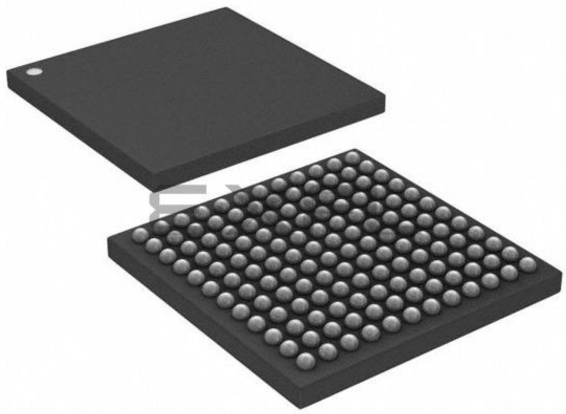

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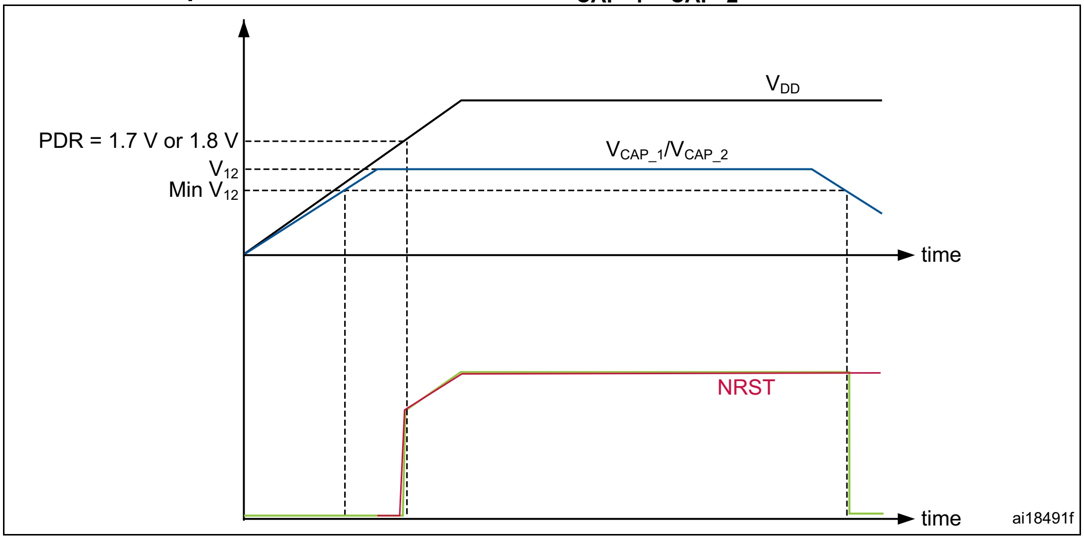
Applications of "Embedded - Microcontrollers"

Details	
Product Status	Active
Core Processor	ARM® Cortex®-M4
Core Size	32-Bit Single-Core
Speed	180MHz
Connectivity	CANbus, EBI/EMI, I²C, IrDA, LINbus, SAI, SD, SPDIF-Rx, SPI, UART/USART, USB, USB OTG
Peripherals	Brown-out Detect/Reset, DMA, I²S, LVD, POR, PWM, WDT
Number of I/O	114
Program Memory Size	512KB (512K x 8)
Program Memory Type	FLASH
EEPROM Size	-
RAM Size	128K x 8
Voltage - Supply (Vcc/Vdd)	1.7V ~ 3.6V
Data Converters	A/D 24x12b; D/A 2x12b
Oscillator Type	Internal
Operating Temperature	-40°C ~ 85°C (TA)
Mounting Type	Surface Mount
Package / Case	144-UFBGA
Supplier Device Package	144-UFBGA (7x7)
Purchase URL	https://www.e-xfl.com/product-detail/stmicroelectronics/stm32f446zeh6tr

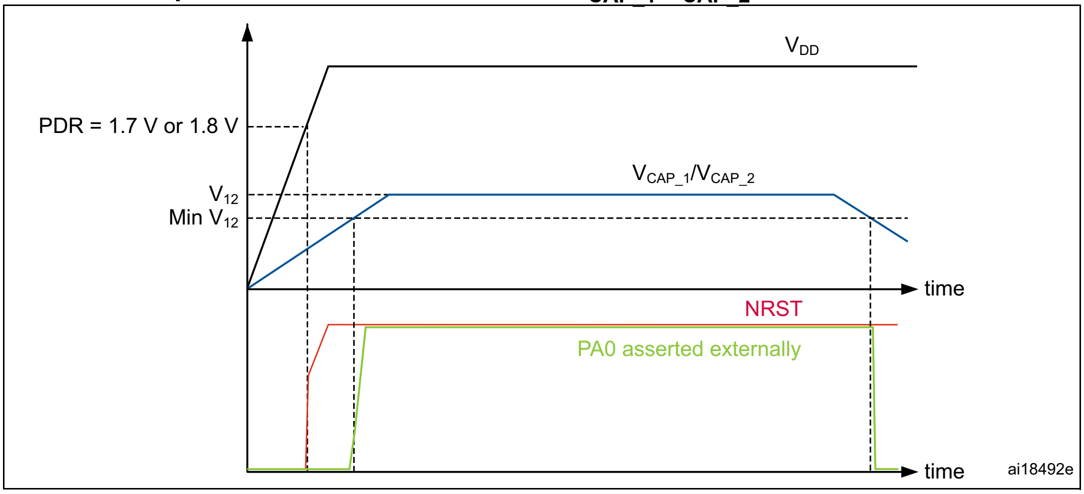
Contents

Figure 8. Startup in regulator OFF: slow V_{DD} slope power-down reset risen after V_{CAP_1}/V_{CAP_2} stabilization



1. This figure is valid whatever the internal reset mode (ON or OFF).

Figure 9. Startup in regulator OFF mode: fast V_{DD} slope power-down reset risen before V_{CAP_1}/V_{CAP_2} stabilization



1. This figure is valid whatever the internal reset mode (ON or OFF).

3.17.3 Regulator ON/OFF and internal reset ON/OFF availability

Table 4. Regulator ON/OFF and internal reset ON/OFF availability

Package	Regulator ON	Regulator OFF	Internal reset ON	Internal reset OFF
LQFP64 LQFP100	Yes	No	Yes	No

Note: When the microcontroller is supplied from V_{BAT}, external interrupts and RTC alarm/events do not exit it from V_{BAT} operation.

When PDR_ON pin is not connected to V_{DD} (Internal Reset OFF), the V_{BAT} functionality is no more available and V_{BAT} pin should be connected to V_{DD}.

