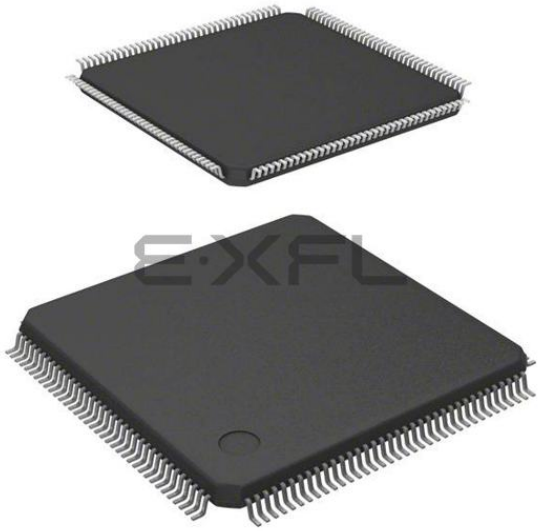

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Applications of "Embedded - Microcontrollers"

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	114
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 16x12b; D/A 2x12b
Oscillator Type	Internal
Operating Temperature	-40°C ~ 85°C (TA)
Mounting Type	Surface Mount
Package / Case	144-LQFP
Supplier Device Package	144-LQFP (20x20)
Purchase URL	https://www.e-xfl.com/product-detail/stmicroelectronics/stm32f732zet6

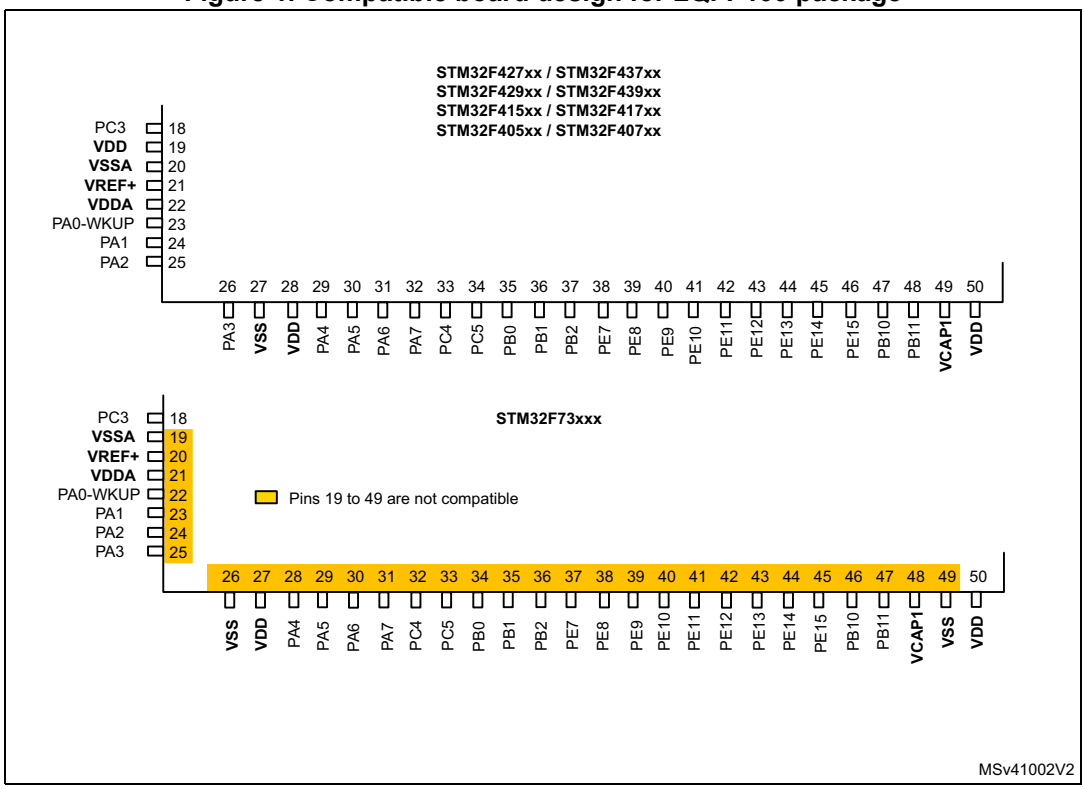
2.1 Full compatibility throughout the family

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



3.16 Voltage regulator

The regulator has four operating modes:

- Regulator ON
  - Main regulator mode (MR)
  - Low power regulator (LPR)
  - Power-down
- Regulator OFF

3.16.1 Regulator ON

On packages embedding the BYPASS_REG pin, the regulator is enabled by holding BYPASS_REG low. On all other packages, the regulator is always enabled.

There are three power modes configured by software when the regulator is ON:

- MR mode used in Run/sleep modes or in Stop modes
  - In Run/Sleep modes

    The MR mode is used either in the normal mode (default mode) or the over-drive mode (enabled by software). A different voltage scaling is provided to reach the best compromise between maximum frequency and dynamic power consumption. The over-drive mode allows operating at a higher frequency than the normal mode for a given voltage scaling.
  - In Stop modes

    The MR can be configured in two ways during stop mode:

    MR operates in normal mode (default mode of MR in stop mode)

    MR operates in under-drive mode (reduced leakage mode).
- LPR is used in the Stop modes:

  The LP regulator mode is configured by software when entering Stop mode.

  Like the MR mode, the LPR can be configured in two ways during stop mode:
  - LPR operates in normal mode (default mode when LPR is ON)
  - LPR operates in under-drive mode (reduced leakage mode).
- Power-down is used in Standby mode.

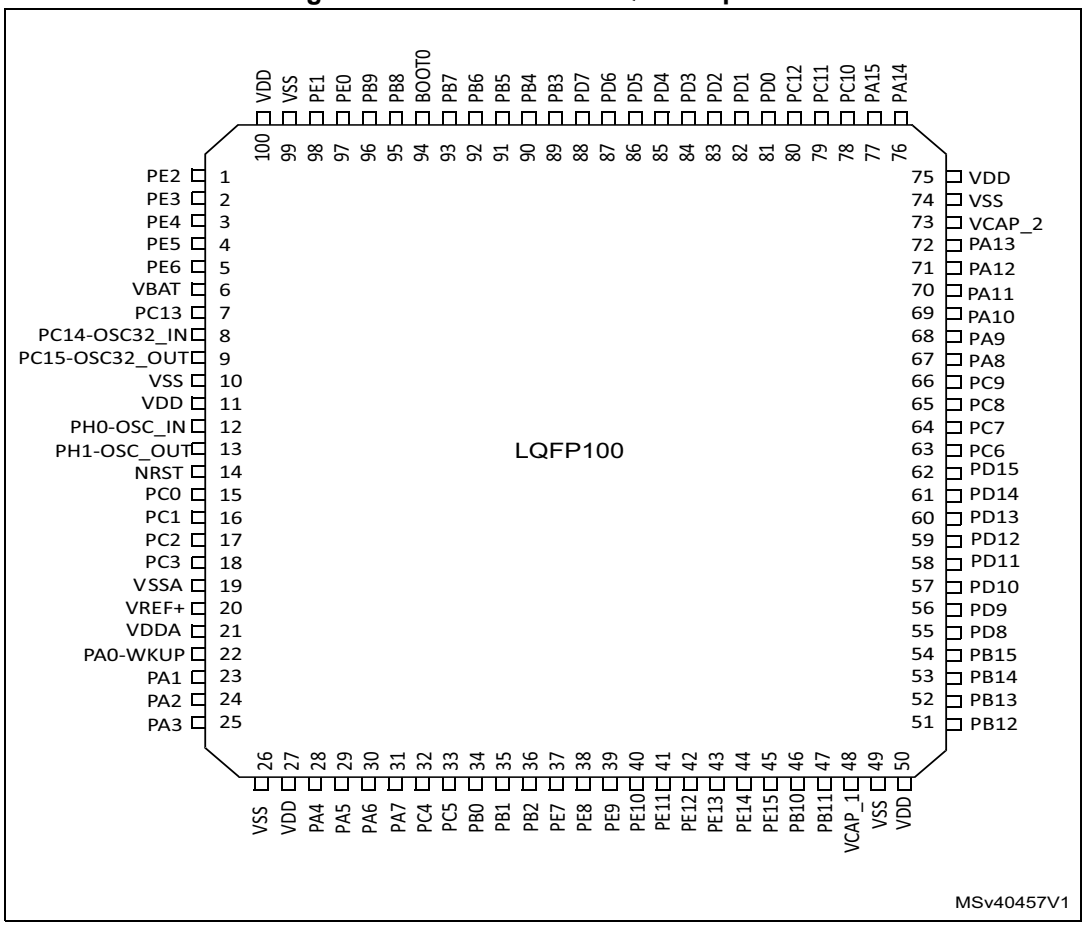
  The Power-down mode is activated only when entering in Standby mode. The regulator output is in high impedance and the kernel circuitry is powered down, inducing zero consumption. The contents of the registers and SRAM are lost.

