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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	36MHz
Connectivity	I²C, IrDA, LINbus, SPI, UART/USART
Peripherals	DMA, PDR, POR, PVD, PWM, Temp Sensor, WDT
Number of I/O	51
Program Memory Size	768KB (768K x 8)
Program Memory Type	FLASH
EEPROM Size	-
RAM Size	80K x 8
Voltage - Supply (Vcc/Vdd)	2V ~ 3.6V
Data Converters	A/D 16x12b; 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/stm32f101rft6tr

List of figures

2.1 Device overview

The STM32F101xx XL-density access line family offers devices in 3 different package types: from 64 pins to 144 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.

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

Table 2. STM32F101xF and STM32F101xG features and peripheral counts

Peripherals		STM32F101Rx		STM32F101Vx		STM32F101Zx	
Flash memory		768 KB	1 MB	768 KB	1 MB	768 KB	1 MB
SRAM in Kbytes		80		80		80	
FSMC		No		Yes		Yes	
Timers	General-purpose	10					
	Basic	2					
Communication interfaces	SPI	3					
	I^2C	2					
	USART	5					
GPIOs		51		80		112	
12-bit ADC Number of channels		1 16					
12-bit DAC Number of channels		YES 2					
CPU frequency		36 MHz					
Operating voltage		2.0 to 3.6 V					
Operating temperatures		Ambient temperature: –40 to +85 °C (see *Table 10*) Junction temperature: –40 to +105 °C (see *Table 10*)					
Package		LQFP64		LQFP100(1)		LQFP144	

1. For the LQFP100 package, only FSMC Bank1 and Bank2 are available. Bank1 can only support a multiplexed NOR/PSRAM memory using the NE1 Chip Select. Bank2 can only support a 16- or 8-bit NAND Flash memory using the NCE2 Chip Select. The interrupt line cannot be used since Port G is not available in this package.

2.3.10 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 4-16 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 is available when necessary (for example with failure of an indirectly used external oscillator).

Several prescalers are used to configure the AHB frequency, the high-speed APB (APB2) domain and the low-speed APB (APB1) domain. The maximum frequency of the AHB and APB domains is 36 MHz. See *Figure 2* for details on the clock tree.

2.3.11 Boot modes

At startup, boot pins are used to select one of three boot options:

- Boot from user Flash: you have an option to boot from any of two memory banks. By default, boot from Flash memory bank 1 is selected. You can choose to boot from Flash memory bank 2 by setting a bit in the option bytes.
- Boot from system memory
- Boot from embedded SRAM

The bootloader is located in system memory. It is used to reprogram the Flash memory by using USART1.

2.3.12 Power supply schemes

- V_{DD} = 2.0 to 3.6 V: external power supply for I/Os and the internal regulator. Provided externally through V_{DD} pins.
- V_{SSA}, V_{DDA} = 2.0 to 3.6 V: external analog power supplies for ADC, DAC, Reset blocks, RCs and PLL (minimum voltage to be applied to V_{DDA} is 2.4 V when the ADC or DAC is used). V_{DDA} and V_{SSA} must be connected to V_{DD} and V_{SS}, respectively.
- V_{BAT} = 1.8 to 3.6 V: power supply for RTC, external clock 32 kHz oscillator and backup registers (through power switch) when V_{DD} is not present.

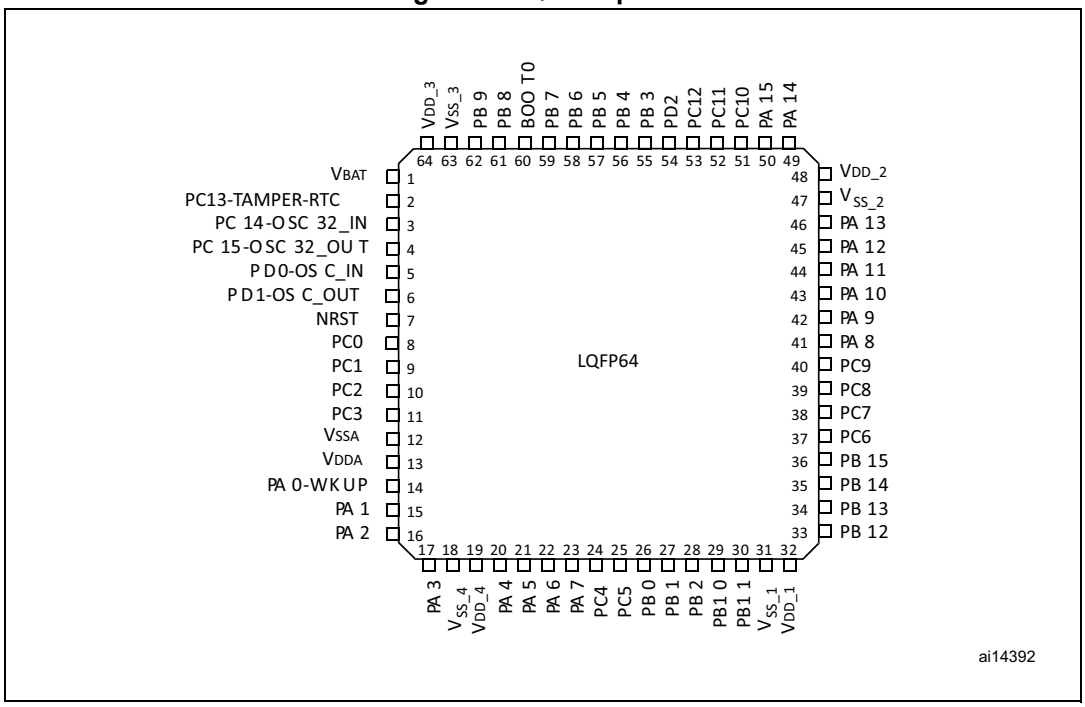
For more details on how to connect power pins, refer to *Figure 9: Power supply scheme*.

2.3.13 Power supply supervisor

The device has an integrated power-on reset (POR)/power-down reset (PDR) circuitry. It is always active, and ensures proper operation starting from/down to 2 V. The device remains in reset mode when V_{DD} is below a specified threshold, $V_{POR/PDR}$, without the need for an external reset circuit.

The device features an embedded programmable voltage detector (PVD) that monitors the V_{DD}/V_{DDA} power supply and compares it to the V_{PVD} threshold. An interrupt can be generated when V_{DD}/V_{DDA} drops below the V_{PVD} threshold and/or when V_{DD}/V_{DDA} is higher than the V_{PVD} threshold. The interrupt service routine can then generate a warning message and/or put the MCU into a safe state. The PVD is enabled by software. Refer to *Table 12: Embedded reset and power control block characteristics* for the values of $V_{POR/PDR}$ and V_{PVD}.

