Welcome to E-XFL.COM

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®-M4
Core Size	32-Bit Single-Core
Speed	80MHz
Connectivity	CANbus, EBI/EMI, I²C, IrDA, LINbus, MMC/SD, QSPI, SAI, SPI, SWPMI, UART/USART, USB OTG
Peripherals	Brown-out Detect/Reset, DMA, LCD, PWM, WDT
Number of I/O	52
Program Memory Size	1MB (1M x 8)
Program Memory Type	FLASH
EEPROM Size	-
RAM Size	320K x 8
Voltage - Supply (Vcc/Vdd)	1.71V ~ 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	64-LQFP
Supplier Device Package	64-LQFP (10x10)
Purchase URL	https://www.e-xfl.com/product-detail/stmicroelectronics/stm32l4a6rgt6p

  - without having any impact on the timing of “injected” conversions
  - “injected” conversions for precise timing and with high conversion priority

3.25 Random number generator (RNG)

All devices embed an RNG that delivers 32-bit random numbers generated by an integrated analog circuit.

3.26 Digital camera interface (DCMI)

The devices embed a camera interface that can connect with camera modules and CMOS sensors through an 8-bit to 14-bit parallel interface, to receive video data. The camera interface can sustain a data transfer rate up to 54 Mbyte/s at 54 MHz. It features:

- Programmable polarity for the input pixel clock and synchronization signals
- Parallel data communication can be 8-, 10-, 12- or 14-bit
- Supports 8-bit progressive video monochrome or raw bayer format, YCbCr 4:2:2 progressive video, RGB 565 progressive video or compressed data (like JPEG)
- Supports continuous mode or snapshot (a single frame) mode
- Capability to automatically crop the image

3.27 Advanced encryption standard hardware accelerator (AES)

The devices embed an AES hardware accelerator can be used to both encipher and decipher data using AES algorithm.

The AES peripheral supports:

- Encryption/Decryption using AES Rijndael Block Cipher algorithm
- NIST FIPS 197 compliant implementation of AES encryption/decryption algorithm
- 128-bit and 256-bit register for storing the encryption, decryption or derivation key (4x 32-bit registers)
- Electronic codebook (ECB), Cipher block chaining (CBC), Counter mode (CTR), Galois Counter Mode (GCM), Galois Message Authentication Code mode (GMAC) and Cipher Message Authentication Code mode (CMAC) supported.
- Key scheduler
- Key derivation for decryption
- 128-bit data block processing
- 128-bit, 256-bit key length
- 1x32-bit INPUT buffer and 1x32-bit OUTPUT buffer.
- Register access supporting 32-bit data width only.
- One 128-bit Register for the initialization vector when AES is configured in CBC mode or for the 32-bit counter initialization when CTR mode is selected, GCM mode or CMAC mode.
- Automatic data flow control with support of direct memory access (DMA) using 2 channels, one for incoming data, and one for outcoming data.
- Suspend a message if another message with a higher priority needs to be processed

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

The device embeds four I2C. Refer to *Table 11: I2C implementation* for the features implementation.

The I^2C bus interface handles communications between the microcontroller and the serial I^2C bus. It controls all I^2C bus-specific sequencing, protocol, arbitration and timing.

The I2C peripheral supports:

- I^2C-bus specification and user manual rev. 5 compatibility:
  - Slave and master modes, multimaster capability
  - Standard-mode (Sm), with a bitrate up to 100 kbit/s
  - Fast-mode (Fm), with a bitrate up to 400 kbit/s
  - Fast-mode Plus (Fm+), with a bitrate up to 1 Mbit/s and 20 mA output drive I/Os
  - 7-bit and 10-bit addressing mode, multiple 7-bit slave addresses
  - Programmable setup and hold times
  - Optional clock stretching
- System Management Bus (SMBus) specification rev 2.0 compatibility:
  - Hardware PEC (Packet Error Checking) generation and verification with ACK control
  - Address resolution protocol (ARP) support
  - SMBus alert
- Power System Management Protocol (PMBus™) specification rev 1.1 compatibility
- Independent clock: a choice of independent clock sources allowing the I2C communication speed to be independent from the PCLK reprogramming. Refer to *Figure 5: Clock tree*.
- Wakeup from Stop mode on address match
- Programmable analog and digital noise filters
- 1-byte buffer with DMA capability

Table 11. I2C implementation

I2C features(1)	I2C1	I2C2	I2C3	I2C4
Standard-mode (up to 100 kbit/s)	X	X	X	X
Fast-mode (up to 400 kbit/s)	X	X	X	X
Fast-mode Plus with 20mA output drive I/Os (up to 1 Mbit/s)	X	X	X	X
Programmable analog and digital noise filters	X	X	X	X
SMBus/PMBus hardware support	X	X	X	X
Independent clock	X	X	X	X
Wakeup from Stop0, Stop 1 mode on address match	X	X	X	X
Wakeup from Stop 2 mode on address match	-	-	X	-

1. X: supported

Table 14. 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
		TT	3.6 V tolerant I/O
		RST	Bidirectional reset pin with embedded weak pull-up resistor
		Option for TT or FT I/Os	
		_f (1)	I/O, Fm+ capable
		_l (2)	I/O, with LCD function supplied by V_{LCD}
		_u (3)	I/O, with USB function supplied by V_{DDUSB}
		_a (4)	I/O, with Analog switch function supplied by V_{DDA}
		_s (5)	I/O supplied only by V_{DDIO2}
Notes		Unless otherwise specified by a note, all I/Os are set as analog inputs during and after reset.	
Pin functions	Alternate functions	Functions selected through GPIOx_AFR registers	
	Additional functions	Functions directly selected/enabled through peripheral registers	

1. The related I/O structures in *Table 15* are: FT_f, FT_fa, FT_fl, FT_fla.
2. The related I/O structures in *Table 15* are: FT_l, FT_fl, FT_lu.
3. The related I/O structures in *Table 15* are: FT_u, FT_lu.
4. The related I/O structures in *Table 15* are: FT_a, FT_la, FT_fa, FT_fla, TT_a, TT_la.
5. The related I/O structures in *Table 15* are: FT_s, FT_fs.

