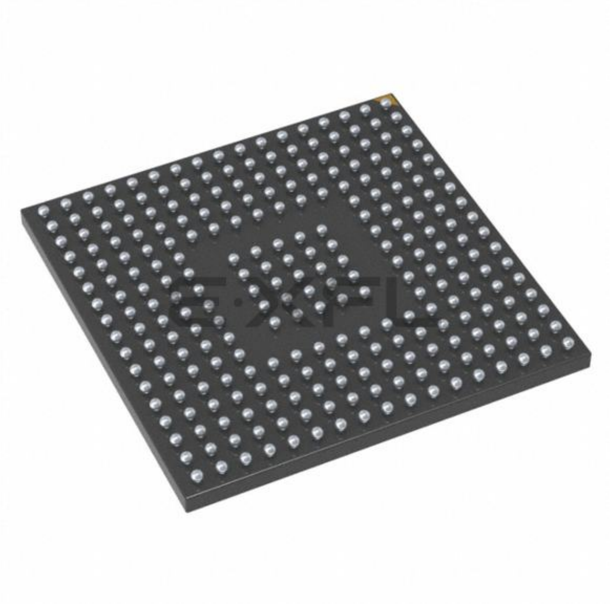

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What is "Embedded - Microcontrollers"?

"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, Ethernet, I²C, IrDA, LINbus, SAI, SD, SPDIF-Rx, SPI, UART/USART, USB OTG
Peripherals	Brown-out Detect/Reset, DMA, I²S, POR, PWM, WDT
Number of I/O	140
Program Memory Size	1MB (1M 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	201-UFBGA
Supplier Device Package	176+25UFBGA (10x10)
Purchase URL	https://www.e-xfl.com/product-detail/stmicroelectronics/stm32f745igk6

SAI1 and SAI2 can be served by the DMA controller

2.27 SPDIFRX Receiver Interface (SPDIFRX)

The SPDIFRX peripheral, is designed to receive an S/PDIF flow compliant with IEC-60958 and IEC-61937. These standards support simple stereo streams up to high sample rate, and compressed multi-channel surround sound, such as those defined by Dolby or DTS (up to 5.1).

The main features of the SPDIFRX are the following:

- Up to 4 inputs available
- Automatic symbol rate detection
- Maximum symbol rate: 12.288 MHz
- Stereo stream from 32 to 192 kHz supported
- Supports Audio IEC-60958 and IEC-61937, consumer applications
- Parity bit management
- Communication using DMA for audio samples
- Communication using DMA for control and user channel information
- Interrupt capabilities

The SPDIFRX receiver provides all the necessary features to detect the symbol rate, and decode the incoming data stream. The user can select the wanted SPDIF input, and when a valid signal will be available, the SPDIFRX will re-sample the incoming signal, decode the manchester stream, recognize frames, sub-frames and blocks elements. It delivers to the CPU decoded data, and associated status flags.

The SPDIFRX also offers a signal named spdif_frame_sync, which toggles at the S/PDIF sub-frame rate that will be used to compute the exact sample rate for clock drift algorithms.

2.28 Audio PLL (PLLI2S)

The devices feature an additional dedicated PLL for audio I^2S and SAI applications. It allows to achieve error-free I^2S sampling clock accuracy without compromising on the CPU performance, while using USB peripherals.

The PLLI2S configuration can be modified to manage an I^2S/SAI sample rate change without disabling the main PLL (PLL) used for CPU, USB and Ethernet interfaces.

The audio PLL can be programmed with very low error to obtain sampling rates ranging from 8 KHz to 192 KHz.

In addition to the audio PLL, a master clock input pin can be used to synchronize the I^2S/SAI flow with an external PLL (or Codec output).

This dual digital Interface supports the following features:

- two DAC converters: one for each output channel
- 8-bit or 12-bit monotonic output
- left or right data alignment in 12-bit mode
- synchronized update capability
- noise-wave generation
- triangular-wave generation
- dual DAC channel independent or simultaneous conversions
- DMA capability for each channel
- external triggers for conversion
- input voltage reference V_{REF+}

Eight DAC trigger inputs are used in the device. The DAC channels are triggered through the timer update outputs that are also connected to different DMA streams.

2.42 Serial wire JTAG debug port (SWJ-DP)

The ARM SWJ-DP interface is embedded, and is a combined JTAG and serial wire debug port that enables either a serial wire debug or a JTAG probe to be connected to the target.

Debug is performed using 2 pins only instead of 5 required by the JTAG (JTAG pins could be re-use as GPIO with alternate function): the JTAG TMS and TCK pins are shared with SWDIO and SWCLK, respectively, and a specific sequence on the TMS pin is used to switch between JTAG-DP and SW-DP.

2.43 Embedded Trace Macrocell™

The ARM Embedded Trace Macrocell provides a greater visibility of the instruction and data flow inside the CPU core by streaming compressed data at a very high rate from the STM32F74xxx through a small number of ETM pins to an external hardware trace port analyzer (TPA) device. The TPA is connected to a host computer using USB, Ethernet, or any other high-speed channel. Real-time instruction and data flow activity can be recorded and then formatted for display on the host computer that runs the debugger software. TPA hardware is commercially available from common development tool vendors.

The Embedded Trace Macrocell operates with third party debugger software tools.

Table 9. Legend/abbreviations used in the pinout table

Name	Abbreviation	Definition
Pin name	Unless otherwise specified in brackets below the pin name, the pin function during and after reset is the same as the actual pin name	
Pin type	S	Supply pin
	I	Input only pin
	I/O	Input / output pin
I/O structure	FT	5 V tolerant I/O
	TTa	3.3 V tolerant I/O directly connected to ADC
	B	Dedicated BOOT pin
	RST	Bidirectional reset pin with weak pull-up resistor
Notes	Unless otherwise specified by a note, all I/Os are set as floating inputs during and after reset	
Alternate functions	Functions selected through GPIOx_AFR registers	
Additional functions	Functions directly selected/enabled through peripheral registers	