3.21.1 Advanced-control timers (TIM1, TIM8)

The advanced-control timers (TIM1, TIM8) can be seen as three-phase PWM generators multiplexed on 6 channels. They have complementary PWM outputs with programmable inserted dead times. They can also be considered as complete general-purpose timers. Their 4 independent channels can be used for:

- Input capture
- Output compare
- PWM generation (edge- or center-aligned modes)
- One-pulse mode output

If configured as standard 16-bit timers, they have the same features as the general-purpose TIMx timers. If configured as 16-bit PWM generators, they have full modulation capability (0-100%).

The advanced-control timer can work together with the TIMx timers via the Timer Link feature for synchronization or event chaining.

TIM1 and TIM8 support independent DMA request generation.

3.21.2 General-purpose timers (TIMx)

There are ten synchronized general-purpose timers embedded in the STM32F446xC/E devices (see *Table 6* for differences).

- **TIM2, TIM3, TIM4, TIM5**

  The STM32F446xC/E include 4 full-featured general-purpose timers: TIM2, TIM5, TIM3, and TIM4.The TIM2 and TIM5 timers are based on a 32-bit auto-reload up/downcounter and a 16-bit prescaler. The TIM3 and TIM4 timers are based on a 16-bit auto-reload up/downcounter and a 16-bit prescaler. They all feature 4 independent channels for input capture/output compare, PWM or one-pulse mode output. This gives up to 16 input capture/output compare/PWMs on the largest packages.

  The TIM2, TIM3, TIM4, TIM5 general-purpose timers can work together, or with the other general-purpose timers and the advanced-control timers TIM1 and TIM8 via the Timer Link feature for synchronization or event chaining.

  Any of these general-purpose timers can be used to generate PWM outputs.

  TIM2, TIM3, TIM4, TIM5 all have independent DMA request generation. They are capable of handling quadrature (incremental) encoder signals and the digital outputs from 1 to 4 hall-effect sensors.

- **TIM9, TIM10, TIM11, TIM12, TIM13, and TIM14**

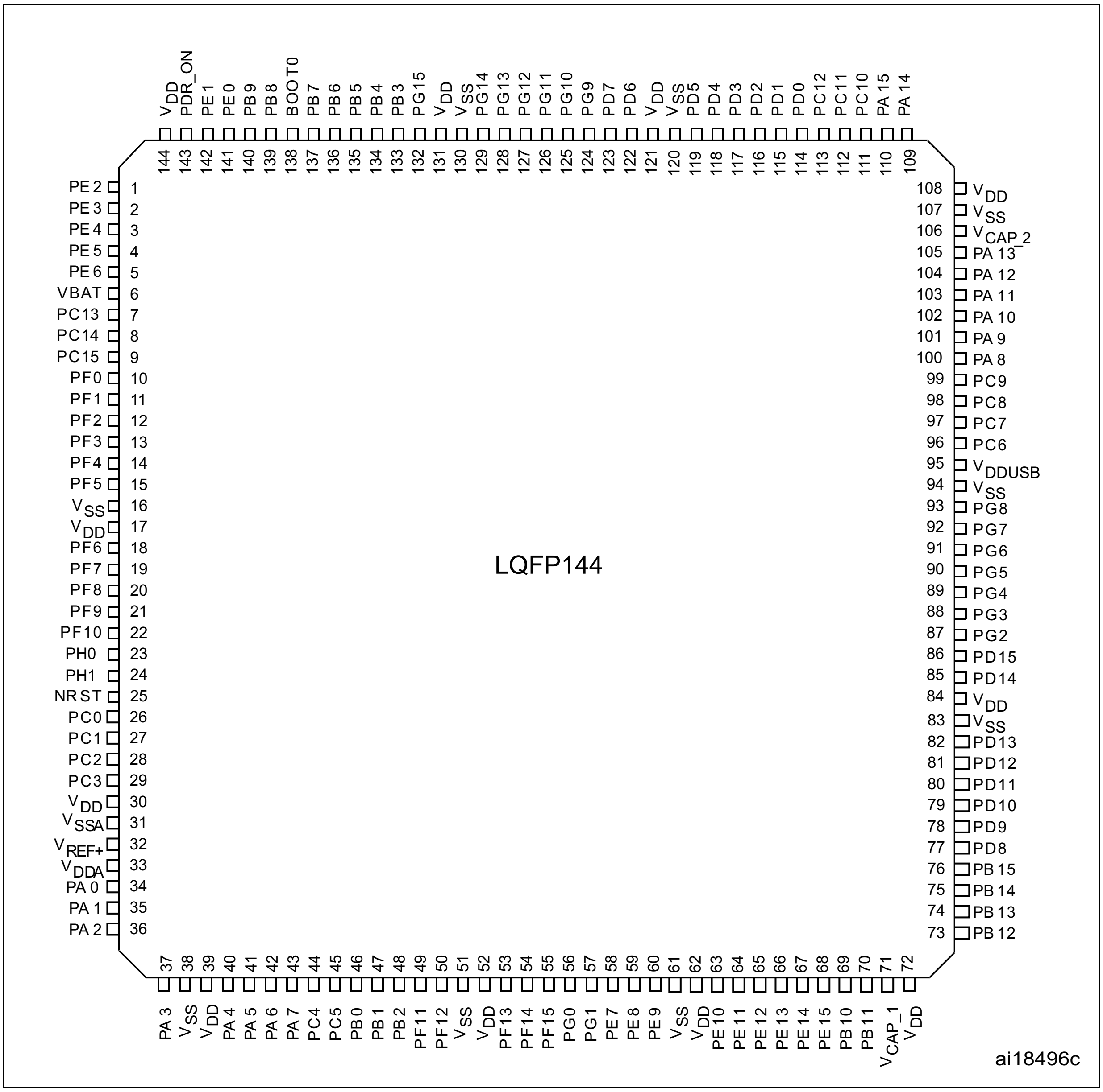
  These timers are based on a 16-bit auto-reload upcounter and a 16-bit prescaler. TIM10, TIM11, TIM13, and TIM14 feature one independent channel, whereas TIM9 and TIM12 have two independent channels for input capture/output compare, PWM or one-pulse mode output. They can be synchronized with the TIM2, TIM3, TIM4, TIM5 full-featured general-purpose timers. They can also be used as simple time bases.

3.21.3 Basic timers TIM6 and TIM7

These timers are mainly used for DAC trigger and waveform generation. They can also be used as a generic 16-bit time base.

TIM6 and TIM7 support independent DMA request generation.

