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Applications of "Embedded - Microcontrollers"

Details	
Product Status	Active
Core Processor	ARM® Cortex®-M3
Core Size	32-Bit Single-Core
Speed	32MHz
Connectivity	I²C, IrDA, LINbus, SPI, UART/USART, USB
Peripherals	Brown-out Detect/Reset, DMA, I²S, LCD, POR, PWM, WDT
Number of I/O	109
Program Memory Size	384KB (384K x 8)
Program Memory Type	FLASH
EEPROM Size	12K x 8
RAM Size	48K x 8
Voltage - Supply (Vcc/Vdd)	1.8V ~ 3.6V
Data Converters	A/D 40x12b; D/A 2x12b
Oscillator Type	Internal
Operating Temperature	-40°C ~ 85°C (TA)
Mounting Type	Surface Mount
Package / Case	132-UFBGA
Supplier Device Package	132-UFBGA (7x7)
Purchase URL	https://www.e-xfl.com/product-detail/stmicroelectronics/stm32l162qdh6tr

- **Stop** mode without RTC

  Stop mode achieves the lowest power consumption while retaining the RAM and register contents. All clocks are stopped, the PLL, MSI RC, HSI and LSI RC, LSE and HSE crystal oscillators are disabled. The voltage regulator is in the low-power mode. The device can be woken up from Stop mode by any of the EXTI line, in 8 µs. The EXTI line source can be one of the 16 external lines. It can be the PVD output, the Comparator 1 event or Comparator 2 event (if internal reference voltage is on). It can also be wakened by the USB wakeup.

- **Standby** mode with RTC

  Standby mode is used to achieve the lowest power consumption and real time clock. The internal voltage regulator is switched off so that the entire V_{CORE} domain is powered off. The PLL, MSI RC, HSI RC and HSE crystal oscillators are also switched off. The LSE or LSI is still running. After entering Standby mode, the RAM and register contents are lost except for registers in the Standby circuitry (wakeup logic, IWDG, RTC, LSI, LSE Crystal 32K osc, RCC_CSR).

  The device exits Standby mode in 60 µs when an external reset (NRST pin), an IWDG reset, a rising edge on one of the three WKUP pins, RTC alarm (Alarm A or Alarm B), RTC tamper event, RTC timestamp event or RTC Wakeup event occurs.

- **Standby** mode without RTC

  Standby mode is used to achieve the lowest power consumption. The internal voltage regulator is switched off so that the entire V_{CORE} domain is powered off. The PLL, MSI RC, HSI and LSI RC, HSE and LSE crystal oscillators are also switched off. After entering Standby mode, the RAM and register contents are lost except for registers in the Standby circuitry (wakeup logic, IWDG, RTC, LSI, LSE Crystal 32K osc, RCC_CSR).

  The device exits Standby mode in 60 µs when an external reset (NRST pin) or a rising edge on one of the three WKUP pin occurs.

Note: The RTC, the IWDG, and the corresponding clock sources are not stopped automatically by entering Stop or Standby mode.

Table 2. Functionalities depending on the operating power supply range

	Functionalities depending on the operating power supply range			
Operating power supply range	**DAC and ADC operation**	**USB**	**Dynamic voltage scaling range**	**I/O operation**
V_{DD}= V_{DDA} = 1.65 to 1.71 V	Not functional	Not functional	Range 2 or Range 3	Degraded speed performance
V_{DD}=V_{DDA}= 1.71 to 1.8 V(1)	Not functional	Not functional	Range 1, Range 2 or Range 3	Degraded speed performance
V_{DD}=V_{DDA}= 1.8 to 2.0 V(1)	Conversion time up to 500 Ksps	Not functional	Range 1, Range 2 or Range 3	Degraded speed performance

3.7 Memories

The STM32L162xD devices have the following features:

- 48 Kbytes of embedded RAM accessed (read/write) at CPU clock speed with 0 wait states. With the enhanced bus matrix, operating the RAM does not lead to any performance penalty during accesses to the system bus (AHB and APB buses).
- The non-volatile memory is divided into three arrays:
  - 384 Kbytes of embedded Flash program memory
  - 12 Kbytes of data EEPROM
  - Options bytes

  Flash program and data EEPROM are divided into two banks, this enables writing in one bank while running code or reading data in the other bank.

