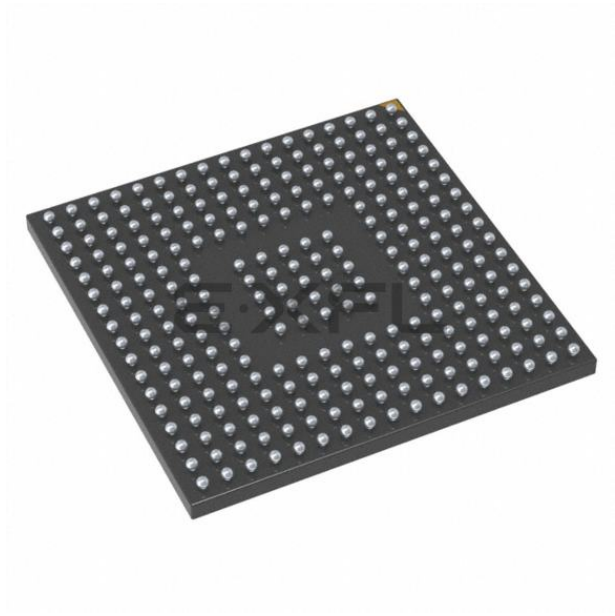

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"Embedded - Microcontrollers" refer to small, integrated circuits designed to perform specific tasks within larger systems. These microcontrollers are essentially compact computers on a single chip, containing a processor core, memory, and programmable 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, EBI/EMI, I²C, IrDA, LINbus, MMC/SD, QSPI, SAI, SPI, UART/USART, USB
Peripherals	Brown-out Detect/Reset, DMA, I²S, POR, PWM, WDT
Number of I/O	138
Program Memory Size	512KB (512K x 8)
Program Memory Type	FLASH
EEPROM Size	-
RAM Size	256K 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	201-UFBGA
Supplier Device Package	176+25UFBGA (10x10)
Purchase URL	https://www.e-xfl.com/product-detail/stmicroelectronics/stm32f733iek6

2.1 Full compatibility throughout the family

The STM32F732xx devices are fully pin-to-pin, compatible with the STM32F7x5xx, STM32F7x6xx, STM32F7x7xx devices.

The STM32F732xx devices are fully pin-to-pin, compatible with the STM32F4xxxx devices, allowing the user to try different peripherals, and reaching higher performances (higher frequency) for a greater degree of freedom during the development cycle.

Figure 1 and *Figure 2* give compatible board designs between the STM32F732xx and STM32F4xx families.

Figure 1. Compatible board design for LQFP100 package

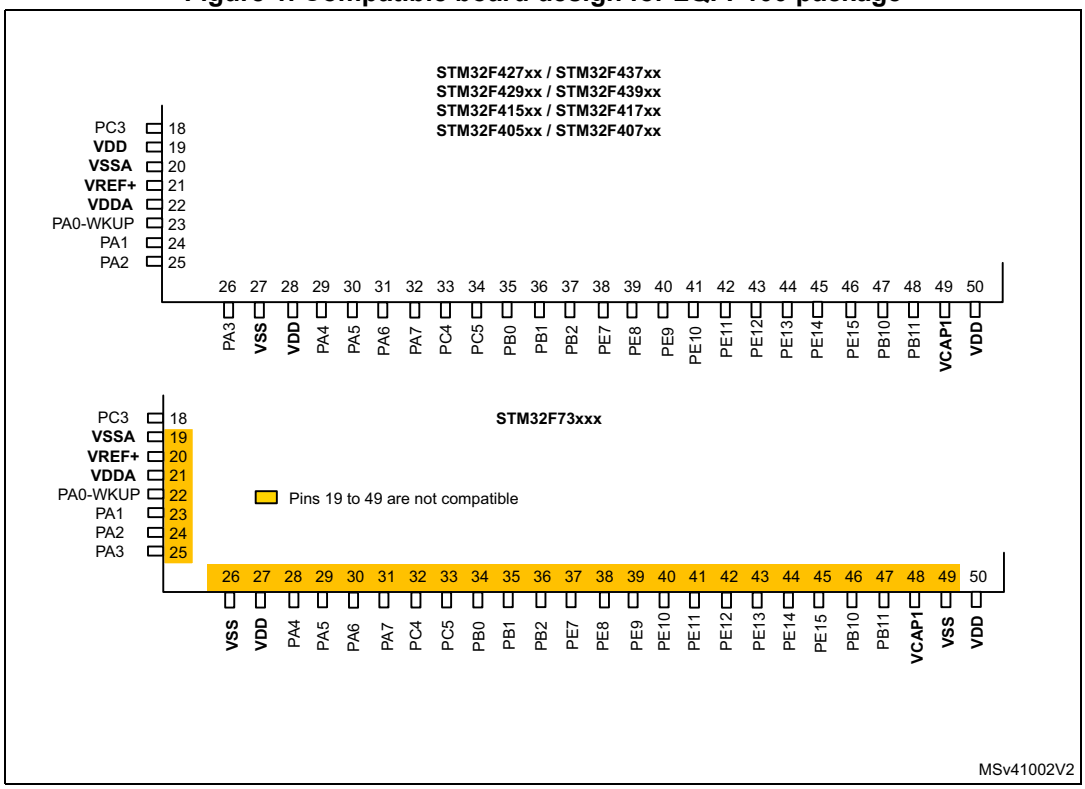


Table 3. Voltage regulator configuration mode versus device operating mode(1)

Voltage regulator configuration	Run mode	Sleep mode	Stop mode	Standby mode
Normal mode	MR	MR	MR or LPR	-
Over-drive mode(2)	MR	MR	-	-
Under-drive mode	-	-	MR or LPR	-
Power-down mode	-	-	-	Yes

1. '-' means that the corresponding configuration is not available.
2. The over-drive mode is not available when V_{DD} = 1.7 to 2.1 V.

3.16.2 Regulator OFF

This feature is available only on packages featuring the BYPASS_REG pin. The regulator is disabled by holding BYPASS_REG high. The regulator OFF mode allows to supply externally a V_{12} voltage source through V_{CAP_1} and V_{CAP_2} pins.