Table 10. STM32F745xx and STM32F746xx pin and ball definition

Pin Number								Pin name (function after reset)(1)	Pin type	I/O structure	Notes	Alternate functions	Additional functions
LQFP100	TFBGA100	WLCSP143	LQFP144	UFBGA176	LQFP176	LQFP208	TFBGA216						
1	A3	D8	1	A2	1	1	A3	PE2	I/O	FT	-	TRACECLK, SPI4_SCK, SAI1_MCLK_A, QUADSPI_BK1_IO2, ETH_MII_TXD3, FMC_A23, EVENTOUT	-
2	B3	C10	2	A1	2	2	A2	PE3	I/O	FT	-	TRACED0, SAI1_SD_B, FMC_A19, EVENTOUT	-
3	C3	B11	3	B1	3	3	A1	PE4	I/O	FT	-	TRACED1, SPI4_NSS, SAI1_FS_A, FMC_A20, DCMI_D4, LCD_B0, EVENTOUT	-

Table 12. STM32F745xx and STM32F746xx alternate function mapping (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/LPTIM1/CEC	I2C1/2/3/4/CEC	SPI1/2/3/4/5/6	SPI3/SAI1	SPI2/3/USART1/2/3/UART5/SPDIFRX	SAI2/USART6/UART4/5/7/8/SPDIFRX	CAN1/2/TIM12/13/14/QUADSPI/LCD	SAI2/QUADSPI/OTG2_HS/OTG1_FS	ETH/OTG1_FS	FMC/SDMMC1/OTG2_FS	DCMI	LCD	SYS
Port D	PD0	-	-	-	-	-	-	-	-	-	CAN1_RX	-	-	FMC_D2	-	-	EVENTOUT
	PD1	-	-	-	-	-	-	-	-	-	CAN1_TX	-	-	FMC_D3	-	-	EVENTOUT
	PD2	TRACED2	-	TIM3_ETR	-	-	-	-	-	UART5_RX	-	-	-	SDMMC1_CMD	DCMI_D11	-	EVENTOUT
	PD3	-	-	-	-	-	SPI2_SCK/I2S2_CK	-	USART2_CTS	-	-	-	-	FMC_CLK	DCMI_D5	LCD_G7	EVENTOUT
	PD4	-	-	-	-	-	-	-	USART2_RTS	-	-	-	-	FMC_NOE	-	-	EVENTOUT
	PD5	-	-	-	-	-	-	-	USART2_TX	-	-	-	-	FMC_NWE	-	-	EVENTOUT
	PD6	-	-	-	-	-	SPI3_MOSI/I2S3_SD	SAI1_SD_A	USART2_RX	-	-	-	-	FMC_NWAIT	DCMI_D10	LCD_B2	EVENTOUT
	PD7	-	-	-	-	-	-	-	USART2_CK	SPDIFRX_IN0	-	-	-	FMC_NE1	-	-	EVENTOUT
	PD8	-	-	-	-	-	-	-	USART3_TX	SPDIFRX_IN1	-	-	-	FMC_D13	-	-	EVENTOUT
	PD9	-	-	-	-	-	-	-	USART3_RX	-	-	-	-	FMC_D14	-	-	EVENTOUT
	PD10	-	-	-	-	-	-	-	USART3_CK	-	-	-	-	FMC_D15	-	LCD_B3	EVENTOUT
	PD11	-	-	-	-	I2C4_SMBA	-	-	USART3_CTS	-	QUADSPI_BK1_IO0	SAI2_SD_A	-	FMC_A16/FMC_CLE	-	-	EVENTOUT
	PD12	-	-	TIM4_CH1	LPTIM1_IN1	I2C4_SCL	-	-	USART3_RTS	-	QUADSPI_BK1_IO1	SAI2_FS_A	-	FMC_A17/FMC_ALE	-	-	EVENTOUT
	PD13	-	-	TIM4_CH2	LPTIM1_OUT	I2C4_SDA	-	-	-	-	QUADSPI_BK1_IO3	SAI2_SCK_A	-	FMC_A18	-	-	EVENTOUT

Table 12. STM32F745xx and STM32F746xx alternate function mapping (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/LPTIM1/CEC	I2C1/2/3/4/CEC	SPI1/2/3/4/5/6	SPI3/SAI1	SPI2/3/USART1/2/3/UART5/SPDIFRX	SAI2/USART6/UART4/5/7/8/SPDIFRX	CAN1/2/TIM12/13/14/QUADSPI/LCD	SAI2/QUADSPI/OTG2_HS/OTG1_FS	ETH/OTG1_FS	FMC/SDMMC1/OTG2_FS	DCMI	LCD	SYS
Port G	PG11	-	-	-	-	-	-	-	SPDIFRX_IN0	-	-	-	ETH_MII_TX_EN/ETH_RMII_TX_EN	-	DCMI_D3	LCD_B3	EVENTOUT
	PG12	-	-	-	LPTIM1_IN1	-	SPI6_MISO	-	SPDIFRX_IN1	USART6_RTS	LCD_B4	-	-	FMC_NE4	-	LCD_B1	EVENTOUT
	PG13	TRACED0	-	-	LPTIM1_OUT	-	SPI6_SCK	-	-	USART6_CTS	-	-	ETH_MII_TXD0/ETH_RMII_TXD0	FMC_A24	-	LCD_R0	EVENTOUT
	PG14	TRACED1	-	-	LPTIM1_ETR	-	SPI6_MOSI	-	-	USART6_TX	QUADSPI_BK2_IO3	-	ETH_MII_TXD1/ETH_RMII_TXD1	FMC_A25	-	LCD_B0	EVENTOUT
	PG15	-	-	-	-	-	-	-	-	USART6_CTS	-	-	-	FMC_SDNCAS	DCMI_D13	-	EVENTOUT
Port H	PH0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	EVENTOUT
	PH1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	EVENTOUT
	PH2	-	-	-	LPTIM1_IN2	-	-	-	-	-	QUADSPI_BK2_IO0	SAI2_SCK_B	ETH_MII_CRS	FMC_SDCKE0	-	LCD_R0	EVENTOUT
	PH3	-	-	-	-	-	-	-	-	-	QUADSPI_BK2_IO1	SAI2_MCK_B	ETH_MII_COL	FMC_SDNE0	-	LCD_R1	EVENTOUT
	PH4	-	-	-	-	I2C2_SCL	-	-	-	-	-	OTG_HS_ULPI_NXT	-	-	-	-	EVENTOUT
	PH5	-	-	-	-	I2C2_SDA	SPI5_NSS	-	-	-	-	-	-	FMC_SDNWE	-	-	EVENTOUT
	PH6	-	-	-	-	I2C2_SMBA	SPI5_SCK	-	-	-	TIM12_CH1	-	ETH_MII_RXD2	FMC_SDNE1	DCMI_D8	-	EVENTOUT
	PH7	-	-	-	-	I2C3_SCL	SPI5_MISO	-	-	-	-	-	ETH_MII_RXD3	FMC_SDCKE1	DCMI_D9	-	EVENTOUT

