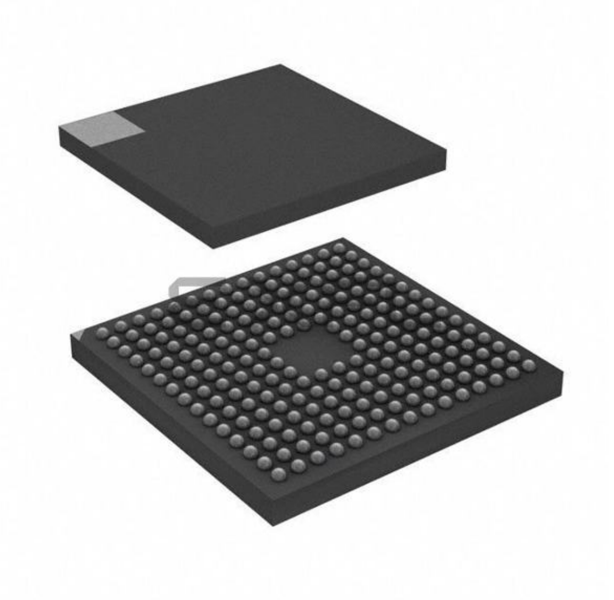

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Applications of "Embedded - Microcontrollers"

Details	
Product Status	Active
Core Processor	ARM® Cortex®-M4
Core Size	32-Bit Single-Core
Speed	180MHz
Connectivity	CANbus, EBI/EMI, Ethernet, I²C, IrDA, LINbus, SAI, SDIO, SPI, UART/USART, USB, USB OTG
Peripherals	Brown-out Detect/Reset, DMA, I²S, LCD, POR, PWM, WDT
Number of I/O	161
Program Memory Size	2MB (2M x 8)
Program Memory Type	FLASH
EEPROM Size	-
RAM Size	384K 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/stm32f469nih6tr

1.1 Compatibility throughout the family

STM32F469xx devices are not compatible with other STM32F4xx devices.

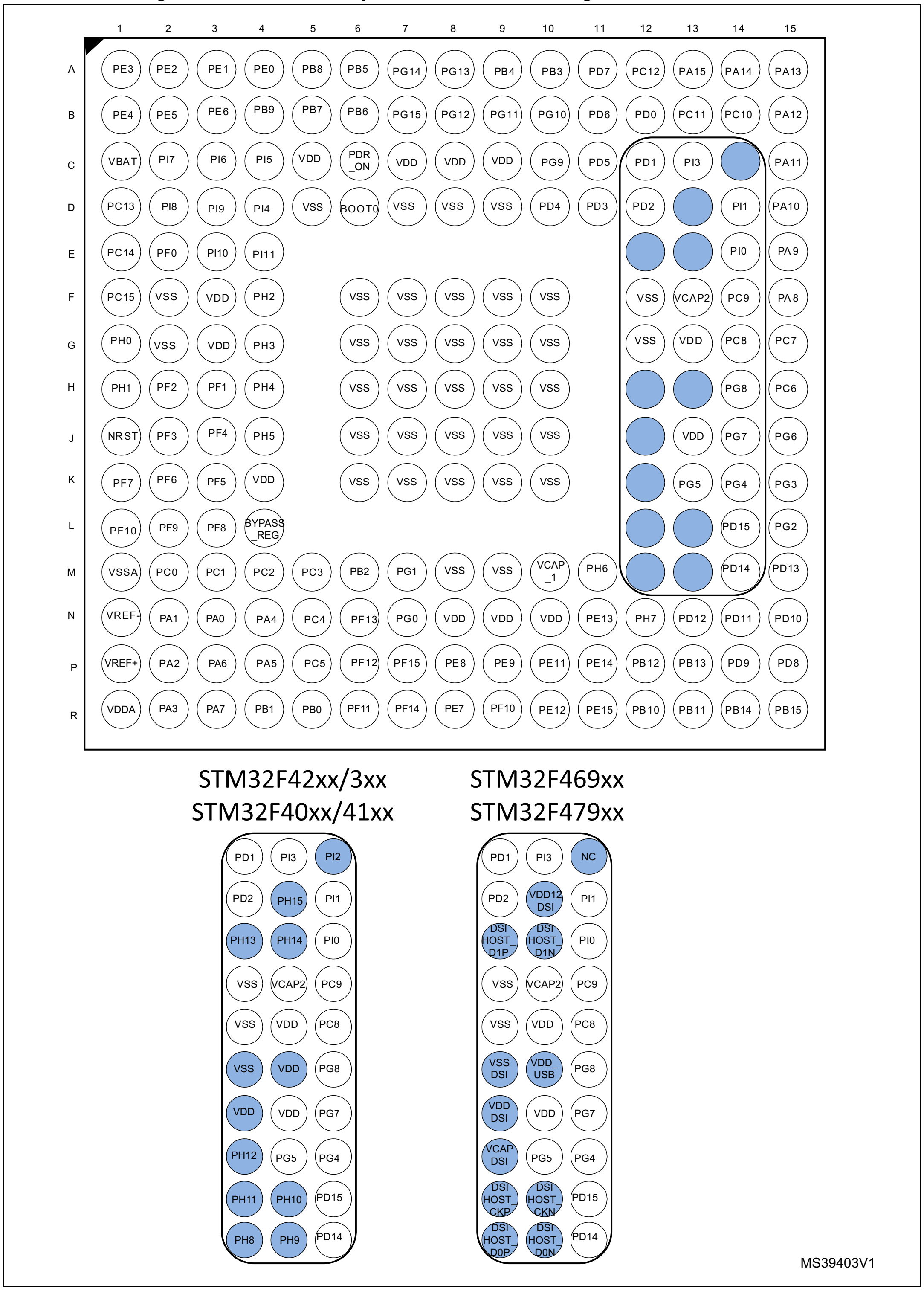
Figure 1 and *Figure 2* show incompatible board designs, respectively, for LQFP176 and LQFP208 packages (highlighted pins).