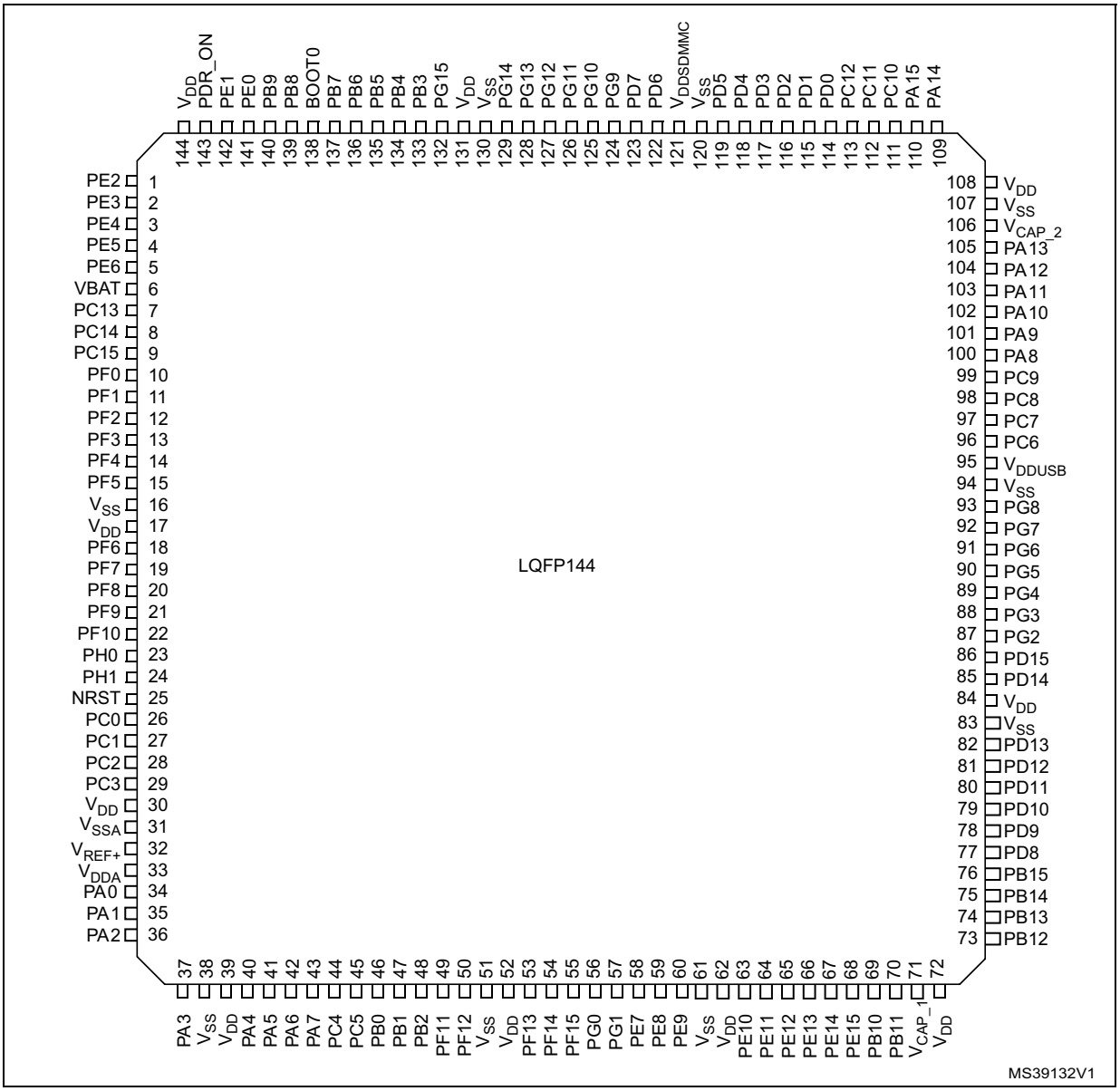
Since the internal voltage scaling is not managed internally, the external voltage value must be aligned with the targeted maximum frequency.The two 2.2 µF ceramic capacitors should be replaced by two 100 nF decoupling capacitors.

When the regulator is OFF, there is no more internal monitoring on V_{12}. An external power supply supervisor should be used to monitor the V_{12} of the logic power domain. The PA0 pin should be used for this purpose, and act as power-on reset on V_{12} power domain.