Table 15. STM32L4A6xG pin definitions (continued)

Pin Number										Pin name (function after reset)	Pin type	I/O structure	Notes	Pin functions	
LQFP64	WLCSP100	WLCSP100_SMPS	LQFP100	UFBGA132	UFBGA132_SMPS	LQFP144	LQFP144_SMPS	UFBGA169	UFBGA169_SMPS					Alternate functions	Additional functions
23	J7	G6	32	J5	J5	43	43	L4	L4	PA7	I/O	FT_fla	(3)	TIM1_CH1N, TIM3_CH2, TIM8_CH1N, I2C3_SCL, SPI1_MOSI, QUADSPI_BK1_IO2, LCD_SEG4, TIM17_CH1, EVENTOUT	OPAMP2_VINM, ADC12_IN12
24	H6	K8	33	K5	K5	44	44	H5	H5	PC4	I/O	FT_la	-	USART3_TX, QUADSPI_BK2_IO3, LCD_SEG22, EVENTOUT	COMP1_INM, ADC12_IN13
25	K8	-	34	L5	L5	45	45	J5	J5	PC5	I/O	FT_la	-	USART3_RX, LCD_SEG23, EVENTOUT	COMP1_INP, ADC12_IN14, WKUP5
26	J6	H6	35	M5	M5	46	46	K5	K5	PB0	I/O	TT_la	-	TIM1_CH2N, TIM3_CH3, TIM8_CH2N, SPI1_NSS, USART3_CK, QUADSPI_BK1_IO1, LCD_SEG5, COMP1_OUT, SAI1_EXTCLK, EVENTOUT	OPAMP2_VOUT, ADC12_IN15
27	K7	K7	36	M6	M6	47	47	L5	L5	PB1	I/O	FT_la	-	TIM1_CH3N, TIM3_CH4, TIM8_CH3N, DFSDM1_DATIN0, USART3_RTS_DE, LPUART1_RTS_DE, QUADSPI_BK1_IO0, LCD_SEG6, LPTIM2_IN1, EVENTOUT	COMP1_INM, ADC12_IN16
28	F5	J6	37	L6	L6	48	48	N5	N5	PB2	I/O	FT_la	-	RTC_OUT, LPTIM1_OUT, I2C3_SMBA, DFSDM1_CKIN0, LCD_VLCD, EVENTOUT	COMP1_INP
-	-	-	-	K6	K6	49	49	M5	M5	PF11	I/O	FT	-	DCMI_D12, EVENTOUT	-
-	-	-	-	J7	J7	50	50	N6	N6	PF12	I/O	FT	-	FMC_A6, EVENTOUT	-

Table 15. STM32L4A6xG pin definitions (continued)

Pin Number										Pin name (function after reset)	Pin type	I/O structure	Notes	Pin functions	
LQFP64	WLCSP100	WLCSP100_SMPS	LQFP100	UFBGA132	UFBGA132_SMPS	LQFP144	LQFP144_SMPS	UFBGA169	UFBGA169_SMPS					Alternate functions	Additional functions
-	H5	H5	41	L8	L8	63	63	H7	H7	PE10	I/O	FT	-	TIM1_CH2N, DFSDM1_DATIN4, TSC_G5_IO1, QUADSPI_CLK, FMC_D7, SAI1_MCLK_B, EVENTOUT	-
-	K4	K4	42	M9	M9	64	64	N8	N8	PE11	I/O	FT	-	TIM1_CH2, DFSDM1_CKIN4, TSC_G5_IO2, QUADSPI_BK1_NCS, FMC_D8, EVENTOUT	-
-	G5	J4	43	L9	L9	65	65	M8	M8	PE12	I/O	FT	-	TIM1_CH3N, SPI1_NSS, DFSDM1_DATIN5, TSC_G5_IO3, QUADSPI_BK1_IO0, FMC_D9, EVENTOUT	-
-	G4	G5	44	M10	M10	66	66	L8	L8	PE13	I/O	FT	-	TIM1_CH3, SPI1_SCK, DFSDM1_CKIN5, TSC_G5_IO4, QUADSPI_BK1_IO1, FMC_D10, EVENTOUT	-
-	J4	G4	45	M11	M11	67	67	K8	K8	PE14	I/O	FT	-	TIM1_CH4, TIM1_BKIN2, TIM1_BKIN2_COMP2, SPI1_MISO, QUADSPI_BK1_IO2, FMC_D11, EVENTOUT	-
-	H4	H4	46	M12	M12	68	68	J8	J8	PE15	I/O	FT	-	TIM1_BKIN, TIM1_BKIN_COMP1, SPI1_MOSI, QUADSPI_BK1_IO3, FMC_D12, EVENTOUT	-
29	K3	K3	47	L10	L10	69	69	N9	N9	PB10	I/O	FT_fl	-	TIM2_CH3, I2C4_SCL, I2C2_SCL, SPI2_SCK, DFSDM1_DATIN7, USART3_TX, LPUART1_RX, TSC_SYNC, QUADSPI_CLK, LCD_SEG10, COMP1_OUT, SAI1_SCK_A, EVENTOUT	-

Table 18. STM32L4A6xG memory map and peripheral register boundary addresses(1)

