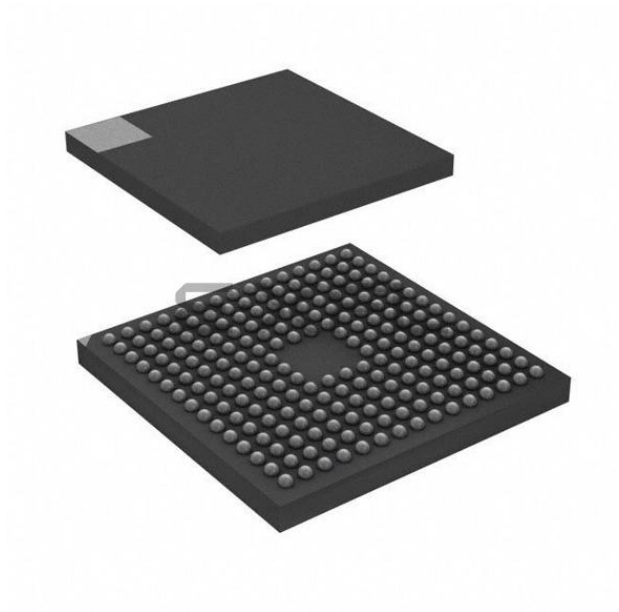

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"Embedded - Microcontrollers" refer to small, integrated circuits designed to perform specific tasks within larger systems. These microcontrollers are essentially compact computers on a single chip, containing a processor core, memory, and programmable 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.

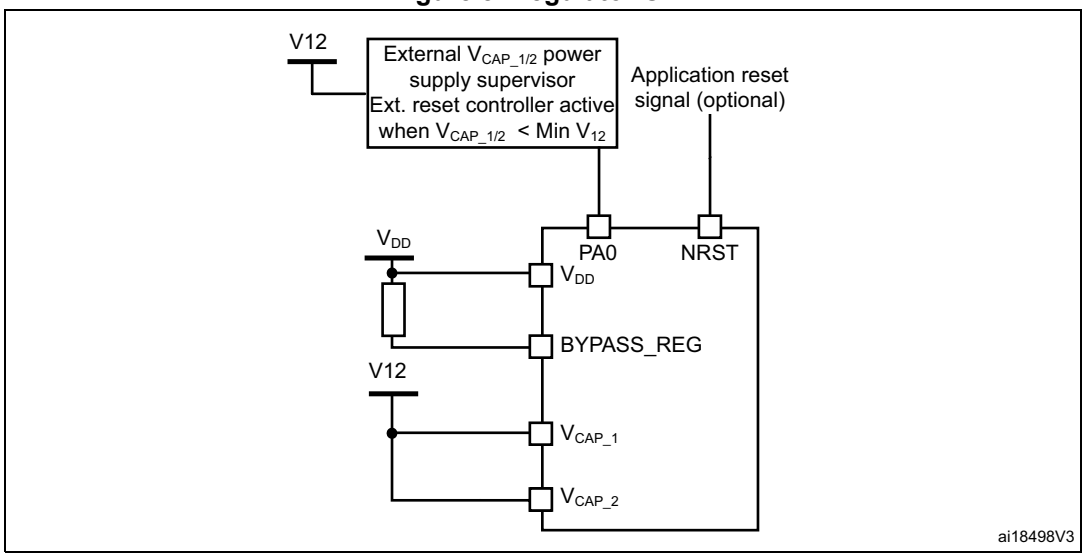
Applications of "Embedded - Microcontrollers"

Details	
Product Status	Active
Core Processor	ARM® Cortex®-M7
Core Size	32-Bit Single-Core
Speed	216MHz
Connectivity	CANbus, Ethernet, HDMI-CEC, I²C, IrDA, LINbus, MMC/SD, SAI, SPDIFRX, SPI, UART/USART, USB OTG
Peripherals	Brown-out Detect/Reset, DMA, LCD, POR, PWM, WDT
Number of I/O	168
Program Memory Size	64KB (64K x 8)
Program Memory Type	FLASH
EEPROM Size	-
RAM Size	320K 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	216-TFBGA
Supplier Device Package	216-TFBGA (13x13)
Purchase URL	https://www.e-xfl.com/product-detail/stmicroelectronics/stm32f750n8h6

In regulator OFF mode, the following features are no more supported:

- PA0 cannot be used as a GPIO pin since it allows to reset a part of the V_{12} logic power domain which is not reset by the NRST pin.
- As long as PA0 is kept low, the debug mode cannot be used under power-on reset. As a consequence, PA0 and NRST pins must be managed separately if the debug connection under reset or pre-reset is required.
- The over-drive and under-drive modes are not available.
- The Standby mode is not available.

Figure 8. Regulator OFF



The following conditions must be respected:

- V_{DD} should always be higher than V_{CAP_1} and V_{CAP_2} to avoid current injection between power domains.
- If the time for V_{CAP_1} and V_{CAP_2} to reach V_{12} minimum value is faster than the time for V_{DD} to reach 1.7 V, then PA0 should be kept low to cover both conditions: until V_{CAP_1} and V_{CAP_2} reach V_{12} minimum value and until V_{DD} reaches 1.7 V (see *Figure 9*).
- Otherwise, if the time for V_{CAP_1} and V_{CAP_2} to reach V_{12} minimum value is slower than the time for V_{DD} to reach 1.7 V, then PA0 could be asserted low externally (see *Figure 10*).
- If V_{CAP_1} and V_{CAP_2} go below V_{12} minimum value and V_{DD} is higher than 1.7 V, then a reset must be asserted on PA0 pin.