The UFBGA176 and TFBGA216 ballouts are compatible with other STM32F4xx devices, only few IO port pins are substituted, as shown in *Figure 3* and *Figure 4*.

The LQFP100, LQFP144 and UFBGA169 packages are incompatible with other STM32F4xx devices.

1.1.3 UFBGA176 package

Figure 3. UFBGA176 port-to-terminal assignment differences



1. The highlighted pins are substituted with dedicated DSI IO pins on STM32F469xx/479xx devices.

Like backup SRAM, the RTC and backup registers are supplied through a switch that is powered either from the V_{DD} supply when present or from the V_{BAT} pin.

2.22 Low-power modes

The devices support three low-power modes to achieve the best compromise between low power consumption, short startup time and available wakeup sources:

- **Sleep mode**

  In Sleep mode, only the CPU is stopped. All peripherals continue to operate and can wake up the CPU when an interrupt/event occurs.

- **Stop mode**

  The Stop mode achieves the lowest power consumption while retaining the contents of SRAM and registers. All clocks in the 1.2 V domain are stopped, the PLL, the HSI RC and the HSE crystal oscillators are disabled.

  The voltage regulator can be put either in main regulator mode (MR) or in low-power mode (LPR). Both modes can be configured as follows (see *Table 5*):

  – Normal mode (default mode when MR or LPR is enabled)

  – Under-drive mode.

  The device can be woken up from the Stop mode by any of the EXTI line (the EXTI line source can be one of the 16 external lines, the PVD output, the RTC alarm / wakeup / tamper / time stamp events, the USB OTG FS/HS wakeup or the Ethernet wakeup).

Table 5. Voltage regulator modes in stop mode

Voltage regulator configuration	Main regulator (MR)	Low-power regulator (LPR)
Normal mode	MR ON	LPR ON
Under-drive mode	MR in under-drive mode	LPR in under-drive mode

- **Standby mode**

  The Standby mode is used to achieve the lowest power consumption. The internal voltage regulator is switched off so that the entire 1.2 V domain is powered off. The PLL, the HSI RC and the HSE crystal oscillators are also switched off. After entering Standby mode, the SRAM and register contents are lost except for registers in the backup domain and the backup SRAM when selected.

  The device exits the Standby mode when an external reset (NRST pin), an IWDG reset, a rising edge on the WKUP pin, or an RTC alarm / wakeup / tamper /time stamp event occurs.

  The standby mode is not supported when the embedded voltage regulator is bypassed and the 1.2 V domain is controlled by an external power.

2.23 V_{BAT} operation

The V_{BAT} pin allows to power the device V_{BAT} domain from an external battery, an external supercapacitor, or from V_{DD} when no external battery and an external supercapacitor are present.

2.24.1 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.

2.24.2 General-purpose timers (TIMx)

There are ten synchronizable general-purpose timers embedded in the STM32F46x devices (see *Table 6* for differences).

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

  The STM32F46x 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/down counter and a 16-bit prescaler. The TIM3 and TIM4 timers are based on a 16-bit auto-reload up/down counter 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.

2.24.3 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.

2.24.4 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.

2.24.5 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.

2.24.6 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.

2.25 Inter-integrated circuit interface (I^2C)

Up to three I²C bus interfaces can operate in multimaster and slave modes. They can support the standard (up to 100 KHz), and fast (up to 400 KHz) modes. They support the 7/10-bit addressing mode and the 7-bit dual addressing mode (as slave). A hardware CRC generation/verification is embedded.

They can be served by DMA and they support SMBus 2.0/PMBus.

The devices also include programmable analog and digital noise filters (see *Table 7*).

Table 7. Comparison of I2C analog and digital filters

Filter	Analog	Digital
Pulse width of suppressed spikes	≥ 50 ns	Programmable length from 1 to 15 I2C peripheral clocks

2.26 Universal synchronous/asynchronous receiver transmitters (USART)

The devices embed four universal synchronous/asynchronous receiver transmitters (USART1, USART2, USART3 and USART6) and four universal asynchronous receiver transmitters (UART4, UART5, UART7, and UART8).