Bus	Boundary address	Size (bytes)	Peripheral
AHB4	0xA000 1000 - 0xA000 13FF	1 KB	QUADSPI
AHB3	0xA000 0400 - 0xA000 0FFF	3 KB	Reserved
	0xA000 0000 - 0xA000 03FF	1 KB	FMC
-	0x5006 0C00 - 0x5FFF FFFF	~260 MB	Reserved
AHB2	0x5006 0800 - 0x5006 0BFF	1 KB	RNG
	0x5006 0400 - 0x5006 07FF	1 KB	HASH
	0x5006 0000 - 0x5006 03FF	1 KB	AES
	0x5005 0400 - 0x5005 FFFF	62 KB	Reserved
	0x5005 0000 - 0x5005 03FF	1 KB	DCMI
	0x5004 0400 - 0x5004 FFFF	62 KB	Reserved
	0x5004 0000 - 0x5004 03FF	1 KB	ADC
	0x5000 0000 - 0x5003 FFFF	16 KB	OTG_FS
	0x4800 2400 - 0x4FFF FFFF	~127 MB	Reserved
	0x4800 2000 - 0x4800 23FF	1 KB	GPIOI
	0x4800 1C00 - 0x4800 1FFF	1 KB	GPIOH
	0x4800 1800 - 0x4800 1BFF	1 KB	GPIOG
	0x4800 1400 - 0x4800 17FF	1 KB	GPIOF
	0x4800 1000 - 0x4800 13FF	1 KB	GPIOE
	0x4800 0C00 - 0x4800 0FFF	1 KB	GPIOD
	0x4800 0800 - 0x4800 0BFF	1 KB	GPIOC
	0x4800 0400 - 0x4800 07FF	1 KB	GPIOB
	0x4800 0000 - 0x4800 03FF	1 KB	GPIOA
-	0x4002 BC00 - 0x47FF FFFF	~127 MB	Reserved

6 Electrical characteristics

6.1 Parameter conditions

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

6.1.1 Minimum and maximum values

Unless otherwise specified, the minimum and maximum values are guaranteed in the worst conditions of ambient temperature, supply voltage and frequencies by tests in production on 100% of the devices with an ambient temperature at T_A = 25 °C and T_A = $T_A$max (given by the selected temperature range).

Data based on characterization results, design simulation and/or technology characteristics are indicated in the table footnotes and are not tested in production. Based on characterization, the minimum and maximum values refer to sample tests and represent the mean value plus or minus three times the standard deviation (mean ±3σ).

6.1.2 Typical values

Unless otherwise specified, typical data are based on T_A = 25 °C, V_{DD} = V_{DDA} = 3 V. They are given only as design guidelines and are not tested.

Typical ADC accuracy values are determined by characterization of a batch of samples from a standard diffusion lot over the full temperature range, where 95% of the devices have an error less than or equal to the value indicated (mean ±2σ).

6.1.3 Typical curves

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

6.1.4 Loading capacitor

The loading conditions used for pin parameter measurement are shown in *Figure 18*.

6.1.5 Pin input voltage

The input voltage measurement on a pin of the device is described in *Figure 19*.

Figure 18. Pin loading conditions

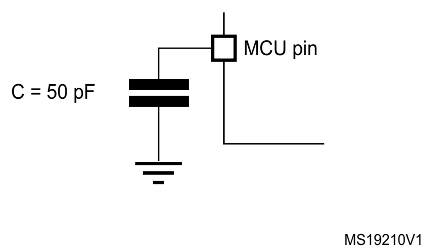


Figure 19. Pin input voltage

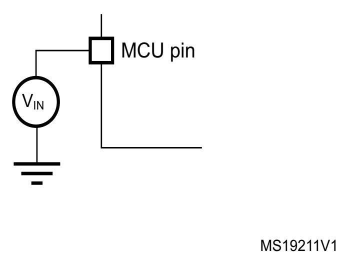


Table 38. Typical current consumption in Run and Low-power run modes, with different codes running from SRAM1

Symbol	Parameter	Conditions -	Voltage scaling	Code	TYP 25 °C	Unit	TYP 25 °C	Unit
I_{DD_ALL} (Run)	Supply current in Run mode	$f_{HCLK} = f_{HSE}$ up to 48 MHz included, bypass mode PLL ON above 48 MHz all peripherals disable	Range 2 f_{HCLK} = 26 MHz	Reduced code[1]	2.72	mA	105	µA/MHz
				Coremark	2.72		105	
				Dhrystone 2.1	2.65		102	
				Fibonacci	2.47		95	
				While(1)	2.37		91	
			Range 1 f_{HCLK} = 80 MHz	Reduced code[1]	9.71	mA	121	µA/MHz
				Coremark	9.7		121	
				Dhrystone 2.1	9.48		119	
				Fibonacci	8.79		110	
				While(1)	8.45		106	
I_{DD_ALL} (LPRun)	Supply current in Low-power run	$f_{HCLK} = f_{MSI}$ = 2 MHz all peripherals disable		Reduced code[1]	258	µA	129	µA/MHz
				Coremark	268		134	
				Dhrystone 2.1	240		120	
				Fibonacci	230		115	
				While(1)	255		128	

1. Reduced code used for characterization results provided in *Table 26*, *Table 28*, *Table 30*.

Table 39. Typical current consumption in Run, with different codesrunning from SRAM1 and power supplied by external SMPS (V_{DD12} = 1.10 V)

Symbol	Parameter	Conditions[1] -	Voltage scaling	Code	TYP 25 °C	Unit	TYP 25 °C	Unit
I_{DD_ALL} (Run)	Supply current in Run mode	$f_{HCLK} = f_{HSE}$ up to 48 MHz included, bypass mode PLL ON above 48 MHz all peripherals disable	f_{HCLK} = 26 MHz	Reduced code[2]	1.17	mA	45	µA/MHz
				Coremark	1.17		45	
				Dhrystone 2.1	1.14		44	
				Fibonacci	1.07		41	
				While(1)	1.02		39	
			f_{HCLK} = 80 MHz	Reduced code[1]	3.49		44	
				Coremark	3.49		44	
				Dhrystone 2.1	3.41		43	
				Fibonacci	3.16		39	
				While(1)	3.04		38	

1. All values are obtained by calculation based on measurements done without SMPS and using following parameters: SMPS input = 3.3 V, SMPS efficiency = 85%, V_{DD12} = 1.10 V
2. Reduced code used for characterization results provided in *Table 26*, *Table 28*, *Table 30*.