Refer to *Table 3* for a summary of voltage regulator modes versus device operating modes.

The V_{CAP_1} and V_{CAP_2} pins must be connected to 2*2.2 µF, ESR < 2 Ω (or 1*4.7 µF, ESR between 0.1 Ω and 0.2 Ω if only the V_{CAP_1} pin is provided (on LQFP64 package)).

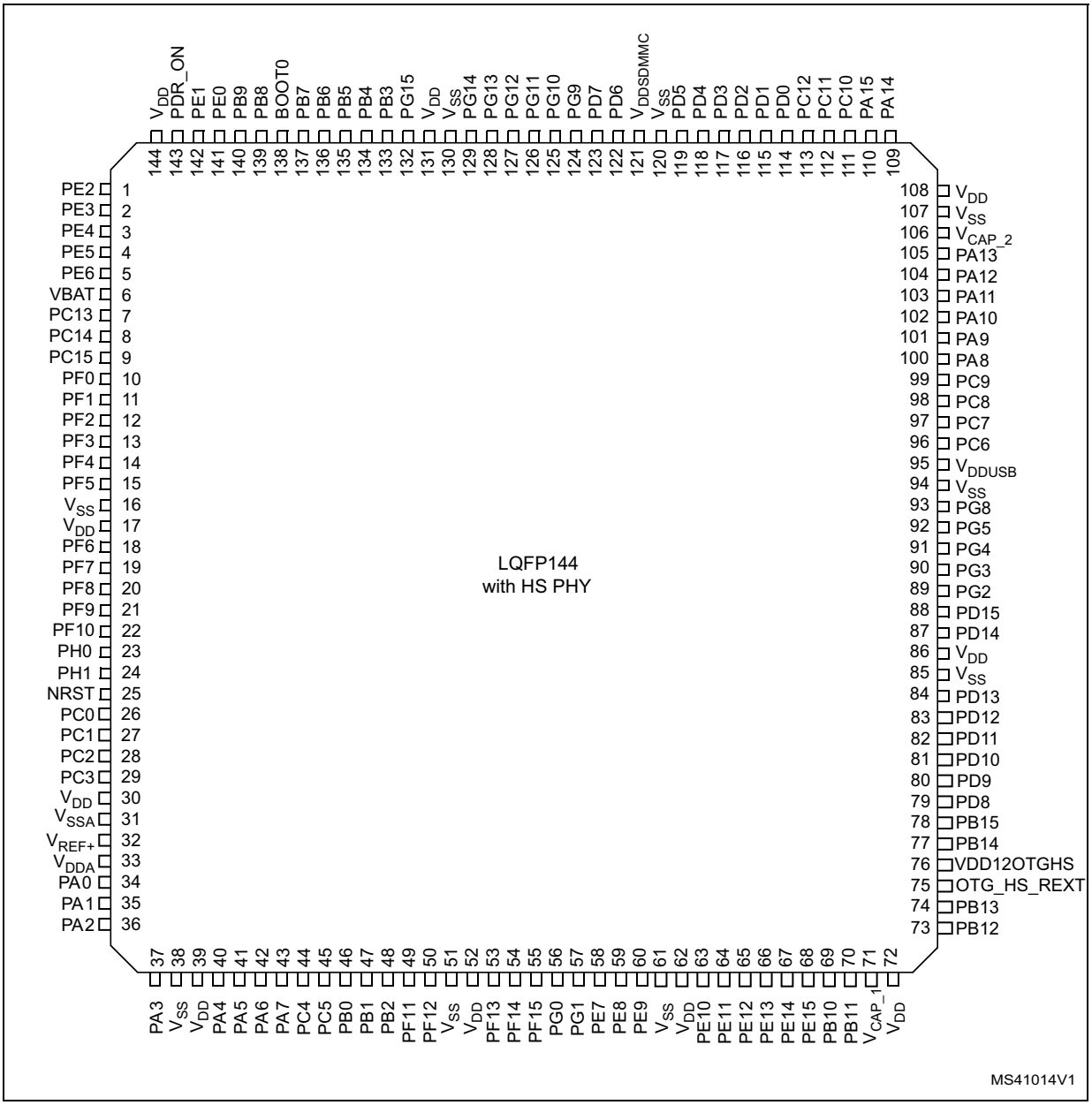
All the packages have the regulator ON feature.

Figure 15. STM32F732xx LQFP100 pinout



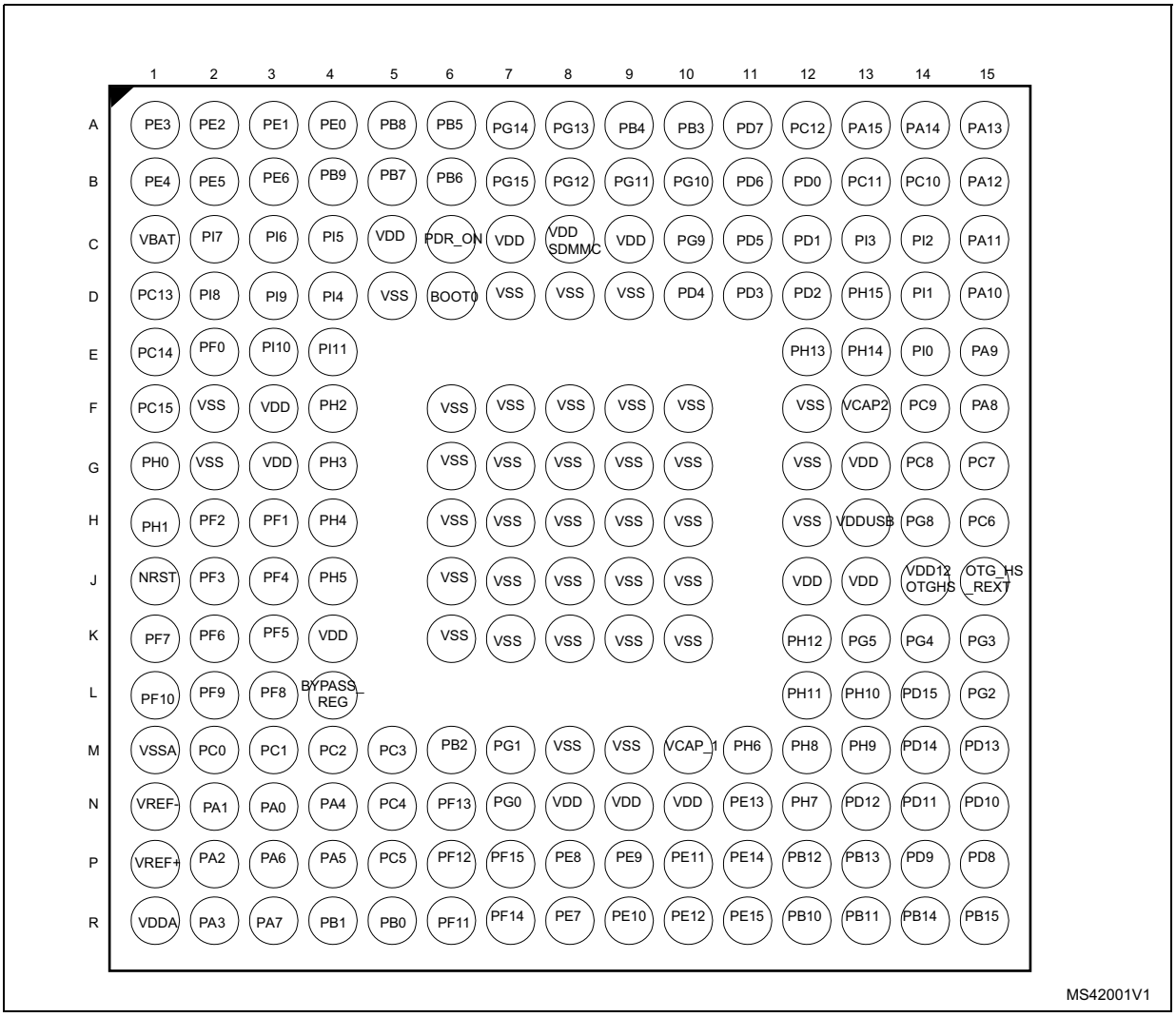
1. The above figure shows the package top view.