  The options bytes are used to write-protect or read-out protect the memory (with 4 Kbytes granularity) and/or readout-protect the whole memory with the following options:
  - Level 0: no readout protection
  - Level 1: memory readout protection, the Flash memory cannot be read from or written to if either debug features are connected or boot in RAM is selected
  - Level 2: chip readout protection, debug features (ARM Cortex-M3 JTAG and serial wire) and boot in RAM selection disabled (JTAG fuse)

  The whole non-volatile memory embeds the error correction code (ECC) feature.

3.8 FSMC (flexible static memory controller)

The FSMC supports the following modes: SRAM, PSRAM, NOR/OneNAND Flash.

Functionality overview:

- Up to 26 bit address bus
- Up to 16-bit data bus
- Write FIFO
- Burst mode
- Code execution from external memory
- Four chip select signals
- Up to 32 MHz external access

3.9 DMA (direct memory access)

The flexible 12-channel, general-purpose DMA is able to manage memory-to-memory, peripheral-to-memory and memory-to-peripheral transfers. The DMA controller supports circular buffer management, avoiding the generation of interrupts when the controller reaches the end of the buffer.

Each channel is connected to dedicated hardware DMA requests, with software trigger support for each channel. Configuration is done by software and transfer sizes between source and destination are independent.

The DMA can be used with the main peripherals: AES, SPI, I^2C, USART, SDIO, general-purpose timers, DAC and ADC.

3.10 LCD (liquid crystal display)

The LCD drives up to 8 common terminals and 44 segment terminals to drive up to 320 pixels.

- Internal step-up converter to guarantee functionality and contrast control irrespective of V_{DD}. This converter can be deactivated, in which case the V_{LCD} pin is used to provide the voltage to the LCD
- Supports static, 1/2, 1/3, 1/4 and 1/8 duty
- Supports static, 1/2, 1/3 and 1/4 bias
- Phase inversion to reduce power consumption and EMI
- Up to 8 pixels can be programmed to blink
- Unneeded segments and common pins can be used as general I/O pins
- LCD RAM can be updated at any time owing to a double-buffer
- The LCD controller can operate in Stop mode

3.11 ADC (analog-to-digital converter)

A 12-bit analog-to-digital converters is embedded into STM32L162xD devices with up to 40 external channels, performing conversions in single-shot or scan mode. In scan mode, automatic conversion is performed on a selected group of analog inputs with up to 28 external channels in a group.

The ADC can be served by the DMA controller.

An analog watchdog feature allows very precise monitoring of the converted voltage of one, some or all scanned channels. An interrupt is generated when the converted voltage is outside the programmed thresholds.

The events generated by the general-purpose timers (TIMx) can be internally connected to the ADC start triggers, to allow the application to synchronize A/D conversions and timers. An injection mode allows high priority conversions to be done by interrupting a scan mode which runs in as a background task.

The ADC includes a specific low-power mode. The converter is able to operate at maximum speed even if the CPU is operating at a very low frequency and has an auto-shutdown function. The ADC's runtime and analog front-end current consumption are thus minimized whatever the MCU operating mode.