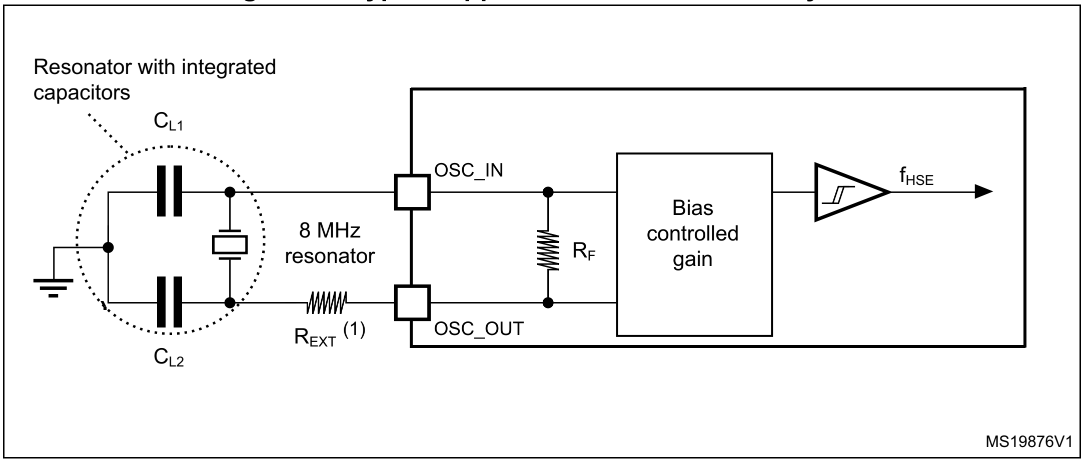
Table 49. Current consumption in VBAT mode

Symbol	Parameter	Conditions		TYP					MAX[(1)]					Unit
		-	V_{BAT}	25 °C	55 °C	85 °C	105 °C	125 °C	25 °C	55 °C	85 °C	105 °C	125 °C	
$I_{VDD\_VBAT}(V_{BAT})$	Backup domain supply current	RTC disabled	1.8 V	2	18	110	329	908	-	-	-	-	-	nA
			2.4 V	2	20	125	371	1016	-	-	-	-	-	
			3 V	3	25	154	546	1965	-	-	-	-	-	
			3.6 V	10	57	324	963	2688	-	-	-	-	-	
		RTC enabled and clocked by LSE bypassed at 32768 Hz	1.8 V	198	216	312	535	-	-	-	-	-	-	
			2.4 V	280	300	411	664	-	-	-	-	-	-	
			3 V	375	402	544	943	-	-	-	-	-	-	
			3.6 V	488	529	791	1459	-	-	-	-	-	-	
		RTC enabled and clocked by LSE quartz[(2)]	1.8 V	320	347	448	856	1432	-	-	-	-	-	
			2.4 V	405	436	550	921	1567	-	-	-	-	-	
			3 V	512	545	686	1128	2529	-	-	-	-	-	
			3.6 V	648	705	976	1588	3293	-	-	-	-	-	

1. Guaranteed by characterization results, unless otherwise specified.
2. Based on characterization done with a 32.768 kHz crystal (MC306-G-06Q-32.768, manufacturer JFVNY) with two 6.8 pF loading capacitors.

Note: For information on selecting the crystal, refer to the application note AN2867 “Oscillator design guide for ST microcontrollers” available from the ST website www.st.com.

Figure 25. Typical application with an 8 MHz crystal



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

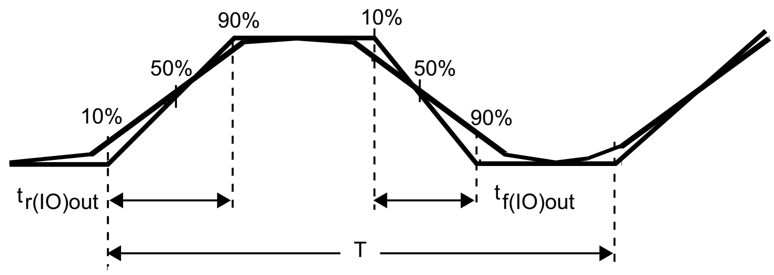
Low-speed external clock generated from a crystal resonator

The low-speed external (LSE) clock can be supplied with a 32.768 kHz crystal resonator oscillator. All the information given in this paragraph are based on design simulation results obtained with typical external components specified in *Table 57*. 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 57. LSE oscillator characteristics (f_{LSE} = 32.768 kHz)(1)

Symbol	Parameter	Conditions(2)	Min	Typ	Max	Unit
$I_{DD(LSE)}$	LSE current consumption	LSEDRV[1:0] = 00 Low drive capability	-	250	-	nA
		LSEDRV[1:0] = 01 Medium low drive capability	-	315	-	
		LSEDRV[1:0] = 10 Medium high drive capability	-	500	-	
		LSEDRV[1:0] = 11 High drive capability	-	630	-	
$Gm_{critmax}$	Maximum critical crystal gm	LSEDRV[1:0] = 00 Low drive capability	-	-	0.5	µA/V
		LSEDRV[1:0] = 01 Medium low drive capability	-	-	0.75	
		LSEDRV[1:0] = 10 Medium high drive capability	-	-	1.7	
		LSEDRV[1:0] = 11 High drive capability	-	-	2.7	
$t_{SU(LSE)}$(3)	Startup time	V_{DD} is stabilized	-	2	-	s

Figure 31. I/O AC characteristics definition[1]



1. Refer to *Table 72: I/O AC characteristics*.

6.3.15 NRST pin characteristics

The NRST pin input driver uses the CMOS technology. It is connected to a permanent pull-up resistor, R_{PU}.