Figure 18. STM32F733xx 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						
35	53	75	R14	94	-	-	-	-	-	PB14	I/O	FT	-	TIM1_CH2N, TIM8_CH2N, SPI2_MISO, USART3_RTS, TIM12_CH1, SDMMC2_D0, OTG_HS_DM, EVENTOUT	-
-	-	-	-	-	J1	R14	L11	77	96	PB14	I/O	FT	-	OTG_HS_DM	-
36	54	76	R15	95	-	-	-	-	-	PB15	I/O	FT	-	RTC_REFIN, TIM1_CH3N, TIM8_CH3N, SPI2_MOSI/I2S2_SD, TIM12_CH2, SDMMC2_D1, OTG_HS_DP, EVENTOUT	-
-	-	-	-	-	H1	R15	L12	78	97	PB15	I/O	FT	-	OTG_HS_DP	-
-	55	77	P15	96	-	P15	L9	79	98	PD8	I/O	FT	-	USART3_TX, FMC_D13, EVENTOUT	-
-	56	78	P14	97	-	P14	K9	80	99	PD9	I/O	FT	-	USART3_RX, FMC_D14, EVENTOUT	-
-	57	79	N15	98	-	N15	J9	81	100	PD10	I/O	FT	-	USART3_CK, FMC_D15, EVENTOUT	-

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

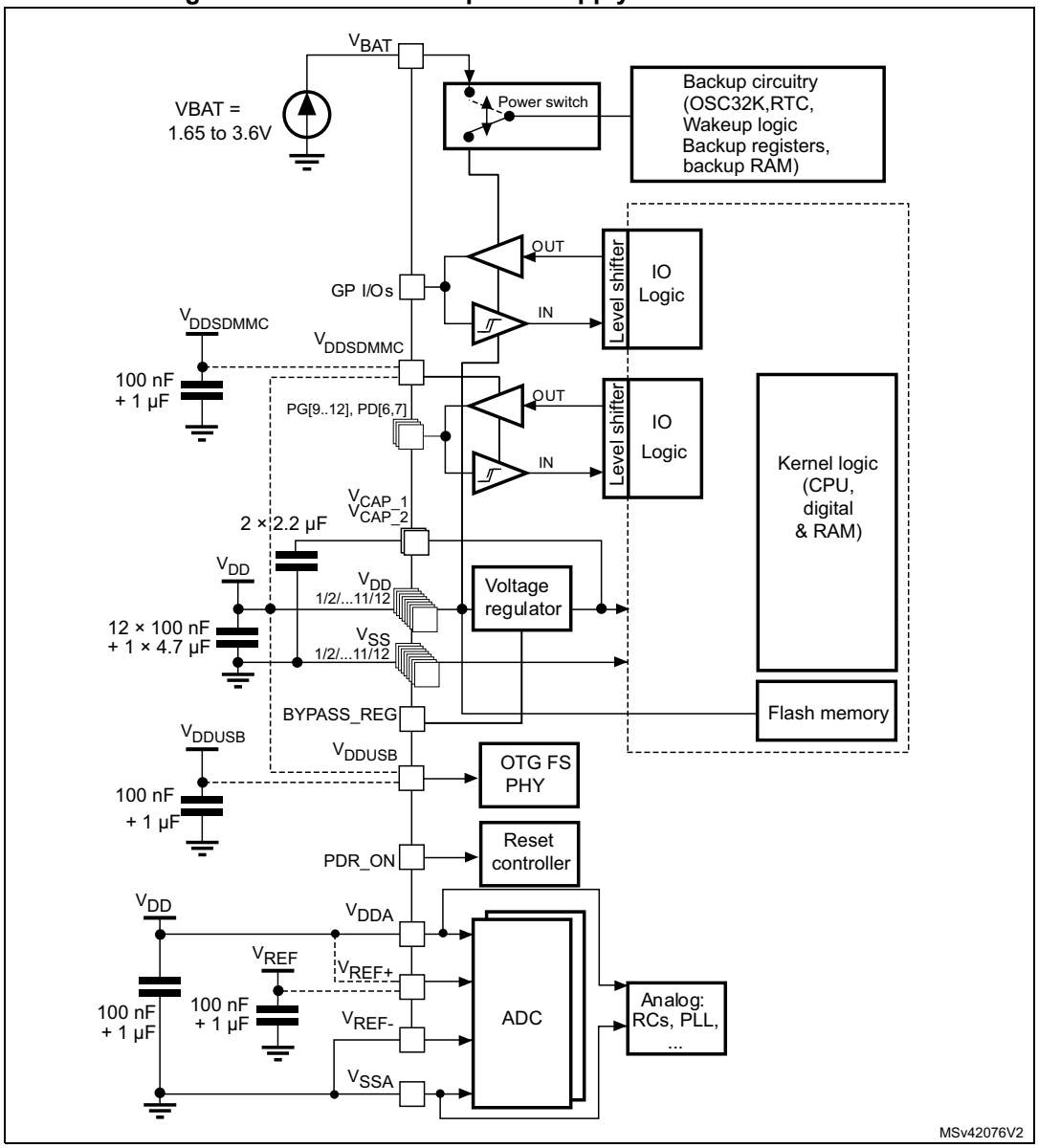
Port		AF0	AF1	AF2	AF3	AF4	AF5	AF6	AF7	AF8	AF9	AF10	AF11	AF12	AF15
		SYS	TIM1/2	TIM3/4/5	TIM8/9/10/11/LPTIM1	I2C1/2/3/USART1	SPI1/I2S1/SPI2/I2S2/SPI3/I2S3/SPI4/5	SPI2/I2S2/SPI3/I2S3/SPI3/I2S3/SAI1/UART4	SPI2/I2S2/SPI3/I2S3/USART1/2/3/UART5	SAI2/USART6/UART4/5/7/8/OTG1_FS	CAN1/TIM12/13/14/QUADSPI/FMC/OTG2_HS	SAI2/QUADSPI/SDMMC2/OTG2_HS/OTG1_FS	SDMMC2	UART7/FMC/SDMMC1/OTG2_FS	SYS
Port F	PF0	-	-	-	-	I2C2_SDA	-	-	-	-	-	-	-	FMC_A0	EVENTOUT
	PF1	-	-	-	-	I2C2_SCL	-	-	-	-	-	-	-	FMC_A1	EVENTOUT
	PF2	-	-	-	-	I2C2_SMBA	-	-	-	-	-	-	-	FMC_A2	EVENTOUT
	PF3	-	-	-	-	-	-	-	-	-	-	-	-	FMC_A3	EVENTOUT
	PF4	-	-	-	-	-	-	-	-	-	-	-	-	FMC_A4	EVENTOUT
	PF5	-	-	-	-	-	-	-	-	-	-	-	-	FMC_A5	EVENTOUT
	PF6	-	-	-	TIM10_CH1	-	SPI5_NSS	SAI1_SD_B	-	UART7_Rx	QUADSPI_BK1_IO3	-	-	-	EVENTOUT
	PF7	-	-	-	TIM11_CH1	-	SPI5_SCK	SAI1_MCLK_B	-	UART7_Tx	QUADSPI_BK1_IO2	-	-	-	EVENTOUT
	PF8	-	-	-	-	-	SPI5_MISO	SAI1_SCK_B	-	UART7_RTS	TIM13_CH1	QUADSPI_BK1_IO0	-	-	EVENTOUT
	PF9	-	-	-	-	-	SPI5_MOSI	SAI1_FS_B	-	UART7_CTS	TIM14_CH1	QUADSPI_BK1_IO1	-	-	EVENTOUT
	PF10	-	-	-	-	-	-	-	-	-	-	-	-	-	EVENTOUT
	PF11	-	-	-	-	-	SPI5_MOSI	-	-	-	-	SAI2_SD_B	-	FMC_SDNRAS	EVENTOUT
	PF12	-	-	-	-	-	-	-	-	-	-	-	-	FMC_A6	EVENTOUT
Port F	PF13	-	-	-	-	-	-	-	-	-	-	-	-	FMC_A7	EVENTOUT
	PF14	-	-	-	-	-	-	-	-	-	-	-	-	FMC_A8	EVENTOUT
	PF15	-	-	-	-	-	-	-	-	-	-	-	-	FMC_A9	EVENTOUT