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

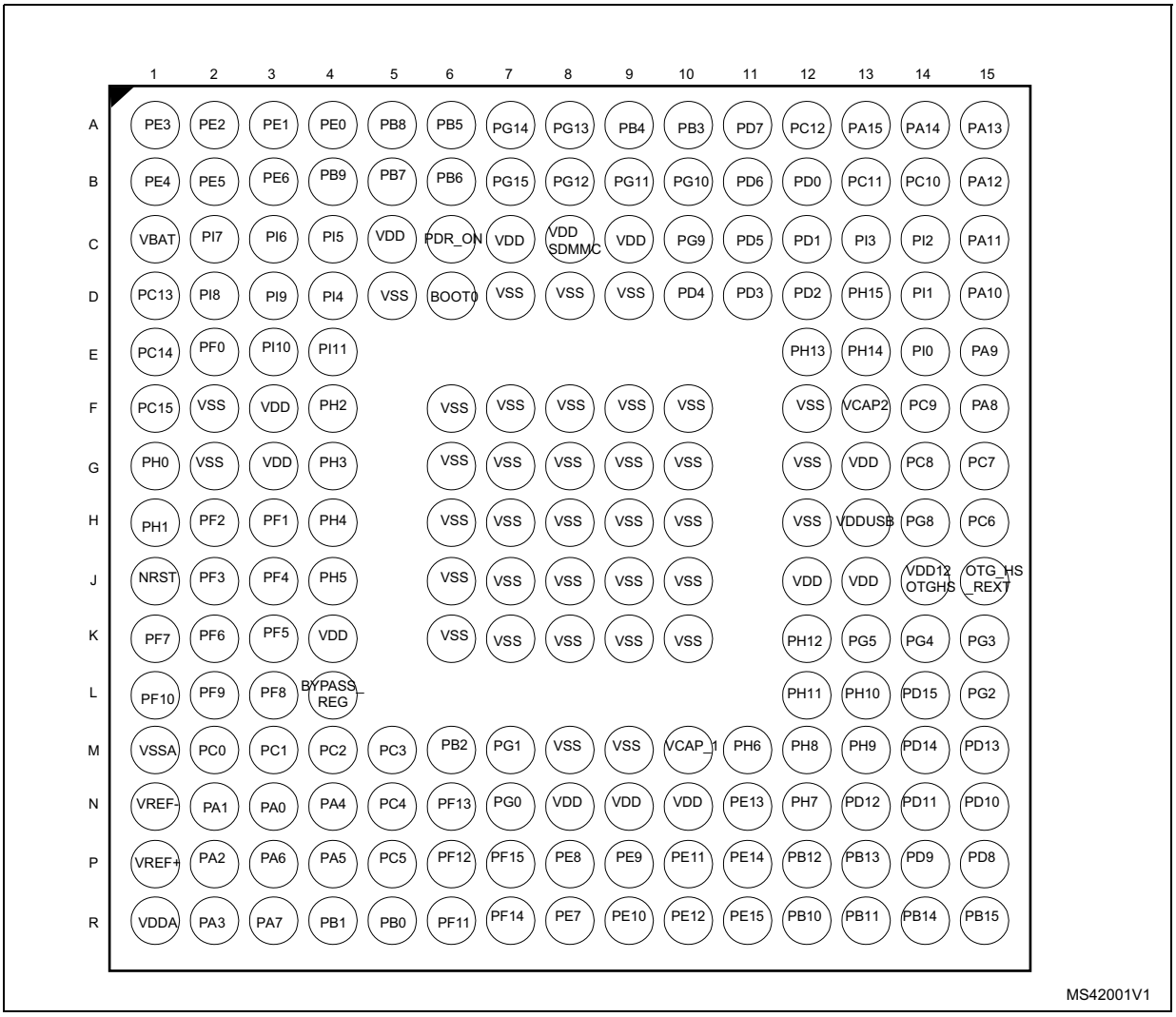
- PA0 cannot be used as a GPIO pin since it allows to reset a part of the V_{12} logic power domain which is not reset by the NRST pin.
- As long as PA0 is kept low, the debug mode cannot be used under power-on reset. As a consequence, PA0 and NRST pins must be managed separately if the debug connection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

Figure 17. STM32F732xx LQFP144 pinout



1. The above figure shows the package top view.

Figure 23. STM32F733xx UFBGA176 ballout (with OTG PHY HS)



1. The above figure shows the package top view.

Table 10. STM32F732xx and STM32F733xx pin and ball definition (continued)

Pin Number										Pin name (function after reset)[1]	Pin type	I/O structure	Notes	Alternate functions	Additional functions
STM32F732xx					STM32F733xx										
LQFP64	LQFP100	LQFP144	UFBGA176	LQFP176	WLCSP100	UFBGA176	UFBGA144	LQFP144	LQFP176						
15	23	35	N2	41	J8	N2	K2	35	41	PA1	I/O	FT	-	TIM2_CH2, TIM5_CH2, USART2_RTS, UART4_RX, QUADSPI_BK1_IO3, SAI2_MCK_B, EVENTOUT	ADC1_IN1, ADC2_IN1, ADC3_IN1
16	24	36	P2	42	H8	P2	L2	36	42	PA2	I/O	FT	-	TIM2_CH3, TIM5_CH3, TIM9_CH1, USART2_TX, SAI2_SCK_B, EVENTOUT	ADC1_IN2, ADC2_IN2, ADC3_IN2, WKUP2
-	-	-	F4	43	-	F4	-	-	43	PH2	I/O	FT	-	LPTIM1_IN2, QUADSPI_BK2_IO0, SAI2_SCK_B, FMC_SDCKE0, EVENTOUT	-
-	-	-	G4	44	-	G4	-	-	44	PH3	I/O	FT	-	QUADSPI_BK2_IO1, SAI2_MCK_B, FMC_SDNE0, EVENTOUT	-
-	-	-	H4	45	-	H4	-	-	45	PH4	I/O	FTf	(4)	I2C2_SCL, OTG_HS_ULPI_NXT, EVENTOUT	-
-	-	-	J4	46	-	J4	-	-	46	PH5	I/O	FTf	-	I2C2_SDA, SPI5_NSS, FMC_SDNWE, EVENTOUT	-
17	25	37	R2	47	H7	R2	M2	37	47	PA3	I/O	FT	(4)	TIM2_CH4, TIM5_CH4, TIM9_CH2, USART2_RX, OTG_HS_ULPI_D0, EVENTOUT	ADC1_IN3, ADC2_IN3, ADC3_IN3
18	26	38	-	-	K8	-	G4	38	-	VSS	S	-	-	-	-
-	-	-	L4	48	-	L4	H5	-	48	BYPASS_REG	I	FT	-	-	-

Table 10. STM32F732xx and STM32F733xx pin and ball definition (continued)