Note: The minimum value of V_{12} depends on the maximum frequency targeted in the application.

3.22.3 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.

3.22.4 Low-power timer (LPTIM1)

The low-power timer has an independent clock and is running also in Stop mode if it is clocked by LSE, LSI or an external clock. It is able to wakeup the devices from Stop mode.

This low-power timer supports the following features:

- 16-bit up counter with 16-bit autoreload register
- 16-bit compare register
- Configurable output: pulse, PWM
- Continuous / one-shot mode
- Selectable software / hardware input trigger
- Selectable clock source:
- Internal clock source: LSE, LSI, HSI or APB clock
- External clock source over LPTIM input (working even with no internal clock source running, used by the Pulse Counter Application)
- Programmable digital glitch filter
- Encoder mode

3.22.5 Independent watchdog

The independent watchdog is based on a 12-bit downcounter and 8-bit prescaler. It is clocked from an independent 32 kHz internal RC and as it operates independently from the main clock, it can operate in Stop and Standby modes. It can be used either as a watchdog to reset the device when a problem occurs, or as a free-running timer for application timeout management. It is hardware- or software-configurable through the option bytes.

3.22.6 Window watchdog

The window watchdog is based on a 7-bit downcounter that can be set as free-running. It can be used as a watchdog to reset the device when a problem occurs. It is clocked from the main clock. It has an early warning interrupt capability and the counter can be frozen in debug mode.

3.22.7 SysTick timer

This timer is dedicated to real-time operating systems, but could also be used as a standard downcounter. It features:

- A 24-bit downcounter
- Autoreload capability
- Maskable system interrupt generation when the counter reaches 0
- Programmable clock source.

Table 10. STM32F750x8 pin and ball definition (continued)

Pin Number			Pin name (function after reset)(1)	Pin type	I/O structure	Notes	Alternate functions	Additional functions
LQFP100	LQFP144	TFBGA216						
23	35	N2	PA1	I/O	FT	(4)	TIM2_CH2, TIM5_CH2, USART2_RTS, UART4_RX, QUADSPI_BK1_IO3, SAI2_MCK_B, ETH_MII_RX_CLK/ETH_RMII_REF_CLK, LCD_R2, EVENTOUT	ADC123_IN1
24	36	P2	PA2	I/O	FT	(4)	TIM2_CH3, TIM5_CH3, TIM9_CH1, USART2_TX, SAI2_SCK_B, ETH_MDIO, LCD_R1, EVENTOUT	ADC123_IN2, WKUP2
-	-	K4	PH2	I/O	FT		LPTIM1_IN2, QUADSPI_BK2_IO0, SAI2_SCK_B, ETH_MII_CRS, FMC_SDCKE0, LCD_R0, EVENTOUT	-
-	-	J4	PH3	I/O	FT	-	QUADSPI_BK2_IO1, SAI2_MCK_B, ETH_MII_COL, FMC_SDNE0, LCD_R1, EVENTOUT	-
-	-	H4	PH4	I/O	FT	-	I2C2_SCL, OTG_HS_ULPI_NXT, EVENTOUT	-
-	-	J3	PH5	I/O	FT	-	I2C2_SDA, SPI5_NSS, FMC_SDNWE, EVENTOUT	-
25	37	R2	PA3	I/O	FT	(4)	TIM2_CH4, TIM5_CH4, TIM9_CH2, USART2_RX, OTG_HS_ULPI_D0, ETH_MII_COL, LCD_B5, EVENTOUT	ADC123_IN3
26	38	K6	VSS	S	-	-	-	-
-	-	L5	BYPASS_REG	I	FT	-	-	-
27	39	K5	VDD	S	-	-	-	-
28	40	N4	PA4	I/O	TTa	(4)	SPI1_NSS/I2S1_WS, SPI3_NSS/I2S3_WS, USART2_CK, OTG_HS_SOF, DCMI_HSYNC, LCD_VSYNC, EVENTOUT	ADC12_IN4, DAC_OUT1
29	41	P4	PA5	I/O	TTa	(4)	TIM2_CH1/TIM2_ETR, TIM8_CH1N, SPI1_SCK/I2S1_CK, OTG_HS_ULPI_CK, LCD_R4, EVENTOUT	ADC12_IN5, DAC_OUT2
30	42	P3	PA6	I/O	FT	(4)	TIM1_BKIN, TIM3_CH1, TIM8_BKIN, SPI1_MISO, TIM13_CH1, DCMI_PIXCLK, LCD_G2, EVENTOUT	ADC12_IN6

Table 10. STM32F750x8 pin and ball definition (continued)