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 G	PG0	-	-	-	-	-	-	-	-	-	-	-	-	FMC_A10	EVENTOUT
	PG1	-	-	-	-	-	-	-	-	-	-	-	-	FMC_A11	EVENTOUT
	PG2	-	-	-	-	-	-	-	-	-	-	-	-	FMC_A12	EVENTOUT
	PG3	-	-	-	-	-	-	-	-	-	-	-	-	FMC_A13	EVENTOUT
	PG4	-	-	-	-	-	-	-	-	-	-	-	-	FMC_A14/FMC_BA0	EVENTOUT
	PG5	-	-	-	-	-	-	-	-	-	-	-	-	FMC_A15/FMC_BA1	EVENTOUT
	PG6	-	-	-	-	-	-	-	-	-	-	-	-	-	EVENTOUT
	PG7	-	-	-	-	-	-	-	-	USART6_CK	-	-	-	FMC_INT	EVENTOUT
	PG8	-	-	-	-	-	-	-	-	USART6_RTS	-	-	-	FMC_SDCLK	EVENTOUT
	PG9	-	-	-	-	-	-	-	-	USART6_RX	QUADSPI_BK2_IO2	SAI2_FS_B	SDMMC2_D0	FMC_NE2/FMC_NCE	EVENTOUT
	PG10	-	-	-	-	-	-	-	-	-	-	SAI2_SD_B	SDMMC2_D1	FMC_NE3	EVENTOUT

6.1.6 Power supply scheme

Figure 26. STM32F732xx power supply scheme



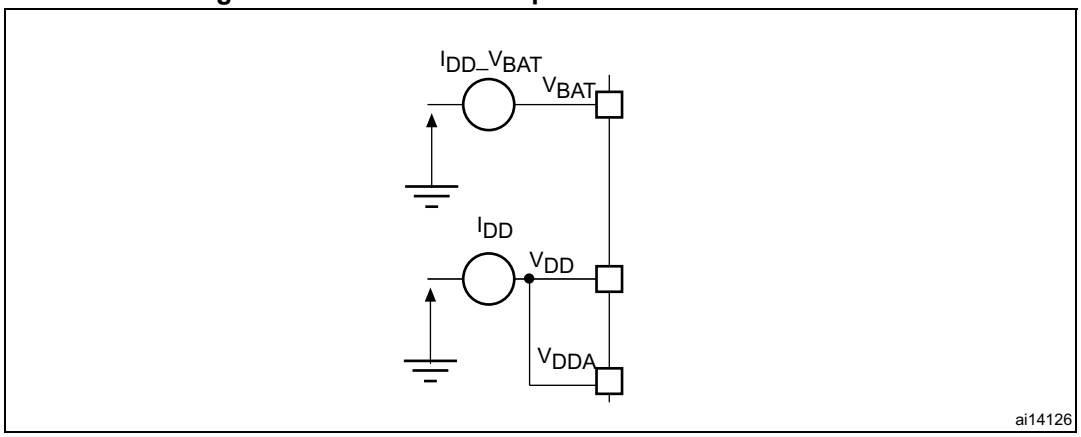
1. The two 2.2 µF ceramic capacitors should be replaced by two 100 nF decoupling capacitors when the voltage regulator is OFF.
2. The 4.7 µF ceramic capacitor must be connected to one of the V_{DD} pin.
3. $V_{DDA}=V_{DD}$ and $V_{SSA}=V_{SS}$.

2. The two 2.2 µF ceramic capacitors should be replaced by two 100 nF decoupling capacitors when the voltage regulator is OFF.
3. The 4.7 µF ceramic capacitor must be connected to one of the V_{DD} pin.
4. V_{DDA}=V_{DD} and V_{SSA}=V_{SS}.

Caution: Each power supply pair (V_{DD}/V_{SS}, V_{DDA}/V_{SSA} ...) must be decoupled with filtering ceramic capacitors as shown above. These capacitors must be placed as close as possible to, or below, the appropriate pins on the underside of the PCB to ensure good operation of the device. It is not recommended to remove filtering capacitors to reduce PCB size or cost. This might cause incorrect operation of the device.

6.1.7 Current consumption measurement

Figure 28. 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. The device mission profile (application conditions) is compliant with JEDEC JESD47 Qualification Standard. Extended mission profiles are available on demand.

Table 13. Voltage characteristics

Symbol	Ratings	Min	Max	Unit
V_{DD}–V_{SS}	External main supply voltage (including V_{DDA}, V_{DD}, V_{BAT}, V_{DDUSB} and $V_{DDSDMMC}$) (1)	− 0.3	4.0	V
V_{IN}	Input voltage on FT pins(2)	V_{SS} − 0.3	V_{DD}+4.0	
	Input voltage on TTa pins	V_{SS} − 0.3	4.0	
	Input voltage on any other pin	V_{SS} − 0.3	4.0	
	Input voltage on BOOT pin	V_{SS}	9.0	

Table 15. Thermal characteristics

Symbol	Ratings	Value	Unit
T_{STG}	Storage temperature range	− 65 to +150	°C
T_J	Maximum junction temperature	125	

6.3 Operating conditions

6.3.1 General operating conditions

Table 16. General operating conditions

Symbol	Parameter	Conditions[1]		Min	Typ	Max	Unit
f_{HCLK}	Internal AHB clock frequency	Power Scale 3 (VOS[1:0] bits in PWR_CR register = 0x01), Regulator ON, over-drive OFF		0	-	144	MHz
		Power Scale 2 (VOS[1:0] bits in PWR_CR register = 0x10), Regulator ON	Over-drive OFF	0	-	168	
			Over-drive ON		-	180	
		Power Scale 1 (VOS[1:0] bits in PWR_CR register= 0x11), Regulator ON	Over-drive OFF	0	-	180	
			Over-drive ON		-	216[2]	
f_{PCLK1}	Internal APB1 clock frequency	Over-drive OFF		0	-	45	
		Over-drive ON		0	-	54	
f_{PCLK2}	Internal APB2 clock frequency	Over-drive OFF		0	-	90	
		Over-drive ON		0	-	108	
V_{DD}	Standard operating voltage	-		1.7[3]	-	3.6	V
V_{DDA}[4][5]	Analog operating voltage (ADC limited to 1.2 M samples)	Must be the same potential as V_{DD}[6]		1.7[3]	-	2.4	
	Analog operating voltage (ADC limited to 2.4 M samples)			2.4	-	3.6	
V_{DDUSB}	USB supply voltage (supply voltage for PA11,PA12, PB14 and PB15 pins)	USB not used		1.7	3.3	3.6	
		USB used		3.0	-	3.6	
V_{BAT}	Backup operating voltage	-		1.65	-	3.6	
$V_{DDSDMMC}$	SDMMC2 supply voltage (supply voltage for PG[12:9] and PD6 pins)	It can be different from V_{DD}		1.7	-	3.6	