These six interfaces provide asynchronous communication, IrDA SIR ENDEC support, multiprocessor communication mode, single-wire half-duplex communication mode and have LIN Master/Slave capability. The USART1 and USART6 interfaces are able to

Table 10. STM32F469xx pin and ball definitions (continued)

Pin number								Pin name (function after reset)(1)	Pin types	I/O structures	Notes	Alternate functions	Additional functions
LQFP100	LQFP144	UFBGA169	WLCSP168	UFBGA176	LQFP176	LQFP208	TFBGA216						
83	115	A9	C4	A12	141	163	A12	PC12	I/O	FT	-	TRACED3, SPI3_MOSI/I2S3_SD, USART3_CK, UART5_TX, SDIO_CK, DCMI_D9, EVENTOUT	-
84	116	C9	E6	B12	142	164	B12	PD0	I/O	FT	-	CAN1_RX, FMC_D2, EVENTOUT	-
85	117	C7	A3	C12	143	165	C12	PD1	I/O	FT	-	CAN1_TX, FMC_D3, EVENTOUT	-
86	118	B8	C5	D12	144	166	D12	PD2	I/O	FT	-	TRACED2, TIM3_ETR, UART5_RX, SDIO_CMD, DCMI_D11, EVENTOUT	-
87	119	C8	D6	D11	145	167	C11	PD3	I/O	FT	-	SPI2_SCK/I2S2_CK, USART2_CTS, FMC_CLK, DCMI_D5, LCD_G7, EVENTOUT	-
88	120	C6	B4	D10	146	168	D11	PD4	I/O	FT	-	USART2_RTS, FMC_NOE, EVENTOUT	-
89	121	B7	C6	C11	147	169	C10	PD5	I/O	FT	-	USART2_TX, FMC_NWE, EVENTOUT	-
-	122	F8	A4	D8	148	170	F8	VSS	S	-	-	-	-
-	123	F7	-	C8	149	171	E9	VDD	S	-	-	-	-
90	124	D7	E7	B11	150	172	B11	PD6	I/O	FT	-	SPI3_MOSI/I2S3_SD, SAI1_SD_A, USART2_RX, FMC_NWAIT, DCMI_D10, LCD_B2, EVENTOUT	-
91	-	A8	A5	A11	151	173	A11	PD7	I/O	FT	-	USART2_CK, FMC_NE1, EVENTOUT	-
-	-	-	-	-	-	174	B10	PJ12	I/O	FT	-	LCD_G3, LCD_B0, EVENTOUT	-
-	-	-	-	-	-	175	B9	PJ13	I/O	FT	-	LCD_G4, LCD_B1, EVENTOUT	-
-	-	-	-	-	-	176	C9	PJ14	I/O	FT	-	LCD_B2, EVENTOUT	-
-	-	-	-	-	-	177	D10	PJ15	I/O	FT	-	LCD_B3, EVENTOUT	-
-	125	E6	D7	C10	152	178	D9	PG9	I/O	FT	-	USART6_RX, QUADSPI_BK2_IO2, FMC_NE2/FMC_NCE, DCMI_VSYNC, EVENTOUT	-
-	126	E7	C7	B10	153	179	C8	PG10	I/O	FT	-	LCD_G3, FMC_NE3, DCMI_D2, LCD_B2, EVENTOUT	-
-	127	B6	B6	B9	154	180	B8	PG11	I/O	FT	-	ETH_MII_TX_EN/ETH_RMII_TX_EN, DCMI_D3, LCD_B3, EVENTOUT	-

Table 10. STM32F469xx pin and ball definitions (continued)

Pin number								Pin name (function after reset)(1)	Pin types	I/O structures	Notes	Alternate functions	Additional functions
LQFP100	LQFP144	UFBGA169	WLCSP168	UFBGA176	LQFP176	LQFP208	TFBGA216						
-	128	A7	A6	B8	155	181	C7	PG12	I/O	FT	-	SPI6_MISO, USART6_RTS, LCD_B4, FMC_NE4, LCD_B1, EVENTOUT	-
-	-	A6	E8	A8	156	182	B3	PG13	I/O	FT	-	TRACED0, SPI6_SCK, USART6_CTS, ETH_MII_TXD0/ETH_RMII_TXD0, FMC_A24, LCD_R0, EVENTOUT	-
-	-	-	-	A7	157	183	A4	PG14	I/O	FT	-	TRACED1, SPI6_MOSI, USART6_TX, QUADSPI_BK2_IO3, ETH_MII_TXD1/ETH_RMII_TXD1, FMC_A25, LCD_B0, EVENTOUT	-
-	129	-	B7	D7	158	184	F7	VSS	S	-	-	-	-
-	130	-	A7	C7	159	185	E8	VDD	S	-	-	-	-
-	-	-	-	-	-	186	D8	PK3	I/O	FT	-	LCD_B4, EVENTOUT	-
-	-	-	-	-	-	187	D7	PK4	I/O	FT	-	LCD_B5, EVENTOUT	-
-	-	-	-	-	-	188	C6	PK5	I/O	FT	-	LCD_B6, EVENTOUT	-
-	-	-	-	-	-	189	C5	PK6	I/O	FT	-	LCD_B7, EVENTOUT	-
-	-	-	-	-	-	190	C4	PK7	I/O	FT	-	LCD_DE, EVENTOUT	-
-	131	F6	D8	B7	160	191	B7	PG15	I/O	FT	-	USART6_CTS, FMC_SDNCAS, DCMI_D13, EVENTOUT	-
92	132	B5	A8	A10	161	192	A10	PB3(JTDO/TRACESWO)	I/O	FT	-	JTDO/TRACESWO, TIM2_CH2, SPI1_SCK, SPI3_SCK/I2S3_CK, EVENTOUT	-
93	133	D6	C8	A9	162	193	A9	PB4(NJTRST)	I/O	FT	-	NJTRST, TIM3_CH1, SPI1_MISO, SPI3_MISO, I2S3ext_SD, EVENTOUT	-
94	134	D5	B8	A6	163	194	A8	PB5	I/O	FT	-	TIM3_CH2, I2C1_SMBA, SPI1_MOSI, SPI3_MOSI/I2S3_SD, CAN2_RX, OTG_HS_ULPI_D7, ETH_PPS_OUT, FMC_SDCKE1, DCMI_D10, LCD_G7, EVENTOUT	-
95	135	C5	G8	B6	164	195	B6	PB6	I/O	FT	-	TIM4_CH1, I2C1_SCL, USART1_TX, CAN2_TX, QUADSPI_BK1_NCS, FMC_SDNE1, DCMI_D5, EVENTOUT	-