Pin Number			Pin name (function after reset)(1)	Pin type	I/O structure	Notes	Alternate functions	Additional functions
LQFP100	LQFP144	TFBGA216						
31	43	R3	PA7	I/O	FT	(4)	TIM1_CH1N, TIM3_CH2, TIM8_CH1N, SPI1_MOSI/I2S1_SD, TIM14_CH1, ETH_MII_RX_DV/ETH_RMII_CRS_DV, FMC_SDNWE, EVENTOUT	ADC12_IN7
32	44	N5	PC4	I/O	FT	(4)	I2S1_MCK, SPDIFRX_IN2, ETH_MII_RXD0/ETH_RMII_RXD0, FMC_SDNE0, EVENTOUT	ADC12_IN14
33	45	P5	PC5	I/O	FT	(4)	SPDIFRX_IN3, ETH_MII_RXD1/ETH_RMII_RXD1, FMC_SDCKE0, EVENTOUT	ADC12_IN15
-	-	L7	VDD	S	-	-	-	-
-	-	L6	VSS	S	-	-	-	-
34	46	R5	PB0	I/O	FT	(4)	TIM1_CH2N, TIM3_CH3, TIM8_CH2N, UART4_CTS, LCD_R3, OTG_HS_ULPI_D1, ETH_MII_RXD2, EVENTOUT	ADC12_IN8
35	47	R4	PB1	I/O	FT	(4)	TIM1_CH3N, TIM3_CH4, TIM8_CH3N, LCD_R6, OTG_HS_ULPI_D2, ETH_MII_RXD3, EVENTOUT	ADC12_IN9
36	48	M5	PB2	I/O	FT	-	SAI1_SD_A, SPI3_MOSI/I2S3_SD, QUADSPI_CLK, EVENTOUT	-
-	-	G4	PI15	I/O	FT	-	LCD_R0, EVENTOUT	-
-	-	R6	PJ0	I/O	FT	-	LCD_R1, EVENTOUT	-
-	-	R7	PJ1	I/O	FT	-	LCD_R2, EVENTOUT	-
-	-	P7	PJ2	I/O	FT	-	LCD_R3, EVENTOUT	-
-	-	N8	PJ3	I/O	FT	-	LCD_R4, EVENTOUT	-
-	-	M9	PJ4	I/O	FT	-	LCD_R5, EVENTOUT	-
-	49	P8	PF11	I/O	FT	-	SPI5_MOSI, SAI2_SD_B, FMC_SDNRAS, DCMI_D12, EVENTOUT	-
-	50	M6	PF12	I/O	FT	-	FMC_A6, EVENTOUT	-
-	51	K7	VSS	S	-	-	-	-
-	52	L8	VDD	S	-	-	-	-
-	53	N6	PF13	I/O	FT	-	I2C4_SMBA, FMC_A7, EVENTOUT	-

Table 10. STM32F750x8 pin and ball definition (continued)

Pin Number			Pin name (function after reset)(1)	Pin type	I/O structure	Notes	Alternate functions	Additional functions
LQFP100	LQFP144	TFBGA216						
52	74	K14	PB13	I/O	FT	-	TIM1_CH1N, SPI2_SCK/I2S2_CK, USART3_CTS, CAN2_TX, OTG_HS_ULPI_D6, ETH_MII_TXD1/ETH_RMII_TXD1, EVENTOUT	OTG_HS_VBUS
53	75	R14	PB14	I/O	FT	-	TIM1_CH2N, TIM8_CH2N, SPI2_MISO, USART3_RTS, TIM12_CH1, OTG_HS_DM, EVENTOUT	-
54	76	R15	PB15	I/O	FT	-	RTC_REFIN, TIM1_CH3N, TIM8_CH3N, SPI2_MOSI/I2S2_SD, TIM12_CH2, OTG_HS_DP, EVENTOUT	-
55	77	L15	PD8	I/O	FT	-	USART3_TX, SPDIFRX_IN11, FMC_D13, EVENTOUT	-
56	78	L14	PD9	I/O	FT	-	USART3_RX, FMC_D14, EVENTOUT	-
57	79	K15	PD10	I/O	FT	-	USART3_CK, FMC_D15, LCD_B3, EVENTOUT	-
58	80	N10	PD11	I/O	FT	-	I2C4_SMBA, USART3_CTS, QUADSPI_BK1_IO0, SAI2_SD_A, FMC_A16/FMC_CLE, EVENTOUT	-
59	81	M10	PD12	I/O	FT	-	TIM4_CH1, LPTIM1_IN1, I2C4_SCL, USART3_RTS, QUADSPI_BK1_IO1, SAI2_FS_A, FMC_A17/FMC_ALE, EVENTOUT	-
60	82	M11	PD13	I/O	FT	-	TIM4_CH2, LPTIM1_OUT, I2C4_SDA, QUADSPI_BK1_IO3, SAI2_SCK_A, FMC_A18, EVENTOUT	-
-	83	J10	VSS	S	-	-	-	-
-	84	J11	VDD	S	-	-	-	-
61	85	L12	PD14	I/O	FT	-	TIM4_CH3, UART8_CTS, FMC_D0, EVENTOUT	-
62	86	K13	PD15	I/O	FT	-	TIM4_CH4, UART8_RTS, FMC_D1, EVENTOUT	-
-	-	K12	PJ6	I/O	FT	-	LCD_R7, EVENTOUT	-
-	-	J12	PJ7	I/O	FT	-	LCD_G0, EVENTOUT	-