Figure 32. Typical V_{BAT} current consumption (RTC ON/BKP SRAM OFF and LSE in medium high drive mode)

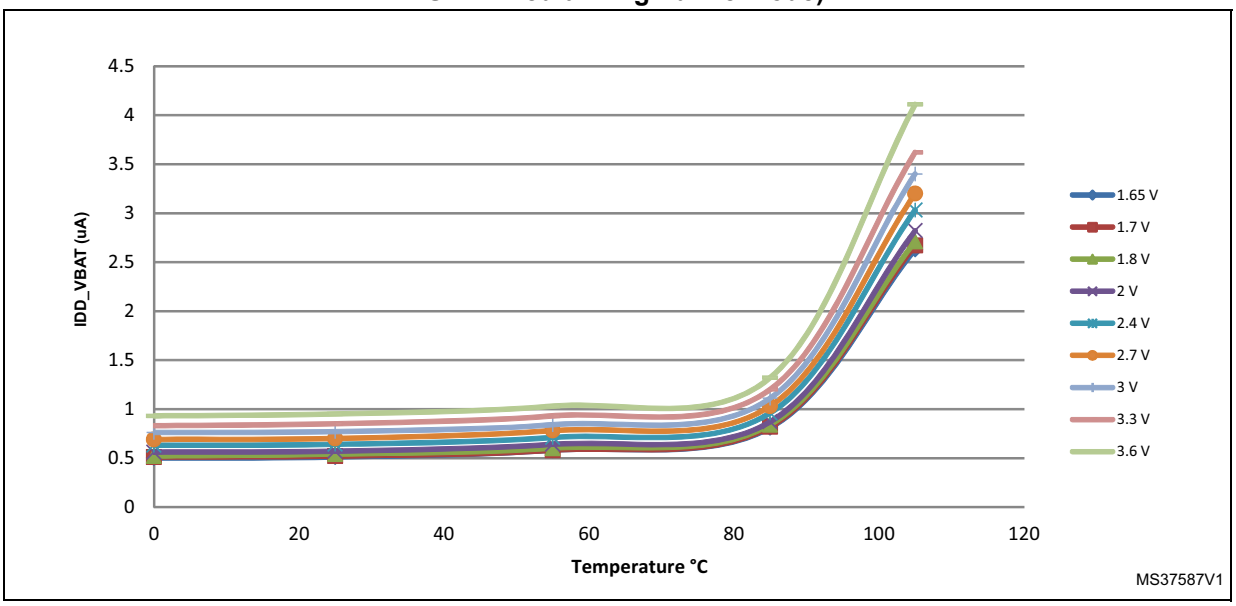


Figure 33. Typical V_{BAT} current consumption (RTC ON/BKP SRAM OFF and LSE in high drive mode)

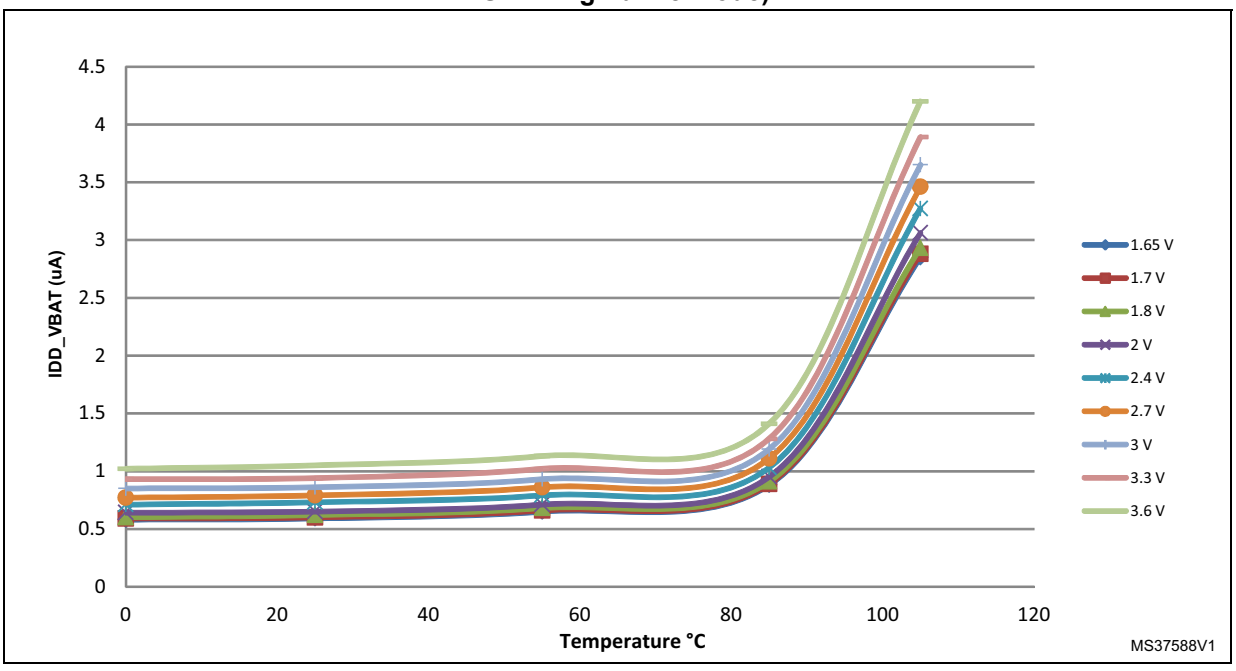
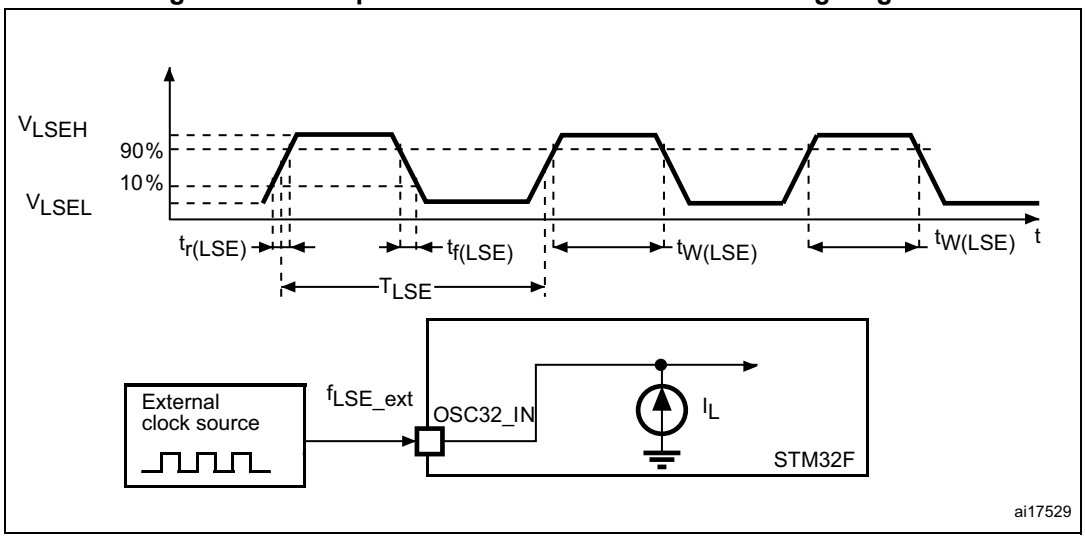