Pin Number										Pin name (function after reset)[1]	Pin type	I/O structure	Notes	Alternate functions	Additional functions
STM32F732xx					STM32F733xx										
LQFP64	LQFP100	LQFP144	UFBGA176	LQFP176	WLCSP100	UFBGA176	UFBGA144	LQFP144	LQFP176						
19	27	39	K4	49	-	K4	F4	39	49	VDD	S	-	-	-	-
20	28	40	N4	50	G7	N4	J3	40	50	PA4	I/O	TTa	-	SPI1_NSS/I2S1_WS, SPI3_NSS/I2S3_WS, USART2_CK, OTG_HS_SOF, EVENTOUT	ADC1_IN4, ADC2_IN4, DAC_OUT1
21	29	41	P4	51	F6	P4	K3	41	51	PA5	I/O	TTa	(4)	TIM2_CH1/TIM2_ETR, TIM8_CH1N, SPI1_SCK/I2S1_CK, OTG_HS_ULPI_CK, EVENTOUT	ADC1_IN5, ADC2_IN5, DAC_OUT2
22	30	42	P3	52	G6	P3	L3	42	52	PA6	I/O	FT	-	TIM1_BKIN, TIM3_CH1, TIM8_BKIN, SPI1_MISO, TIM13_CH1, EVENTOUT	ADC1_IN6, ADC2_IN6
23	31	43	R3	53	K7	R3	M3	43	53	PA7	I/O	FT	-	TIM1_CH1N, TIM3_CH2, TIM8_CH1N, SPI1_MOSI/I2S1_SD, TIM14_CH1, FMC_SDNWE, EVENTOUT	ADC1_IN7, ADC2_IN7
24	32	44	N5	54	H6	N5	J4	44	54	PC4	I/O	FT	-	I2S1_MCK, FMC_SDNE0, EVENTOUT	ADC1_IN14, ADC2_IN14
-	33	45	P5	55	J6	P5	K4	45	55	PC5	I/O	FT	-	FMC_SDCKE0, EVENTOUT	ADC1_IN15, ADC2_IN15

Table 10. STM32F732xx and STM32F733xx pin and ball definition (continued)

Pin Number										Pin name (function after reset)[1]	Pin type	I/O structure	Notes	Alternate functions	Additional functions
STM32F732xx					STM32F733xx										
LQFP64	LQFP100	LQFP144	UFBGA176	LQFP176	WLCSP100	UFBGA176	UFBGA144	LQFP144	LQFP176						
-	-	-	C9	136	-	C9	-	-	136	VDD	S	-	-	-	-
49	76	109	A14	137	C4	A14	A11	109	137	PA14(JTCK-SWCLK)	I/O	FT	-	JTCK-SWCLK, EVENTOUT	-
50	77	110	A13	138	B4	A13	A10	110	138	PA15(JTDI)	I/O	FT	-	JTDI, TIM2_CH1/TIM2_ETR, SPI1_NSS/I2S1_WS, SPI3_NSS/I2S3_WS, UART4_RTS, EVENTOUT	-
51	78	111	B14	139	A3	B14	B11	111	139	PC10	I/O	FT	-	SPI3_SCK/I2S3_CK, USART3_TX, UART4_TX, QUADSPI_BK1_IO1, SDMMC1_D2, EVENTOUT	-
52	79	112	B13	140	C5	B13	B10	112	140	PC11	I/O	FT	-	SPI3_MISO, USART3_RX, UART4_RX, QUADSPI_BK2_NCS, SDMMC1_D3, EVENTOUT	-
53	80	113	A12	141	D5	A12	C10	113	141	PC12	I/O	FT	-	TRACED3, SPI3_MOSI/I2S3_SD, USART3_CK, UART5_TX, SDMMC1_CK, EVENTOUT	-
-	81	114	B12	142	B5	B12	E10	114	142	PD0	I/O	FT	-	CAN1_RX, FMC_D2, EVENTOUT	-
-	82	115	C12	143	A4	C12	D10	115	143	PD1	I/O	FT	-	CAN1_TX, FMC_D3, EVENTOUT	-

Table 10. STM32F732xx and STM32F733xx pin and ball definition (continued)

Pin Number										Pin name (function after reset)[1]	Pin type	I/O structure	Notes	Alternate functions	Additional functions
STM32F732xx					STM32F733xx										
LQFP64	LQFP100	LQFP144	UFBGA176	LQFP176	WLCSP100	UFBGA176	UFBGA144	LQFP144	LQFP176						
-	-	143	C6	171	-	C6	E5	143	171	PDR_ON	S	-	-	-	-
64	100	144	C5	172	A9	C5	F5	144	172	VDD	S	-	-	-	-
-	-	-	D4	173	-	D4	-	-	173	PI4	I/O	FT	-	TIM8_BKIN, SAI2_MCK_A, FMC_NBL2, EVENTOUT	-
-	-	-	C4	174	-	C4	-	-	174	PI5	I/O	FT	-	TIM8_CH1, SAI2_SCK_A, FMC_NBL3, EVENTOUT	-
-	-	-	C3	175	-	C3	-	-	175	PI6	I/O	FT	-	TIM8_CH2, SAI2_SD_A, FMC_D28, EVENTOUT	-
-	-	-	C2	176	-	C2	-	-	176	PI7	I/O	FT	-	TIM8_CH3, SAI2_FS_A, FMC_D29, EVENTOUT	-
-	-	-	F6	-	-	F6	-	-	-	VSS	S	-	-	-	-
-	-	-	F7	-	-	F7	-	-	-	VSS	S	-	-	-	-
-	-	-	F8	-	-	F8	-	-	-	VSS	S	-	-	-	-
-	-	-	F9	-	-	F9	-	-	-	VSS	S	-	-	-	-
-	-	-	F10	-	-	F10	-	-	-	VSS	S	-	-	-	-

Table 11. FMC pin definition (continued)

Pin name	NOR/PSRAM/SRAM	NOR/PSRAM Mux	NAND16	SDRAM
PE10	D7	DA7	D7	D7
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	-

Table 12. STM32F732xx and STM32F733xx alternate function mapping (continued)