Figure 5. LQFP64 pinout



1. The above figure shows the package top view.

Table 5. STM32F101xF/STM32F101xG pin definitions

Pins			Pin name	Type(1)	I / O level(2)	Main function(3) (after reset)	Alternate functions(4)	
LQFP144	LQFP64	LQFP100					Default	Remap
1	-	1	PE2	I/O	FT	PE2	TRACECLK / FSMC_A23	-
2	-	2	PE3	I/O	FT	PE3	TRACED0 / FSMC_A19	-
3	-	3	PE4	I/O	FT	PE4	TRACED1 / FSMC_A20	-
4	-	4	PE5	I/O	FT	PE5	TRACED2 / FSMC_A21	TIM9_CH1
5	-	5	PE6	I/O	FT	PE6	TRACED3 / FSMC_A22	TIM9_CH2
6	1	6	V_{BAT}	S	-	V_{BAT}	-	-
7	2	7	PC13-TAMPER-RTC(5)	I/O	-	PC13(6)	TAMPER-RTC	-
8	3	8	PC14-OSC32_IN(5)	I/O	-	PC14(6)	OSC32_IN	-
9	4	9	PC15-OSC32_OUT(5)	I/O	-	PC15(6)	OSC32_OUT	-
10	-	-	PF0	I/O	FT	PF0	FSMC_A0	-
11	-	-	PF1	I/O	FT	PF1	FSMC_A1	-

Table 5. STM32F101xF/STM32F101xG pin definitions (continued)

Pins			Pin name	Type(1)	I / O level(2)	Main function(3) (after reset)	Alternate functions(4)	
LQFP144	LQFP64	LQFP100					Default	Remap
37	17	26	PA3	I/O	-	PA3	USART2_RX(8) / TIM5_CH4/ ADC_IN3 / TIM2_CH4(8)/ TIM9_CH2	-
38	18	27	V_{SS_4}	S	-	V_{SS_4}	-	-
39	19	28	V_{DD_4}	S	-	V_{DD_4}	-	-
40	20	29	PA4	I/O	-	PA4	SPI1_NSS/ DAC_OUT1 / ADC_IN4 / USART2_CK(8)	-
41	21	30	PA5	I/O	-	PA5	SPI1_SCK / DAC_OUT2 / ADC_IN5	-
42	22	31	PA6	I/O	-	PA6	SPI1_MISO / ADC_IN6 / TIM3_CH1(8) / TIM13_CH1	-
43	23	32	PA7	I/O	-	PA7	SPI1_MOSI / ADC_IN7 / TIM3_CH2(8)/ TIM14_CH1	-
44	24	33	PC4	I/O	-	PC4	ADC_IN14	-
45	25	34	PC5	I/O	-	PC5	ADC_IN15	-
46	26	35	PB0	I/O	-	PB0	ADC_IN8 / TIM3_CH3(8)	-
47	27	36	PB1	I/O	-	PB1	ADC_IN9 / TIM3_CH4(8)	-
48	28	37	PB2	I/O	FT	PB2/BOOT1	-	-
49	-	-	PF11	I/O	FT	PF11	FSMC_NIOS16	-
50	-	-	PF12	I/O	FT	PF12	FSMC_A6	-
51	-	-	V_{SS_6}	S	-	V_{SS_6}	-	-
52	-	-	V_{DD_6}	S	-	V_{DD_6}	-	-
53	-	-	PF13	I/O	FT	PF13	FSMC_A7	-
54	-	-	PF14	I/O	FT	PF14	FSMC_A8	-
55	-	-	PF15	I/O	FT	PF15	FSMC_A9	-
56	-	-	PG0	I/O	FT	PG0	FSMC_A10	-
57	-	-	PG1	I/O	FT	PG1	FSMC_A11	-
58	-	38	PE7	I/O	FT	PE7	FSMC_D4	-
59	-	39	PE8	I/O	FT	PE8	FSMC_D5	-
60	-	40	PE9	I/O	FT	PE9	FSMC_D6	-
61	-	-	V_{SS_7}	S	-	V_{SS_7}	-	-

5 Electrical characteristics

5.1 Parameter conditions

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

5.1.1 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).

5.1.2 Typical values

Unless otherwise specified, typical data are based on T_A = 25 °C, V_{DD} = 3.3 V (for the 2 V ≤ V_{DD} ≤ 3.6 V voltage range). 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).

5.1.3 Typical curves

Unless otherwise specified, all typical curves are given only as design guidelines and are not tested.

5.1.4 Loading capacitor

The loading conditions used for pin parameter measurement are shown in *Figure 7*.

Figure 13. Typical current consumption on V_{BAT} with RTC on vs. temperature at different V_{BAT} values