Table 11. FMC pin definition (continued)

Pin name	NOR/PSRAM/SRAM	NOR/PSRAM Mux	NAND16	SDRAM
PF8	-	-	-	-
PF9	-	-	-	-
PF10	-	-	-	-
PG6	-	-	-	-
PG7	-	-	INT	-
PE0	NBL0	NBL0	-	NBL0
PE1	NBL1	NBL1	-	NBL1
PI4	NBL2	-	-	NBL2
PI5	NBL3	-	-	NBL3
PG8	-	-	-	SDCLK
PC0	-	-	-	SDNWE
PF11	-	-	-	SDNRAS
PG15	-	-	-	SDNCAS
PH2	-	-	-	SDCKE0
PH3	-	-	-	SDNE0
PH6	-	-	-	SDNE1
PH7	-	-	-	SDCKE1
PH5	-	-	-	SDNWE
PC2	-	-	-	SDNE0
PC3	-	-	-	SDCKE0
PB5	-	-	-	SDCKE1
PB6	-	-	-	SDNE1

Table 12. Alternate function (continued)

Port		AF0	AF1	AF2	AF3	AF4	AF5	AF6	AF7	AF8	AF9	AF10	AF11	AF12	AF13	AF14	AF15
		SYS	TIM1/2	TIM3/4/5	TIM8/9/10/11	I2C1/2/3	SPI1/2/3/4/5/6	SPI2/3/SAI1	SPI2/3/USART1/2/3	USART6/UART4/5/7/8	CAN1/2/TIM12/13/14/QUADSPI/LCD	QUADSPI/OTG2_HS/OTG1_FS	ETH	FMC/SDIO/OTG2_FS	DCMI/DSI HOST	LCD	SYS
Port I	PI0	-	-	TIM5_CH4	-	-	SPI2_NSS/I2S2_WS	-	-	-	-	-	-	FMC_D24	DCMI_D13	LCD_G5	EVENT OUT
	PI1	-	-	-	-	-	SPI2_SCK/I2S2_CK	-	-	-	-	-	-	FMC_D25	DCMI_D8	LCD_G6	EVENT OUT
	PI2	-	-	-	TIM8_CH4	-	SPI2_MISO	I2S2ext_SD	-	-	-	-	-	FMC_D26	DCMI_D9	LCD_G7	EVENT OUT
	PI3	-	-	-	TIM8_ETR	-	SPI2_MOSI/I2S2_SD	-	-	-	-	-	-	FMC_D27	DCMI_D10		EVENT OUT
	PI4	-	-	-	TIM8_BKIN	-	-	-	-	-	-	-	-	FMC_NBL2	DCMI_D5	LCD_B4	EVENT OUT
	PI5	-	-	-	TIM8_CH1	-	-	-	-	-	-	-	-	FMC_NBL3	DCMI_VSYNC	LCD_B5	EVENT OUT
	PI6	-	-	-	TIM8_CH2	-	-	-	-	-	-	-	-	FMC_D28	DCMI_D6	LCD_B6	EVENT OUT
	PI7	-	-	-	TIM8_CH3	-	-	-	-	-	-	-	-	FMC_D29	DCMI_D7	LCD_B7	EVENT OUT
	PI8	-	-	-	-	-	-	-	-	-	-	-	-	-	-		EVENT OUT
	PI9	-	-	-	-	-	-	-	-	-	CAN1_RX	-	-	FMC_D30	-	LCD_VSYNC	EVENT OUT
	PI10	-	-	-	-	-	-	-	-	-	-	-	ETH_MII_RX_ER	FMC_D31	-	LCD_HSYNC	EVENT OUT
	PI11	-	-	-	-	-	-	-	-	-	LCD_G6	OTG_HS_ULPI_DIR	-	-	-	-	EVENT OUT
	PI12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	LCD_HSYNC	EVENT OUT
	PI13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	LCD_VSYNC	EVENT OUT
	PI14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	LCD_CLK	EVENT OUT
	PI15	-	-	-	-	-	-	-	-	-	LCD_G2	-	-	-	-	LCD_R0	EVENT ‘OUT

5.3.12 PLL spread spectrum clock generation (SSCG) characteristics

The spread spectrum clock generation (SSCG) feature allows to reduce electromagnetic interferences (see *Table 54*). It is available only on the main PLL.