Table 13. STM32F745xx and STM32F746xx register boundary addresses (continued)

Bus	Boundary address	Peripheral
	0x4008 0000- 0x4FFF FFFF	Reserved
AHB1	0x4004 0000 - 0x4007 FFFF	USB OTG HS
	0x4002 BC00- 0x4003 FFFF	Reserved
	0x4002 B000 - 0x4002 BBFF	Chrom-ART (DMA2D)
	0x4002 9400 - 0x4002 AFFF	Reserved
	0x4002 9000 - 0x4002 93FF	ETHERNET MAC
	0x4002 8C00 - 0x4002 8FFF	
	0x4002 8800 - 0x4002 8BFF	
	0x4002 8400 - 0x4002 87FF	
	0x4002 8000 - 0x4002 83FF	
	0x4002 6800 - 0x4002 7FFF	Reserved
	0x4002 6400 - 0x4002 67FF	DMA2
	0x4002 6000 - 0x4002 63FF	DMA1
	0x4002 5000 - 0X4002 5FFF	Reserved
	0x4002 4000 - 0x4002 4FFF	BKPSRAM
	0x4002 3C00 - 0x4002 3FFF	Flash interface register
	0x4002 3800 - 0x4002 3BFF	RCC
	0X4002 3400 - 0X4002 37FF	Reserved
	0x4002 3000 - 0x4002 33FF	CRC
	0x4002 2C00 - 0x4002 2FFF	Reserved
	0x4002 2800 - 0x4002 2BFF	GPIOK
	0x4002 2400 - 0x4002 27FF	GPIOJ
	0x4002 2000 - 0x4002 23FF	GPIOI
	0x4002 1C00 - 0x4002 1FFF	GPIOH
	0x4002 1800 - 0x4002 1BFF	GPIOG
	0x4002 1400 - 0x4002 17FF	GPIOF
	0x4002 1000 - 0x4002 13FF	GPIOE
	0X4002 0C00 - 0x4002 0FFF	GPIOD
	0x4002 0800 - 0x4002 0BFF	GPIOC
	0x4002 0400 - 0x4002 07FF	GPIOB
	0x4002 0000 - 0x4002 03FF	GPIOA

Table 13. STM32F745xx and STM32F746xx register boundary addresses (continued)

Bus	Boundary address	Peripheral
	0x4000 8000- 0x4000 FFFF	Reserved
APB1	0x4000 7C00 - 0x4000 7FFF	UART8
	0x4000 7800 - 0x4000 7BFF	UART7
	0x4000 7400 - 0x4000 77FF	DAC
	0x4000 7000 - 0x4000 73FF	PWR
	0x4000 6C00 - 0x4000 6FFF	HDMI-CEC
	0x4000 6800 - 0x4000 6BFF	CAN2
	0x4000 6400 - 0x4000 67FF	CAN1
	0x4000 6000 - 0x4000 63FF	I2C4
	0x4000 5C00 - 0x4000 5FFF	I2C3
	0x4000 5800 - 0x4000 5BFF	I2C2
	0x4000 5400 - 0x4000 57FF	I2C1
	0x4000 5000 - 0x4000 53FF	UART5
	0x4000 4C00 - 0x4000 4FFF	UART4
	0x4000 4800 - 0x4000 4BFF	USART3
	0x4000 4400 - 0x4000 47FF	USART2
	0x4000 4000 - 0x4000 43FF	SPDIFRX
	0x4000 3C00 - 0x4000 3FFF	SPI3 / I2S3
	0x4000 3800 - 0x4000 3BFF	SPI2 / I2S2
	0x4000 3400 - 0x4000 37FF	Reserved
	0x4000 3000 - 0x4000 33FF	IWDG
	0x4000 2C00 - 0x4000 2FFF	WWDG
	0x4000 2800 - 0x4000 2BFF	RTC & BKP Registers
	0x4000 2400 - 0x4000 27FF	LPTIM1
	0x4000 2000 - 0x4000 23FF	TIM14
	0x4000 1C00 - 0x4000 1FFF	TIM13
	0x4000 1800 - 0x4000 1BFF	TIM12
	0x4000 1400 - 0x4000 17FF	TIM7
	0x4000 1000 - 0x4000 13FF	TIM6
	0x4000 0C00 - 0x4000 0FFF	TIM5
	0x4000 0800 - 0x4000 0BFF	TIM4
	0x4000 0400 - 0x4000 07FF	TIM3
	0x4000 0000 - 0x4000 03FF	TIM2

Typical and maximum current consumption

The MCU is placed under the following conditions:

- All I/O pins are in input mode with a static value at V_{DD} or V_{SS} (no load).
- All peripherals are disabled except if it is explicitly mentioned.
- The Flash memory access time is adjusted both to f_{HCLK} frequency and V_{DD} range (see *Table 18: Limitations depending on the operating power supply range*).
- When the regulator is ON, the voltage scaling and over-drive mode are adjusted to f_{HCLK} frequency as follows:
  - Scale 3 for $f_{HCLK} \leq 144$ MHz
  - Scale 2 for 144 MHz < $f_{HCLK} \leq 168$ MHz
  - Scale 1 for 168 MHz < $f_{HCLK} \leq 216$ MHz. The over-drive is only ON at 216 MHz.
- When the regulator is OFF, the V12 is provided externally as described in *Table 17: General operating conditions*:
- The system clock is HCLK, $f_{PCLK1} = f_{HCLK}/4$, and $f_{PCLK2} = f_{HCLK}/2$.
- External clock frequency is 25 MHz and PLL is ON when f_{HCLK} is higher than 25 MHz.
- The typical current consumption values are obtained for 1.7 V ≤ V_{DD} ≤ 3.6 V voltage range and for T_A= 25 °C unless otherwise specified.
- The maximum values are obtained for 1.7 V ≤ V_{DD} ≤ 3.6 V voltage range and a maximum ambient temperature (T_A) unless otherwise specified.
- For the voltage range 1.7 V ≤ V_{DD} ≤ 3.6 V, the maximum frequency is 180 MHz.