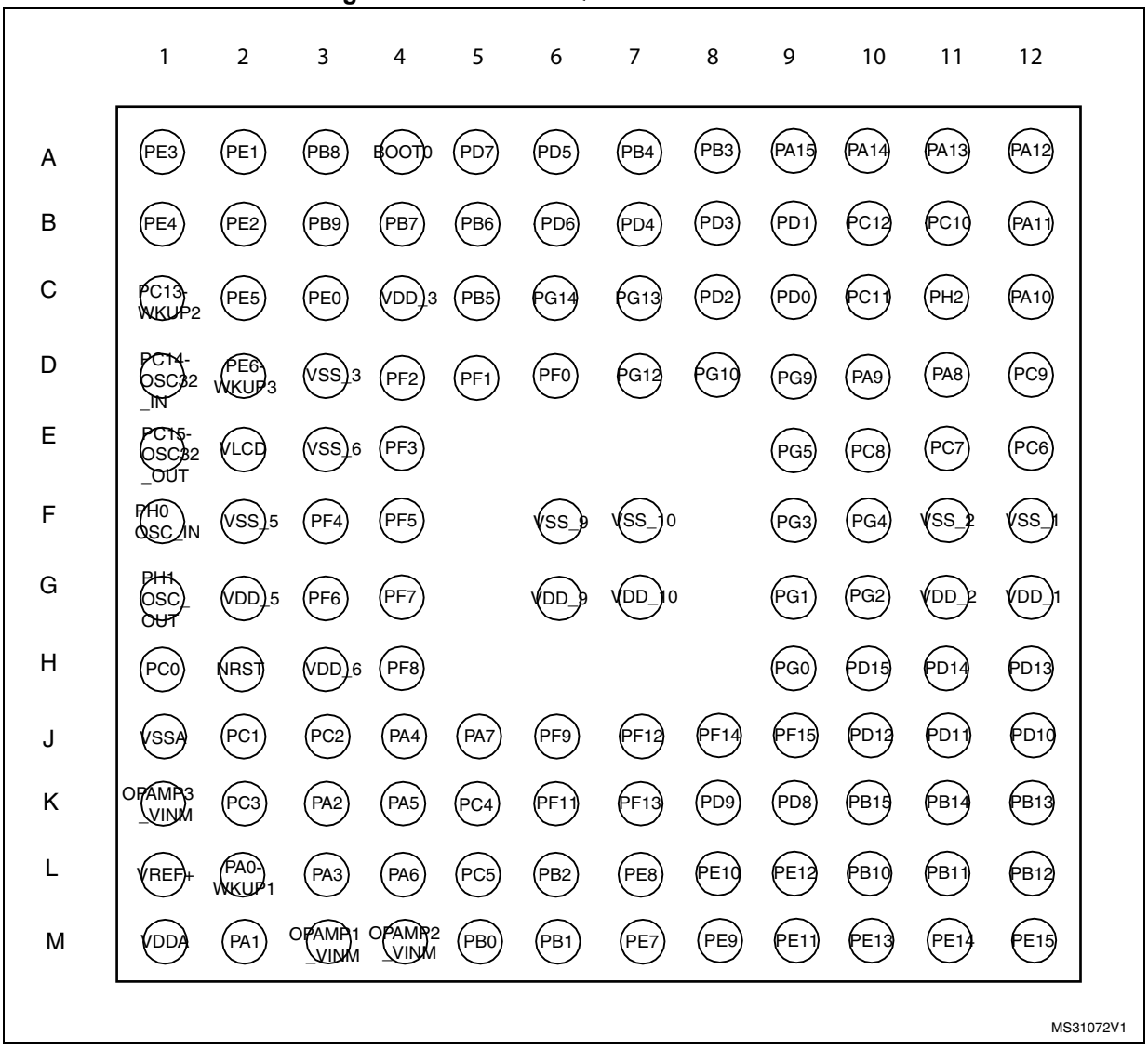
3.11.1 Temperature sensor

The temperature sensor (TS) generates a voltage V_{SENSE} that varies linearly with temperature.

The temperature sensor is internally connected to the ADC_IN16 input channel which is used to convert the sensor output voltage into a digital value.

The sensor provides good linearity but it has to be calibrated to obtain good overall accuracy of the temperature measurement. As the offset of the temperature sensor varies

Figure 4. STM32L162QD UFBGA132 ballout



1. This figure shows the package top view.

Table 7. STM32L162xD pin definitions (continued)