Port		AF0	AF1	AF2	AF3	AF4	AF5	AF6	AF7	AF8	AF9	AF10	AF11	AF12	AF15
		SYS	TIM1/2	TIM3/4/5	TIM8/9/10/11/LPTIM1	I2C1/2/3/USART1	SPI1/I2S1/SPI2/I2S2/SPI3/I2S3/SPI4/5	SPI2/I2S2/SPI3/I2S3/SPI3/I2S3/SAI1/UART4	SPI2/I2S2/SPI3/I2S3/USART1/2/3/UART5	SAI2/USART6/UART4/5/7/8/OTG1_FS	CAN1/TIM12/13/14/QUADSPI/FMC/OTG2_HS	SAI2/QUADSPI/SDMMC2/OTG2_HS/OTG1_FS	SDMMC2	UART7/FMC/SDMMC1/OTG2_FS	SYS
Port I	PI7	-	-	-	TIM8_CH3	-	-	-	-	-	-	SAI2_FS_A	-	FMC_D29	EVENTOUT
	PI8	-	-	-	-	-	-	-	-	-	-	-	-	-	EVENTOUT
	PI9	-	-	-	-	-	-	-	-	UART4_RX	CAN1_RX	-	-	FMC_D30	EVENTOUT
	PI10	-	-	-	-	-	-	-	-	-	-	-	-	FMC_D31	EVENTOUT
	PI11	-	-	-	-	-	-	-	-	-	-	OTG_HS_ULPI_DIR	-	-	EVENTOUT
	PI12	-	-	-	-	-	-	-	-	-	-	-	-	-	EVENTOUT
	PI13	-	-	-	-	-	-	-	-	-	-	-	-	-	EVENTOUT
	PI14	-	-	-	-	-	-	-	-	-	-	-	-	-	EVENTOUT
	PI15	-	-	-	-	-	-	-	-	-	-	-	-	-	EVENTOUT

Table 18. VCAP1/VCAP2 operating conditions(1)

Symbol	Parameter	Conditions
CEXT	Capacitance of external capacitor	2.2 µF
ESR	ESR of external capacitor	< 2 Ω

1. When bypassing the voltage regulator, the two 2.2 µF V_{CAP} capacitors are not required and should be replaced by two 100 nF decoupling capacitors.

Table 19. VCAP1 operating conditions in the LQFP64 package(1)

Symbol	Parameter	Conditions
CEXT	Capacitance of external capacitor	4.7 µF
ESR	ESR of external capacitor	between 0.1 Ω and 0.2 Ω

1. When bypassing the voltage regulator, the 4.7 µF V_{CAP} capacitor is not required and should be replaced by two 100 nF decoupling capacitors.

6.3.3 Operating conditions at power-up / power-down (regulator ON)

Subject to general operating conditions for T_A.

Table 20. Operating conditions at power-up / power-down (regulator ON)

Symbol	Parameter	Min	Max	Unit
t_{VDD}	V_{DD} rise time rate	20	∞	µs/V
	V_{DD} fall time rate	20	∞	

6.3.4 Operating conditions at power-up / power-down (regulator OFF)

Subject to general operating conditions for T_A.

Table 21. Operating conditions at power-up / power-down (regulator OFF)(1)

Symbol	Parameter	Conditions	Min	Max	Unit
t_{VDD}	V_{DD} rise time rate	Power-up	20	∞	µs/V
	V_{DD} fall time rate	Power-down	20	∞	
t_{VCAP}	V_{CAP_1} and V_{CAP_2} rise time rate	Power-up	20	∞	
	V_{CAP_1} and V_{CAP_2} fall time rate	Power-down	20	∞	

1. To reset the internal logic at power-down, a reset must be applied on pin PA0 when V_{DD} reach below 1.08 V.

6.3.5 Reset and power control block characteristics

The parameters given in *Table 22* are derived from tests performed under ambient temperature and V_{DD} supply voltage conditions summarized in *Table 16*.

Table 35. Peripheral current consumption (continued)

Peripheral		I_{DD}(Typ)(1)			Unit
		Scale 1	Scale 2	Scale 3	
APB1 (up to 54 MHz)	TIM2	19.3	18.2	15.6	µA/MHz
	TIM3	15	14	12.2	
	TIM4	15.7	15.1	12.8	
	TIM5	18	16.9	14.4	
	TIM6	3.7	3.1	2.8	
	TIM7	3.5	2.9	2.5	
	TIM12	8.1	7.8	6.4	
	TIM13	6.1	5.1	4.7	
	TIM14	6.3	5.6	4.7	
	LPTIM1	9.4	9.8	8.3	
	WWDG	2.4	1.3	1.4	
	SPI2/I2S2(3)	6.7	6	5.3	
	SPI3/I2S3(3)	4.8	3.8	3.3	
	USART2	13.3	12	10.6	
	USART3	12.8	12	10.3	
	UART4	11.7	10.7	9.2	
	UART5	11.7	10.2	8.9	
	I2C1	10.6	9.6	8.3	
	I2C2	10.6	9.6	8.3	
	I2C3	10.7	9.8	8.3	
	CAN1	8.9	8	6.9	
	PWR	11.3	11.3	8.9	
	DAC(4)	6.1	5.1	4.4	
	UART7	13.3	12	10.3	
	UART8	12.6	11.6	9.7	

USB OTG HS and USB OTG HS PHY current consumption (on STM32F733xx devices)

The MCU is placed under the following conditions:

- STM32 MCU is enumerated as a HID device.
- f_{HCLK} = 216 MHz (Scale 1 + over-drive ON), f_{HCLK} = 168 MHz (Scale 2), f_{HCLK} = 144 MHz (Scale 3)
  The given value is calculated by measuring the difference of current consumption in case:
  - USB is configured but no transfer is done.
  - USB is configured and there is a transmission on going.
- Ambient operating temperature is 25 °C, V_{DD} = V_{DDUSB} = 3.3 V.

Table 36. USB OTG HS and USB OTG PHY HS current consumption

-	I_{DD} (Typ)			Unit
	Scale 1	Scale 2	Scale 3	
USB OTG HS and USB OTG HS PHY current consumption	50.16	44.92	38.98	mA

6.3.8 Wakeup time from low-power modes

The wakeup times given in *Table 37* are measured starting from the wakeup event trigger up to the first instruction executed by the CPU:

- For Stop or Sleep modes: the wakeup event is WFE.
- WKUP (PA0) pin is used to wakeup from Standby, Stop and Sleep modes.

All timings are derived from tests performed under ambient temperature and V_{DD}=3.3 V.

Table 37. Low-power mode wakeup timings

Symbol	Parameter	Conditions	Typ(1)	Max(1)	Unit
$t_{WUSLEEP}$(2)	Wakeup from Sleep	-	13	13	CPU clock cycles
t_{WUSTOP}(2)	Wakeup from Stop mode with MR/LP regulator in normal mode	Main regulator is ON	14	14.9	µs
		Main regulator is ON and Flash memory in Deep power down mode	104.1	107.6	
		Low power regulator is ON	21.4	24.2	
		Low power regulator is ON and Flash memory in Deep power down mode	111.5	116.5	

Static latchup

Two complementary static tests are required on six parts to assess the latchup 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 latchup standard.