Table 24. Typical and maximum current consumption in Run mode, code with data processing running from ITCM RAM, 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	178	208(4)	230(4)	-	mA
			200	165	193	212	230	
			180	147	171(4)	185(4)	198(4)	
			168	130	152	164	177	
			144	100	116	127	137	
			60	44	52	63	73	
			25	21	25	36	46	
		All peripherals disabled(3)	216	102	120(4)	141(4)	-	
			200	95	111	131	149	
			180	84	98(4)	112(4)	125(4)	
			168	75	87	100	112	
			144	58	67	77	88	
			60	25	30	41	51	
			25	12	15	25	36	

1. Guaranteed by characterization results.

Table 35. Peripheral current consumption (continued)

Peripheral		I_{DD}(Typ)[1]			Unit
		Scale 1	Scale 2	Scale 3	
APB1 (up to 54 MHz)	TIM2	19.8	18.7	16.1	µA/MHz
	TIM3	16.6	15.1	13.6	
	TIM4	16.2	15.1	13.3	
	TIM5	19	17.8	15.8	
	TIM6	3	2.7	2.5	
	TIM7	3	2.7	2.5	
	TIM12	12.4	11.3	10.3	
	TIM13	6	5.3	5	
	TIM14	6	5.3	5	
	LPTIM1	9.4	8.7	8.1	
	WWDG	1.8	1.6	1.4	
	SPI2/I2S2[3]	3	2.9	2.8	
	SPI3/I2S3[3]	3.2	2.9	2.8	
	SPDIFRX	2.2	2	1.7	
	USART2	12.8	12	10.8	
	USART3	15.6	14.2	13.1	
	UART4	11.8	10.7	9.7	
	UART5	11.2	10	9.2	
	I2C1	9.8	8.7	7.8	
	I2C2	8.6	7.8	7.2	
	I2C3	8.6	7.8	7.2	
	I2C4	12	10.9	9.7	
	CAN1	6.8	6	5.6	
	CAN2	6.8	6	5.8	
	CEC	1	0.7	0.8	
	PWR	1.2	0.9	0.8	
	DAC[4]	3	2.7	2.5	
	UART7	12.4	11.6	10	
	UART8	10.4	9.3	8.6	

Table 50. Flash memory endurance and data retention

Symbol	Parameter	Conditions	Value Min(1)	Unit
N_{END}	Endurance	T_A = –40 to +85 °C (6 suffix versions) T_A = –40 to +105 °C (7 suffix versions)	10	kcycles
t_{RET}	Data retention	1 kcycle(2) at T_A = 85 °C	30	Years
		1 kcycle(2) at T_A = 105 °C	10	
		10 kcycles(2) at T_A = 55 °C	20	

1. Guaranteed by characterization results.
2. Cycling performed over the whole temperature range.

5.3.14 EMC characteristics

Susceptibility tests are performed on a sample basis during device characterization.

Functional EMS (electromagnetic susceptibility)

While a simple application is executed on the device (toggling 2 LEDs through I/O ports). the device is stressed by two electromagnetic events until a failure occurs. The failure is indicated by the LEDs:

- **Electrostatic discharge (ESD)** (positive and negative) is applied to all device pins until a functional disturbance occurs. This test is compliant with the IEC 61000-4-2 standard.
- **FTB**: A burst of fast transient voltage (positive and negative) is applied to V_{DD} and V_{SS} through a 100 pF capacitor, until a functional disturbance occurs. This test is compliant with the IEC 61000-4-4 standard.

A device reset allows normal operations to be resumed.

The test results are given in *Table 51*. They are based on the EMS levels and classes defined in application note AN1709.

Table 51. EMS characteristics

Symbol	Parameter	Conditions	Level/ Class
V_{FESD}	Voltage limits to be applied on any I/O pin to induce a functional disturbance	V_{DD} = 3.3 V, LQFP176, T_A = +25 °C, f_{HCLK} = 216 MHz, conforms to IEC 61000-4-2	2B
V_{EFTB}	Fast transient voltage burst limits to be applied through 100 pF on V_{DD} and V_{SS} pins to induce a functional disturbance	V_{DD} = 3.3 V, TFBGA216, T_A =+25 °C, f_{HCLK} = 216 MHz, conforms to IEC 61000-4-2	4A

As a consequence, it is recommended to add a serial resistor (1 kΩ) located as close as possible to the MCU to the pins exposed to noise (connected to tracks longer than 50 mm on PCB).

5.3.19 TIM timer characteristics

The parameters given in *Table 60* are guaranteed by design.

Refer to *Section 5.3.17: I/O port characteristics* for details on the input/output alternate function characteristics (output compare, input capture, external clock, PWM output).

Table 60. TIMx characteristics(1)(2)

Symbol	Parameter	Conditions(3)	Min	Max	Unit
$t_{res(TIM)}$	Timer resolution time	AHB/APBx prescaler=1 or 2 or 4, $f_{TIMxCLK}$ = 216 MHz	1	-	$t_{TIMxCLK}$
		AHB/APBx prescaler>4, $f_{TIMxCLK}$ = 108 MHz	1	-	$t_{TIMxCLK}$
f_{EXT}	Timer external clock frequency on CH1 to CH4	$f_{TIMxCLK}$ = 216 MHz	0	$f_{TIMxCLK}/2$	MHz
Res_{TIM}	Timer resolution		-	16/32	bit
t_{MAX_COUNT}	Maximum possible count with 32-bit counter	-	-	65536 × 65536	$t_{TIMxCLK}$

1. TIMx is used as a general term to refer to the TIM1 to TIM12 timers.
2. Guaranteed by design.
3. The maximum timer frequency on APB1 or APB2 is up to 216 MHz, by setting the TIMPRE bit in the RCC_DCKCFGR register, if APBx prescaler is 1 or 2 or 4, then TIMxCLK = HCLK, otherwise TIMxCLK = 4x PCLKx.

5.3.20 RTC characteristics

Table 61. RTC characteristics

Symbol	Parameter	Conditions	Min	Max
-	f_{PCLK1}/RTCCLK frequency ratio	Any read/write operation from/to an RTC register	4	-

5.3.21 12-bit ADC characteristics

Unless otherwise specified, the parameters given in *Table 62* are derived from tests performed under the ambient temperature, f_{PCLK2} frequency and V_{DDA} supply voltage conditions summarized in *Table 17*.