Figure 12. STM32F446xC LQFP144 pinout



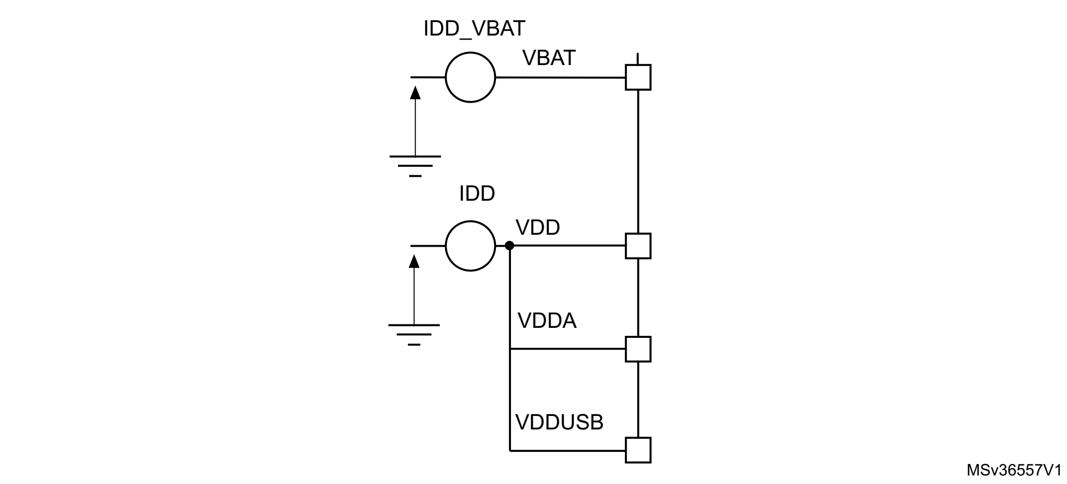
1. The above figure shows the package top view.

Table 10. STM32F446xx pin and ball descriptions (continued)

Pin Number					Pin name (function after reset)	Pin type	I/O structure	Notes	Alternate functions	Additional functions
LQFP64	LQFP100	WLCSP 81	UFBGA144	LQFP144						
17	26	E6	M2	37	PA3	I/O	FT	-	TIM2_CH4, TIM5_CH4, TIM9_CH2, SAI1_FS_A, USART2_RX, OTG_HS_ULPI_D0, EVENTOUT	ADC123_IN3
18	27	-	G4	38	VSS	S	-	-	-	-
-	-	J8	H5	-	BYPASS_REG	I	FT	-	-	-
19	28	-	F4	39	VDD	S	-	-	-	-
20	29	H7	J3	40	PA4	I/O	TC	-	SPI1_NSS/I2S1_WS, SPI3_NSS/I2S3_WS, USART2_CK, OTG_HS_SOF, DCMI_HSYNC, EVENTOUT	ADC12_IN4, DAC_OUT1
21	30	F6	K3	41	PA5	I/O	TC	-	TIM2_CH1/TIM2_ETR, TIM8_CH1N, SPI1_SCK/I2S1_CK, OTG_HS_ULPI_CK, EVENTOUT	ADC12_IN5, DAC_OUT2
22	31	G6	L3	42	PA6	I/O	FT	-	TIM1_BKIN, TIM3_CH1, TIM8_BKIN, SPI1_MISO, I2S2_MCK, TIM13_CH1, DCMI_PIXCLK, EVENTOUT	ADC12_IN6
23	32	E5	M3	43	PA7	I/O	FT	-	TIM1_CH1N, TIM3_CH2, TIM8_CH1N, SPI1_MOSI/I2S1_SD, TIM14_CH1, FMC_SDNWE, EVENTOUT	ADC12_IN7
24	33	J7	J4	44	PC4	I/O	FT	-	I2S1_MCK, SPDIFRX_IN2, FMC_SDNE0, EVENTOUT	ADC12_IN14
25	34	-	K4	45	PC5	I/O	FT	-	USART3_RX, SPDIFRX_IN3, FMC_SDCKE0, EVENTOUT	ADC12_IN15

6.1.7 Current consumption measurement

Figure 19. Current consumption measurement scheme



6.2 Absolute maximum ratings

Stresses above the absolute maximum ratings listed in *Table 13: Voltage characteristics*, *Table 14: Current characteristics*, and *Table 15: Thermal characteristics* may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these conditions is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.

Table 13. Voltage characteristics

Symbol	Ratings	Min	Max	Unit
V_{DD}–V_{SS}	External main supply voltage (including V_{DDA}, V_{DD}, V_{DDUSB} and V_{BAT})(1)	–0.3	4.0	V
V_{IN}	Input voltage on FT & FTf pins(2)	V_{SS}–0.3	V_{DD}+4.0	V
	Input voltage on TTa pins	V_{SS}–0.3	4.0	V
	Input voltage on any other pin	V_{SS}–0.3	4.0	V
	Input voltage on BOOT0 pin	V_{SS}	9.0	V
$\lvert\Delta V_{DDx}\rvert$	Variations between different V_{DD} power pins	-	50	mV
$\lvert V_{SSX} - V_{SS}\rvert$	Variations between all the different ground pins	-	50	mV
$V_{ESD(HBM)}$	Electrostatic discharge voltage (human body model)	see *Section 6.3.15: Absolute maximum ratings (electrical sensitivity)*		-

1. All main power (V_{DD}, V_{DDA}) and ground (V_{SS}, V_{SSA}) pins must always be connected to the external power supply, in the permitted range.
2. V_{IN} maximum value must always be respected. Refer to *Table 14* for the values of the maximum allowed injected current.

Typical and maximum 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 memory access time is adjusted both to f_{HCLK} frequency and V_{DD} range (see *Table 17: Limitations depending on the operating power supply range*).
- Regulator ON
- The voltage scaling and over-drive mode are adjusted to f_{HCLK} frequency as follows:
  - Scale 3 for $f_{HCLK} \leq 120$ MHz
  - Scale 2 for 120 MHz < $f_{HCLK} \leq 144$ MHz
  - Scale 1 for 144 MHz < $f_{HCLK} \leq 180$ MHz. The over-drive is only ON at 180 MHz.
- The system clock is HCLK, $f_{PCLK1} = f_{HCLK}/4$, and $f_{PCLK2} = f_{HCLK}/2$.
- External clock frequency is 8 MHz and PLL is ON when f_{HCLK} is higher than 16 MHz.
- Flash is enabled except if explicitly mentioned as disable.
- The maximum values are obtained for V_{DD} = 3.6 V and a maximum ambient temperature (T_A), and the typical values for T_A= 25 °C and V_{DD} = 3.3 V unless otherwise specified.