Figure 36. Low-speed external clock source AC timing diagram



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

The high-speed external (HSE) clock can be supplied with a 4 to 26 MHz crystal/ceramic resonator oscillator. All the information given in this paragraph are based on characterization results obtained with typical external components specified in *Table 40*. 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 40. HSE 4-26 MHz oscillator characteristics(1)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
f_{OSC_IN}	Oscillator frequency	-	4	-	26	MHz
R_F	Feedback resistor	-	-	200	-	kΩ
I_{DD}	HSE current consumption	V_{DD}=3.3 V, ESR= 30 Ω, C_L=5 pF@25 MHz	-	450	-	µA
		V_{DD}=3.3 V, ESR= 30 Ω, C_L=10 pF@25 MHz	-	530	-	
ACC_{HSE}(2)	HSE accuracy	-	− 500	-	500	ppm
G_m_crit_max	Maximum critical crystal g_m	Startup	-	-	1	mA/V
$t_{SU(HSE}$(3)	Startup time	V_{DD} is stabilized	-	2	-	ms

1. Guaranteed by design.
2. This parameter depends on the crystal used in the application. The minimum and maximum values must be respected to comply with USB standard specifications.
3. $t_{SU(HSE)}$ is the startup time measured from the moment it is enabled (by software) to a stabilized 8 MHz oscillation is reached. This value is based on characterization results. It is measured for a standard crystal resonator and it can vary significantly with the crystal manufacturer.

6.3.13 USB OTG HS PHY PLLs characteristics (on STM32F733xx devices)

The parameters given in *Table 48* are derived from tests performed under temperature and V_{DD} supply voltage conditions summarized in *Table 16*.

Table 48. USB OTG HS PLL1 characteristics(1)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
f_{PLL1_IN}	PLL1 input clock	-	12, 12.5, 16, 24, 25			MHz
f_{PLL1_OUT}	PLL1 output clock(2)	-	-	60	-	
f_{VCO_OUT}	PLL1 VCO output	-	600	-	720	
t_{LOCK}	PLL1 lock time(2)	-	-	-	22	µs
$I_{DD(PLL1)}$	PLL1 digital power consumption	-	-	-	1.8	mA
$I_{DDA(PLL1)}$	PLL1 analog power consumption	-	-	-	2.75	

1. Guaranteed by design.
2. Based on test during characterization.

Table 49. USB OTG HS PLL2 characteristics(1)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
f_{PLL2_IN}	PLL2 input clock	-	-	60	-	MHz
f_{PLL2_OUT}	PLL2 output clock(2)	-	-	480	-	
f_{VCO_OUT}	PLL2 VCO output	-	-	480	-	
t_{LOCK}	PLL2 lock time(2)	-	-	-	91	µs
$I_{DD(PLL2)}$	PLL2 digital power consumption	-	-	-	2.1	mA
$I_{DDA(PLL2)}$	PLL2 analog power consumption	-	-	-	1.5	

1. Guaranteed by design.
2. Based on test during characterization.

6.3.14 USB OTG HS PHY regulator characteristics (on STM32F733xx devices)

The parameters given in *Table 50* are derived from tests performed under temperature and V_{DD} supply voltage conditions summarized in *Table 16*.

Table 50. USB OTG HS PHY regulator characteristics(1)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$V_{DD12OTGHS}$	1.2 V internal voltage on $V_{DD12OTGHS}$	-	1.18	1.2	1.24	V
CEXT	External capacitor on $V_{DD12OTGHS}$	-	1.1	2.2	3.3	µF
$I_{DDPHYHSREG}$	Regulator power consumption	-	100	120	125	µA

1. Based on test during characterization.

Table 62. Output voltage characteristics

Symbol	Parameter	Conditions	Min	Max	Unit
V_{OL}(1)	Output low level voltage for an I/O pin	CMOS port(2) I_{IO} = +8 mA 2.7 V ≤V_{DD} ≤3.6 V	-	0.4	V
V_{OH}(3)	Output high level voltage for an I/O pin except PC14	CMOS port(2) I_{IO} = -8 mA 2.7 V ≤V_{DD} ≤3.6 V	V_{DD} − 0.4	-	
V_{OH}(3)	Output high level voltage for PC14	CMOS port(2) I_{IO} = -2 mA 2.7 V ≤V_{DD} ≤3.6 V	V_{DD} − 0.4	-	
V_{OL} (1)	Output low level voltage for an I/O pin	TTL port(2) I_{IO} =+8mA 2.7 V ≤V_{DD} ≤3.6 V	-	0.4	V
V_{OH} (3)	Output high level voltage for an I/O pin except PC14	TTL port(2) I_{IO} =-8mA 2.7 V ≤V_{DD} ≤3.6 V	2.4	-	
V_{OL}(1)	Output low level voltage for an I/O pin	I_{IO} = +20 mA 2.7 V ≤V_{DD} ≤3.6 V	-	1.3(4)	V
V_{OH}(3)	Output high level voltage for an I/O pin except PC14	I_{IO} = -20 mA 2.7 V ≤V_{DD} ≤3.6 V	V_{DD}−1.3(4)	-	
V_{OL}(1)	Output low level voltage for an I/O pin	I_{IO} = +6 mA 1.8 V ≤V_{DD} ≤3.6 V	-	0.4(4)	V
V_{OH}(3)	Output high level voltage for an I/O pin except PC14	I_{IO} = -6 mA 1.8 V ≤V_{DD} ≤3.6 V	V_{DD}−0.4(4)	-	
V_{OL}(1)	Output low level voltage for an I/O pin	I_{IO} = +4 mA 1.7 V ≤V_{DD} ≤3.6V	-	0.4(5)	V
V_{OH}(3)	Output high level voltage for an I/O pin except PC14	I_{IO} = -4 mA 1.7 V ≤V_{DD} ≤3.6V	V_{DD}−0.4(5)	-	
V_{OH}(3)	Output high level voltage for PC14	I_{IO} = -1 mA 1.7 V ≤V_{DD} ≤3.6V	V_{DD}−0.4(5)	-	

1. The I_{IO} current sunk by the device must always respect the absolute maximum rating specified in *Table 14*. and the sum of I_{IO} (I/O ports and control pins) must not exceed I_{VSS}.
2. TTL and CMOS outputs are compatible with JEDEC standards JESD36 and JESD52.
3. The I_{IO} current sourced by the device must always respect the absolute maximum rating specified in *Table 14* and the sum of I_{IO} (I/O ports and control pins) must not exceed I_{VDD}.
4. Based on characterization data.
5. Guaranteed by design.

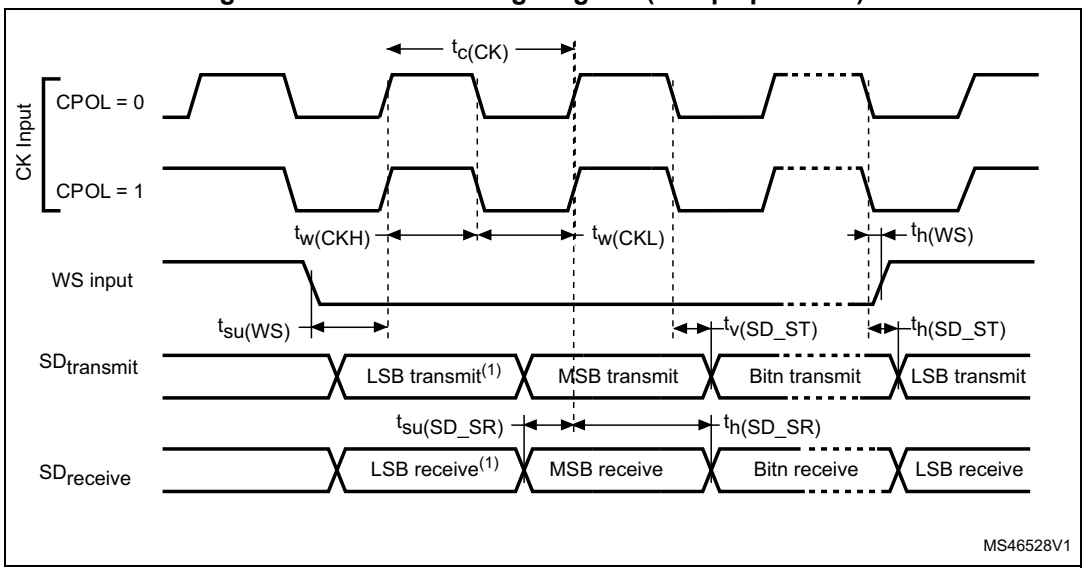
Input/output AC characteristics

The definition and values of input/output AC characteristics are given in *Figure 44* and *Table 63*, respectively.