Table 62. ADC characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{DDA}	Power supply	$V_{DDA} - V_{REF+} < 1.2$ V	1.7(1)	-	3.6	V
V_{REF+}	Positive reference voltage		1.7(1)	-	V_{DDA}	V
V_{REF-}	Negative reference voltage	-	-	0	-	V

Table 71. internal reference voltage (continued)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
T_{Coeff}(2)	Temperature coefficient	-	-	30	50	ppm/°C
t_{START}(2)	Startup time	-	-	6	10	µs

1. Shortest sampling time can be determined in the application by multiple iterations.
2. Guaranteed by design.

Table 72. Internal reference voltage calibration values

Symbol	Parameter	Memory address
V_{REFIN_CAL}	Raw data acquired at temperature of 30 °C V_{DDA} = 3.3 V	0x1FF0 F44A - 0x1FF0 F44B

5.3.25 DAC electrical characteristics

Table 73. DAC characteristics

Symbol	Parameter	Min	Typ	Max	Unit	Comments
V_{DDA}	Analog supply voltage	1.7(1)	-	3.6	V	-
V_{REF+}	Reference supply voltage	1.7(1)	-	3.6	V	$V_{REF+} \leq V_{DDA}$
V_{SSA}	Ground	0	-	0	V	-
R_{LOAD}(2)	Resistive load with buffer ON	5	-	-	kΩ	-
R_O(2)	Impedance output with buffer OFF	-	-	15	kΩ	When the buffer is OFF, the Minimum resistive load between DAC_OUT and V_{SS} to have a 1% accuracy is 1.5 MΩ
C_{LOAD}(2)	Capacitive load	-	-	50	pF	Maximum capacitive load at DAC_OUT pin (when the buffer is ON).
DAC_OUT min(2)	Lower DAC_OUT voltage with buffer ON	0.2	-	-	V	It gives the maximum output excursion of the DAC. It corresponds to 12-bit input code (0x0E0) to (0xF1C) at V_{REF+} = 3.6 V and (0x1C7) to (0xE38) at V_{REF+} = 1.7 V
DAC_OUT max(2)	Higher DAC_OUT voltage with buffer ON	-	-	V_{DDA} – 0.2	V	
DAC_OUT min(2)	Lower DAC_OUT voltage with buffer OFF	-	0.5	-	mV	It gives the maximum output excursion of the DAC.
DAC_OUT max(2)	Higher DAC_OUT voltage with buffer OFF	-	-	V_{REF+} – 1LSB	V	
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

USB OTG full speed (FS) characteristics

This interface is present in both the USB OTG HS and USB OTG FS controllers.

Table 79. USB OTG full speed startup time

Symbol	Parameter	Max	Unit
$t_{STARTUP}$(1)	USB OTG full speed transceiver startup time	1	µs

1. Guaranteed by design.

Table 80. USB OTG full speed DC electrical characteristics

Symbol		Parameter	Conditions	Min. (1)	Typ.	Max. (1)	Unit
Input levels	V_{DDUSB}	USB OTG full speed transceiver operating voltage	-	3.0(2)	-	3.6	V
	V_{DI}(3)	Differential input sensitivity	I(USB_FS_DP/DM, USB_HS_DP/DM)	0.2	-	-	V
	V_{CM}(3)	Differential common mode range	Includes V_{DI} range	0.8	-	2.5	
	V_{SE}(3)	Single ended receiver threshold	-	1.3	-	2.0	
Output levels	V_{OL}	Static output level low	R_L of 1.5 kΩ to 3.6 V(4)	-	-	0.3	V
	V_{OH}	Static output level high	R_L of 15 kΩ to V_{SS}(4)	2.8	-	3.6	
R_{PD}		PA11, PA12, PB14, PB15 (USB_FS_DP/DM, USB_HS_DP/DM)	$V_{IN} = V_{DD}$	17	21	24	kΩ
		PA9, PB13 (OTG_FS_VBUS, OTG_HS_VBUS)		0.65	1.1	2.0	
R_{PU}		PA12, PB15 (USB_FS_DP, USB_HS_DP)	$V_{IN} = V_{SS}$	1.5	1.8	2.1	
		PA9, PB13 (OTG_FS_VBUS, OTG_HS_VBUS)	$V_{IN} = V_{SS}$	0.25	0.37	0.55	

1. All the voltages are measured from the local ground potential.
2. The USB OTG full speed transceiver functionality is ensured down to 2.7 V but not the full USB full speed electrical characteristics which are degraded in the 2.7-to-3.0 V V_{DDUSB} voltage range.
3. Guaranteed by design.
4. R_L is the load connected on the USB OTG full speed drivers.

Note: When VBUS sensing feature is enabled, PA9 and PB13 should be left at their default state (floating input), not as alternate function. A typical 200 µA current consumption of the sensing block (current to voltage conversion to determine the different sessions) can be observed on PA9 and PB13 when the feature is enabled.

Table 83. USB HS clock timing parameters[1]

Symbol	Parameter		Min	Typ	Max	Unit
-	f_{HCLK} value to guarantee proper operation of USB HS interface		30	-	-	MHz
F_{START_8BIT}	Frequency (first transition)	8-bit ±10%	54	60	66	MHz
F_{STEADY}	Frequency (steady state) ±500 ppm		59.97	60	60.03	MHz
D_{START_8BIT}	Duty cycle (first transition)	8-bit ±10%	40	50	60	%
D_{STEADY}	Duty cycle (steady state) ±500 ppm		49.975	50	50.025	%
t_{STEADY}	Time to reach the steady state frequency and duty cycle after the first transition		-	-	1.4	ms
t_{START_DEV}	Clock startup time after the de-assertion of SuspendM	Peripheral	-	-	5.6	ms
t_{START_HOST}		Host	-	-	-	
t_{PREP}	PHY preparation time after the first transition of the input clock		-	-	-	µs

1. Guaranteed by design.

Figure 54. ULPI timing diagram

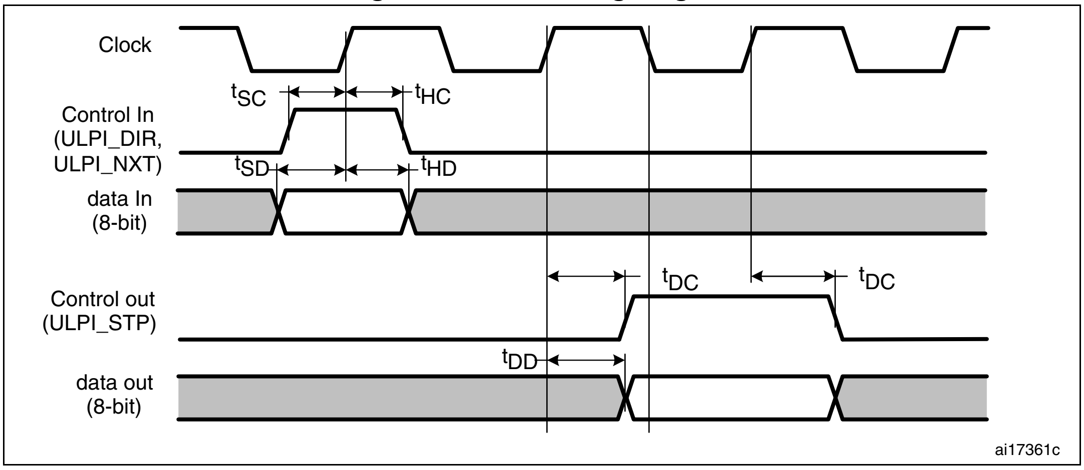


Table 92. Asynchronous multiplexed PSRAM/NOR read timings(1)