Table 26. Typical and maximum current consumption in Sleep mode[1] (continued)

Symbol	Parameter	Conditions		fHCLK (MHz)	Typ	Max			Unit
						T_A = 25 °C	T_A = 25 °C	T_A = 25 °C	
IDD	Supply current in Sleep mode	External clock, PLL on all peripherals disabled	Flash on	180	11.36	17.59	28.2	51.6	mA
				168[2]	10.20	16.19	22.0	31.8	
				150	9.53	15.59	21.1	30.9	
				144[2]	8.90	14.87	19.7	28.4	
				120	7.35	13.24	16.5	23.3	
				90	6.39	12.40	15.3	21.9	
				60	5.28	11.17	14.1	20.7	
				30	4.43	10.31	13.1	19.6	
				25	4.23	10.12	12.85	19.30	
			Flash in Deep Power Down mode	180	8.3	13.44	30.72	37.20	
				168[2]	7.3	12.25	25.16	28.80	
				150	6.7	11.60	24.27	27.84	
				144[2]	6.1	11.08	23.25	26.28	
				120	4.7	9.64	20.95	23.72	
				90	3.8	8.80	19.77	22.57	
				60	2.8	7.74	18.69	21.32	
				30	2.0	6.89	17.66	20.40	
				25	1.8	6.70	17.43	20.17	
			Flash in STOP mode	180	8.3	13.44	30.72	37.20	
				168[2]	7.3	12.25	25.16	28.80	
				150	6.7	11.60	24.27	27.84	
				144[2]	6.1	11.08	23.25	26.28	
				120	4.7	9.64	20.95	23.72	
				90	3.8	8.80	19.77	22.57	
				60	2.8	7.74	18.69	21.32	
				30	2.0	6.89	17.66	20.40	
				25	1.8	6.70	17.43	20.17	

Table 48. Flash memory programming

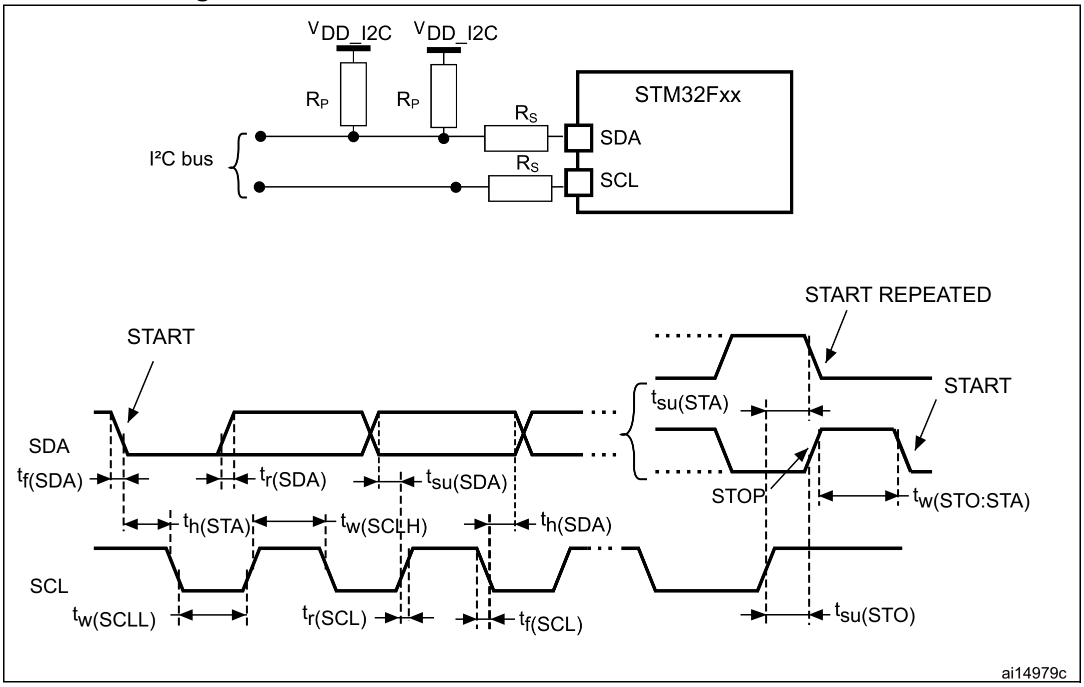
Symbol	Parameter	Conditions	Min(1)	Typ	Max(1)	Unit
t_{prog}	Word programming time	Program/erase parallelism (PSIZE) = x 8/16/32	-	16	100(2)	µs
$t_{ERASE16KB}$	Sector (16 KB) erase time	Program/erase parallelism (PSIZE) = x 8	-	400	800	ms
		Program/erase parallelism (PSIZE) = x 16	-	300	600	
		Program/erase parallelism (PSIZE) = x 32	-	250	500	
$t_{ERASE64KB}$	Sector (64 KB) erase time	Program/erase parallelism (PSIZE) = x 8	-	1200	2400	ms
		Program/erase parallelism (PSIZE) = x 16	-	700	1400	
		Program/erase parallelism (PSIZE) = x 32	-	550	1100	
$t_{ERASE128KB}$	Sector (128 KB) erase time	Program/erase parallelism (PSIZE) = x 8	-	2	4	s
		Program/erase parallelism (PSIZE) = x 16	-	1.3	2.6	
		Program/erase parallelism (PSIZE) = x 32	-	1	2	
t_{ME}	Mass erase time	Program/erase parallelism (PSIZE) = x 8	-	8	16	s
		Program/erase parallelism (PSIZE) = x 16	-	5.5	11	
		Program/erase parallelism (PSIZE) = x 32	-	8	16	
V_{prog}	Programming voltage	32-bit program operation	2.7	-	3.6	V
		16-bit program operation	2.1	-	3.6	V
		8-bit program operation	1.7	-	3.6	V

1. Guaranteed based on test during characterization.
2. The maximum programming time is measured after 100K erase operations.

Table 49. Flash memory programming with V_{PP}

Symbol	Parameter	Conditions	Min(1)	Typ	Max(1)	Unit
t_{prog}	Double word programming	T_A = 0 to +40 °C V_{DD} = 3.3 V V_{PP} = 8.5 V	-	16	100(2)	µs
$t_{ERASE16KB}$	Sector (16 KB) erase time		-	230	-	ms
$t_{ERASE64KB}$	Sector (64 KB) erase time		-	490	-	
$t_{ERASE128KB}$	Sector (128 KB) erase time		-	875	-	
t_{ME}	Mass erase time		-	3.5	-	s
V_{prog}	Programming voltage	-	2.7	-	3.6	V

Figure 34. I^2C bus AC waveforms and measurement circuit



1. R_S = series protection resistor.
2. R_P = external pull-up resistor.
3. V_{DD_I2C} is the I2C bus power supply.

SAI characteristics

Unless otherwise specified, the parameters given in Table 67 for SAI are derived from tests performed under the ambient temperature, f_{PCLKx} frequency and VDD supply voltage conditions summarized in Table 16, with the following configuration:

- Output speed is set to OSPEEDRy[1:0] = 10
- Capacitive load C=30 pF
- Measurement points are performed at CMOS levels: $0.5V_{DD}$

Refer to Section 6.3.17: I/O port characteristics for more details on the input/output alternate function characteristics (SCK,SD,WS).