Table 78. DAC characteristics (continued)

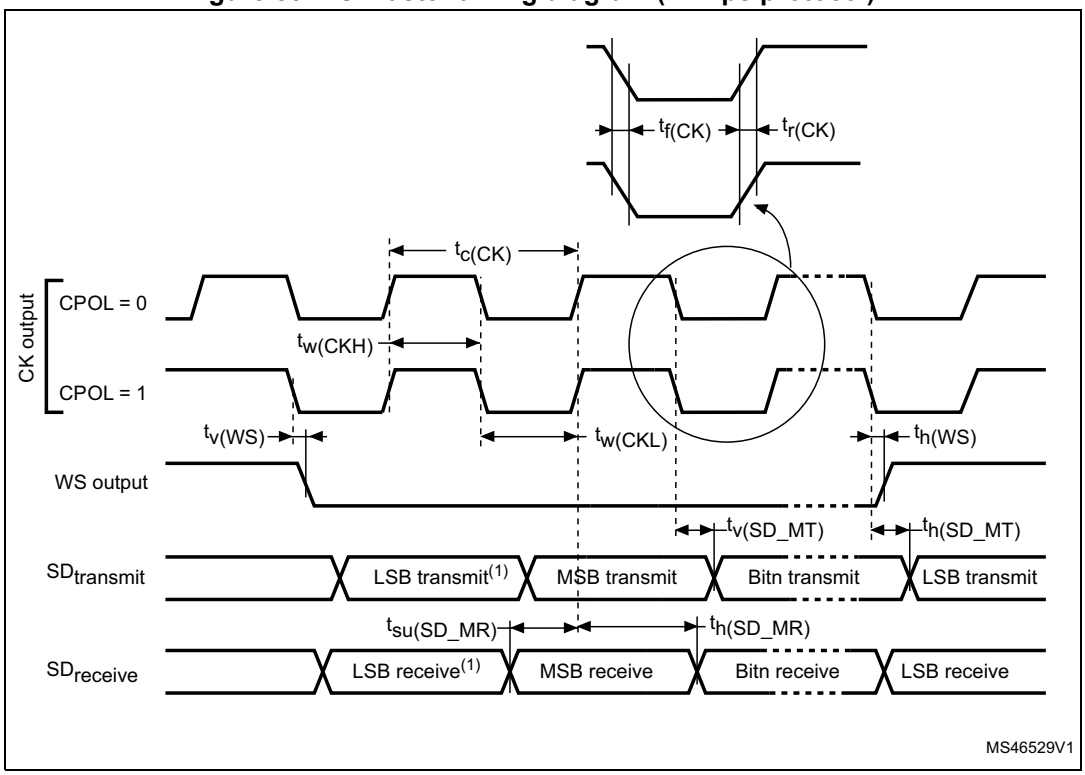
Symbol	Parameter	Min	Typ	Max	Unit	Comments
I_{VREF+}(4)	DAC DC V_{REF} current consumption in quiescent mode (Standby mode)	-	170	240	µA	With no load, worst code (0x800) at V_{REF+} = 3.6 V in terms of DC consumption on the inputs
		-	50	75		With no load, worst code (0xF1C) at V_{REF+} = 3.6 V in terms of DC consumption on the inputs
I_{DDA}(4)	DAC DC V_{DDA} current consumption in quiescent mode(3)	-	280	380	µA	With no load, middle code (0x800) on the inputs
		-	475	625	µA	With no load, worst code (0xF1C) at V_{REF+} = 3.6 V in terms of DC consumption on the inputs
DNL(4)	Differential non linearity Difference between two consecutive code-1LSB)	-	-	±0.5	LSB	Given for the DAC in 10-bit configuration.
		-	-	±2	LSB	Given for the DAC in 12-bit configuration.
INL(4)	Integral non linearity (difference between measured value at Code i and the value at Code i on a line drawn between Code 0 and last Code 1023)	-	-	±1	LSB	Given for the DAC in 10-bit configuration.
		-	-	±4	LSB	Given for the DAC in 12-bit configuration.
Offset(4)	Offset error (difference between measured value at Code (0x800) and the ideal value = V_{REF+}/2)	-	-	±10	mV	Given for the DAC in 12-bit configuration
		-	-	±3	LSB	Given for the DAC in 10-bit at V_{REF+} = 3.6 V
		-	-	±12	LSB	Given for the DAC in 12-bit at V_{REF+} = 3.6 V
Gain error(4)	Gain error	-	-	±0.5	%	Given for the DAC in 12-bit configuration
$t_{SETTLING}$(4)	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 ±4LSB	-	3	6	µs	$C_{LOAD} \leq 50$ pF, $R_{LOAD} \geq 5$ kΩ
THD(4)	Total Harmonic Distortion Buffer ON	-	-	-	dB	$C_{LOAD} \leq 50$ pF, $R_{LOAD} \geq 5$ kΩ
Update rate(2)	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

Figure 54. I²S slave timing diagram (Philips protocol)(1)



1. LSB transmit/receive of the previously transmitted byte. No LSB transmit/receive is sent before the first byte.

Figure 55. I²S master timing diagram (Philips protocol)(1)



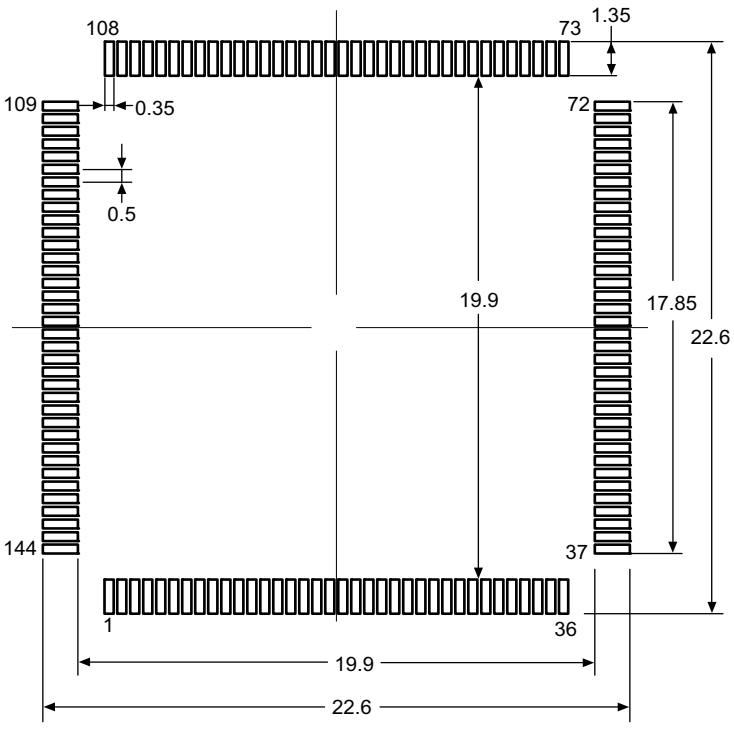
1. LSB transmit/receive of the previously transmitted byte. No LSB transmit/receive is sent before the first byte.