Unless otherwise specified, the parameters given in the table below are derived from tests performed under the ambient temperature and supply voltage conditions summarized in *Table 22: General operating conditions*.

Table 73. NRST pin characteristics[1]

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$V_{IL(NRST)}$	NRST input low level voltage	-	-	-	$0.3 \times V_{DDIOx}$	V
$V_{IH(NRST)}$	NRST input high level voltage	-	$0.7 \times V_{DDIOx}$	-	-	
$V_{hys(NRST)}$	NRST Schmitt trigger voltage hysteresis	-	-	200	-	mV
R_{PU}	Weak pull-up equivalent resistor[2]	$V_{IN} = V_{SS}$	25	40	55	kΩ
$V_{F(NRST)}$	NRST input filtered pulse	-	-	-	70	ns
$V_{NF(NRST)}$	NRST input not filtered pulse	1.71 V ≤ V_{DD} ≤ 3.6 V	350	-	-	ns

1. Guaranteed by design.
2. The pull-up is designed with a true resistance in series with a switchable PMOS. This PMOS contribution to the series resistance is minimal (~10% order).

2. The I/O analog switch voltage booster is enable when V_{DDA} < 2.4 V (BOOSTEN = 1 in the SYSCFG_CFGR1 when V_{DDA} < 2.4V). It is disable when $V_{DDA} \geq 2.4$ V.
3. Fast channels are: PC0, PC1, PC2, PC3, PA0.
4. Slow channels are: all ADC inputs except the fast channels.

Table 79. ADC accuracy - limited test conditions 2(1)(2)(3) (continued)

Sym-bol	Parameter	Conditions(4)			Min	Typ	Max	Unit
THD	Total harmonic distortion	ADC clock frequency ≤ 80 MHz, Sampling rate ≤ 5.33 Msps, 2 V ≤ V_{DDA}	Single ended	Fast channel (max speed)	-	-74	-65	dB
				Slow channel (max speed)	-	-74	-67	
			Differential	Fast channel (max speed)	-	-79	-70	
				Slow channel (max speed)	-	-79	-71	

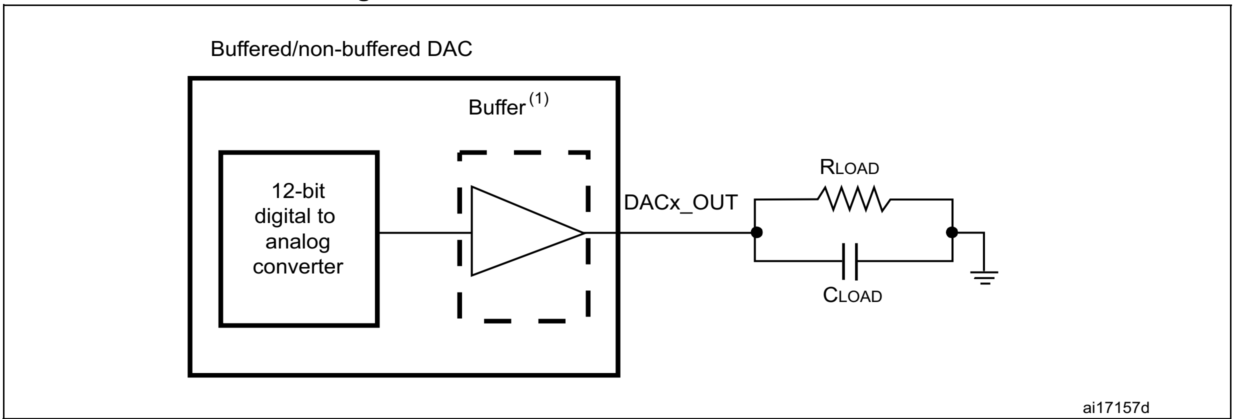
1. Guaranteed by design.
2. ADC DC accuracy values are measured after internal calibration.
3. ADC accuracy vs. negative Injection Current: Injecting negative current on any analog input pins should be avoided as this significantly reduces the accuracy of the conversion being performed on another analog input. It is recommended to add a Schottky diode (pin to ground) to analog pins which may potentially inject negative current.
4. The I/O analog switch voltage booster is enable when V_{DDA} < 2.4 V (BOOSTEN = 1 in the SYSCFG_CFGR1 when V_{DDA} < 2.4 V). It is disable when V_{DDA} ≥ 2.4 V. No oversampling.

Table 82. DAC characteristics(1) (continued)

Symbol	Parameter	Conditions		Min	Typ	Max	Unit
I_{DDV}(DAC)	DAC consumption from V_{REF+}	DAC output buffer ON	No load, middle code (0x800)	-	185	240	μA
			No load, worst code (0xF1C)	-	340	400	
		DAC output buffer OFF	No load, middle code (0x800)	-	155	205	
		Sample and hold mode, buffer ON, C_{SH} = 100 nF, worst case		-	185 x Ton/(Ton +Toff) (4)	400 x Ton/(Ton +Toff) (4)	
		Sample and hold mode, buffer OFF, C_{SH} = 100 nF, worst case		-	155 x Ton/(Ton +Toff) (4)	205 x Ton/(Ton +Toff) (4)	

1. Guaranteed by design.
2. In buffered mode, the output can overshoot above the final value for low input code (starting from min value).
3. Refer to *Table 70: I/O static characteristics*.
4. Ton is the Refresh phase duration. Toff is the Hold phase duration. Refer to RM0351 reference manual for more details.