Table 67. SAI characteristics(1)

Symbol	Parameter	Conditions	Min	Max	Unit
f_{MCK}	SAI Main clock output	-	256 x 8K	256 x Fs	MHz
f_{CK}	SAI clock frequency(2)	Master data: 32 bits	-	128 x Fs(3)	MHz
		Slave data: 32 bits	-	128 x Fs(3)	
$t_{v(FS)}$	FS valid time	Master mode 2.7 V ≤ V_{DD} ≤3.6 V	-	14	%
		Master mode 1.71 V ≤ V_{DD} ≤3.6 V	-	17.5	ns
$t_{h(FS)}$	FS hold time	Master mode	7	-	
$t_{su(FS)}$	FS setup time	Slave mode	1	-	
$t_{h(FS)}$	FS hold time	Slave mode	1	-	
$t_{su(SD\_A\_MR)}$	Data input setup time	Master receiver	1	-	
$t_{su(SD\_B\_SR)}$		Slave receiver	1	-	
$t_{h(SD\_A\_MR)}$	Data input hold time	Master receiver	5	-	
$t_{h(SD\_B\_SR)}$		Slave receiver	1	-	
$t_{v(SD\_B\_ST)}$	Data output valid time	Slave trasmitter (after enable edge 2.7 V ≤ V_{DD} ≤3.6 V	-	9.5	
		Slave transmitter (after enable edge 1.71 V ≤ V_{DD} ≤3.6 V	-	16	
$t_{h(SD\_B\_ST)}$	Data output hold time	Slave transmitter (after enable edge	6	-	
$t_{v(SD\_B\_ST)}$	Data output valid time	Master transmitter (after enable edge 2.7 V ≤ V_{DD} ≤3.6 V	-	15	
		Master transmitter (after enable edge 1.71 V ≤ V_{DD} ≤3.6 V	-	18	
$t_{h(SD\_B\_ST)}$	Data output hold time	Master transmitter (after enable edge	7	-	

1. Guaranteed based on test during characterization.
2. 256xFs maximum corresponds to 45 MHz (APB2 xaximum frequency)
3. With Fs = 192 KHz

Table 76. ADC static accuracy at f_{ADC} = 30 MHz(1)

Symbol	Parameter	Test conditions	Typ	Max(2)	Unit
ET	Total unadjusted error	f_{ADC} = 30 MHz, R_{AIN} < 10 kΩ, V_{DDA} = 2.4 to 3.6 V, V_{REF} = 1.7 to 3.6 V, $V_{DDA} - V_{REF}$ < 1.2 V	±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. Better performance could be achieved in restricted V_{DD}, frequency and temperature ranges.
2. Guaranteed based on test during characterization.

Table 77. ADC static accuracy at f_{ADC} = 36 MHz(1)

Symbol	Parameter	Test conditions	Typ	Max(2)	Unit
ET	Total unadjusted error	f_{ADC} =36 MHz, V_{DDA} = 2.4 to 3.6 V, V_{REF} = 1.7 to 3.6 V $V_{DDA} - V_{REF}$ < 1.2 V	±4	±7	LSB
EO	Offset error		±2	±3	
EG	Gain error		±3	±6	
ED	Differential linearity error		±2	±3	
EL	Integral linearity error		±3	±6	

1. Better performance could be achieved in restricted V_{DD}, frequency and temperature ranges.
2. Guaranteed based on test during characterization.

Table 78. ADC dynamic accuracy at f_{ADC} = 18 MHz - limited test conditions(1)

Symbol	Parameter	Test conditions	Min	Typ	Max	Unit
ENOB	Effective number of bits	f_{ADC} =18 MHz V_{DDA} = V_{REF+}= 1.7 V Input Frequency = 20 KHz Temperature = 25 °C	10.3	10.4	-	bits
SINAD	Signal-to-noise and distortion ratio		64	64.2	-	dB
SNR	Signal-to-noise ratio		64	65	-	
THD	Total harmonic distortion		-67	-72	-	

1. Guaranteed based on test during characterization.

Table 79. ADC dynamic accuracy at f_{ADC} = 36 MHz - limited test conditions(1)

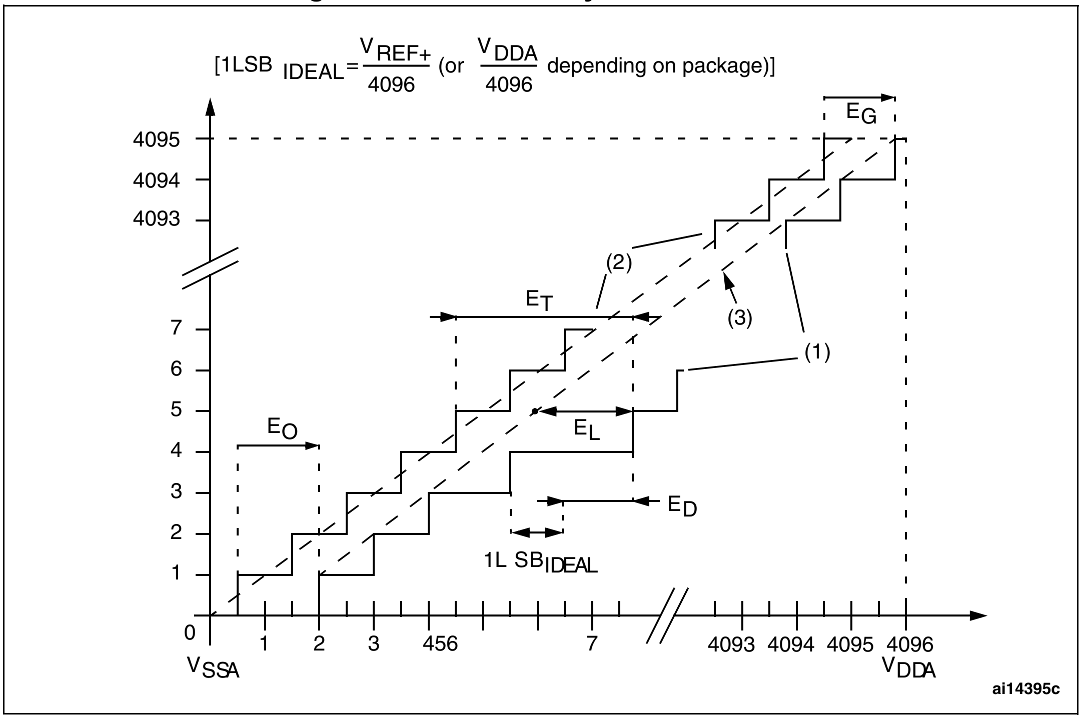
Symbol	Parameter	Test conditions	Min	Typ	Max	Unit
ENOB	Effective number of bits	f_{ADC} =36 MHz V_{DDA} = V_{REF+} = 3.3 V Input Frequency = 20 KHz Temperature = 25 °C	10.6	10.8	-	bits
SINAD	Signal-to noise and distortion ratio		66	67	-	dB
SNR	Signal-to noise ratio		64	68	-	
THD	Total harmonic distortion		- 70	- 72	-	

