/4	-	8.5	-	f_{PCLK} cycle
t_{latr}(2)	Trigger conversion latency	f_{ADC} = f_{PCLK}/2 = 14 MHz	0.196			µs
		f_{ADC} = f_{PCLK}/2	5.5			1/f_{PCLK}
		f_{ADC} = f_{PCLK}/4 = 12 MHz	0.219			µs
		f_{ADC} = f_{PCLK}/4	10.5			1/f_{PCLK}
		f_{ADC} = f_{HSI14} = 14 MHz	0.179	-	0.250	µs
$Jitter_{ADC}$	ADC jitter on trigger conversion	f_{ADC} = f_{HSI14}	-	1	-	1/f_{HSI14}
t_S(2)	Sampling time	f_{ADC} = 14 MHz	0.107	-	17.1	µs
		-	1.5	-	239.5	1/f_{ADC}
t_{STAB}(2)	Stabilization time	-	14			1/f_{ADC}
t_{CONV}(2)	Total conversion time (including sampling time)	f_{ADC} = 14 MHz, 12-bit resolution	1	-	18	µs
		12-bit resolution	14 to 252 (t_S for sampling +12.5 for successive approximation)			1/f_{ADC}

1. During conversion of the sampled value (12.5 x ADC clock period), an additional consumption of 100 µA on I_{DDA} and 60 µA on I_{DD} should be taken into account.
2. Guaranteed by design, not tested in production.
3. Specified value includes only ADC timing. It does not include the latency of the register access.
4. This parameter specify latency for transfer of the conversion result to the ADC_DR register. EOC flag is set at this time.

Equation 1: R_{AIN} max formula

$$R_{AIN} < \frac{T_S}{f_{ADC} \times C_{ADC} \times \ln(2^{N+2})} - R_{ADC}$$

The formula above (*Equation 1*) is used to determine the maximum external impedance allowed for an error below 1/4 of LSB. Here N = 12 (from 12-bit resolution).

Table 50. R_{AIN} max for f_{ADC} = 14 MHz

T_s (cycles)	t_S (µs)	R_{AIN} max (kΩ)(1)
1.5	0.11	0.4
7.5	0.54	5.9
13.5	0.96	11.4

6.3.16 Temperature sensor characteristics

Table 52. TS characteristics

Symbol	Parameter	Min	Typ	Max	Unit
T_L[1]	V_{SENSE} linearity with temperature	-	± 1	± 2	°C
Avg_Slope[1]	Average slope	4.0	4.3	4.6	mV/°C
V_{30}	Voltage at 30 °C (± 5 °C)[2]	1.34	1.43	1.52	V
t_{START}[1]	ADC_IN16 buffer startup time	-	-	10	µs
t_{S_temp}[1]	ADC sampling time when reading the temperature	4	-	-	µs

1. Guaranteed by design, not tested in production.
2. Measured at V_{DDA} = 3.3 V ± 10 mV. The V_{30} ADC conversion result is stored in the TS_CAL1 byte. Refer to *Table 3: Temperature sensor calibration values*.

6.3.17 V_{BAT} monitoring characteristics

Table 53. V_{BAT} monitoring characteristics

Symbol	Parameter	Min	Typ	Max	Unit
R	Resistor bridge for V_{BAT}	-	2 x 50	-	kΩ
Q	Ratio on V_{BAT} measurement	-	2	-	-
Er[1]	Error on Q	–1	-	+1	%
t_{S_vbat}[1]	ADC sampling time when reading the V_{BAT}	4	-	-	µs

1. Guaranteed by design, not tested in production.

6.3.18 Timer characteristics

The parameters given in the following tables are guaranteed by design.

Refer to *Section 6.3.13: I/O port characteristics* for details on the input/output alternate function characteristics (output compare, input capture, external clock, PWM output).