Symbol	Parameter	Min	Max	Unit
$t_{w(NE)}$	FMC_NE low time	$3T_{HCLK}-0.5$	$3T_{HCLK}+1.5$	ns
$t_{v(NOE\_NE)}$	FMC_NEx low to FMC_NOE low	$2T_{HCLK}-1$	$2T_{HCLK}+0.5$	
$t_{tw(NOE)}$	FMC_NOE low time	$T_{HCLK}-0.5$	$T_{HCLK}+0.5$	
$t_{h(NE\_NOE)}$	FMC_NOE high to FMC_NE high hold time	0	-	
$t_{v(A\_NE)}$	FMC_NEx low to FMC_A valid	-	0.5	
$t_{v(NADV\_NE)}$	FMC_NEx low to FMC_NADV low	0	0.5	
$t_{w(NADV)}$	FMC_NADV low time	$T_{HCLK}-0.5$	$T_{HCLK}+1.5$	
$t_{h(AD\_NADV)}$	FMC_AD(address) valid hold time after FMC_NADV high)	0	-	
$t_{h(A\_NOE)}$	Address hold time after FMC_NOE high	$T_{HCLK}-0.5$	-	
$t_{h(BL\_NOE)}$	FMC_BL time after FMC_NOE high	0	-	
$t_{v(BL\_NE)}$	FMC_NEx low to FMC_BL valid	-	0.5	
$t_{su(Data\_NE)}$	Data to FMC_NEx high setup time	$T_{HCLK}-2$	-	
$t_{su(Data\_NOE)}$	Data to FMC_NOE high setup time	$T_{HCLK}-2$	-	
$t_{h(Data\_NE)}$	Data hold time after FMC_NEx high	0	-	
$t_{h(Data\_NOE)}$	Data hold time after FMC_NOE high	0	-	

1. Guaranteed by characterization results.

Table 93. Asynchronous multiplexed PSRAM/NOR read-NWAIT timings(1)

Symbol	Parameter	Min	Max	Unit
$t_{w(NE)}$	FMC_NE low time	$8T_{HCLK}-1$	$8T_{HCLK}+2$	ns
$t_{w(NOE)}$	FMC_NWE low time	$5T_{HCLK}-1$	$5T_{HCLK}+1$	
$t_{su(NWAIT\_NE)}$	FMC_NWAIT valid before FMC_NEx high	$5T_{HCLK}+1.5$	-	
$t_{h(NE\_NWAIT)}$	FMC_NEx hold time after FMC_NWAIT invalid	$4T_{HCLK}+1$	-	

1. Guaranteed by characterization results.

1. Guaranteed by characterization results.

Table 95. Asynchronous multiplexed PSRAM/NOR write-NWAIT timings(1)

Symbol	Parameter	Min	Max	Unit
$t_{w(NE)}$	FMC_NE low time	$9T_{HCLK}$	$9T_{HCLK}+1.5$	ns
$t_{w(NWE)}$	FMC_NWE low time	$7T_{HCLK}-0.5$	$7T_{HCLK}+0.5$	
$t_{su(NWAIT\_NE)}$	FMC_NWAIT valid before FMC_NEx high	$6T_{HCLK}+2$	-	
$t_{h(NE\_NWAIT)}$	FMC_NEx hold time after FMC_NWAIT invalid	$4T_{HCLK}-1$	-	

1. Guaranteed by characterization results.

Synchronous waveforms and timings

Figure 62 through *Figure 65* represent synchronous waveforms and *Table 96* through *Table 99* provide the corresponding timings. The results shown in these tables are obtained with the following FMC configuration:

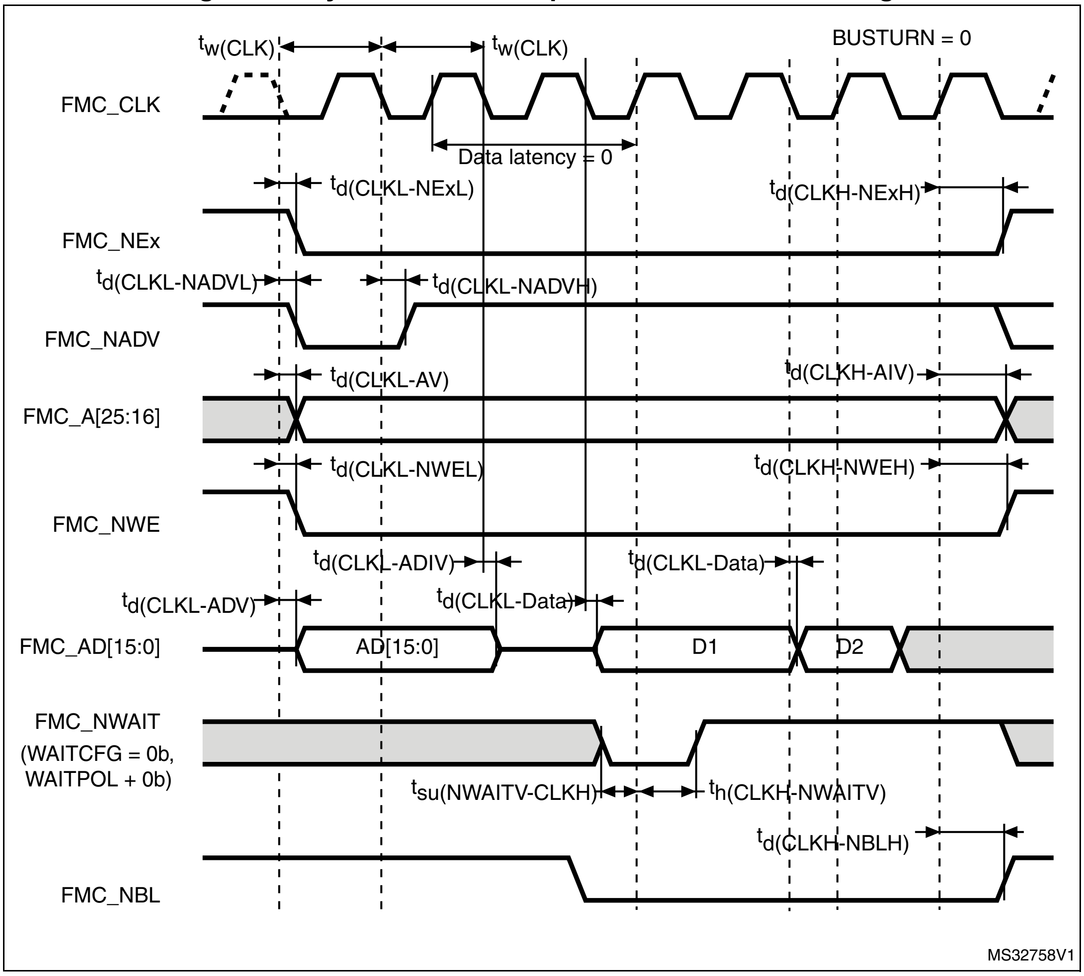
- BurstAccessMode = FMC_BurstAccessMode_Enable;
- MemoryType = FMC_MemoryType_CRAM;
- WriteBurst = FMC_WriteBurst_Enable;
- CLKDivision = 1;
- DataLatency = 1 for NOR Flash; DataLatency = 0 for PSRAM
- CL = 30 pF on data and address lines. CL = 10 pF on FMC_CLK unless otherwise specified.