Table 44. SSCG parameters constraint

Symbol	Parameter	Min	Typ	Max[(1)]	Unit
f_{Mod}	Modulation frequency	-	-	10	KHz
md	Peak modulation depth	0.25	-	2	%
MODEPER * INCSTEP	-	-	-	$2^{15} - 1$	-

1. Guaranteed by design.

Equation 1

The frequency modulation period (MODEPER) is given by the equation below:

$$\mathrm{MODEPER} = \mathrm{round}[f_{PLL\_IN} / (4 \times f_{Mod})]$$

f_{PLL_IN} and f_{Mod} must be expressed in Hz.

As an example:

If f_{PLL_IN} = 1 MHz, and f_{MOD} = 1 kHz, the modulation depth (MODEPER) is given by equation 1:

$$\mathrm{MODEPER} = \mathrm{round}[10^6 / (4 \times 10^3)] = 250$$

Equation 2

Equation 2 allows to calculate the increment step (INCSTEP):

$$\mathrm{INCSTEP} = \mathrm{round}[((2^{15} - 1) \times md \times \mathrm{PLLN}) / (100 \times 5 \times \mathrm{MODEPER})]$$

f_{VCO_OUT} must be expressed in MHz.

With a modulation depth (md) = ±2 % (4 % peak to peak), and PLLN = 240 (in MHz):

$$\mathrm{INCSTEP} = \mathrm{round}[((2^{15} - 1) \times 2 \times 240) / (100 \times 5 \times 250)] = 126\mathrm{md(quantitazed)}\%$$

An amplitude quantization error may be generated because the linear modulation profile is obtained by taking the quantized values (rounded to the nearest integer) of MODPER and INCSTEP. As a result, the achieved modulation depth is quantized. The percentage quantized modulation depth is given by the following formula:

$$md_{quantized}\% = (\mathrm{MODEPER} \times \mathrm{INCSTEP} \times 100 \times 5) / ((2^{15} - 1) \times \mathrm{PLLN})$$

As a result:

$$md_{quantized}\% = (250 \times 126 \times 100 \times 5) / ((2^{15} - 1) \times 240) = 2.002\%(\mathrm{peak})$$

Table 50. Flash memory programming (continued)

Symbol	Parameter	Conditions	Min(1)	Typ	Max(1)	Unit
t_{ME}	Mass erase time	Program/erase parallelism (PSIZE) = x 8	-	16	32	s
		Program/erase parallelism (PSIZE) = x 16	-	11	22	
		Program/erase parallelism (PSIZE) = x 32	-	8	16	
t_{BE}	Bank erase time	Program/erase parallelism (PSIZE) = x 8	-	16	32	
		Program/erase parallelism (PSIZE) = x 16	-	11	22	
		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	
		8-bit program operation	1.7	-	3.6	

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

Table 51. 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		-	6.9	-	s
t_{BE}	Bank erase time	-	-	6.9	-	s
V_{prog}	Programming voltage	-	2.7	-	3.6	V
V_{PP}	V_{PP} voltage range	-	7	-	9	
I_{PP}	Minimum current sunk on the V_{PP} pin	-	10	-	-	mA
t_{VPP}(3)	Cumulative time during which V_{PP} is applied	-	-	-	1	hour

1. Guaranteed by design.
2. The maximum programming time is measured after 100K erase operations.
3. V_{PP} should only be connected during programming/erasing.

Table 58. I/O static characteristics (continued)

Symbol	Parameter		Conditions	Min	Typ	Max	Unit
V_{HYS}	FT, TTa and NRST I/O input hysteresis		$1.7\ V \leq V_{DD} \leq 3.6\ V$	$10\%V_{DD}$(3)	-	-	V
	BOOT0 I/O input hysteresis		$1.75\ V \leq V_{DD} \leq 3.6\ V$, $-40\ °C \leq T_A \leq 105\ °C$	0.1	-	-	
			$1.7\ V \leq V_{DD} \leq 3.6\ V$, $0\ °C \leq T_A \leq 105\ °C$				
I_{lkg}	I/O input leakage current (4)		$V_{SS} \leq V_{IN} \leq V_{DD}$	-	-	±1	μA
	I/O FT input leakage current (5)		$V_{IN} = 5\ V$	-	-	3	
R_{PU}	Weak pull-up equivalent resistor(6)	All pins except for PA10/PB12 (OTG_FS_ID, OTG_HS_ID)	$V_{IN} = V_{SS}$	30	40	50	kΩ
		PA10/PB12 (OTG_FS_ID, OTG_HS_ID)		7	10	14	
R_{PD}	Weak pull-down equivalent resistor(7)	All pins except for PA10/PB12 (OTG_FS_ID, OTG_HS_ID)	$V_{IN} = V_{DD}$	30	40	50	
		PA10/PB12 (OTG_FS_ID, OTG_HS_ID)		7	10	14	
C_{IO}(8)	I/O pin capacitance		-	-	5	-	pF