1. Guaranteed based on test during characterization.

Note: 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.*

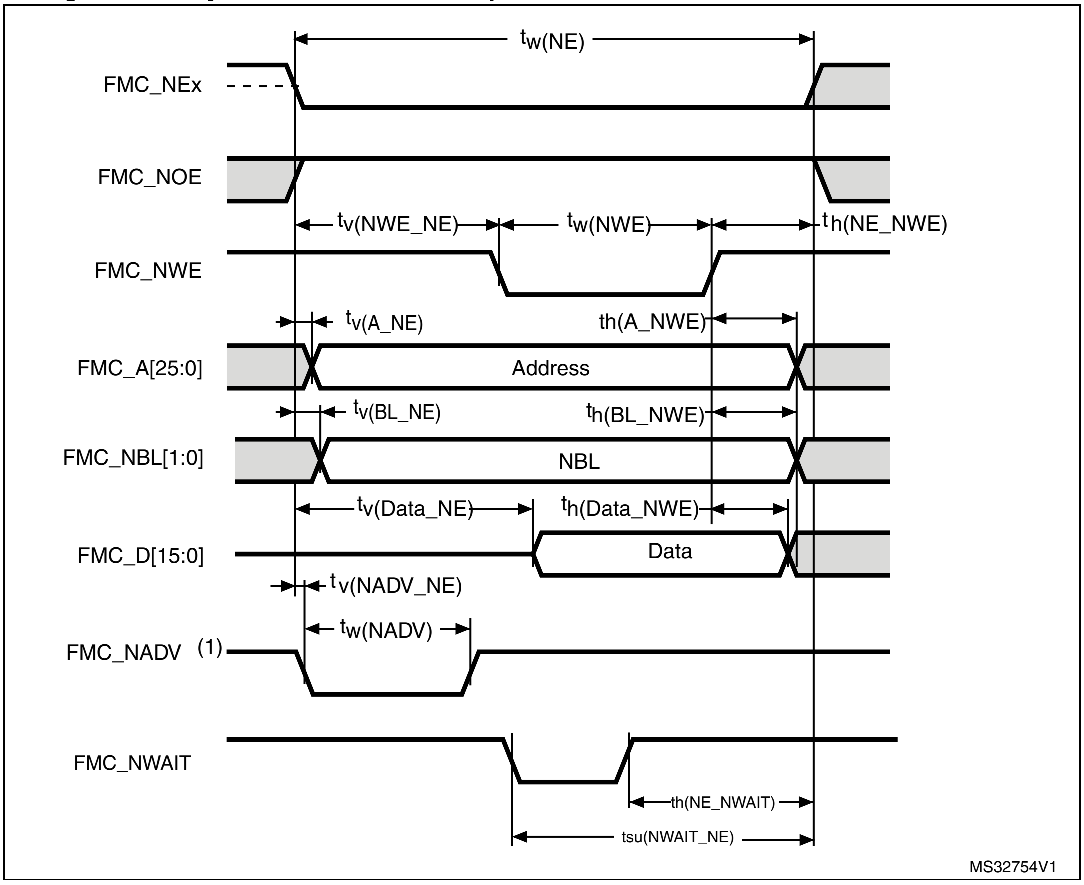
Any positive injection current within the limits specified for $I_{INJ(PIN)}$ and $\Sigma I_{INJ(PIN)}$ in Section 6.3.17 does not affect the ADC accuracy.

Figure 45. ADC accuracy characteristics



1. See also Table 76.
2. Example of an actual transfer curve.
3. Ideal transfer curve.
4. End point correlation line.
5. E_T = Total Unadjusted Error: maximum deviation between the actual and the ideal transfer curves.
EO = Offset Error: deviation between the first actual transition and the first ideal one.
EG = Gain Error: deviation between the last ideal transition and the last actual one.
ED = Differential Linearity Error: maximum deviation between actual steps and the ideal one.
EL = Integral Linearity Error: maximum deviation between any actual transition and the end point correlation line.

Figure 51. Asynchronous non-multiplexed SRAM/PSRAM/NOR write waveforms



1. Mode 2/B, C and D only. In Mode 1, FMC_NADV is not used.

Table 88. Asynchronous non-multiplexed SRAM/PSRAM/NOR write timings(1)(2)

Symbol	Parameter	Min	Max	Unit
$t_{w(NE)}$	FMC_NE low time	$3\ T_{HCLK}$ - 2	$3\ T_{HCLK}$ +0.5	ns
$t_{v(NWE\_NE)}$	FMC_NEx low to FMC_NWE low	T_{HCLK} – 0.5	T_{HCLK} + 0.5	
$t_{w(NWE)}$	FMC_NWE low time	T_{HCLK}	T_{HCLK}+ 0.5	
$t_{h(NE\_NWE)}$	FMC_NWE high to FMC_NE high hold time	T_{HCLK} + 0.5	-	
$t_{v(A\_NE)}$	FMC_NEx low to FMC_A valid	-	0	
$t_{h(A\_NWE)}$	Address hold time after FMC_NWE high	T_{HCLK} - 0.5	-	
$t_{v(BL\_NE)}$	FMC_NEx low to FMC_BL valid	-	1	
$t_{h(BL\_NWE)}$	FMC_BL hold time after FMC_NWE high	T_{HCLK} + 0.5	-	
$t_{v(Data\_NE)}$	Data to FMC_NEx low to Data valid	-	T_{HCLK} + 2	
$t_{h(Data\_NWE)}$	Data hold time after FMC_NWE high	T_{HCLK} + 0.5	-	
$t_{v(NADV\_NE)}$	FMC_NEx low to FMC_NADV low	-	0	
$t_{w(NADV)}$	FMC_NADV low time	-	T_{HCLK}+ 0.5	