Pins					Pin name	Type[1]	I / O Level[2]	Main function[3] (after reset)	Pin functions	
LQFP144	UFBGA132	LQFP100	LQFP64	WLCSP64					Alternate functions	Additional functions
135	C5	91	57	A5	PB5	I/O	FT	PB5	TIM3_CH2/I2C1_SMBA/ SPI1_MOSI/ SPI3_MOSI/ I2S3_SD/LCD_SEG9	COMP2_INP
136	B5	92	58	B5	PB6	I/O	FT	PB6	TIM4_CH1/I2C1_SCL/ USART1_TX	COMP2_INP
137	B4	93	59	C5	PB7	I/O	FT	PB7	TIM4_CH2/I2C1_SDA/ USART1_RX/ FSMC_NADV	COMP2_INP /PVD_IN
138	A4	94	60	A6	BOOT0	I	-	BOOT0	-	-
139	A3	95	61	D5	PB8	I/O	FT	PB8	TIM4_CH3/TIM10_CH1/ I2C1_SCL/ LCD_SEG16/SDIO_D4	-
140	B3	96	62	B6	PB9	I/O	FT	PB9	TIM4_CH4/TIM11_CH1/ I2C1_SDA/ LCD_COM3/ SDIO_D5	-
141	C3	97	-	-	PE0	I/O	FT	PE0	TIM4_ETR/TIM10_CH1/ LCD_SEG36 /FSMC_NBL0	-
142	A2	98	-	-	PE1	I/O	FT	PE1	TIM11_CH1/LCD_SEG37 /FSMC_NBL1	-
143	D3	99	63	A7	V_{SS_3}	S	-	V_{SS_3}	-	-
144	C4	100	64	A8	V_{DD_3}	S	-	V_{DD_3}	-	-

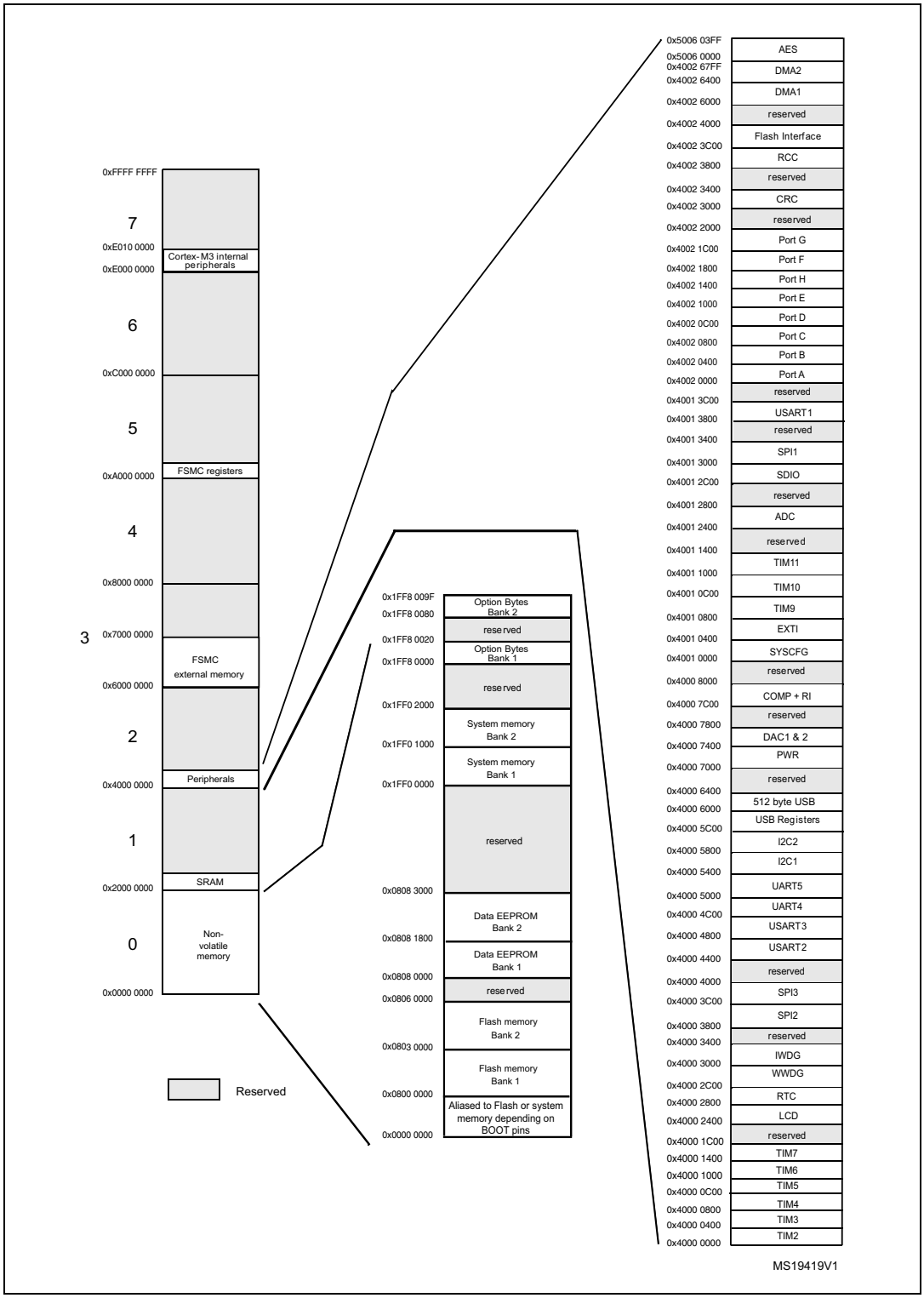
1. I = input, O = output, S = supply.
2. FT = 5 V tolerant.
3. Function availability depends on the chosen device.
4. The PC14 and PC15 I/Os are only configured as OSC32_IN/OSC32_OUT when the LSE oscillator is ON (by setting the LSEON bit in the RCC_CSR register). The LSE oscillator pins OSC32_IN/OSC32_OUT can be used as general-purpose PH0/PH1 I/Os, respectively, when the LSE oscillator is off (after reset, the LSE oscillator is off). The LSE has priority over the GPIO function. For more details, refer to Using the OSC32_IN/OSC32_OUT pins as GPIO PC14/PC15 port pins section in the STM32L151xx, STM32L152xx and STM32L162xx reference manual (RM0038).
5. The PH0 and PH1 I/Os are only configured as OSC_IN/OSC_OUT when the HSE oscillator is ON (by setting the HSEON bit in the RCC_CR register). The HSE oscillator pins OSC_IN/OSC_OUT can be used as general-purpose PH0/PH1 I/Os, respectively, when the HSE oscillator is off (after reset, the HSE oscillator is off). The HSE has priority over the GPIO function.