Figure 35. 12-bit buffered / non-buffered DAC



1. The DAC integrates an output buffer that can be used to reduce the output impedance and to drive external loads directly without the use of an external operational amplifier. The buffer can be bypassed by configuring the BOFFx bit in the DAC_CR register.

6.3.25 LCD controller characteristics

The devices embed a built-in step-up converter to provide a constant LCD reference voltage independently from the V_{DD} voltage. An external capacitor C_{ext} must be connected to the VLCD pin to decouple this converter.

Table 90. LCD controller characteristics(1)

<table>
<tr><th>Symbol</th><th>Parameter</th><th>Conditions</th><th>Min</th><th>Typ</th><th>Max</th><th>Unit</th></tr>
<tr><td>V_{LCD}</td><td colspan="2">LCD external voltage</td><td>-</td><td>-</td><td>3.6</td><td rowspan="9">V</td></tr>
<tr><td>V_{LCD0}</td><td colspan="2">LCD internal reference voltage 0</td><td>-</td><td>2.62</td><td>-</td></tr>
<tr><td>V_{LCD1}</td><td colspan="2">LCD internal reference voltage 1</td><td>-</td><td>2.76</td><td>-</td></tr>
<tr><td>V_{LCD2}</td><td colspan="2">LCD internal reference voltage 2</td><td>-</td><td>2.89</td><td>-</td></tr>
<tr><td>V_{LCD3}</td><td colspan="2">LCD internal reference voltage 3</td><td>-</td><td>3.04</td><td>-</td></tr>
<tr><td>V_{LCD4}</td><td colspan="2">LCD internal reference voltage 4</td><td>-</td><td>3.19</td><td>-</td></tr>
<tr><td>V_{LCD5}</td><td colspan="2">LCD internal reference voltage 5</td><td>-</td><td>3.32</td><td>-</td></tr>
<tr><td>V_{LCD6}</td><td colspan="2">LCD internal reference voltage 6</td><td>-</td><td>3.46</td><td>-</td></tr>
<tr><td>V_{LCD7}</td><td colspan="2">LCD internal reference voltage 7</td><td>-</td><td>3.62</td><td>-</td></tr>
<tr><td rowspan="2">C_{ext}</td><td rowspan="2">V_{LCD} external capacitance</td><td>Buffer OFF
(BUFEN=0 is LCD_CR register)</td><td>0.2</td><td>-</td><td>2</td><td rowspan="2">µF</td></tr>
<tr><td>Buffer ON
(BUFEN=1 is LCD_CR register)</td><td>1</td><td>-</td><td>2</td></tr>
<tr><td rowspan="2">I_{LCD}(2)</td><td>Supply current from V_{DD} at V_{DD} = 2.2 V</td><td>Buffer OFF
(BUFEN=0 is LCD_CR register)</td><td>-</td><td>3</td><td>-</td><td rowspan="2">µA</td></tr>
<tr><td>Supply current from V_{DD} at V_{DD} = 3.0 V</td><td>Buffer OFF
(BUFEN=0 is LCD_CR register)</td><td>-</td><td>1.5</td><td>-</td></tr>
<tr><td rowspan="4">I_{VLCD}</td><td rowspan="4">Supply current from V_{LCD} (V_{LCD} = 3 V)</td><td>Buffer OFF
(BUFFEN = 0, PON = 0)</td><td>-</td><td>0.5</td><td>-</td><td rowspan="4">µA</td></tr>
<tr><td>Buffer ON
(BUFFEN = 1, 1/2 Bias)</td><td>-</td><td>0.6</td><td>-</td></tr>
<tr><td>Buffer ON
(BUFFEN = 1, 1/3 Bias)</td><td>-</td><td>0.8</td><td>-</td></tr>
<tr><td>Buffer ON
(BUFFEN = 1, 1/4 Bias)</td><td>-</td><td>1</td><td>-</td></tr>
<tr><td>R_{HN}</td><td colspan="2">Total High Resistor value for Low drive resistive network</td><td>-</td><td>5.5</td><td>-</td><td>MΩ</td></tr>
<tr><td>R_{LN}</td><td colspan="2">Total Low Resistor value for High drive resistive network</td><td>-</td><td>240</td><td>-</td><td>kΩ</td></tr>
</table>

6.3.28 Communication interfaces characteristics

I^2C interface characteristics

The I2C interface meets the timings requirements of the I^2C-bus specification and user manual rev. 03 for:

- Standard-mode (Sm): with a bit rate up to 100 kbit/s
- Fast-mode (Fm): with a bit rate up to 400 kbit/s
- Fast-mode Plus (Fm+): with a bit rate up to 1 Mbit/s.

The I2C timings requirements are guaranteed by design when the I2C peripheral is properly configured (refer to RM0351 reference manual).

The SDA and SCL I/O requirements are met with the following restrictions: the SDA and SCL I/O pins are not “true” open-drain. When configured as open-drain, the PMOS connected between the I/O pin and V_{DDIOx} is disabled, but is still present. Only FT_f I/O pins support Fm+ low level output current maximum requirement. Refer to *Section 6.3.14: I/O port characteristics* for the I2C I/Os characteristics.