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

– For 2.7 V≤V_{DD}≤3.6 V, maximum FMC_CLK = 108 MHz at CL=20 pF or 90 MHz at CL=30 pF (on FMC_CLK).

– For 1.71 V≤V_{DD}<2.7 V, maximum FMC_CLK = 70 MHz at CL=10 pF (on FMC_CLK).

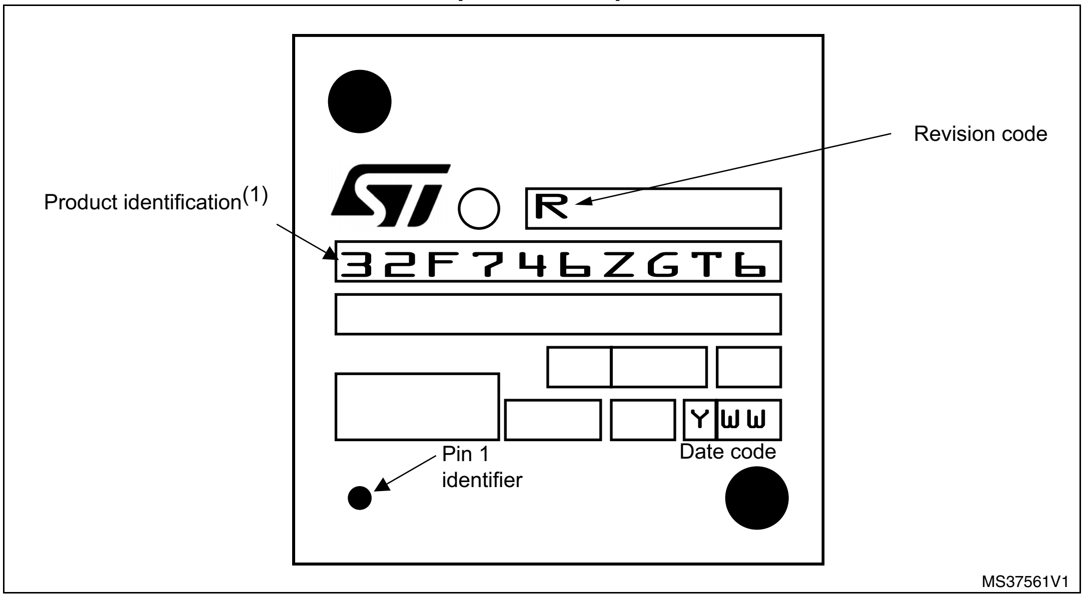
Figure 63. Synchronous multiplexed PSRAM write timings



Marking of engineering samples

The following figure gives an example of topside marking orientation versus pin 1 identifier location.

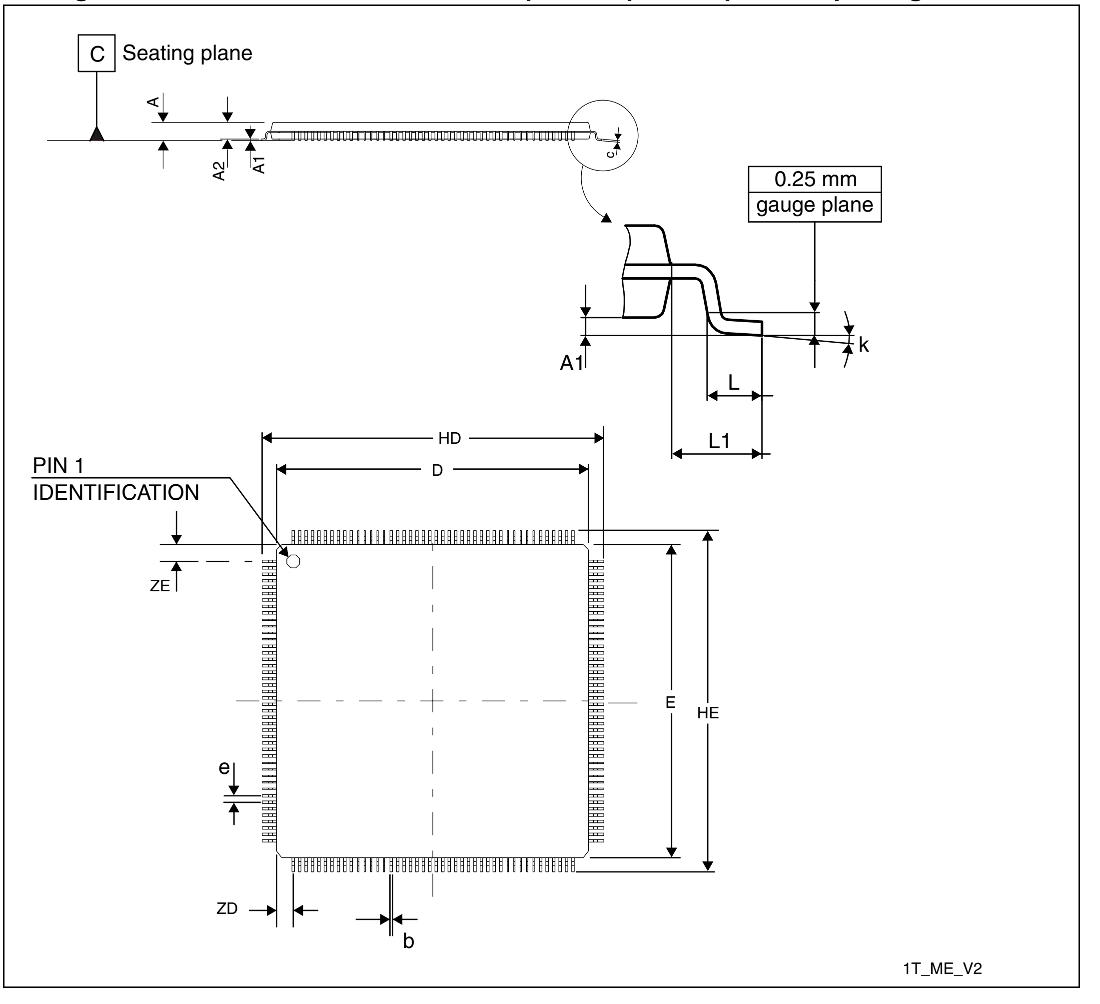
Figure 90. LQFP144, 20 x 20mm, 144-pin low-profile quad flat package top view example