Table 117. LQFP144, 20 x 20 mm, 144-pin low-profile quad flat package mechanical data (continued)

Symbol	millimeters			inches[1]		
	Min	Typ	Max	Min	Typ	Max
D1	19.800	20.000	20.200	0.7795	0.7874	0.7953
D3	-	17.500	-	-	0.689	-
E	21.800	22.000	22.200	0.8583	0.8661	0.8740
E1	19.800	20.000	20.200	0.7795	0.7874	0.7953
E3	-	17.500	-	-	0.6890	-
e	-	0.500	-	-	0.0197	-
L	0.450	0.600	0.750	0.0177	0.0236	0.0295
L1	-	1.000	-	-	0.0394	-
k	0°	3.5°	7°	0°	3.5°	7°
ccc	-	-	0.080	-	-	0.0031

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

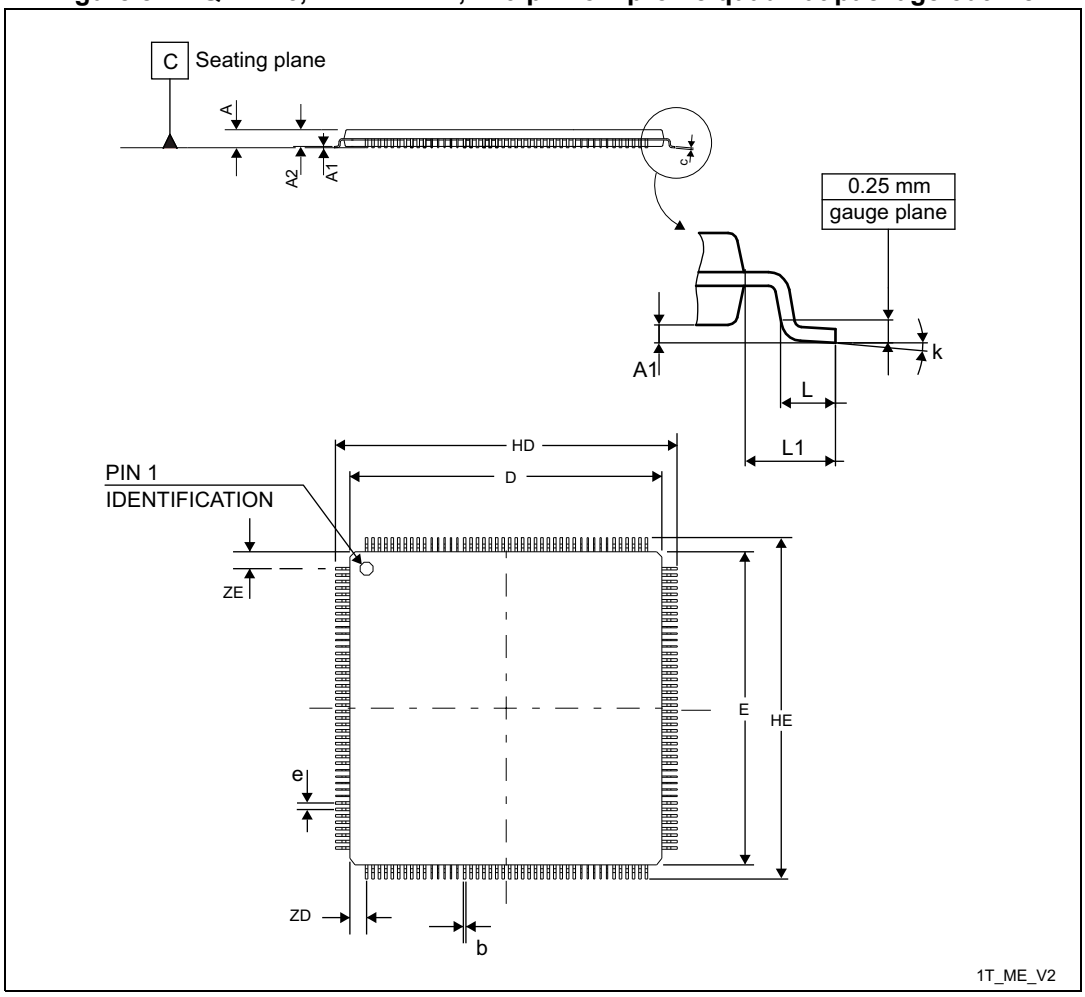
Figure 85. LQFP144, 20 x 20 mm, 144-pin low-profile quad flat package recommended footprint



1. Dimensions are expressed in millimeters.

7.4 LQFP176 24 x 24 mm low-profile quad flat package information

Figure 87. LQFP176, 24 x 24 mm, 176-pin low-profile quad flat package outline



1. Drawing is not to scale.

Table 118. LQFP176, 24 x 24 mm, 176-pin low-profile quad flat package mechanical data

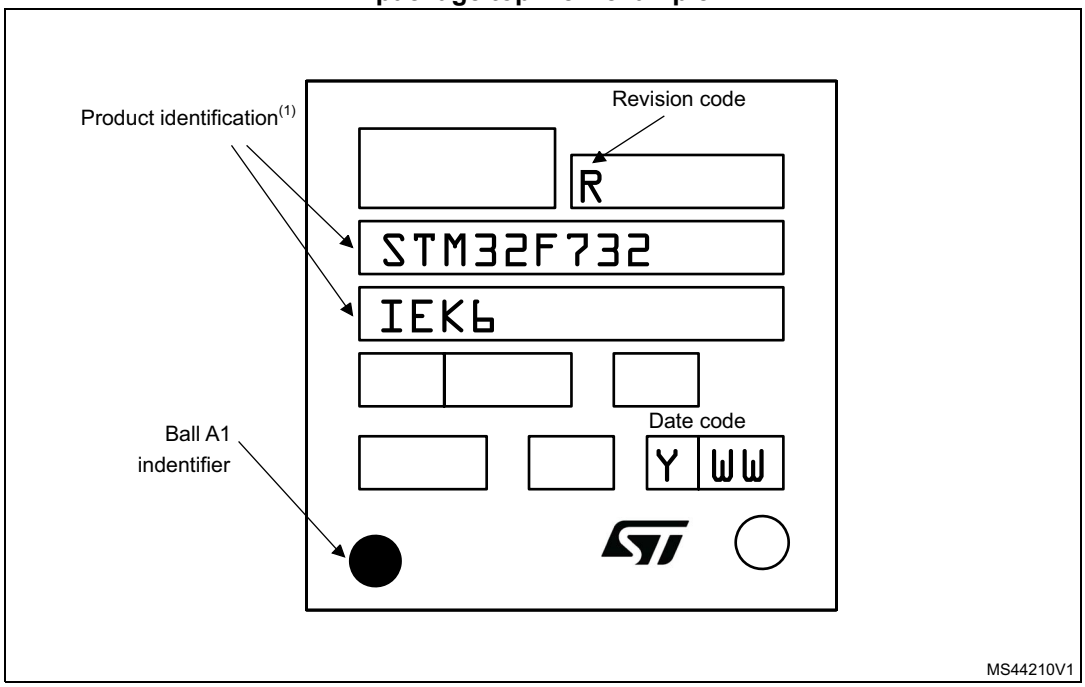
Symbol	millimeters			inches[1]		
	Min	Typ	Max	Min	Typ	Max
A	-	-	1.600	-	-	0.0630
A1	0.050	-	0.150	0.0020	-	0.0059
A2	1.350	-	1.450	0.0531	-	0.0060
b	0.170	-	0.270	0.0067	-	0.0106
C	0.090	-	0.200	0.0035	-	0.0079
D	23.900	-	24.100	0.9409	-	0.9488

UFBGA176+25 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 95. UFBGA176+25, 10 × 10 × 0.6 mm ultra thin fine-pitch ball grid array 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.