Table 8. Alternate function input/output (continued)

Port name	Digital alternate function number									..			..		
	AFIO0	AFIO1	AFIO2	AFIO3	AFIO4	AFIO5	AFIO6	AFIO7	AFIO8		AFIO11	AFIO12		AFIO14	AFIO15
	Alternate function														
	SYSTEM	TIM2	TIM3/4/5	TIM9/ 10/11	I2C1/2	SPI1/2	SPI3	USART1/2/3	UART4/5		LCD	FSMC/ SDIO		CPRI	SYSTEM
PD8	-	-	-	-	-	-	-	USART3_TX	-		SEG28	D13/DA13		TIMx_IC1	EVENT OUT
PD9	-	-	-	-	-	-	-	USART3_RX	-		SEG29	D14/DA14		TIMx_IC2	EVENT OUT
PD10	-	-	-	-	-	-	-	USART3_CK	-		SEG30	D15/DA15		TIMx_IC3	EVENT OUT
PD11	-	-	-	-	-	-	-	USART3_CTS	-		SEG31	A16		TIMx_IC4	EVENT OUT
PD12	-	-	TIM4_CH1	-	-	-	-	USART3_RTS	-		SEG32	A17		TIMx_IC1	EVENT OUT
PD13	-	-	TIM4_CH2	-	-	-	-	-	-		SEG33	A18		TIMx_IC2	EVENT OUT
PD14	-	-	TIM4_CH3	-	-	-	-	-	-		SEG34	D0/DA0		TIMx_IC3	EVENT OUT
PD15	-	-	TIM4_CH4	-	-	-	-	-	-		SEG35	D1/DA1		TIMx_IC4	EVENT OUT
PE0	-	-	TIM4_ETR	TIM10_CH1	-	-	-	-	-		SEG36	NBL0		TIMx_IC1	EVENT OUT
PE1	-	-	-	TIM11_CH1	-	-	-	-	-		SEG37	NBL1		TIMx_IC2	EVENT OUT
PE2	TRACECK	-	TIM3_ETR	-	-	-	-	-	-		SEG 38	A23		TIMx_IC3	EVENT OUT
PE3	TRACED0	-	TIM3_CH1	-	-	-	-	-	-		SEG 39	A19		TIMx_IC4	EVENT OUT
PE4	TRACED1	-	TIM3_CH2	-	-	-	-	-	-		-	A20		TIMx_IC1	EVENT OUT
PE5	TRACED2	-	-	TIM9_CH1	-	-	-	-	-		-	A21		TIMx_IC2	EVENT OUT
PE6-WKUP3	TRACED3	-	-	TIM9_CH2	-	-	-	-	-		-	-		TIMx_IC3	EVENT OUT