1. C_L = 30 pF.
2. Guaranteed based on test during characterization.

Figure 60. NAND controller waveforms for common memory read access

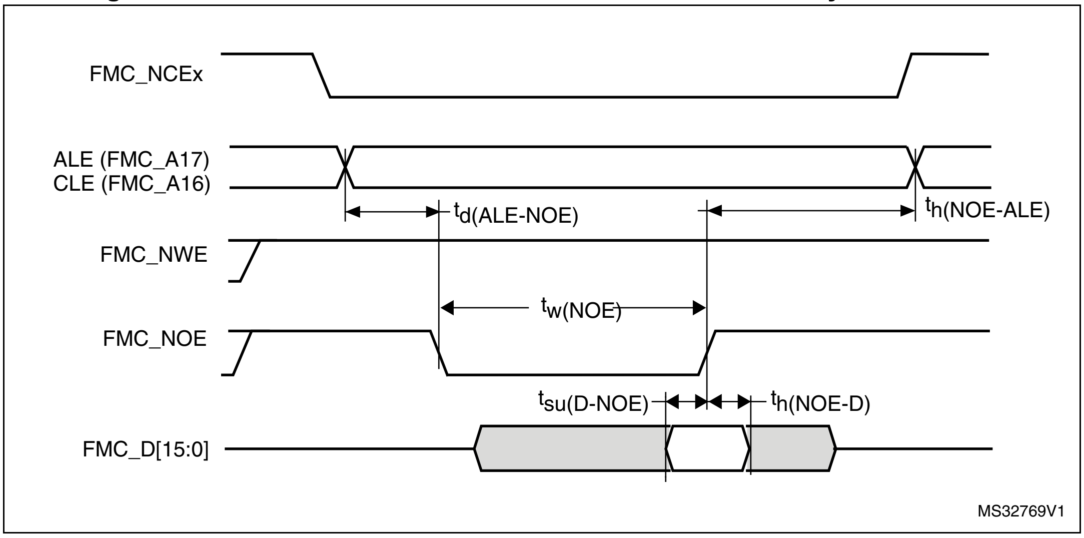


Figure 61. NAND controller waveforms for common memory write access

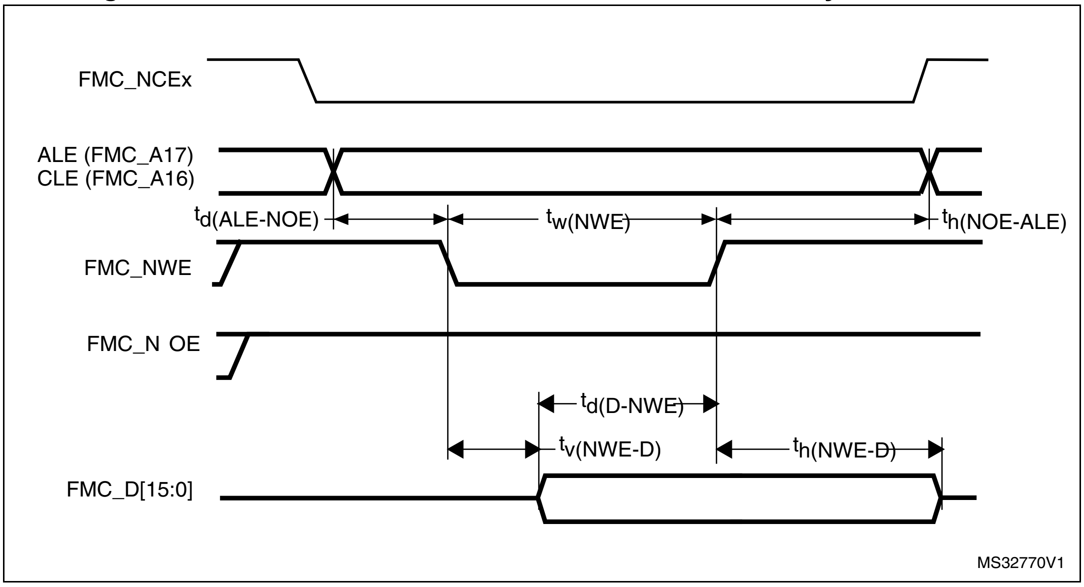
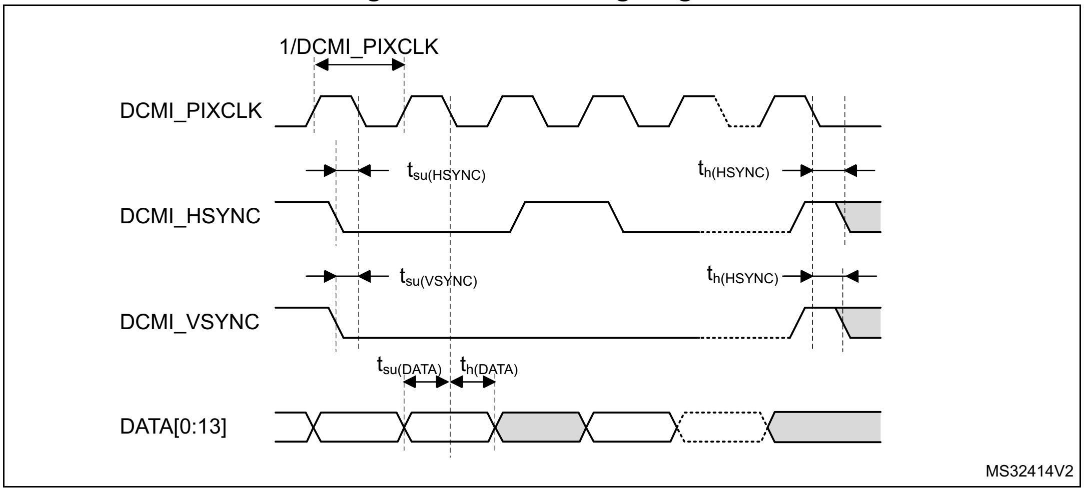


Table 98. Switching characteristics for NAND Flash read cycles(1)

Symbol	Parameter	Min	Max	Unit
$t_{w(N0E)}$	FMC_NOE low width	$4T_{HCLK} - 0.5$	$4T_{HCLK} + 0.5$	ns
$t_{su(D-NOE)}$	FMC_D[15-0] valid data before FMC_NOE high	9	-	
$t_{h(NOE-D)}$	FMC_D[15-0] valid data after FMC_NOE high	2.5	-	
$t_{d(ALE-NOE)}$	FMC_ALE valid before FMC_NOE low	-	$3T_{HCLK}$ - 0.5	
$t_{h(NOE-ALE)}$	FMC_NWE high to FMC_ALE invalid	$3T_{HCLK} - 2$	-	