Table 59. Electrical sensitivities

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

6.3.19 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_{DD} (for standard, 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 susceptibilty 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 (>5 LSB TUE), out of conventional limits of induced leakage current on adjacent pins (out of –5 µA/+0 µA range), or other functional failure (for example reset, oscillator frequency deviation).

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

The test results are given in *Table 60*.

Table 60. I/O current injection susceptibility

Symbol	Description	Functional susceptibility		Unit
		Negative injection	Positive injection	
I_{INJ}	Injected current on BOOT0, PDR_ON, BYPASS_REG, OTG_HS_REXT	-0	0	mA
	Injected current on NRST	-0	NA(1)	
	Injected current on PF9, PF10, PH0_OSCIN, PH1_OSCOUT, PC0, PC1, PC2, PC3, PB14(2), PB15(2)	-0	NA(1)	
	Injected current on any other FT or FTf pins	-5	NA(1)	
	Injected current on any other pins	-5	+5	

1. Injection is not possible.

Unless otherwise specified, the parameters given in *Table 63* are derived from tests performed under the ambient temperature and V_{DD} supply voltage conditions summarized in *Table 16*.

Table 63. I/O AC characteristics(1)(2)

OSPEEDRy [1:0] bit value(1)	Symbol	Parameter	Conditions	Min	Typ	Max	Unit
00	$f_{max(IO)out}$	Maximum frequency(3)	C_L = 50 pF, V_{DD} ≥ 2.7 V	-	-	4	MHz
			C_L = 50 pF, V_{DD} ≥ 1.7 V	-	-	2	
			C_L = 10 pF, V_{DD} ≥ 2.7 V	-	-	8	
			C_L = 10 pF, V_{DD} ≥ 1.8 V	-	-	4	
			C_L = 10 pF, V_{DD} ≥ 1.7 V	-	-	3	
	$t_{f(IO)out}$/ $t_{r(IO)out}$	Output high to low level fall time and output low to high level rise time	C_L = 50 pF, V_{DD} = 1.7 V to 3.6 V	-	-	100	ns
01	$f_{max(IO)out}$	Maximum frequency(3)	C_L = 50 pF, V_{DD}≥ 2.7 V	-	-	25	MHz
			C_L = 50 pF, V_{DD}≥ 1.8 V	-	-	12.5	
			C_L = 50 pF, V_{DD}≥ 1.7 V	-	-	10	
			C_L = 10 pF, V_{DD} ≥ 2.7 V	-	-	50	
			C_L = 10 pF, V_{DD}≥ 1.8 V	-	-	20	
			C_L = 10 pF, V_{DD}≥ 1.7 V	-	-	12.5	
	$t_{f(IO)out}$/ $t_{r(IO)out}$	Output high to low level fall time and output low to high level rise time	C_L = 50 pF, V_{DD} ≥ 2.7 V	-	-	10	ns
			C_L = 10 pF, V_{DD} ≥ 2.7 V	-	-	6	
			C_L = 50 pF, V_{DD} ≥ 1.7 V	-	-	20	
			C_L = 10 pF, V_{DD} ≥ 1.7 V	-	-	10	
10	$f_{max(IO)out}$	Maximum frequency(3)	C_L = 40 pF, V_{DD} ≥ 2.7 V	-	-	50(4)	MHz
			C_L = 10 pF, V_{DD} ≥ 2.7 V	-	-	100(4)	
			C_L = 40 pF, V_{DD} ≥ 1.7 V	-	-	25	
			C_L = 10 pF, V_{DD} ≥ 1.8 V	-	-	50	
			C_L = 10 pF, V_{DD} ≥ 1.7 V	-	-	42.5	
	$t_{f(IO)out}$/ $t_{r(IO)out}$	Output high to low level fall time and output low to high level rise time	C_L = 40 pF, V_{DD} ≥2.7 V	-	-	6	ns
			C_L = 10 pF, V_{DD} ≥ 2.7 V	-	-	4	
			C_L = 40 pF, V_{DD} ≥ 1.7 V	-	-	10	
			C_L = 10 pF, V_{DD} ≥ 1.7 V	-	-	6	

SAI characteristics

Unless otherwise specified, the parameters given in *Table 83* 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 6.3.20: I/O port characteristics* for more details on the input/output alternate function characteristics (SCK,SD,WS).

Table 83. SAI characteristics(1)

Symbol	Parameter	Conditions	Min	Max	Unit
f_{MCKL}	SAI Main clock output	-	256x8K	256xFs	MHz
F_{CK}	SAI clock frequency(2)	Master data: 32 bits	-	128xFs(3)	
		Slave data: 32 bits	-	128xFs(3)	
$t_{v(FS)}$	FS valid time	Master mode 2.7≤VDD≤3.6V	-	18	ns
		Master mode 1.71≤VDD≤3.6V	-	20	
$t_{su(FS)}$	FS setup time	Slave mode	1	-	
$t_{h(FS)}$	FS hold time	Master mode	7	-	
		Slave mode	0.5	-	
$t_{su(SD\_A\_MR)}$	Data input setup time	Master receiver	1	-	
$t_{su(SD\_B\_SR)}$		Slave receiver	2.5	-	
$t_{h(SD\_A\_MR)}$	Data input hold time	Master receiver	3.5	-	
$t_{h(SD\_B\_SR)}$		Slave receiver	0.5	-	
$t_{v(SD\_B\_MT)}$	Data output valid time	Slave transmitter (after enable edge) 2.7≤VDD≤3.6V	-	11	
		Slave transmitter (after enable edge) 1.71≤VDD≤3.6V	-	18	
$t_{h(SD\_B\_ST)}$	Data output hold time	Slave transmitter (after enable edge)	5	-	
$t_{v(SD\_A\_MT)}$	Data output valid time	Master transmitter (after enable edge) 2.7≤VDD≤3.6V	-	16	
		Master transmitter (after enable edge) 1.71≤VDD≤3.6V	-	18.5	
$t_{h(SD\_A\_MT)}$	Data output hold time	Master transmitter (after enable edge)	7.5	-	

1. Guaranteed by characterization results.
2. APB clock frequency must be at least twice SAI clock frequency.
3. With Fs = 192 KHz.