5 Memory mapping

Figure 8. Memory map



6.3.3 Embedded internal reference voltage

The parameters given in *Table 15* are based on characterization results, unless otherwise specified.

Table 14. Embedded internal reference voltage calibration values

Calibration value name	Description	Memory address
VREFINT_CAL	Raw data acquired at temperature of 30 °C ±5 °C V_{DDA}= 3 V ±10 mV	0x1FF8 00F8 - 0x1FF8 00F9

Table 15. Embedded internal reference voltage

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$V_{REFINT\ out}$ (1)	Internal reference voltage	– 40 °C < T_J < +110 °C	1.202	1.224	1.242	V
I_{REFINT}	Internal reference current consumption	-	-	1.4	2.3	µA
$T_{VREFINT}$	Internal reference startup time	-	-	2	3	ms
V_{VREF_MEAS}	V_{DDA} and V_{REF+} voltage during V_{REFINT} factory measure	-	2.99	3	3.01	V
A_{VREF_MEAS}	Accuracy of factory-measured V_{REF} value(2)	Including uncertainties due to ADC and V_{DDA}/V_{REF+} values	-	-	±5	mV
T_{Coeff}(3)	Temperature coefficient	–40 °C < T_J < +110 °C	-	25	100	ppm/°C
A_{Coeff}(3)	Long-term stability	1000 hours, T= 25 °C	-	-	1000	ppm
$V_{DDCoeff}$(3)	Voltage coefficient	3.0 V < V_{DDA} < 3.6 V	-	-	2000	ppm/V
$T_{S\_vrefint}$(3)	ADC sampling time when reading the internal reference voltage	-	4	-	-	µs
T_{ADC_BUF}(3) (4)	Startup time of reference voltage buffer for ADC	-	-	-	10	µs
I_{BUF_ADC}(3)	Consumption of reference voltage buffer for ADC	-	-	13.5	25	µA
I_{VREF_OUT}(3)	VREF_OUT output current (5)	-	-	-	1	µA
C_{VREF_OUT}(3)	VREF_OUT output load	-	-	-	50	pF
I_{LPBUF}(3)	Consumption of reference voltage buffer for VREF_OUT and COMP	-	-	730	1200	nA
V_{REFINT_DIV1}(3)	1/4 reference voltage	-	24	25	26	% V_{REFINT}
V_{REFINT_DIV2}(3)	1/2 reference voltage	-	49	50	51	
V_{REFINT_DIV3}(3)	3/4 reference voltage	-	74	75	76	

1. Guaranteed by test in production.
2. The internal V_{REF} value is individually measured in production and stored in dedicated EEPROM bytes.
3. Guaranteed by characterization results.
4. Shortest sampling time can be determined in the application by multiple iterations.

Table 17. Current consumption in Run mode, code with data processing running from RAM