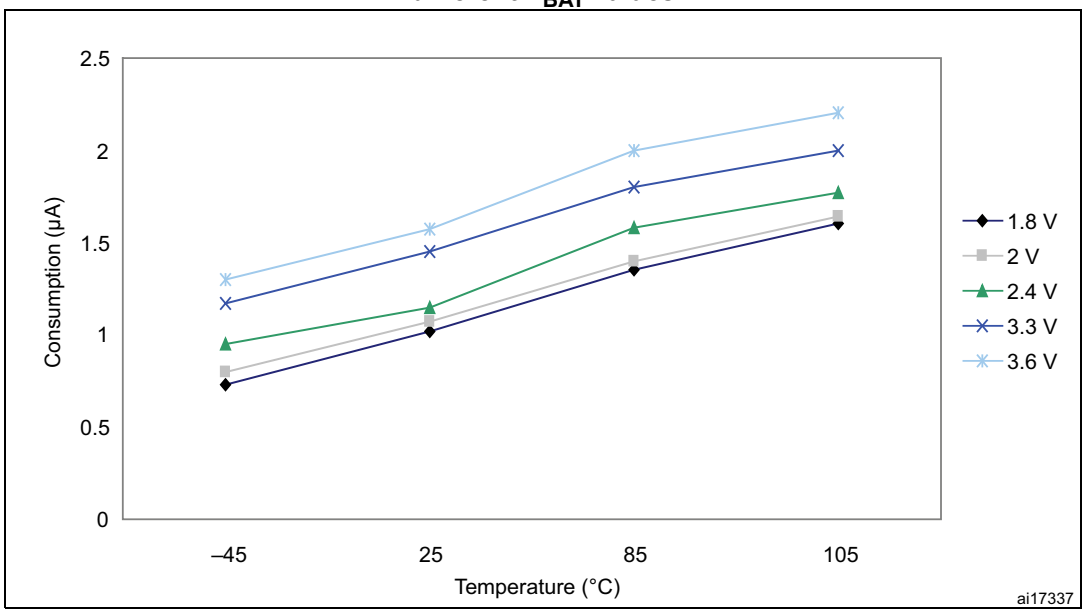
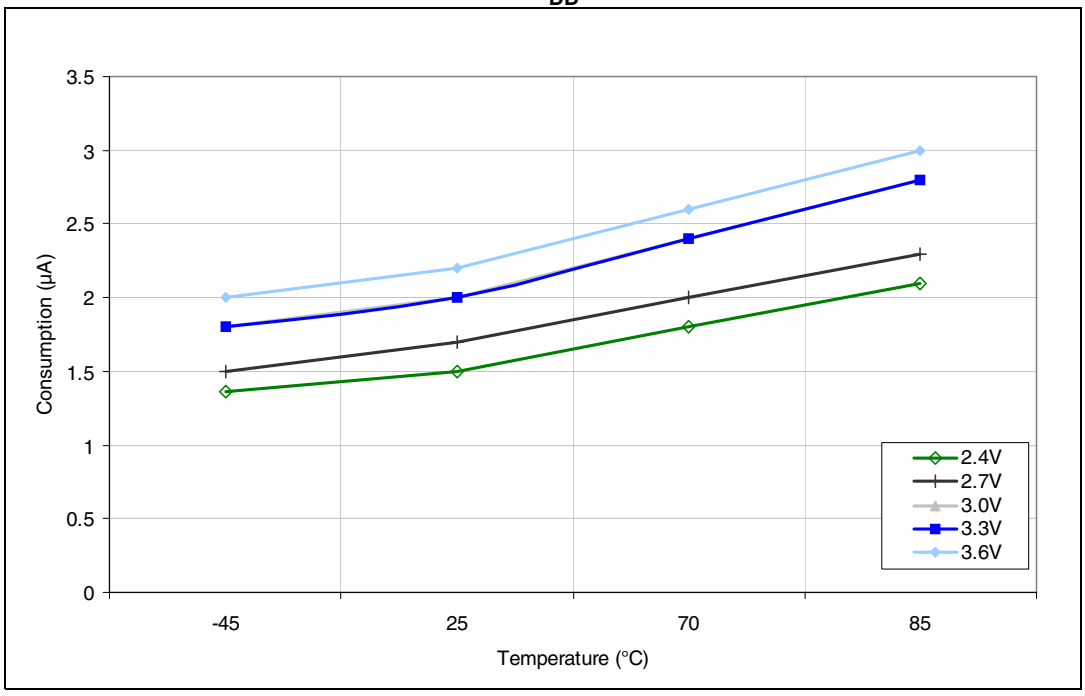


Figure 14. Typical current consumption in Standby mode versus temperature at different V_{DD} values



Typical current consumption

The MCU is placed under the following conditions:

- All I/O pins are in input mode with a static value at V_{DD} or V_{SS} (no load)
- All peripherals are disabled except if it is explicitly mentioned
- The Flash access time is adjusted to f_{HCLK} frequency (0 wait state from 0 to 24 MHz, 1 wait state from 24 to 36 MHz)
- Prefetch is on (reminder: this bit must be set before clock setting and bus prescaling)
- When the peripherals are enabled $f_{PCLK1} = f_{HCLK/4}$, $f_{PCLK2} = f_{HCLK/2}$, $f_{ADCCLK} = f_{PCLK2}/4$
- When the peripherals are enabled $f_{PCLK1} = f_{HCLK}$, $f_{PCLK2} = f_{HCLK}$, $f_{ADCCLK} = f_{PCLK2}/2$

The parameters given in *Table 18* are derived from tests performed under ambient temperature and V_{DD} supply voltage conditions summarized in *Table 10*.

Table 18. Typical current consumption in Run mode, code with data processing running from Flash

Symbol	Parameter	Conditions	f_{HCLK}	Typ(1) All peripherals enabled(2)	Typ(1) All peripherals disabled	Unit
I_{DD}	Supply current in Run mode	External clock(3)	36 MHz	28.5	18.7	mA
			24 MHz	24.1	12.8	
			16 MHz	14	9.2	
			8 MHz	7.7	5.4	
			4 MHz	4.6	3.4	
			2 MHz	3	2.3	
			1 MHz	2.2	1.8	
			500 kHz	1.7	1.5	
			125 kHz	1.4	1.3	
		Running on high speed internal RC (HSI), AHB prescaler used to reduce the frequency	36 MHz	27.5	17.5	
			24 MHz	18.9	11.6	
			16 MHz	12.2	8.2	
			8 MHz	7.2	4.8	
			4 MHz	4	2.7	
			2 MHz	2.3	1.7	
			1 MHz	1.5	1.2	
			500 kHz	1.1	0.9	
			125 kHz	0.75	0.7	

1. Typical values are measures at T_A = 25 °C, V_{DD} = 3.3 V.
2. Add an additional power consumption of 0.8 mA per ADC for the analog part. In applications, this consumption occurs only while the ADC is on (ADON bit is set in the ADC_CR2 register).
3. External clock is 8 MHz and PLL is on when f_{HCLK} > 8 MHz.

5.3.8 PLL characteristics

The parameters given in *Table 28* are derived from tests performed under ambient temperature and V_{DD} supply voltage conditions summarized in *Table 10*.

Table 28. PLL characteristics

Symbol	Parameter	Value			Unit
		Min(1)	Typ	Max(1)	
f_{PLL_IN}	PLL input clock(2)	1	8.0	25	MHz
	PLL input clock duty cycle	40	-	60	%
f_{PLL_OUT}	PLL multiplier output clock	16	-	36	MHz
t_{LOCK}	PLL lock time	-	-	200	µs
Jitter	Cycle-to-cycle jitter	-	-	300	ps

1. Guaranteed by characterization results.
2. Take care of using the appropriate multiplier factors so as to have PLL input clock values compatible with the range defined by f_{PLL_OUT}.

5.3.9 Memory characteristics

Flash memory

The characteristics are given at T_A = –40 to 85 °C unless otherwise specified.