Table 54. TIMx characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$t_{res(TIM)}$	Timer resolution time	-	-	1	-	$t_{TIMxCLK}$
		$f_{TIMxCLK}$ = 48 MHz	-	20.8	-	ns
f_{EXT}	Timer external clock frequency on CH1 to CH4	-	-	$f_{TIMxCLK}/2$	-	MHz
		$f_{TIMxCLK}$ = 48 MHz	-	24	-	MHz
t_{MAX_COUNT}	16-bit timer maximum period	-	-	2^{16}	-	$t_{TIMxCLK}$
		$f_{TIMxCLK}$ = 48 MHz	-	1365	-	µs
	32-bit counter maximum period	-	-	2^{32}	-	$t_{TIMxCLK}$
		$f_{TIMxCLK}$ = 48 MHz	-	89.48	-	s

Table 55. IWDG min/max timeout period at 40 kHz (LSI)(1)

Prescaler divider	PR[2:0] bits	Min timeout RL[11:0]= 0x000	Max timeout RL[11:0]= 0xFFF	Unit
/4	0	0.1	409.6	ms
/8	1	0.2	819.2	
/16	2	0.4	1638.4	
/32	3	0.8	3276.8	
/64	4	1.6	6553.6	
/128	5	3.2	13107.2	
/256	6 or 7	6.4	26214.4	

1. These timings are given for a 40 kHz clock but the microcontroller internal RC frequency can vary from 30 to 60 kHz. Moreover, given an exact RC oscillator frequency, the exact timings still depend on the phasing of the APB interface clock versus the LSI clock so that there is always a full RC period of uncertainty.

Table 56. WWDG min/max timeout value at 48 MHz (PCLK)

Prescaler	WDGTB	Min timeout value	Max timeout value	Unit
1	0	0.0853	5.4613	ms
2	1	0.1706	10.9226	
4	2	0.3413	21.8453	
8	3	0.6826	43.6906	

6.3.19 Communication interfaces

I^2C interface characteristics

The I^2C interface meets the timings requirements of the I^2C-bus specification and user manual rev. 03 for:

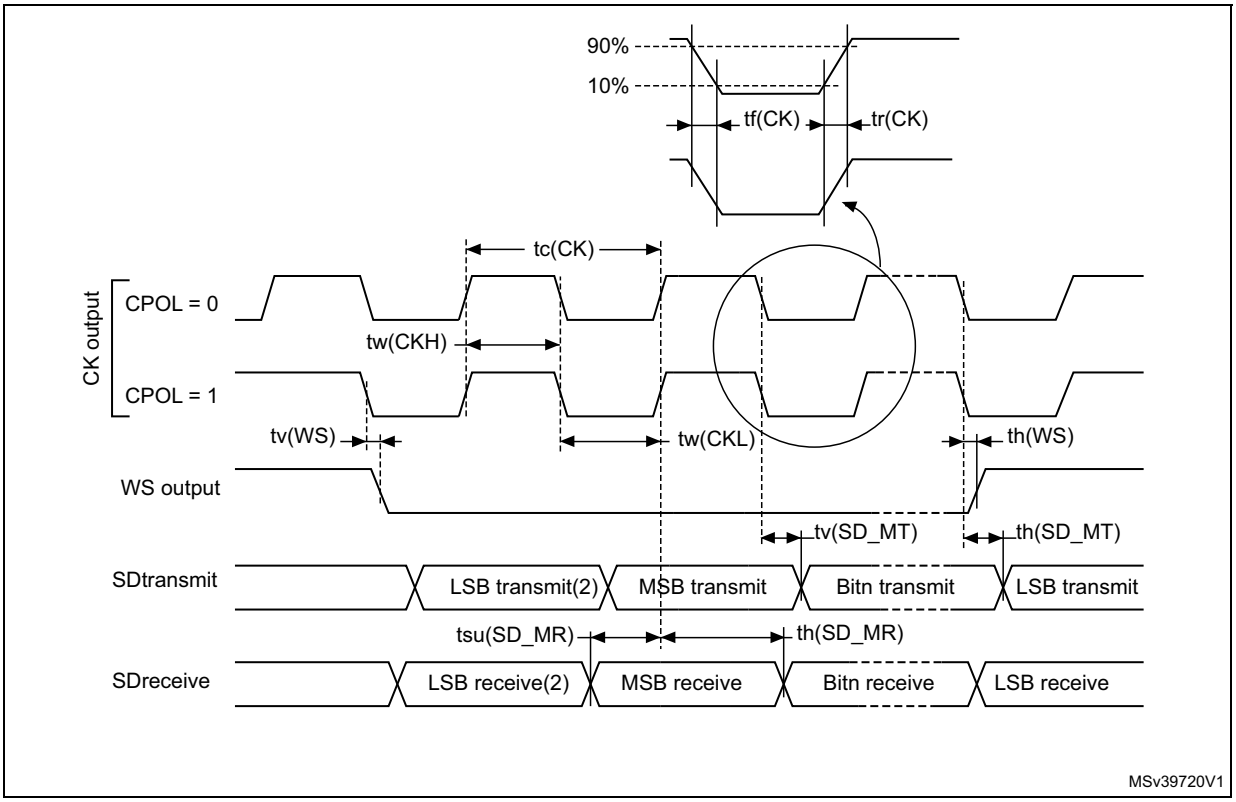
- Standard-mode (Sm): with a bit rate up to 100 kbit/s
- Fast-mode (Fm): with a bit rate up to 400 kbit/s
- Fast-mode Plus (Fm+): with a bit rate up to 1 Mbit/s.