1. Guaranteed by design.
2. Tested in production.
3. With a minimum of 200 mV.
4. Leakage could be higher than the maximum value, if negative current is injected on adjacent pins, Refer to *Table 57*
5. To sustain a voltage higher than VDD +0.3 V, the internal pull-up/pull-down resistors must be disabled. Leakage could be higher than the maximum value, if negative current is injected on adjacent pins.Refer to *Table 57*
6. Pull-up resistors are designed with a true resistance in series with a switchable PMOS. This PMOS contribution to the series resistance is minimum (~10% order).
7. Pull-down resistors are designed with a true resistance in series with a switchable NMOS. This NMOS contribution to the series resistance is minimum (~10% order).
8. Hysteresis voltage between Schmitt trigger switching levels. Based on test during characterization.

Table 77. ADC static accuracy at f_{ADC} = 18 MHz(1)

Symbol	Parameter	Test conditions	Typ	Max(2)	Unit
ET	Total unadjusted error	f_{ADC} =18 MHz V_{DDA} = 1.7 to 3.6 V V_{REF} = 1.7 to 3.6 V V_{DDA} –V_{REF} < 1.2 V	±3	±4	LSB
EO	Offset error		±2	±3	
EG	Gain error		±1	±3	
ED	Differential linearity error		±1	±2	
EL	Integral linearity error		±2	±3	

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

Table 78. 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. Based on test during characterization.

Table 79. 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. Based on test during characterization.

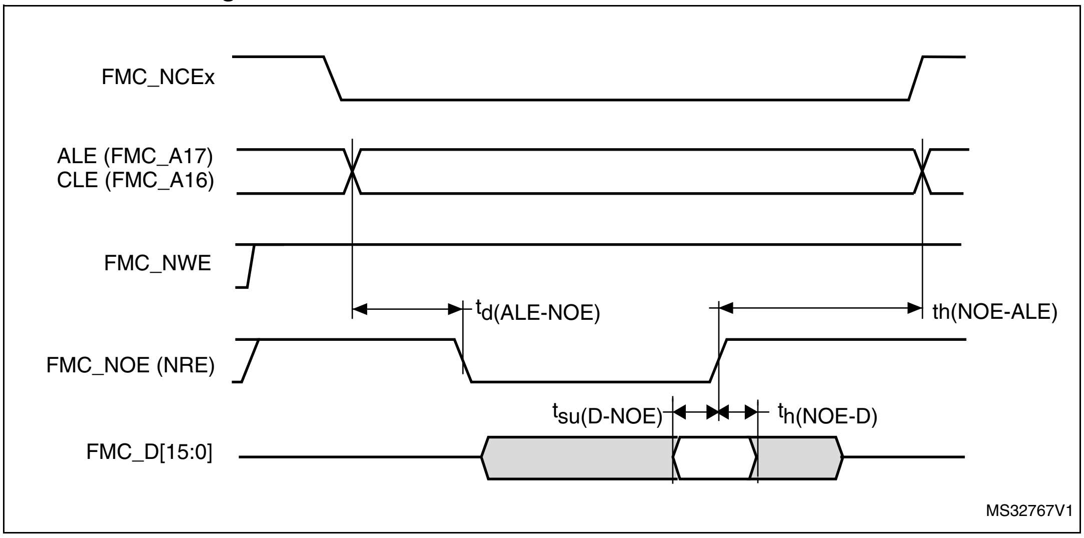
NAND controller waveforms and timings

Figures 67 through 70 represent synchronous waveforms, and Table 100 and Table 101 provide the corresponding timings. The results shown in this table are obtained with the following FMC configuration:

- COM.FMC_SetupTime = 0x01;
- COM.FMC_WaitSetupTime = 0x03;
- COM.FMC_HoldSetupTime = 0x02;
- COM.FMC_HiZSetupTime = 0x01;
- ATT.FMC_SetupTime = 0x01;
- ATT.FMC_WaitSetupTime = 0x03;
- ATT.FMC_HoldSetupTime = 0x02;
- ATT.FMC_HiZSetupTime = 0x01;
- Bank = FMC_Bank_NAND;
- MemoryDataWidth = FMC_MemoryDataWidth_16b;
- ECC = FMC_ECC_Enable;
- ECCPageSize = FMC_ECCPageSize_512Bytes;
- TCLRSetupTime = 0;
- TARSetupTime = 0;
- Capacitive load C_L = 30 pF.

In all timing tables, the T_{HCLK} is the HCLK clock period.

Figure 67. NAND controller waveforms for read access



5.3.30 Quad-SPI interface characteristics

Unless otherwise specified, the parameters given in *Table 106* and *Table 107* for Quad-SPI are derived from tests performed under the ambient temperature, f_{AHB} frequency and V_{DD} supply voltage conditions summarized in Table xx, with the following configuration:

- Output speed is set to OSPEEDRy[1:0] = 11
- Measurement points are done at CMOS levels: 0.5 V_{DD}

Refer to *Section 5.3.20* for more details on the input/output alternate function characteristics.