Table 29. Flash memory characteristics

Symbol	Parameter	Conditions	Min	Typ	Max(1)	Unit
t_{prog}	16-bit programming time	T_A = –40 to +85 °C	40	52.5	70	µs
t_{ERASE}	Page (2 KB) erase time	T_A = –40 to +85 °C	20	-	40	ms
t_{ME}	Mass erase time	T_A = –40 to +85 °C	20	-	40	ms
I_{DD}	Supply current	Read mode f_{HCLK} = 36 MHz with 1 wait state, V_{DD} = 3.3 V	-	-	28	mA
		Write mode f_{HCLK} = 36 MHz, V_{DD} = 3.3 V	-	-	7	mA
		Erase mode f_{HCLK} = 36 MHz, V_{DD} = 3.3 V	-	-	5	mA
		Power-down mode / Halt, V_{DD} = 3.0 to 3.6 V	-	-	50	µA
V_{prog}	Programming voltage	-	2	-	3.6	V

1. Guaranteed by design.

Table 38. Synchronous non-multiplexed PSRAM write timings(1)(2) (continued)

Symbol	Parameter	Min	Max	Unit
$t_{su(NWAITV-CLKH)}$	FSMC_NWAIT valid before FSMC_CLK high	7	-	ns
$t_{h(CLKH-NWAITV)}$	FSMC_NWAIT valid after FSMC_CLK high	2	-	ns

1. C_L = 15 pF.
2. Guaranteed by characterization results.

PC Card/CompactFlash controller waveforms and timings

Figure 27 through *Figure 32* represent synchronous waveforms and *Table 40* and *Table 41* provide the corresponding timings. The results shown in this table are obtained with the following FSMC configuration:

- COM.FSMC_SetupTime = 0x04;
- COM.FSMC_WaitSetupTime = 0x07;
- COM.FSMC_HoldSetupTime = 0x04;
- COM.FSMC_HiZSetupTime = 0x00;
- ATT.FSMC_SetupTime = 0x04;
- ATT.FSMC_WaitSetupTime = 0x07;
- ATT.FSMC_HoldSetupTime = 0x04;
- ATT.FSMC_HiZSetupTime = 0x00;
- IO.FSMC_SetupTime = 0x04;
- IO.FSMC_WaitSetupTime = 0x07;
- IO.FSMC_HoldSetupTime = 0x04;
- IO.FSMC_HiZSetupTime = 0x00;
- TCLRSetupTime = 0;
- TARSetupTime = 0;

Figure 36. NAND controller waveforms for common memory write access

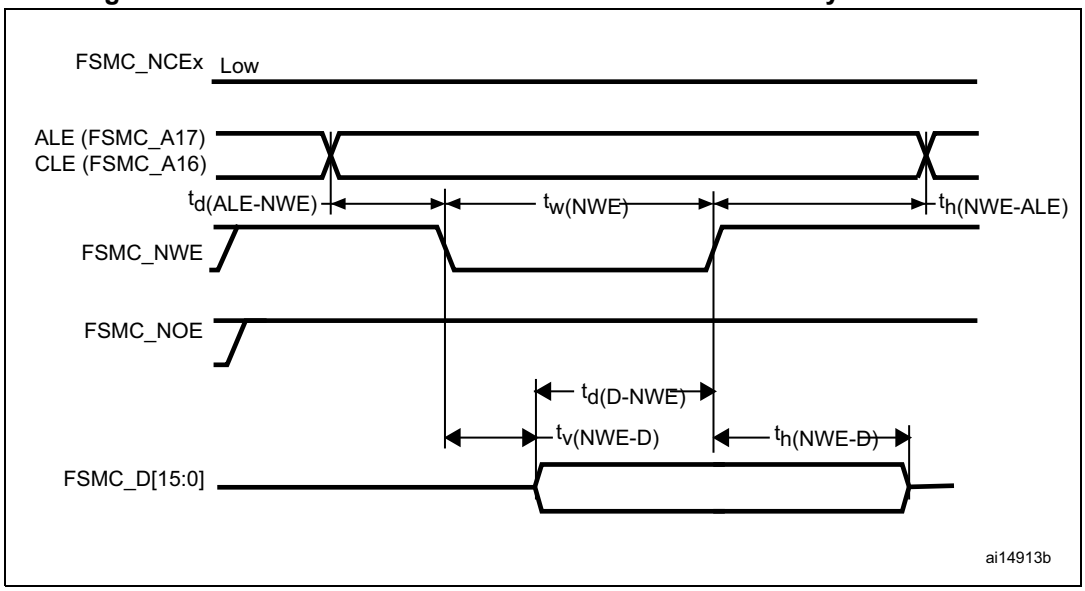


Table 41. Switching characteristics for NAND Flash write cycles(1)

Symbol	Parameter	Min	Max	Unit
$t_{w(NWE)}$	FSMC_NWE low width	$3t_{HCLK}$	$3t_{HCLK}$	ns
$t_{v(NWE-D)}$	FSMC_NWE low to FSMC_D[15:0] valid	-	0	ns
$t_{h(NWE-D)}$	FSMC_NWE high to FSMC_D[15:0] invalid	$2t_{HCLK}$ + 2	-	ns
$t_{d(ALE-NWE)}$	FSMC_ALE valid before FSMC_NWE low	-	$3t_{HCLK}$ + 1.5	ns
$t_{h(NWE-ALE)}$	FSMC_NWE high to FSMC_ALE invalid	$3t_{HCLK}$ + 8	-	ns
$t_{d(ALE-NOE)}$	FSMC_ALE valid before FSMC_NOE low	-	$2t_{HCLK}$	ns
$t_{h(NOE-ALE)}$	FSMC_NWE high to FSMC_ALE invalid	$2t_{HCLK}$	-	ns

1. C_L = 15 pF.

5.3.11 EMC characteristics

Susceptibility tests are performed on a sample basis during device characterization.

Functional EMS (Electromagnetic susceptibility)

While a simple application is executed on the device (toggling 2 LEDs through I/O ports), the device is stressed by two electromagnetic events until a failure occurs. The failure is indicated by the LEDs:

- **Electrostatic discharge (ESD)** (positive and negative) is applied to all device pins until a functional disturbance occurs. This test is compliant with the IEC 61000-4-2 standard.
- **FTB**: A Burst of Fast Transient voltage (positive and negative) is applied to V_{DD} and V_{SS} through a 100 pF capacitor, until a functional disturbance occurs. This test is compliant with the IEC 61000-4-4 standard.

A device reset allows normal operations to be resumed.

The test results are given in *Table 42*. They are based on the EMS levels and classes defined in application note AN1709.