The I^2C timings requirements are guaranteed by design when the I2Cx peripheral is properly configured (refer to Reference manual).

The SDA and SCL I/O requirements are met with the following restrictions: the SDA and SCL I/O pins are not “true” open-drain. When configured as open-drain, the PMOS connected between the I/O pin and V_{DDIOx} is disabled, but is still present. Only FTf I/O pins support Fm+ low level output current maximum requirement. Refer to *Section 6.3.13: I/O port characteristics* for the I^2C I/Os characteristics.

All I^2C SDA and SCL I/Os embed an analog filter. Refer to the table below for the analog filter characteristics:

Figure 29. I²S master timing diagram (Philips protocol)



1. Data based on characterization results, not tested in production.
2. LSB transmit/receive of the previously transmitted byte. No LSB transmit/receive is sent before the first byte.

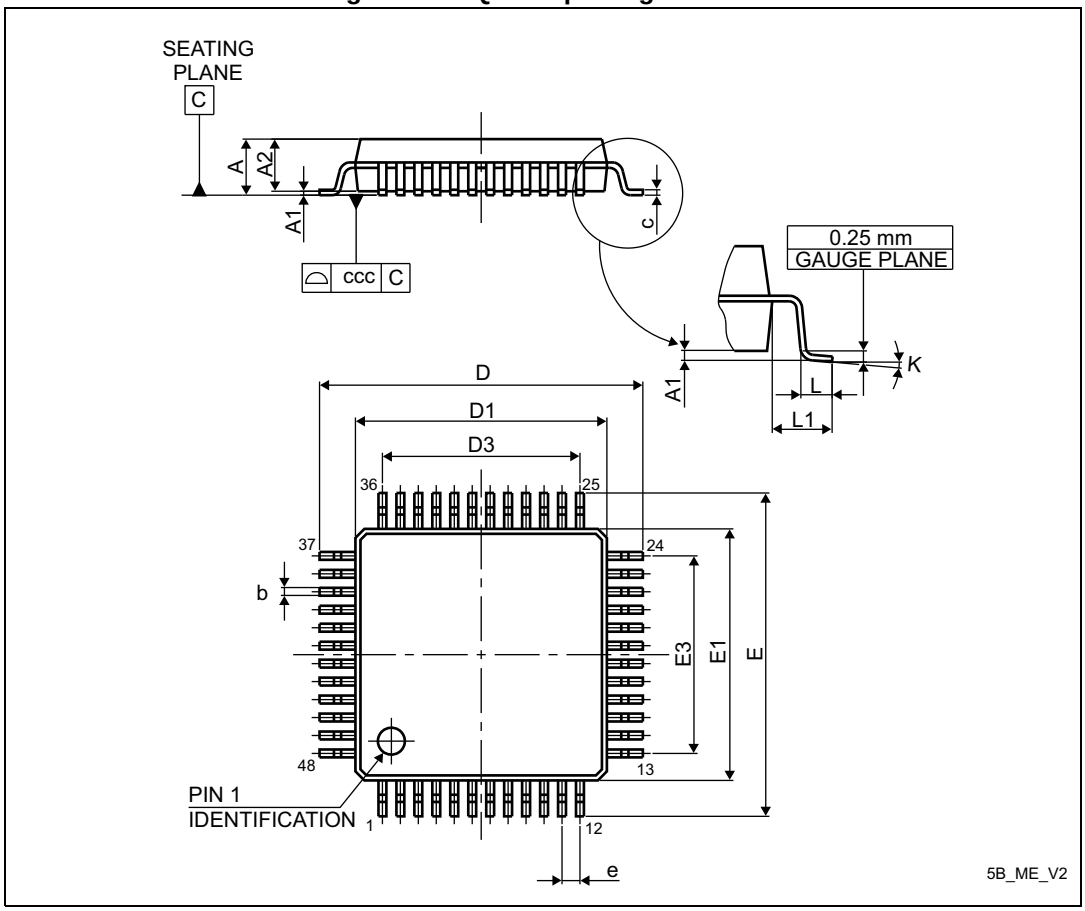
7 Package information

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK® packages, depending on their level of environmental compliance. ECOPACK® specifications, grade definitions and product status are available at: *www.st.com*. ECOPACK® is an ST trademark.

7.1 LQFP48 package information

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

Figure 30. LQFP48 package outline



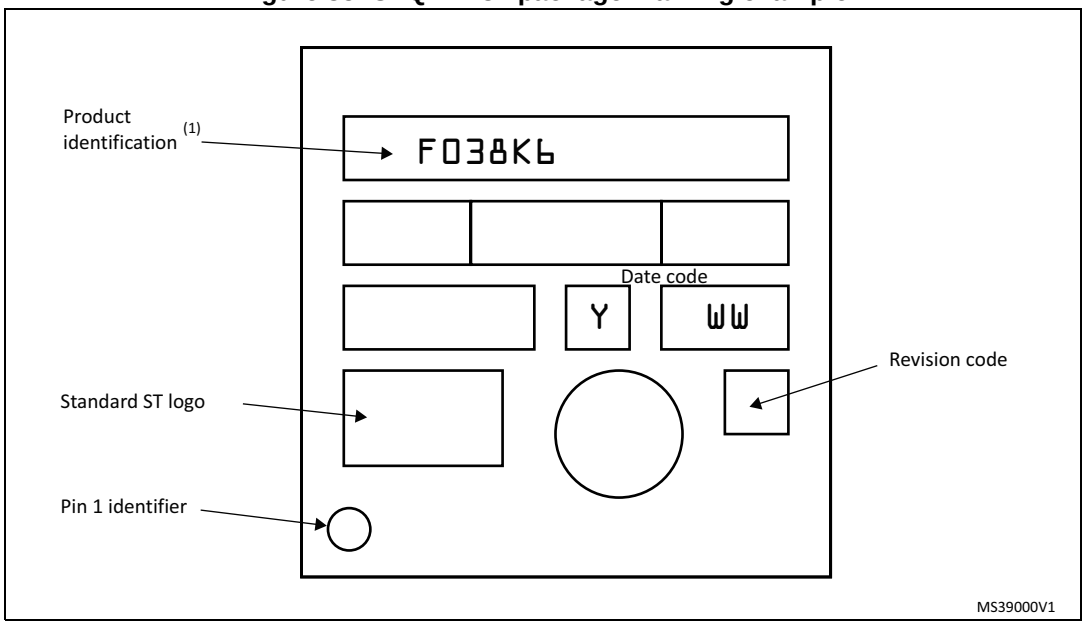
1. Drawing is not to scale.