Table 106. Quad-SPI characteristics in SDR mode(1)

Symbol	Parameter	Test conditions	Min	Typ	Max	Unit
F_{ck} $1/t_{(CK)}$	Quad-SPI clock frequency	2.7 V ≤ V_{DD} ≤ 3.6 V, C_L = 20 pF	-	-	90	MHz
		1.71 V ≤ V_{DD} ≤ 3.6 V, C_L = 15 pF	-	-	84	
$t_{w(CKH)}$	Quad-SPI clock high time	-	$t_{(CK)}/2-1$	-	$t_{(CK)}/2$	ns
$t_{w(CKL)}$	Quad-SPI clock low time	-	$t_{(CK)}/2$	-	$t_{(CK)}/2+1$	
$t_{s(IN)}$	Data input set-up time	-	0.5	-	-	
$t_{h(IN)}$	Data input hold time	-	3	-	-	
$t_{v(OUT)}$	Data output valid time	-	-	3	4	
$t_{h(OUT)}$	Data output hold time	-	2.5	-	-	

1. Guaranteed based on test during characterization.

Figure 73. Quad-SPI SDR timing diagram

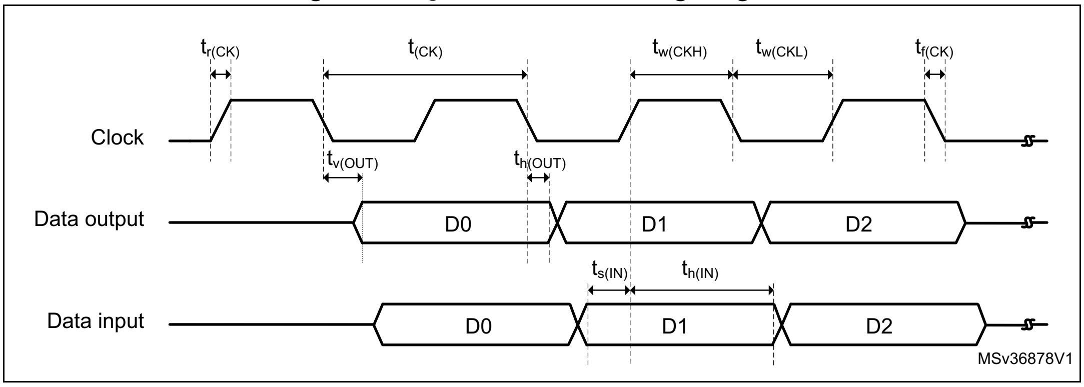


Figure 79. SD default mode

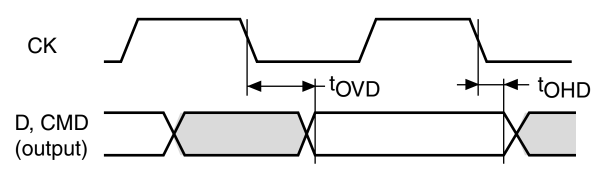


Table 110. Dynamic characteristics: SD / MMC characteristics, V_{DD} = 2.7 to 3.6 V(1)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
f_{PP}	Clock frequency in data transfer mode	-	0	-	50	MHz
-	SDIO_CK/fPCLK2 frequency ratio	-	-	-	8/3	-
$t_{W(CKL)}$	Clock low time	f_{pp} =50 MHz	9.5	10.5	-	ns
$t_{W(CKH)}$	Clock high time		8.5	9.5	-	
CMD, D inputs (referenced to CK) in MMC and SD HS mode						
t_{ISU}	Input setup time HS	f_{pp} =50 MHz	2.0	-	-	ns
t_{IH}	Input hold time HS		2.0	-	-	
CMD, D outputs (referenced to CK) in MMC and SD HS mode						
t_{OV}	Output valid time HS	f_{pp} =50 MHz	-	13	13.5	ns
t_{OH}	Output hold time HS		12.5	-	-	
CMD, D inputs (referenced to CK) in SD default mode						
t_{ISUD}	Input setup time SD	f_{pp} =25 MHz	2.0	-	-	ns
t_{IHD}	Input hold time SD		2.5	-	-	
CMD, D outputs (referenced to CK) in SD default mode						
t_{OVD}	Output valid default time SD	f_{pp} =25 MHz	-	1.5	2.0	ns
t_{OHD}	Output hold default time SD		1.0	-	-	