Table 42. EMS characteristics

Symbol	Parameter	Conditions	Level/Class
V_{FESD}	Voltage limits to be applied on any I/O pin to induce a functional disturbance	V_{DD} = 3.3 V, LQFP144, T_A = +25 °C, f_{HCLK}= 36 MHz conforms to IEC 61000-4-2	2B
V_{EFTB}	Fast transient voltage burst limits to be applied through 100 pF on V_{DD} and V_{SS} pins to induce a functional disturbance	V_{DD} = 3.3 V, LQFP144, T_A = +25 °C, f_{HCLK} = 36 MHz conforms to IEC 61000-4-4	4A

Designing hardened software to avoid noise problems

EMC characterization and optimization are performed at component level with a typical application environment and simplified MCU software. It should be noted that good EMC performance is highly dependent on the user application and the software in particular.

Therefore it is recommended that the user applies EMC software optimization and pre qualification tests in relation with the EMC level requested for his application.

Software recommendations

The software flowchart must include the management of runaway conditions such as:

- Corrupted program counter
- Unexpected reset
- Critical Data corruption (control registers...)

Prequalification trials

Most of the common failures (unexpected reset and program counter corruption) can be reproduced by manually forcing a low state on the NRST pin or the Oscillator pins for 1 second. 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 is 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 43. EMI characteristics

Symbol	Parameter	Conditions	Monitored frequency band	Max vs. [f_{HSE}/f_{HCLK}]	Unit
				8/36 MHz	
S_{EMI}	Peak level	V_{DD} = 3.3 V, T_A = 25 °C, LQFP144 package compliant with IEC 61967-2	0.1 MHz to 30 MHz	8	dBµV
			30 MHz to 130 MHz	27	
			130 MHz to 1 GHz	26	
			SAE EMI Level	4	-

The test results are given in *Table 46*

Table 46. I/O current injection susceptibility

Symbol	Description	Functional susceptibility		Unit
		Negative injection	Positive injection	
I_{INJ}	Injected current on OSC_IN32, OSC_OUT32, PA4, PA5, PC13	-0	+0	mA
	Injected current on all FT pins	-5	+0	
	Injected current on any other pin	-5	+5	