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 35. 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 63. 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 40. Recommended footprint for WLCSP25 package

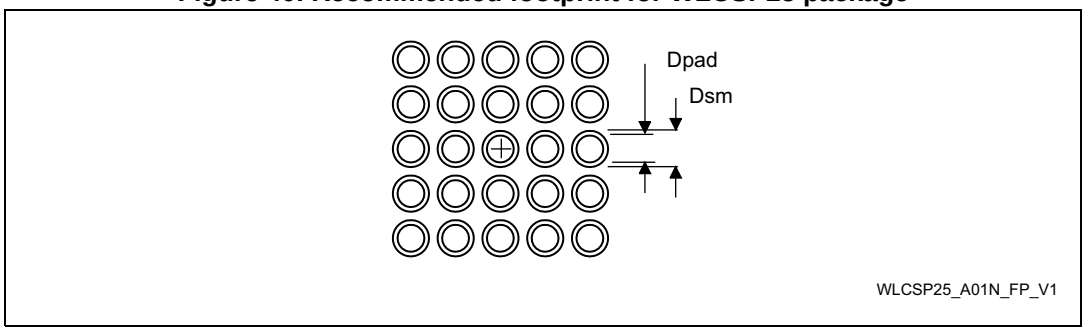


Table 64. WLCSP25 recommended PCB design rules

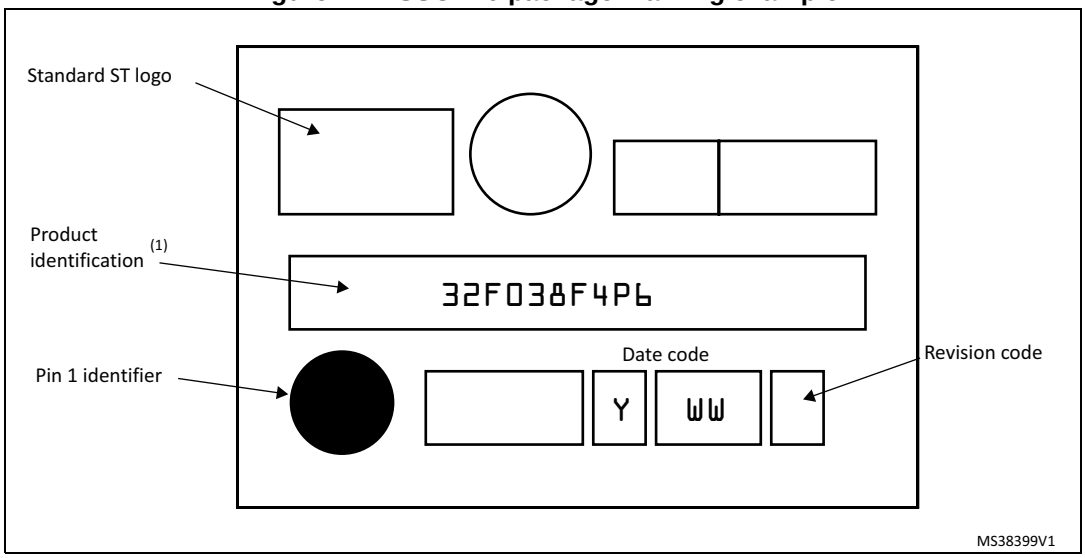
Dimension	Recommended values
Pitch	0.4 mm
Dpad	0.225 mm
Dsm	0.290 mm typ. (depends on the soldermask registration tolerance)
Stencil opening	0.250 mm
Stencil thickness	0.100 mm

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 44. TSSOP20 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.