Table 11. FMC pin definition

Pin name	NOR/PSRAM/SRAM	NOR/PSRAM Mux	NAND16	SDRAM
PF0	A0	-	-	A0
PF1	A1	-	-	A1
PF2	A2	-	-	A2
PF3	A3	-	-	A3
PF4	A4	-	-	A4
PF5	A5	-	-	A5
PF12	A6	-	-	A6
PF13	A7	-	-	A7
PF14	A8	-	-	A8
PF15	A9	-	-	A9
PG0	A10	-	-	A10
PG1	A11	-	-	A11
PG2	A12	-	-	A12
PG3	A13	-	-	-
PG4	A14	-	-	BA0
PG5	A15	-	-	BA1
PD11	A16	A16	CLE	-
PD12	A17	A17	ALE	-
PD13	A18	A18	-	-
PE3	A19	A19	-	-
PE4	A20	A20	-	-
PE5	A21	A21	-	-
PE6	A22	A22	-	-
PE2	A23	A23	-	-
PG13	A24	A24	-	-
PG14	A25	A25	-	-
PD14	D0	DA0	D0	D0
PD15	D1	DA1	D1	D1
PD0	D2	DA2	D2	D2
PD1	D3	DA3	D3	D3
PE7	D4	DA4	D4	D4
PE8	D5	DA5	D5	D5
PE9	D6	DA6	D6	D6
PE10	D7	DA7	D7	D7

Table 11. FMC pin definition (continued)

Pin name	NOR/PSRAM/SRAM	NOR/PSRAM Mux	NAND16	SDRAM
PE11	D8	DA8	D8	D8
PE12	D9	DA9	D9	D9
PE13	D10	DA10	D10	D10
PE14	D11	DA11	D11	D11
PE15	D12	DA12	D12	D12
PD8	D13	DA13	D13	D13
PD9	D14	DA14	D14	D14
PD10	D15	DA15	D15	D15
PH8	D16	-	-	D16
PH9	D17	-	-	D17
PH10	D18	-	-	D18
PH11	D19	-	-	D19
PH12	D20	-	-	D20
PH13	D21	-	-	D21
PH14	D22	-	-	D22
PH15	D23	-	-	D23
PI0	D24	-	-	D24
PI1	D25	-	-	D25
PI2	D26	-	-	D26
PI3	D27	-	-	D27
PI6	D28	-	-	D28
PI7	D29	-	-	D29
PI9	D30	-	-	D30
PI10	D31	-	-	D31
PD7	NE1	NE1	-	-
PG9	NE2	NE2	NCE	-
PG10	NE3	NE3	-	-
PG11	-	-	-	-
PG12	NE4	NE4	-	-
PD3	CLK	CLK	-	-
PD4	NOE	NOE	NOE	-
PD5	NWE	NWE	NWE	-
PD6	NWAIT	NWAIT	NWAIT	-
PB7	NADV	NADV	-	-

6 Electrical characteristics

6.1 Parameter conditions

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

6.1.1 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).

6.1.2 Typical values

Unless otherwise specified, typical data are based on T_A = 25 °C, V_{DD} = 3.3 V (for the 1.7 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).

6.1.3 Typical curves

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

6.1.4 Loading capacitor

The loading conditions used for pin parameter measurement are shown in *Figure 14*.

6.1.5 Pin input voltage

The input voltage measurement on a pin of the device is described in *Figure 15*.

Figure 14. Pin loading conditions

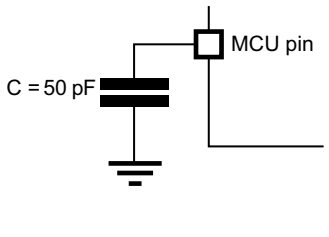
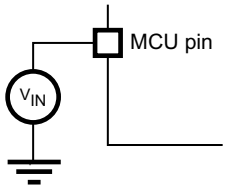


Figure 15. Pin input voltage



1. Guaranteed by design.
2. The reset temporization is measured from the power-on (POR reset or wakeup from V_{BAT}) to the instant when first instruction is read by the user application code.

6.3.6 Over-drive switching characteristics

When the over-drive mode switches from enabled to disabled or disabled to enabled, the system clock is stalled during the internal voltage set-up.

The over-drive switching characteristics are given in *Table 22*. They are sbject to general operating conditions for T_A.

Table 22. Over-drive switching characteristics(1)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Tod_swen	Over_drive switch enable time	HSI	-	45	-	µs
		HSE max for 4 MHz and min for 26 MHz	45	-	100	
		External HSE 50 MHz	-	40	-	
Tod_swdis	Over_drive switch disable time	HSI	-	20	-	
		HSE max for 4 MHz and min for 26 MHz.	20	-	80	
		External HSE 50 MHz	-	15	-	

1. Guaranteed by design.

6.3.7 Supply current characteristics

The current consumption is a function of several parameters and factors such as the operating voltage, ambient temperature, I/O pin loading, device software configuration, operating frequencies, I/O pin switching rate, program location in memory and executed binary code.

The current consumption is measured as described in *Figure 17: Current consumption measurement scheme*.

All the run-mode current consumption measurements given in this section are performed with a reduced code that gives a consumption equivalent to CoreMark code.

2. When analog peripheral blocks such as ADCs, DACs, HSE, LSE, HSI, or LSI are ON, an additional power consumption should be considered.
3. When the ADC is ON (ADON bit set in the ADC_CR2 register), add an additional power consumption of 1.73 mA per ADC for the analog part.
4. Guaranteed by test in production.