All I2C SDA and SCL I/Os embed an analog filter. Refer to the table below for the analog filter characteristics:

Table 95. I2C analog filter characteristics(1)

Symbol	Parameter	Min	Max	Unit
t_{AF}	Maximum pulse width of spikes that are suppressed by the analog filter	50(2)	260(3)	ns

1. Guaranteed by design.
2. Spikes with widths below $t_{AF(min)}$ are filtered.
3. Spikes with widths above $t_{AF(max)}$ are not filtered

Table 114. Synchronous multiplexed PSRAM write timings(1)(2)

Symbol	Parameter	Min	Max	Unit
$t_{w(CLK)}$	FMC_CLK period	$2T_{HCLK}$- 0.5	-	ns
$t_{d(CLKL-NExL)}$	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)	T_{HCLK}+ 0.5	-	
$t_{d(CLKL-NADVL)}$	FMC_CLK low to FMC_NADV low	-	1	
$t_{d(CLKL-NADVH)}$	FMC_CLK low to FMC_NADV high	0	-	
$t_{d(CLKL-AV)}$	FMC_CLK low to FMC_Ax valid (x=16…25)	-	4.5	
$t_{d(CLKH-AIV)}$	FMC_CLK high to FMC_Ax invalid (x=16…25)	T_{HCLK}	-	
$t_{d(CLKL-NWEL)}$	FMC_CLK low to FMC_NWE low	-	1.5	
$t_{d(CLKH-NWEH)}$	FMC_CLK high to FMC_NWE high	T_{HCLK}+ 0.5	-	
$t_{d(CLKL-ADV)}$	FMC_CLK low to FMC_AD[15:0] valid	-	3	
$t_{d(CLKL-ADIV)}$	FMC_CLK low to FMC_AD[15:0] invalid	0	-	
$t_{d(CLKL-DATA)}$	FMC_A/D[15:0] valid data after FMC_CLK low	-	3.5	
$t_{d(CLKL-NBLL)}$	FMC_CLK low to FMC_NBL low	-	2	
$t_{d(CLKH-NBLH)}$	FMC_CLK high to FMC_NBL high	T_{HCLK}+ 0.5	-	
$t_{su(NWAIT-CLKH)}$	FMC_NWAIT valid before FMC_CLK high	2	-	
$t_{h(CLKH-NWAIT)}$	FMC_NWAIT valid after FMC_CLK high	3.5	-	