Figure 37. Standard I/O input characteristics - CMOS port

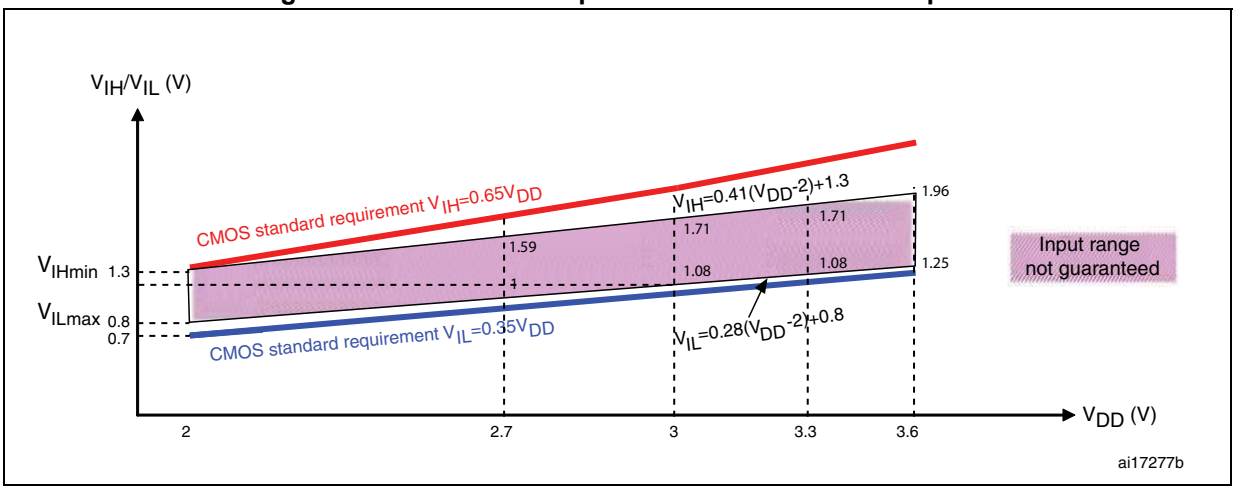


Figure 38. Standard I/O input characteristics - TTL port

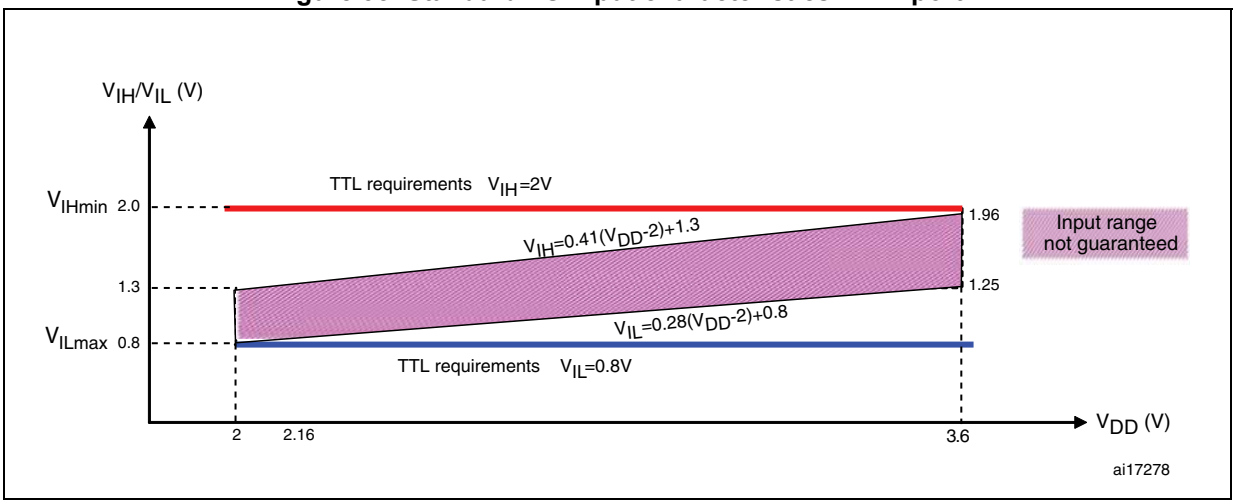


Figure 39. 5 V tolerant I/O input characteristics - CMOS port

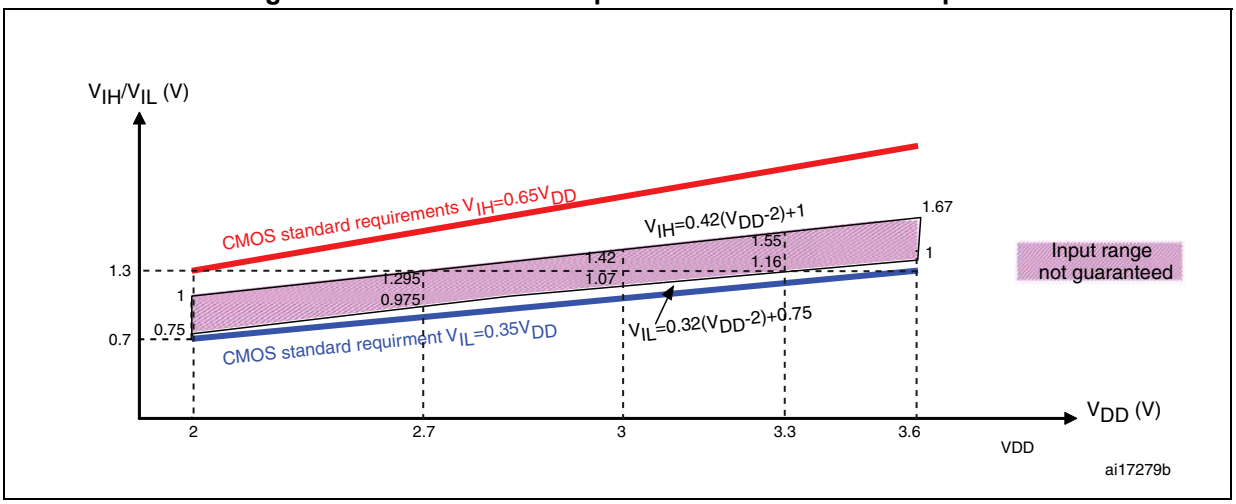
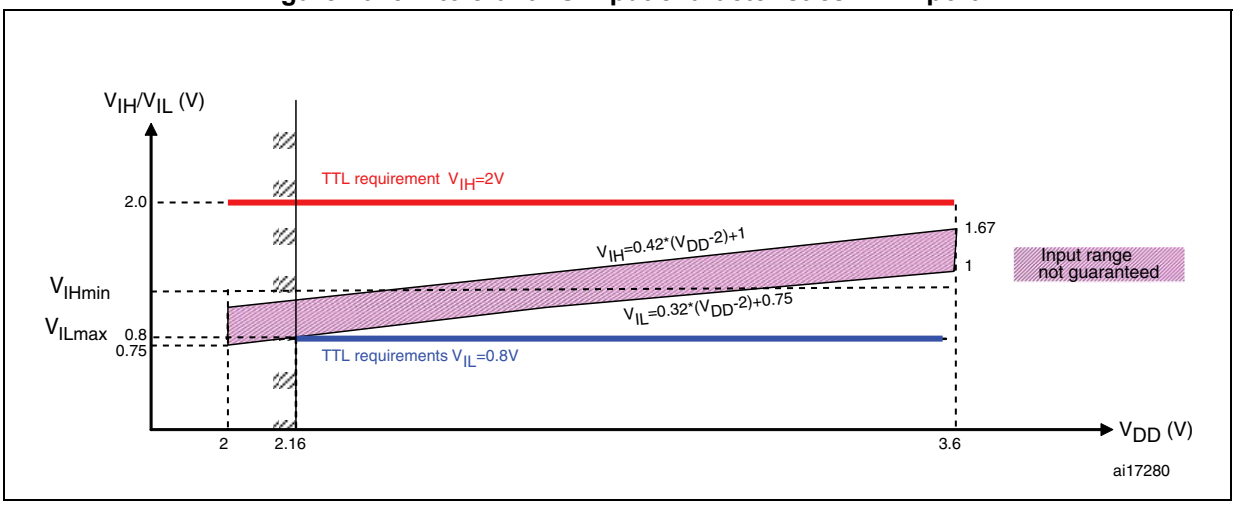


Figure 40. 5 V tolerant I/O input characteristics - TTL port



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 a relaxedV_{OL}/V_{OH}) except PC13, PC14 and PC15 which can sink or source up to ±3 mA. When using the GPIOs PC13 to PC15 in output mode, the speed should not exceed 2 MHz with a maximum load of 30 pF.

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 5.2*:

- 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 I_{VDD} (see *Table 8*).
- 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 I_{VSS} (see *Table 8*).