Table 24. Typical and maximum current consumption in Run mode, code with data processing running from Flash memory (ART ON except prefetch / L1-cache ON) or SRAM on AXI (L1-cache ON), regulator ON

Symbol	Parameter	Conditions	f_{HCLK} (MHz)	Typ	Max(1)			Unit
					T_A = 25 °C	T_A = 85 °C	T_A = 105 °C	
I_{DD}	Supply current in RUN mode	All peripherals enabled(2)(3)	216	186	213	234	-	mA
			200	172	197	217	235	
			180	152	175	189	202	
			168	135	155	168	180	
			144	104	119	130	140	
			60	46	53	64	74	
			25	22	25	36	47	
		All peripherals disabled(3)	216	108	124	146	-	
			200	100	115	135	154	
			180	89	102	116	129	
			168	79	90	103	115	
			144	61	69	80	90	
			60	27	31	42	52	
			25	12	15	26	36	

1. Guaranteed by characterization results.
2. When analog peripheral blocks such as ADCs, DACs, HSE, LSE, HSI, or LSI are ON, an additional power consumption should be considered.
3. When the ADC is ON (ADON bit set in the ADC_CR2 register), add an additional power consumption of 1.73 mA per ADC for the analog part.

2. When analog peripheral blocks such as ADCs, DACs, HSE, LSE, HSI, or LSI are ON, an additional power consumption should be considered.

Table 30. Typical and maximum current consumptions in Stop mode

Symbol	Parameter	Conditions	Typ	Max(1)			Unit
				V_{DD} = 3.6 V			
			T_A = 25 °C	T_A = 25 °C	T_A = 85 °C	T_A = 105 °C	
$I_{DD\_STOP\_NM}$ (normal mode)	Supply current in Stop mode, main regulator in Run mode	Flash memory in Stop mode, all oscillators OFF, no IWDG	0.45	2.00	14.00	22.00	mA
		Flash memory in Deep power down mode, all oscillators OFF	0.40	2.00	14.00	22.00	
	Supply current in Stop mode, main regulator in Low-power mode	Flash memory in Stop mode, all oscillators OFF, no IWDG	0.32	1.50	10.00	18.00	
		Flash memory in Deep power down mode, all oscillators OFF, no IWDG	0.27	1.50	10.00	18.00	
$I_{DD\_STOP\_UDM}$ (under-drive mode)	Supply current in Stop mode, main regulator in Low voltage and under-drive modes	Regulator in Run mode, Flash memory in Deep power down mode, all oscillators OFF, no IWDG	0.15	0.80	4.00	7.00	
		Regulator in Low-power mode, Flash memory in Deep power down mode, all oscillators OFF, no IWDG	0.10	0.70	4.00	7.00	

1. Data based on characterization, tested in production.

pin circuitry and to charge/discharge the capacitive load (internal or external) connected to the pin:

$$I_{SW} = V_{DD} \times f_{SW} \times C$$

where

I_{SW} is the current sunk by a switching I/O to charge/discharge the capacitive load

V_{DD} is the MCU supply voltage

f_{SW} is the I/O switching frequency

C is the total capacitance seen by the I/O pin: $C = C_{INT} + C_{EXT}$

The test pin is configured in push-pull output mode and is toggled by software at a fixed frequency.

Table 33. Switching output I/O current consumption(1)

Symbol	Parameter	Conditions	I/O toggling frequency (fsw) MHz	Typ V_{DD} = 3.3 V	Typ V_{DD} = 1.8 V	Unit
I_{DDIO}	I/O switching Current	C_{EXT} = 0 pF $C = C_{INT} + C_S + C_{EXT}$	2	0.1	0.1	mA
			8	0.4	0.2	
			25	1.1	0.7	
			50	2.4	1.3	
			60	3.1	1.6	
			84	4.3	2.4	
			90	4.9	2.6	
			100	5.4	2.8	
			108	5.6	-	
		C_{EXT} = 10 pF $C = C_{INT} + C_S + C_{EXT}$	2	0.2	0.1	
			8	0.6	0.3	
			25	1.8	1.1	
			50	3.1	2.3	
			60	4.6	3.4	
			84	9.7	3.6	
			90	10.12	5.2	
			100	14.92	5.4	
			108	18.11	-	

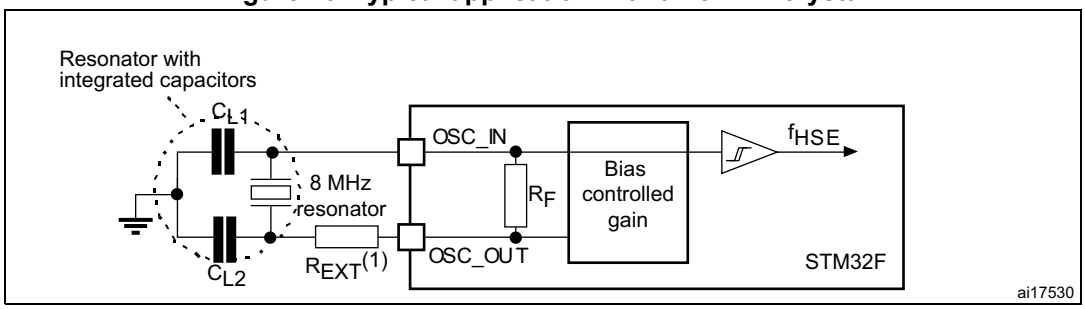
Table 34. Peripheral current consumption