1. Parts marked as “ES”, “E” or accompanied by an Engineering Sample notification letter, are not yet qualified and therefore not yet ready to be used in production and any consequences deriving from such usage will not be at ST charge. In no event, ST will be liable for any customer usage of these engineering samples in production. ST Quality has to be contacted prior to any decision to use these Engineering samples to run qualification activity.

6.5 LQFP176, 24 x 24 mm low-profile quad flat package information

Figure 91. LQFP176, 24 x 24 mm, 176-pin low-profile quad flat package outline



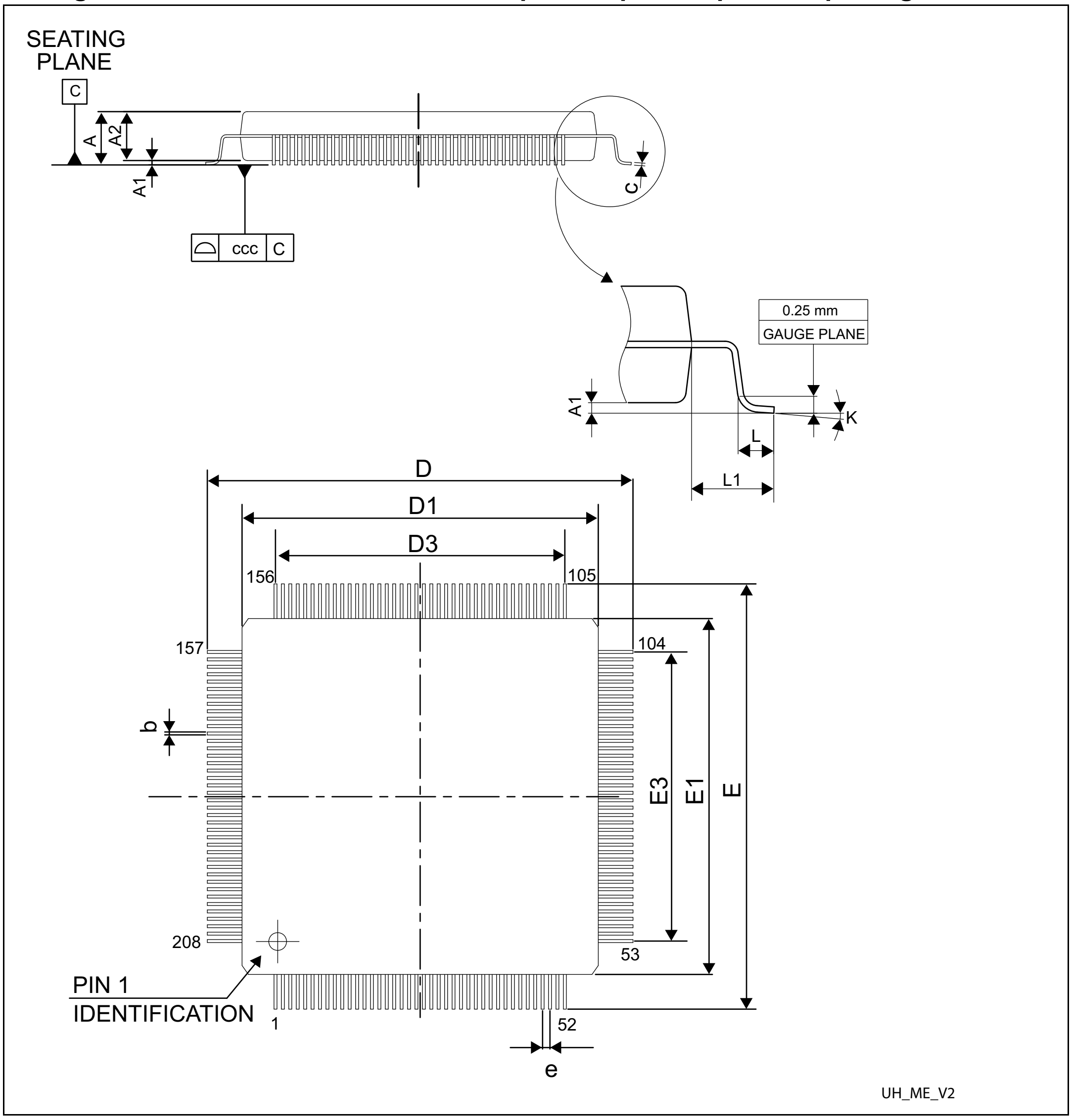
1. Drawing is not to scale.

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

6.6 LQFP208, 28 x 28 mm low-profile quad flat package information

Figure 94. LQFP208, 28 x 28 mm, 208-pin low-profile quad flat package outline



1. Drawing is not to scale.

Table 119. LQFP208, 28 x 28 mm, 208-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	1.400	1.450	0.0531	0.0551	0.0571