Figure 44. SPI timing diagram - slave mode and CPHA=0

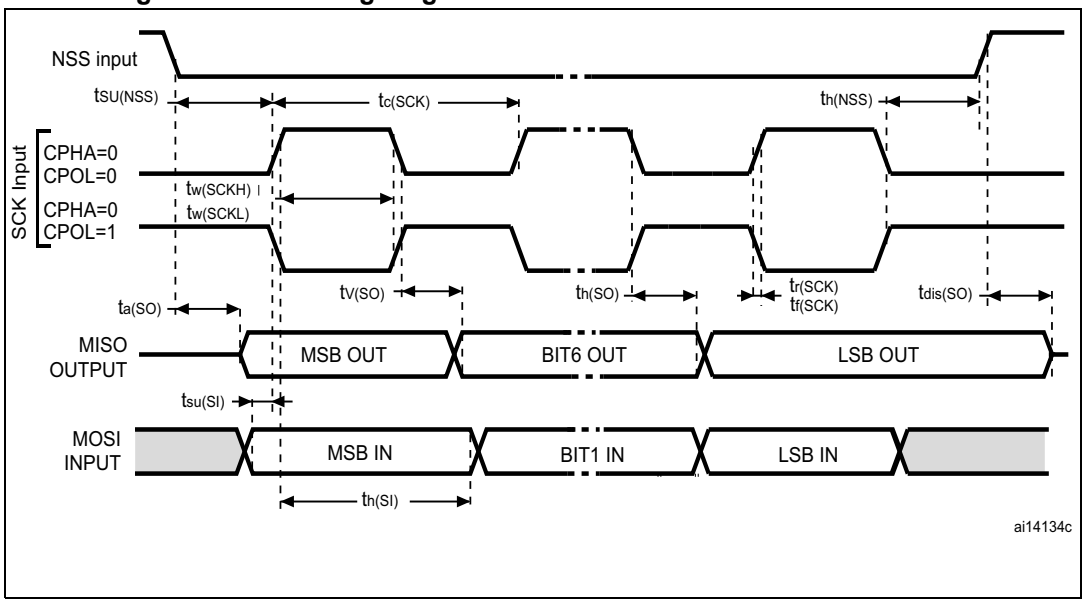
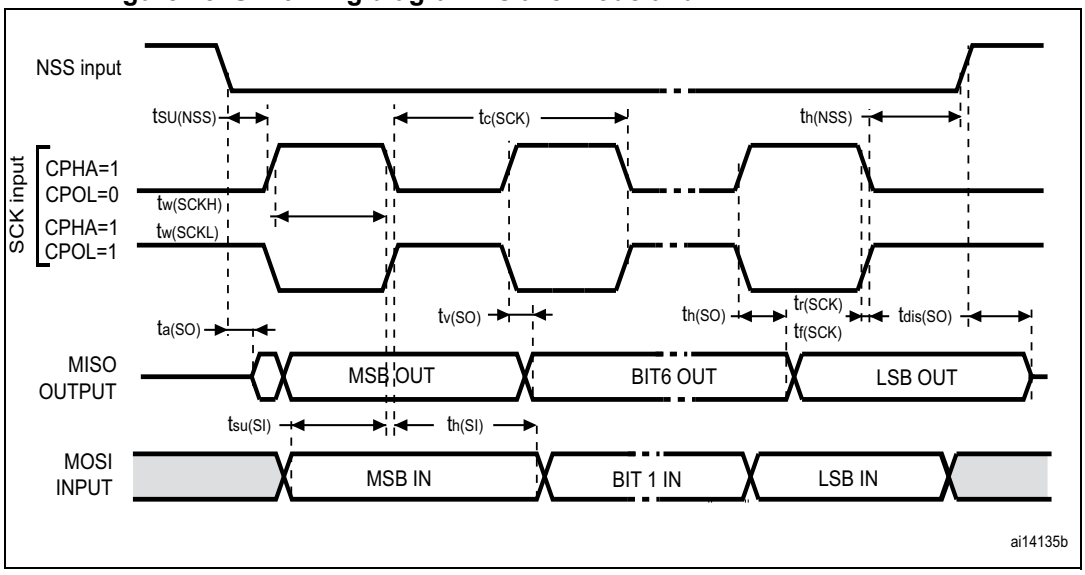


Figure 45. SPI timing diagram - slave mode and CPHA=1(1)



1. Measurement points are done at CMOS levels: $0.3V_{DD}$ and $0.7V_{DD}$.

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 57. R_{AIN} max for f_{ADC} = 14 MHz(1)

T_s (cycles)	t_S (µs)	R_{AIN} max (kΩ)
1.5	0.11	0.4
7.5	0.54	5.9
13.5	0.96	11.4
28.5	2.04	25.2
41.5	2.96	37.2
55.5	3.96	50
71.5	5.11	NA
239.5	17.1	NA

1. Guaranteed by design.

Table 58. ADC accuracy - limited test conditions(1)(2)

Symbol	Parameter	Test conditions	Typ	Max(3)	Unit
ET	Total unadjusted error	f_{PCLK2} = 28 MHz, f_{ADC} = 14 MHz, R_{AIN} < 10 kΩ, V_{DDA} = 3 V to 3.6 V, T_A = 25 °C Measurements made after ADC calibration V_{REF+} = V_{DDA}	±1.3	±2	LSB
EO	Offset error		±1	±1.5	
EG	Gain error		±0.5	±1.5	
ED	Differential linearity error		±0.7	±1	
EL	Integral linearity error		±0.8	±1.5	

1. ADC DC accuracy values are measured after internal calibration.
2. ADC Accuracy vs. Negative Injection Current: Injecting negative current on any of the standard 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 current.
   Any positive injection current within the limits specified for $I_{INJ(PIN)}$ and $\Sigma I_{INJ(PIN)}$ in *Section 5.3.13* does not affect the ADC accuracy.
3. Guaranteed by characterization results.

Table 59. ADC accuracy(1) (2)(3)

Symbol	Parameter	Test conditions	Typ	Max(4)	Unit
ET	Total unadjusted error	f_{PCLK2} = 28 MHz, f_{ADC} = 14 MHz, R_{AIN} < 10 kΩ, V_{DDA} = 2.4 V to 3.6 V Measurements made after ADC calibration	±2	±5	LSB
EO	Offset error		±1.5	±2.5	
EG	Gain error		±1.5	±3	
ED	Differential linearity error		±1	±2	
EL	Integral linearity error		±1.5	±3	

1. ADC DC accuracy values are measured after internal calibration.
2. Better performance could be achieved in restricted V_{DD}, frequency, V_{REF} and temperature ranges.
3. ADC accuracy vs. negative injection current: Injecting negative current on any of the standard (non-robust) 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 standard analog pins which may potentially inject negative current.
   Any positive injection current within the limits specified for $I_{INJ(PIN)}$ and $\Sigma I_{INJ(PIN)}$ in *Section 5.3.13* does not affect the ADC accuracy.
4. Preliminary values.