Peripheral		I_{DD}(Typ)(1)			Unit
		Scale 1	Scale 2	Scale 3	
AHB1 (up to 216 MHz)	GPIOA	2.2	2.1	1.9	µA/MHz
	GPIOB	2.1	1.8	1.7	
	GPIOC	2.3	2.0	1.9	
	GPIOD	2.2	1.9	1.8	
	GPIOE	2.2	1.9	1.8	
	GPIOF	2.2	1.9	1.8	
	GPIOG	2.1	1.8	1.7	
	GPIOH	2.0	1.7	1.7	
	GPIOI	2.3	2.0	1.7	
	GPIOJ	2.2	1.9	1.7	
	GPIOK	2.0	1.7	1.7	
	CRC	1.0	0.9	0.8	
	BKPSRAM	0.8	0.7	0.6	
	DMA1	2.7 x N + 5.1	2.6 x N + 4.7	2.2 x N + 4	
	DMA2	2.2 x N + 4.9	2.6 x N + 4.4	2.2 x N + 4.1	
	DMA2D	87.1	82.5	69.6	
	ETH_MAC ETH_MAC_TX ETH_MAC_RX ETH_MAC_PTP	42.1	39.7	34.1	
	OTG_HS	57.5	54.4	47.6	
	OTG_HS+ULPI				
AHB2 (up to 216 MHz)	DCMI	5.1	4.7	4.0	µA/MHz
	CRYP	3.0	2.6	2.4	
	HASH	4.2	3.7	3.3	
	RNG	2.8	2.4	2.3	
	USB_OTG_FS	31.8	29.9	25.8	
AHB3 (up to 216 MHz)	FMC	18.9	17.7	15.2	µA/MHz
	QSPI	23.2	21.8	18.5	
Bus matrix(2)		21.06	20.3	17.2	µA/MHz

For C_{L1} and C_{L2}, it is recommended to use high-quality external ceramic capacitors in the 5 pF to 25 pF range (typ.), designed for high-frequency applications, and selected to match the requirements of the crystal or resonator (see *Figure 26*). 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.

Figure 26. Typical application with an 8 MHz crystal



1. R_{EXT} value depends on the crystal characteristics.

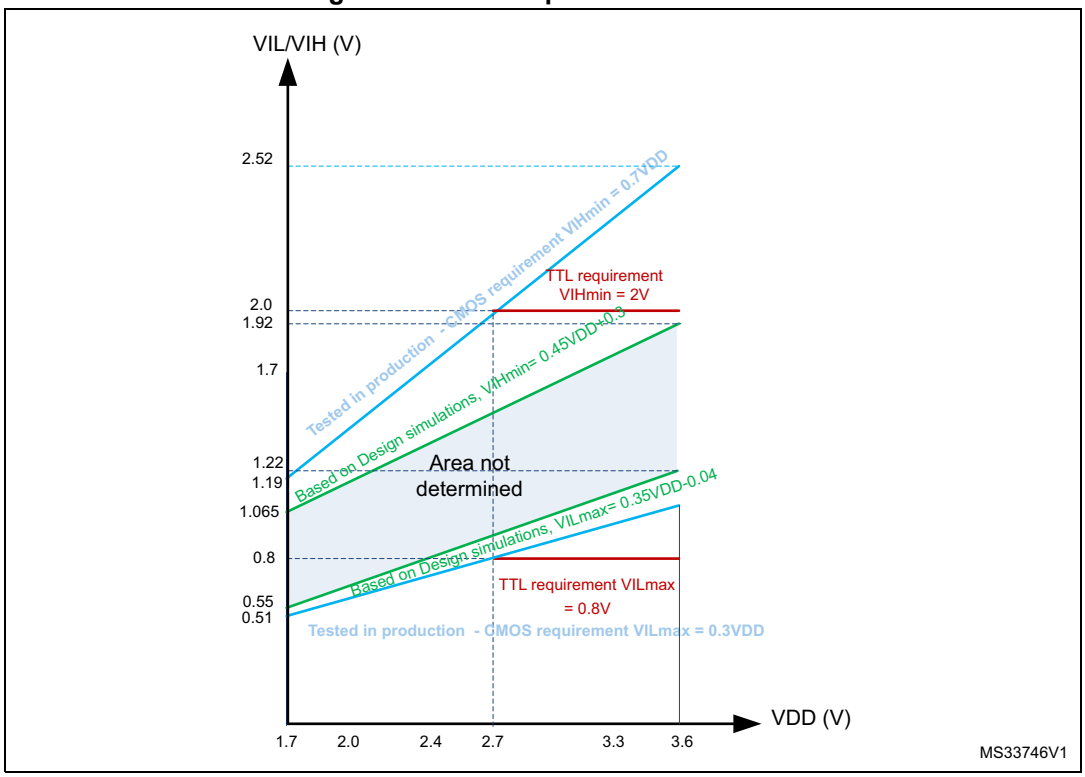
Low-speed external clock generated from a crystal/ceramic resonator

The low-speed external (LSE) clock can be supplied with a 32.768 kHz crystal/ceramic resonator oscillator. All the information given in this paragraph are based on characterization results obtained with typical external components specified in *Table 39*. 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 39. LSE oscillator characteristics (f_{LSE} = 32.768 kHz) (1)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
I_{DD}	LSE current consumption	LSEDRV[1:0]=00 Low drive capability	-	250	-	nA
		LSEDRV[1:0]=10 Medium low drive capability	-	300	-	
		LSEDRV[1:0]=01 Medium high drive capability	-	370	-	
		LSEDRV[1:0]=11 High drive capability	-	480	-	

Figure 32. FT I/O input characteristics



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 relaxed V_{OL}/V_{OH}) except PC13, PC14, PC15 and PI8 which can sink or source up to ±3mA. When using the PC13 to PC15 and PI8 GPIOs 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 6.2*. In particular:

- 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 14*).
- 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 14*).