1. CL = 30 pF.
2. Guaranteed by characterization results.

Figure 54. NAND controller waveforms for read access

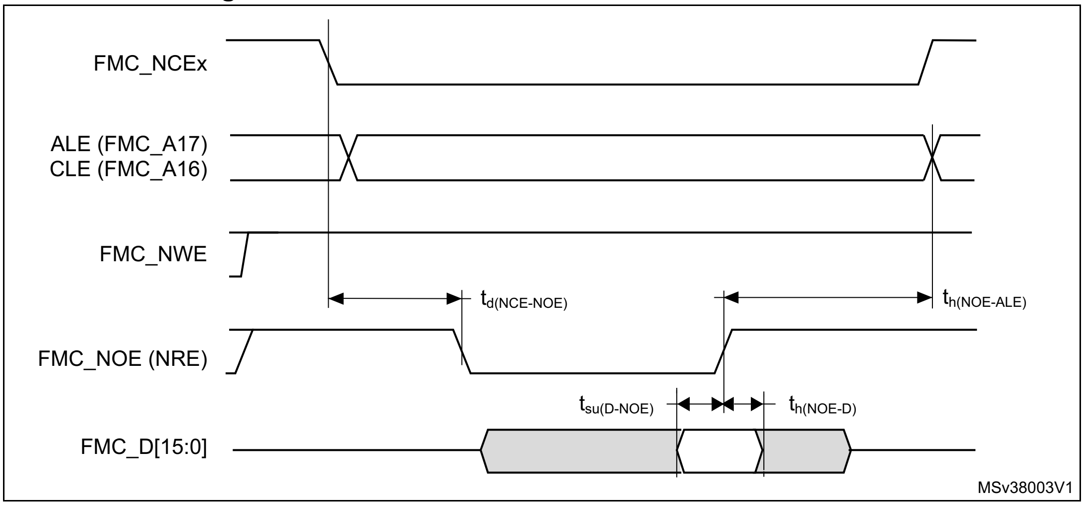


Figure 55. NAND controller waveforms for write access

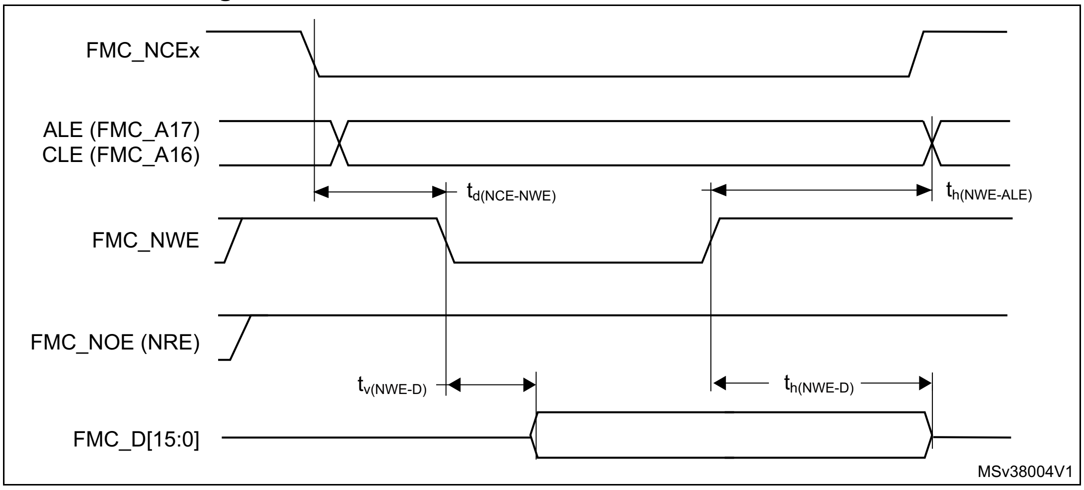
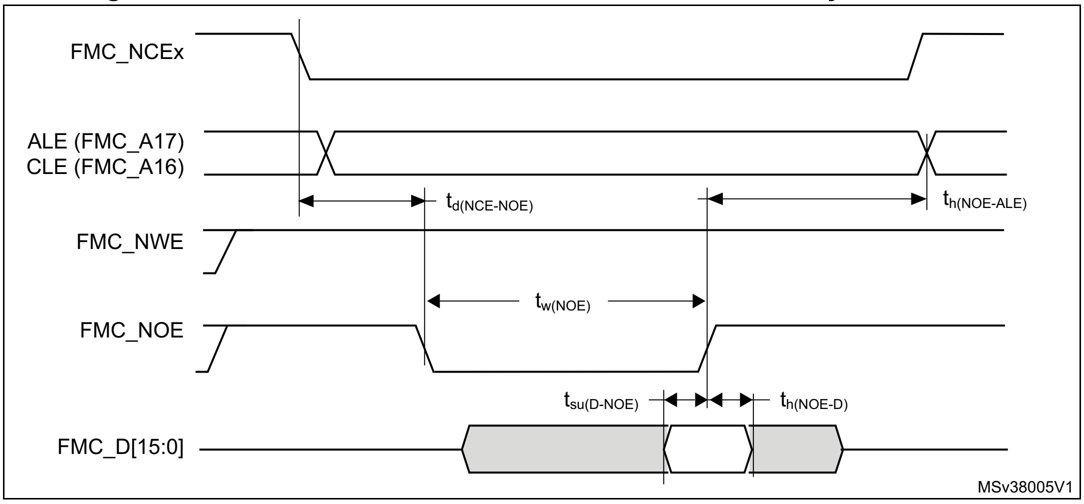
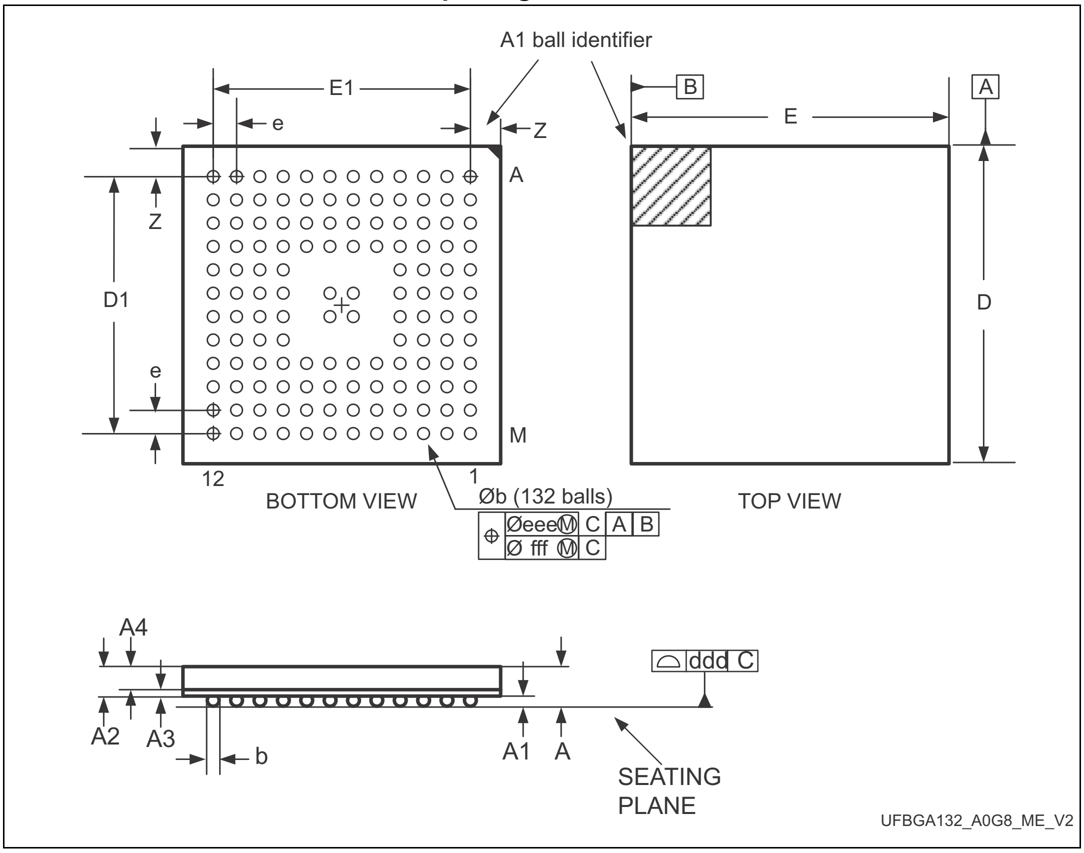


Figure 56. NAND controller waveforms for common memory read access



7.3 UFBGA132 package information

Figure 69. UFBGA132 - 132-ball, 7 x 7 mm ultra thin fine pitch ball grid array package outline



1. Drawing is not to scale.

Table 126. UFBGA132 - 132-ball, 7 x 7 mm ultra thin fine pitch ball grid array package mechanical data

Symbol	millimeters			inches(1)		
	Min	Typ	Max	Min	Typ	Max
A	-	-	0.600	-	-	0.0236
A1	-	-	0.110	-	-	0.0043
A2	-	0.450	-	-	0.0177	-
A3	-	0.130	-	-	0.0051	-
A4	-	0.320	-	-	0.0126	-
b	0.240	0.290	0.340	0.0094	0.0114	0.0134
D	6.850	7.000	7.150	0.2697	0.2756	0.2815
D1	-	5.500	-	-	0.2165	-
E	6.850	7.000	7.150	0.2697	0.2756	0.2815
E1	-	5.500	-	-	0.2165	-