Table 96. Asynchronous non-multiplexed SRAM/PSRAM/NOR write - NWAIT timings(1)

Symbol	Parameter	Min	Max	Unit
$t_{w(NE)}$	FMC_NE low time	8Thclk -1	8Thclk +1	ns
$t_{w(NWE)}$	FMC_NWE low time	6Thclk -1.5	6Thclk +0.5	
$t_{su(NWAIT\_NE)}$	FMC_NWAIT valid before FMC_NEx high	6Thclk -1	-	
$t_{h(NE\_NWAIT)}$	FMC_NEx hold time after FMC_NWAIT invalid	4Thclk + 2	-	

1. Guaranteed by characterization results.

Figure 62. Asynchronous multiplexed PSRAM/NOR read waveforms

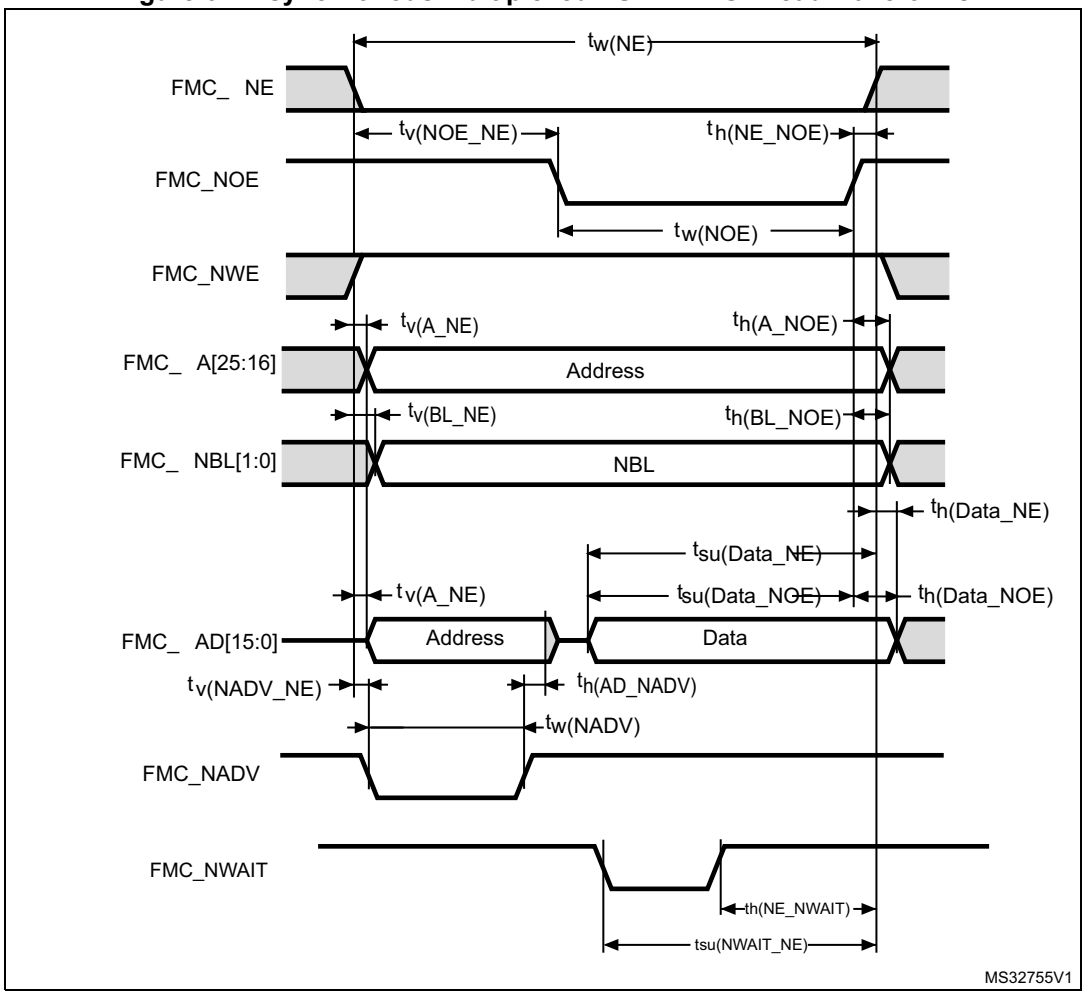


Figure 66. Synchronous non-multiplexed NOR/PSRAM read timings

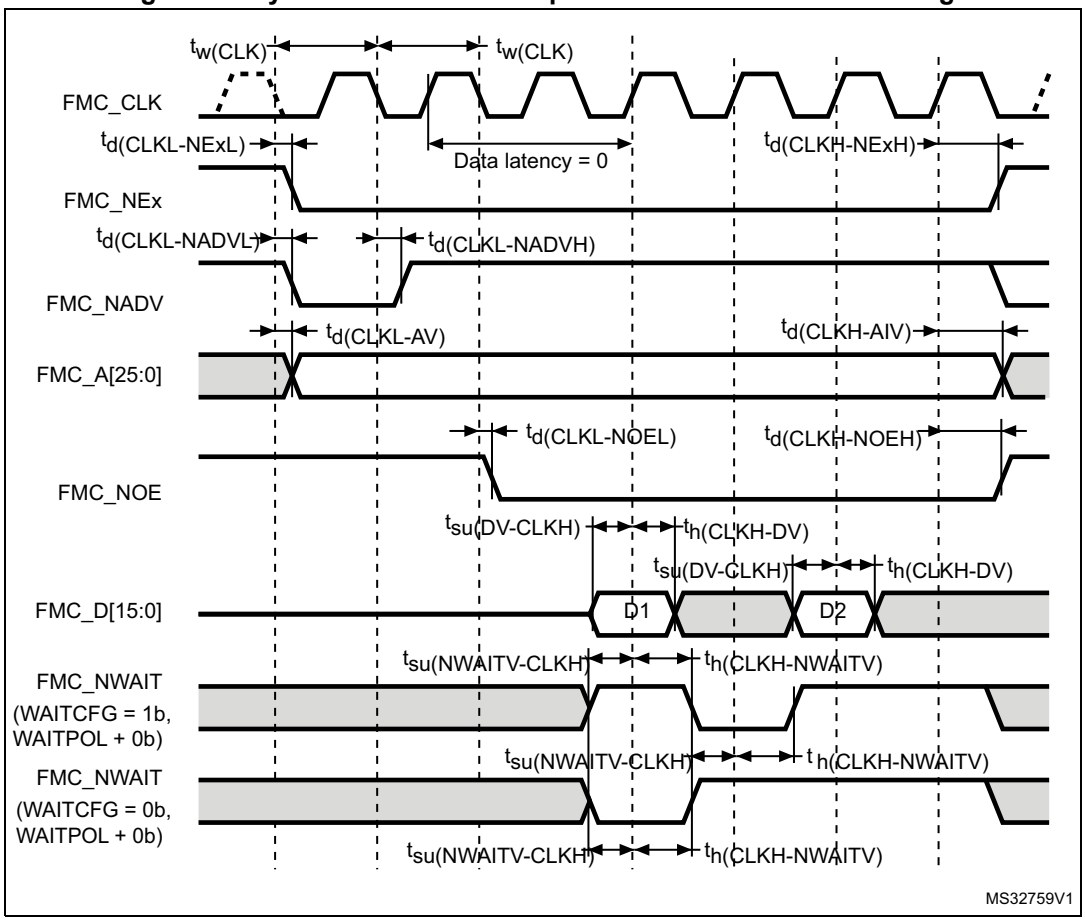


Table 103. Synchronous non-multiplexed NOR/PSRAM read timings(1)

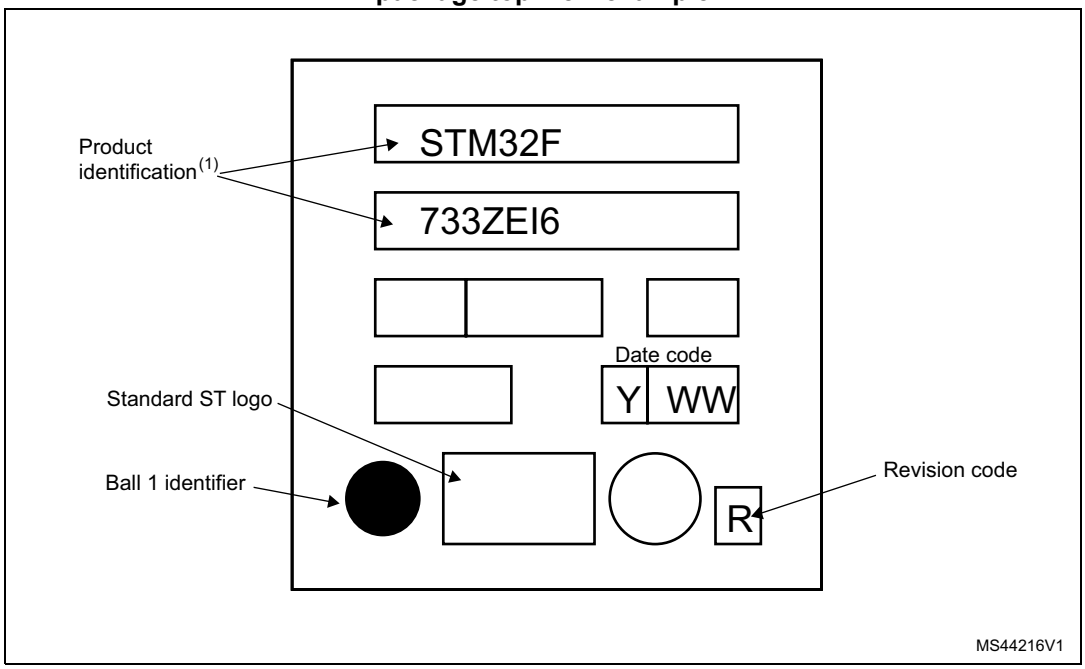
Symbol	Parameter	Min	Max	Unit
$t_{w(CLK)}$	FMC_CLK period	2Thclk - 0.5	-	ns
$t_{(CLKL-NExL)}$	FMC_CLK low to FMC_NEx low (x=0..2)	-	2	
$t_{d(CLKH-NExH)}$	FMC_CLK high to FMC_NEx high (x= 0…2)	Thclk +0.5	-	