1. C_L = 30 pF.

Figure 64. DCMI timing diagram



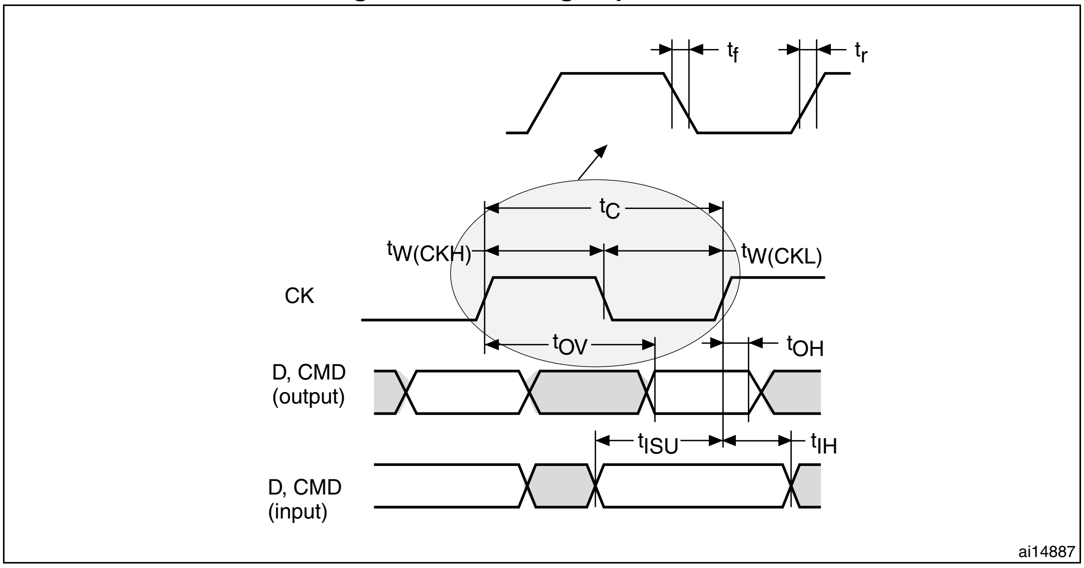
6.3.28 SD/SDIO MMC card host interface (SDIO) characteristics

Unless otherwise specified, the parameters given in *Table 105* for the SDIO are derived from tests performed under the ambient temperature, f_{PCLK2} frequency and V_{DD} supply voltage conditions summarized in *Table 16*, with the following configuration:

- Output speed is set to OSPEEDRy[1:0] = 10
- Capacitive load C = 30 pF
- Measurement points are done at CMOS levels: $0.5V_{DD}$

Refer to *Section 6.3.17: I/O port characteristics* for more details on the input/output characteristics.

Figure 65. SDIO high-speed mode

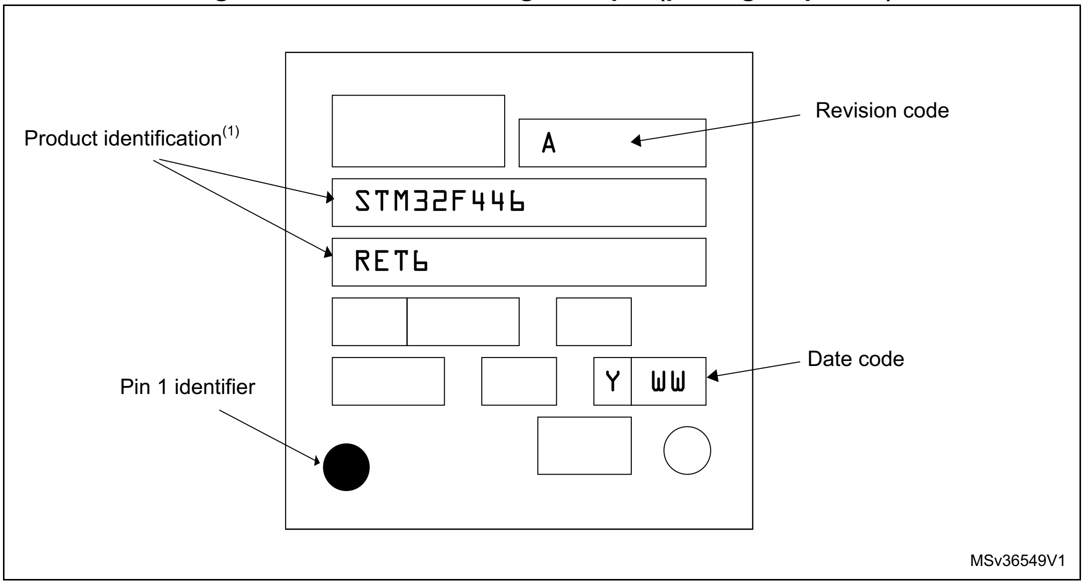


Device marking for LQFP64

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.

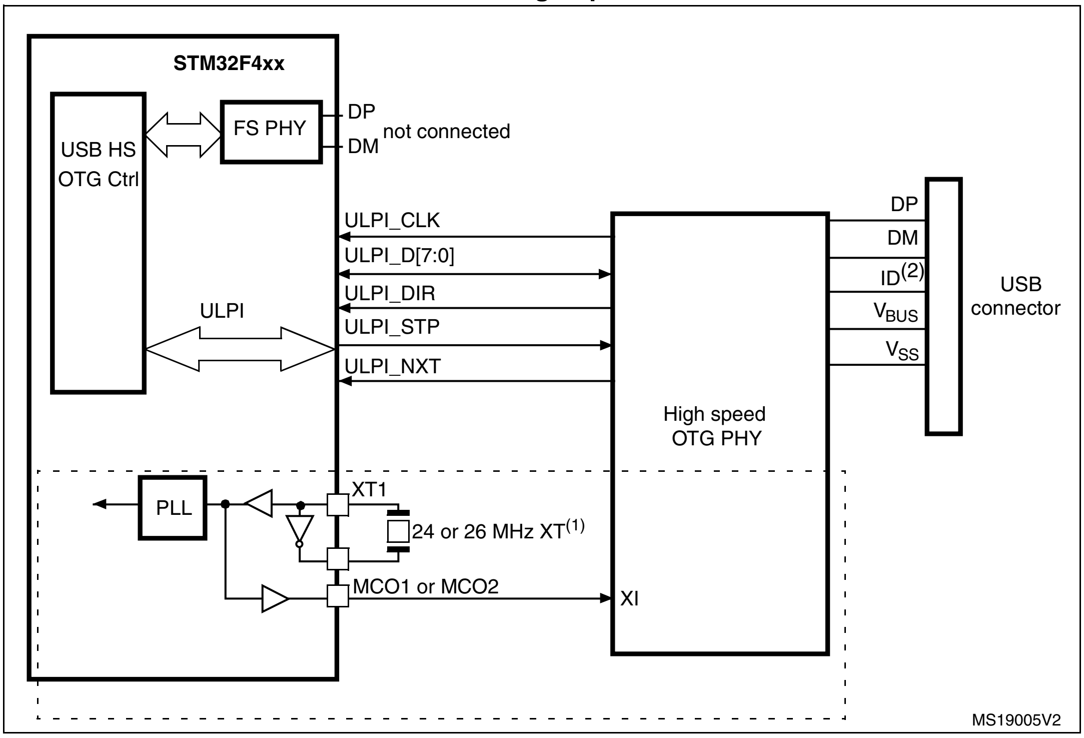
Figure 69. LQFP64 marking example (package top view)



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.

A.2 USB OTG high speed (HS) interface solutions

Figure 88. USB controller configured as peripheral, host, or dual-mode and used in high speed mode



1. It is possible to use MCO1 or MCO2 to save a crystal. It is however not mandatory to clock the STM32F446xx with a 24 or 26 MHz crystal when using USB HS. The above figure only shows an example of a possible connection.
2. The ID pin is required in dual role only.