Figure 47. ADC accuracy characteristics

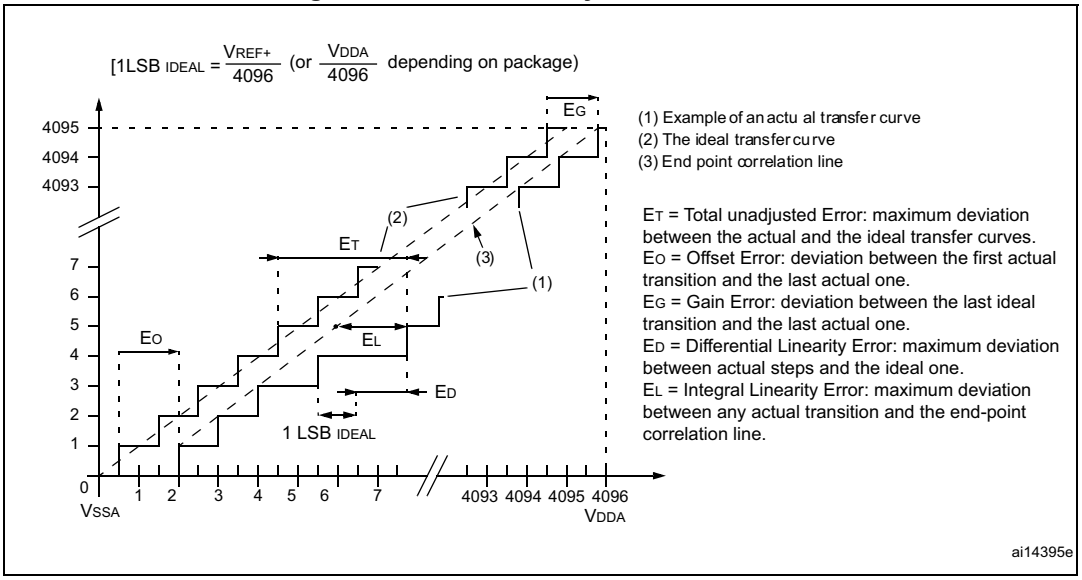
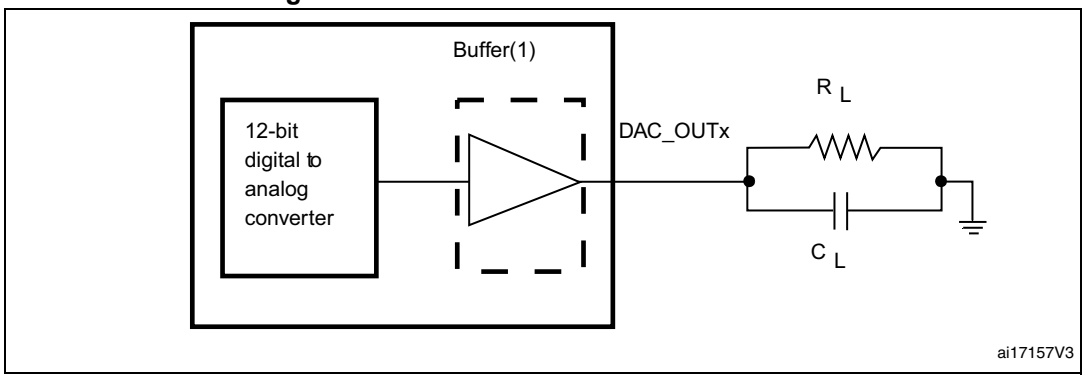


Table 60. DAC characteristics (continued)

Symbol	Parameter	Conditions		Min	Typ	Max(1)	Unit	Comments
$t_{SETTLING}$	Settling time (full scale: for a 10-bit input code transition between the lowest and the highest input codes when DAC_OUT reaches final value ±1LSB			-	3	4	µs	$C_{LOAD} \leq 50$ pF, $R_{LOAD} \geq 5$ kΩ
Update rate(1)	Max frequency for a correct DAC_OUT change when small variation in the input code (from code i to i+1LSB)			-	-	1	MS/s	$C_{LOAD} \leq 50$ pF, $R_{LOAD} \geq 5$ kΩ
t_{WAKEUP}(1)	Wakeup time from off state (Setting the ENx bit in the DAC Control register)			-	6.5	10	µs	$C_{LOAD} \leq 50$ pF, $R_{LOAD} \geq 5$ kΩ input code between lowest and highest possible ones.
PSRR+ (2)	Power supply rejection ratio (to V_{DDA}) (static DC measurement			-	–67	–40	dB	No R_{LOAD}, C_{LOAD} = 50 pF

1. Preliminary values.
2. Guaranteed by design.
3. Quiescent mode refers to the state of the DAC when a steady value is kept on the output so that no dynamic consumption is involved.

Figure 51. 12-bit buffered /non-buffered DAC



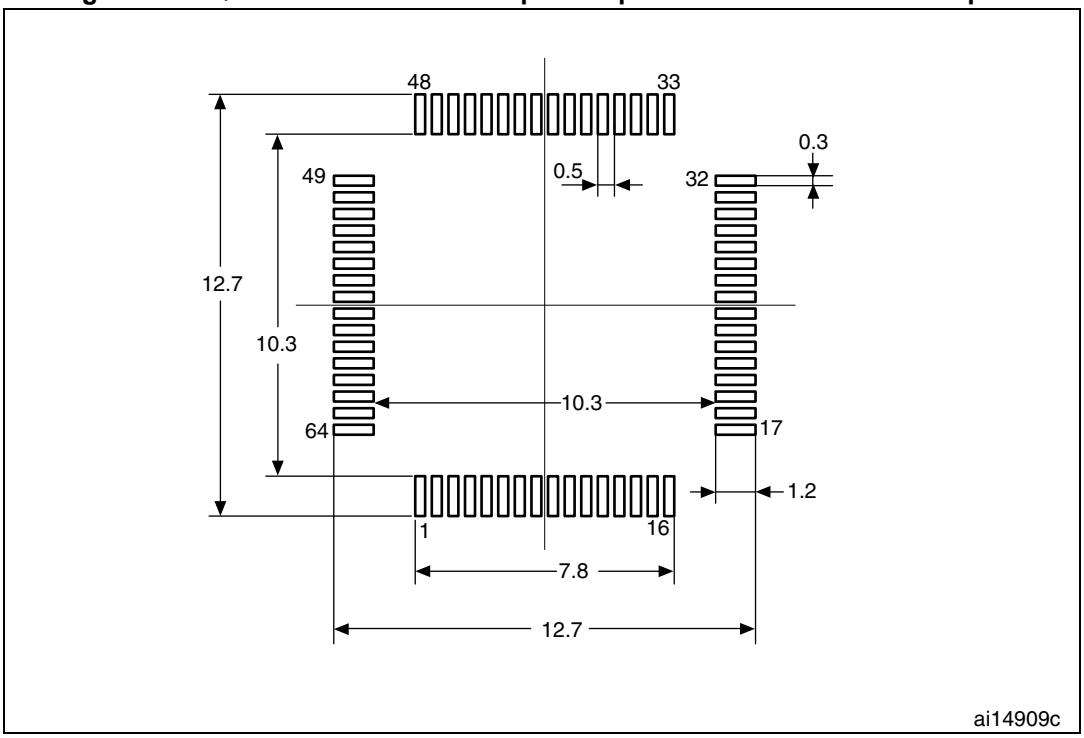
1. The DAC integrates an output buffer that can be used to reduce the output impedance and to drive external loads directly without the use of an external operational amplifier. The buffer can be bypassed by configuring the BOFFx bit in the DAC_CR register.

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

Symbol	millimeters			inches[1]		
	Min	Typ	Max	Min	Typ	Max
e	-	0.500	-	-	0.0197	-
θ	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 59. LQFP64 - 10 x 10 mm low-profile quad flat recommended footprint



1. Dimensions are in millimeters.