$t_{d(CLKL-NADVL)}$	FMC_CLK low to FMC_NADV low	-	0.5	
$t_{d(CLKL-NADVH)}$	FMC_CLK low to FMC_NADV high	0	-	
$t_{d(CLKL-AV)}$	FMC_CLK low to FMC_Ax valid (x=16…25)	-	3	
$t_{d(CLKH-AIV)}$	FMC_CLK high to FMC_Ax invalid (x=16…25)	Thclk	-	
$t_{d(CLKL-NOEL)}$	FMC_CLK low to FMC_NOE low	-	2	
$t_{d(CLKH-NOEH)}$	FMC_CLK high to FMC_NOE high	Thclk -0.5	-	
$t_{su(DV-CLKH)}$	FMC_D[15:0] valid data before FMC_CLK high	0.5	-	
$t_{h(CLKH-DV)}$	FMC_D[15:0] valid data after FMC_CLK high	4	-	
$t_{(NWAIT-CLKH)}$	FMC_NWAIT valid before FMC_CLK high	2	-	
$t_{h(CLKH-NWAIT)}$	FMC_NWAIT valid after FMC_CLK high	3	-	

UFBGA144 device marking

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

Other optional marking or inset/upset marks, which identify the parts throughout supply chain operations, are not indicated below.

Figure 92. UFBGA144- 144-ball, 7 x 7 mm, 0.50 mm pitch 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.