Output voltage levels

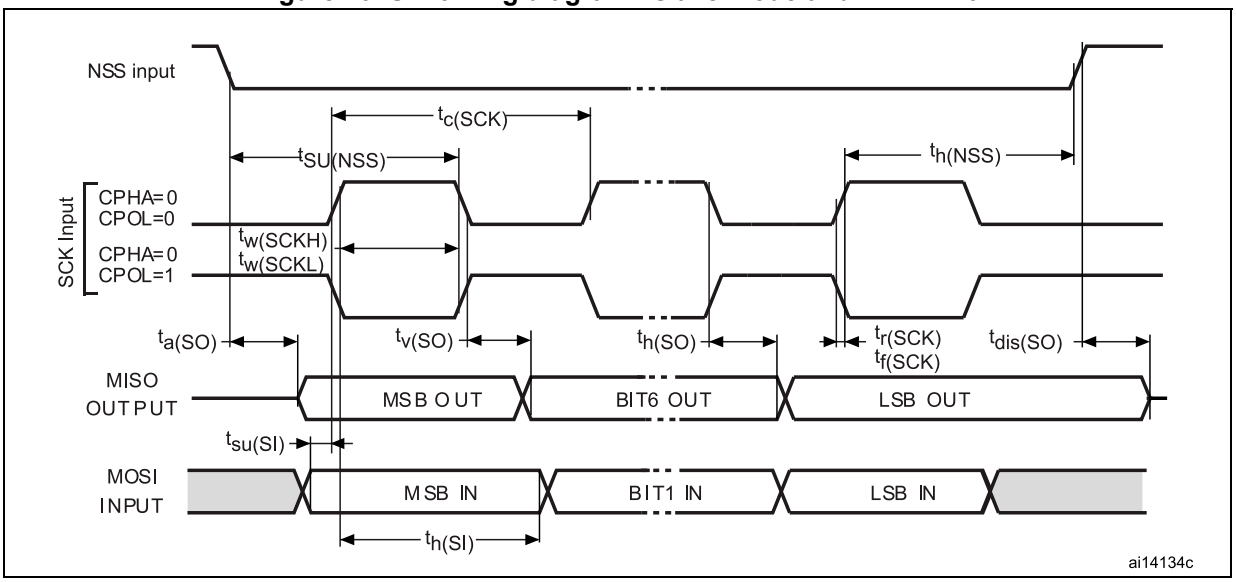
Unless otherwise specified, the parameters given in *Table 56* are derived from tests performed under ambient temperature and V_{DD} supply voltage conditions summarized in *Table 16*. All I/Os are CMOS and TTL compliant.

Table 75. SPI dynamic characteristics(1) (continued)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
tsu(MI)	Data input setup time	Master mode	5.5	-	-	ns
tsu(SI)		Slave mode	4	-	-	
th(MI)	Data input hold time	Master mode	4	-	-	
th(SI)		Slave mode	2	-	-	
ta(SO)	Data output access time	Slave mode	7	-	21	
tdis(SO)	Data output disable time	Slave mode	5	-	12	
tv(SO)	Data output valid time	Slave mode 2.7≤VDD≤3.6V	-	6.5	10	
		Slave mode 1.71≤VDD≤3.6V	-	6.5	13	
tv(MO)		Master mode	-	2	4	
th(SO)	Data output hold time	Slave mode 1.71≤VDD≤3.6V	5.5	-	-	
th(MO)		Master mode	0	-	-	

1. Guaranteed by characterization results.
2. Excepting SPI1 with SCK IO pin mapped on PA5. In this configuration, Maximum achievable frequency is 40MHz.
3. Maximum Frequency of Slave Transmitter is determined by sum of Tv(SO) and Tsu(MI) intervals which has to fit into SCK level phase preceding the SCK sampling edge.This value can be achieved when it communicates with a Master having Tsu(MI)=0 while signal Duty(SCK)=50%.

Figure 40. SPI timing diagram - slave mode and CPHA = 0

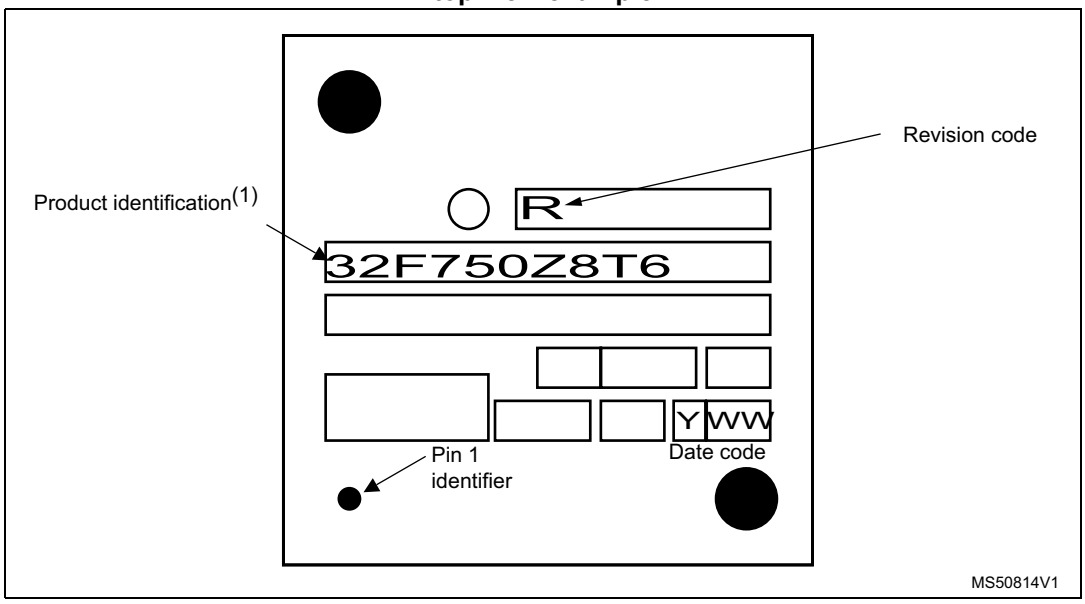


LQFP144 device marking

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 78. LQFP144, 20 x 20mm, 144-pin low-profile quad flat package top view example