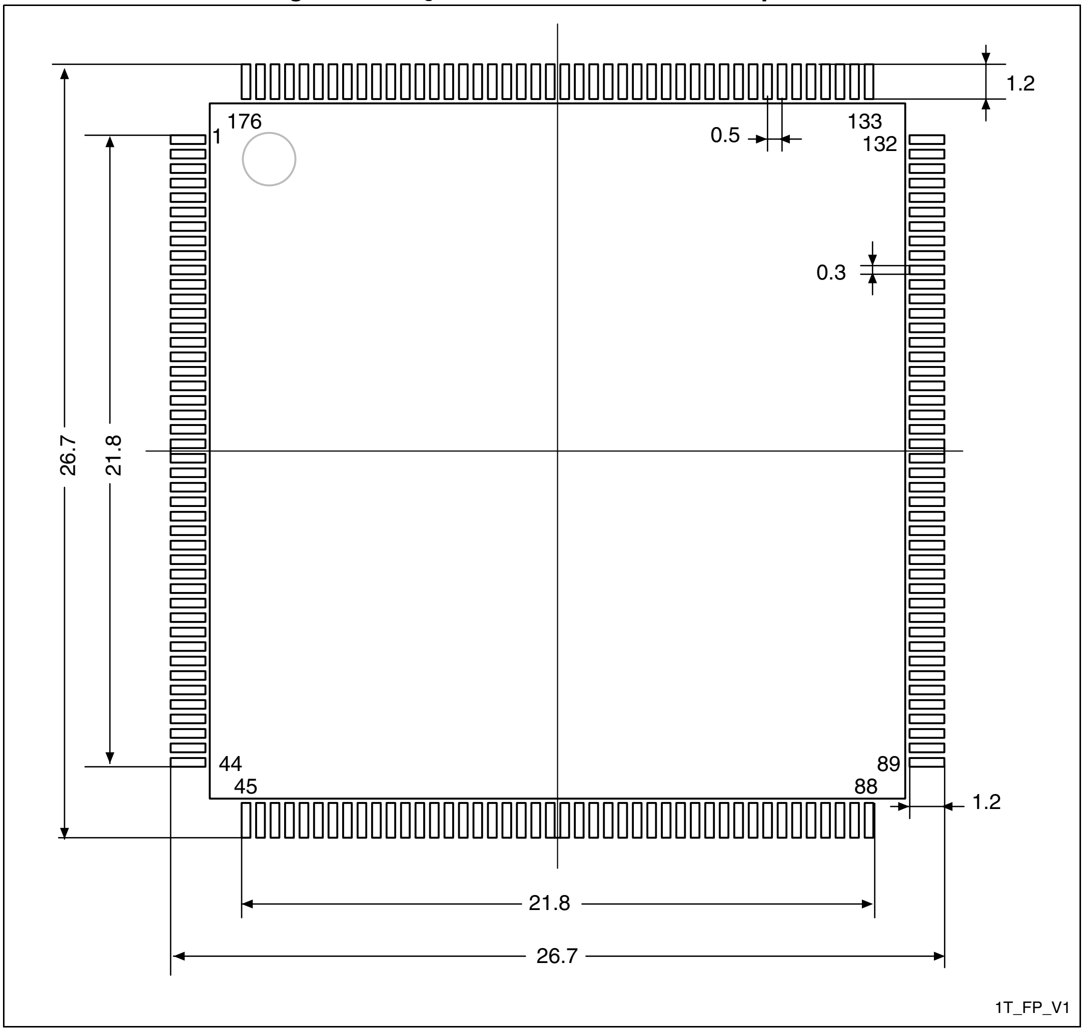
1. Guaranteed based on test during characterization.

Table 115. WLCSP168 - 168-pin, 4.891 x 5.692 mm, 0.4 mm pitch wafer level chip scale package mechanical data

Symbol	millimeters			inches(1)		
	Min	Typ	Max	Min	Typ	Max
A	0.525	0.555	0.585	0.0207	0.0219	0.0230
A1	-	0.170	-	-	0.0067	-
A2	-	0.380	-	-	0.0150	-
A3(2)	-	0.025	-	-	0.0010	-
b(3)	0.220	0.250	0.280	0.0087	0.0098	0.0110
D	4.856	4.891	4.926	0.1912	0.1926	0.1939
E	5.657	5.692	5.727	0.2227	0.2241	0.2255
e	-	0.400	-	-	0.0157	-
e1	-	4.400	-	-	0.1732	-
e2	-	5.200	-	-	0.2047	-
F	-	0.2455	-	-	0.0097	-
G	-	0.246	-	-	0.0097	-
aaa	-	-	0.100	-	-	0.0039
bbb	-	-	0.100	-	-	0.0039
ccc	-	-	0.100	-	-	0.0039
ddd	-	-	0.050	-	-	0.0020
eee	-	-	0.050	-	-	0.0020

1. Values in inches are converted from mm and rounded to 4 decimal digits.
2. Back side coating.
3. Dimension is measured at the maximum bump diameter parallel to primary datum Z.

Figure 90. LQFP176 recommended footprint



1. Dimensions are expressed in millimeters.

Table 120. LQFP208, 28 x 28 mm, 208-pin low-profile quad flat package mechanical data (continued)

Symbol	millimeters			inches[1]		
	Min	Typ	Max	Min	Typ	Max
c	0.090	-	0.200	0.0035	-	0.0079
D	29.800	30.000	30.200	1.1732	1.1811	1.1890
D1	27.800	28.000	28.200	1.0945	1.1024	1.1102
D3	-	25.500	-	-	1.0039	-
E	29.800	30.000	30.200	1.1732	1.1811	1.1890
E1	27.800	28.000	28.200	1.0945	1.1024	1.1102
E3	-	25.500	-	-	1.0039	-
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°	0°	3.5°	7.0°
ccc	-	-	0.080	-	-	0.0031

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

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 124. 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(4)	168 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 and the 128-bit Flash memory, the number of wait states given here does not impact the execution speed from Flash memory since the ART accelerator 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 2.19.1: Internal reset ON).
4. Prefetch is not available. Refer to AN3430 application note for details on how to adjust performance and power.