1. Parts marked as ES or E or accompanied by an engineering sample notification letter are not yet qualified and therefore not approved for use in production. ST is not responsible for any consequences resulting from such use. In no event will ST be liable for the customer using any of these engineering samples in production. ST's Quality department must be contacted prior to any decision to use these engineering samples to run a qualification activity.

Table 113. TFBGA216, 13 × 13 × 0.8 mm thin fine-pitch ball grid array package mechanical data (continued)

Symbol	millimeters			inches[1]		
	Min	Typ	Max	Min	Typ	Max
G	-	0.900	-	-	0.0354	-
ddd	-	-	0.100	-	-	0.0039
eee	-	-	0.150	-	-	0.0059
fff	-	-	0.080	-	-	0.0031

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

Figure 80. TFBGA216, 13 x 13 x 0.8 mm thin fine-pitch ball grid array package recommended footprint

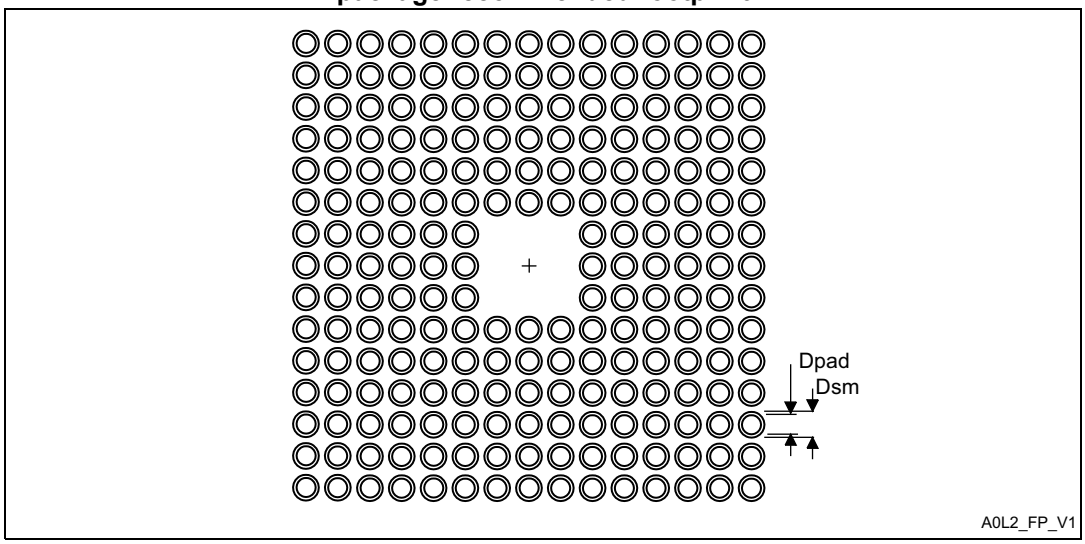


Table 114. TFBGA216 recommended PCB design rules (0.8 mm pitch BGA)

Dimension	Recommended values
Pitch	0.8
Dpad	0.400 mm
Dsm	0.470 mm typ. (depends on the soldermask registration tolerance)
Stencil opening	0.400 mm
Stencil thickness	Between 0.100 mm and 0.125 mm
Pad trace width	0.120 mm

Appendix A Recommendations when using internal reset OFF

When the internal reset is OFF, the following integrated features are no longer supported:

- The integrated power-on reset (POR) / power-down reset (PDR) circuitry is disabled.
- The brownout reset (BOR) circuitry must be disabled.
- The embedded programmable voltage detector (PVD) is disabled.
- V_{BAT} functionality is no more available and VBAT pin should be connected to V_{DD}.
- The over-drive mode is not supported.

A.1 Operating conditions

Table 117. Limitations depending on the operating power supply range

Operating power supply range	ADC operation	Maximum Flash memory access frequency with no wait states ($f_{Flashmax}$)	Maximum Flash memory access frequency with wait states (1)(2)	I/O operation	Possible Flash memory operations
V_{DD} =1.7 to 2.1 V(3)	Conversion time up to 1.2 Msps	20 MHz	180 MHz with 8 wait states and over-drive OFF	– No I/O compensation	8-bit erase and program operations only

1. Applicable only when the code is executed from Flash memory. When the code is executed from RAM, no wait state is required.
2. Thanks to the ART accelerator on ITCM interface and L1-cache on AXI interface, the number of wait states given here does not impact the execution speed from the Flash memory since the ART accelerator or L1-cache allows to achieve a performance equivalent to 0-wait state program execution.
3. V_{DD}/V_{DDA} minimum value of 1.7 V, with the use of an external power supply supervisor (refer to *Section 3.17.1: Internal reset ON*).