Symbol	Parameter	Conditions		f_{HCLK}	Typ	Max	Unit
I_{DD} (Run from RAM)	Supply current in Run mode code executed from RAM	$f_{HSE} = f_{HCLK}$ up to 16 MHz, included $f_{HSE} = f_{HCLK}/2$ above 16MHz (PLL ON)(1)	Range3, V_{CORE}=1.2 V VOS[1:0]=11	1	230	470	µA
				2	415	780	
				4	800	1200	
			Range2, V_{CORE}=1.5 V VOS[1:0]=10	4	0.935	1.5	mA
				8	1.9	3	
				16	3.75	5	
			Range1, V_{CORE}=1.8 V VOS[1:0]=01	8	2.25	3.5	
				16	4.45	5.55	
				32	9.05	10.9	
		HSI clock source (16 MHz)	Range2, V_{CORE}=1.5 V VOS[1:0]=10	16	3.75	4.8	
			Range1, V_{CORE}=1.8 V VOS[1:0]=01	32	8.95	11.7	
		MSI clock, 65 kHZ	Range3, V_{CORE}=1.2 V VOS[1:0]=11	0.065	43.5	100	µA
		MSI clock, 524 kHZ		0.524	135	215	
		MSI clock, 4.2 MHZ		4.2	835	1100	

1. Oscillator bypassed (HSEBYP = 1 in RCC_CR register).

Table 21. Typical and maximum current consumptions in Stop mode

Symbol	Parameter	Conditions			Typ	Max(1)	Unit
I_{DD} (Stop with RTC)	Supply current in Stop mode with RTC enabled	RTC clocked by LSI or LSE external clock (32.768kHz), regulator in LP mode, HSI and HSE OFF (no independent watchdog)	LCD OFF	T_A = -40°C to 25°C V_{DD} = 1.8 V	1.1	-	µA
				T_A = -40°C to 25°C	1.35	4	
				T_A = 55°C	1.95	6	
				T_A= 85°C	4.35	10	
				T_A = 105°C	11.0	23	
			LCD ON (static duty)(2)	T_A = -40°C to 25°C	1.65	6	
				T_A = 55°C	2.1	7	
				T_A= 85°C	4.7	12	
				T_A = 105°C	11.0	27	
			LCD ON (1/8 duty)(3)	T_A = -40°C to 25°C	2.5	10	
				T_A = 55°C	4.65	11	
				T_A= 85°C	7.25	16	
				T_A = 105°C	14.0	44	
		RTC clocked by LSE external quartz (32.768kHz), regulator in LP mode, HSI and HSE OFF (no independent watchdog(4)	LCD OFF	T_A = -40°C to 25°C	1.7	-	
				T_A = 55°C	2.15	-	
				T_A= 85°C	4.7	-	
				T_A = 105°C	11.5	-	
			LCD ON (static duty)(2)	T_A = -40°C to 25°C	1.8	-	
				T_A = 55°C	2.35	-	
				T_A= 85°C	4.85	-	
				T_A = 105°C	11.5	-	
			LCD ON (1/8 duty)(3)	T_A = -40°C to 25°C	2.45	-	
				T_A = 55°C	4.9	-	
				T_A= 85°C	7.7	-	
				T_A = 105°C	14.5	-	
			LCD OFF	T_A = -40°C to 25°C V_{DD} = 1.8V	1.35	-	
				T_A = -40°C to 25°C V_{DD} = 3.0V	1.7	-	
				T_A = -40°C to 25°C V_{DD} = 3.6V	2.0	-	

Table 23. Peripheral current consumption(1) (continued)

Peripheral		Typical consumption, V_{DD} = 3.0 V, T_A = 25 °C				Unit
		Range 1, V_{CORE}= 1.8 V VOS[1:0] = 01	Range 2, V_{CORE}= 1.5 V VOS[1:0] = 10	Range 3, V_{CORE}= 1.2 V VOS[1:0] = 11	Low-power sleep and run	
APB2	SYSCFG & RI	3.5	2.9	2.4	2.9	µA/MHz (f_{HCLK})
	TIM9	9.0	7.4	5.8	7.4	
	TIM10	7.1	5.8	4.6	5.8	
	TIM11	6.5	5.3	4.3	5.3	
	ADC(2)	11.0	9.1	7.2	9.1	
	SDIO	28.4	24.2	19.1	24.2	
	SPI1	5.1	4.2	3.3	4.2	
	USART1	9.4	7.8	6.1	7.8	
AHB	GPIOA	7.3	6.1	4.8	6.1	
	GPIOB	7.5	6.1	4.8	6.1	
	GPIOC	8.2	6.8	5.3	6.8	
	GPIOD	8.7	7.1	5.7	7.1	
	GPIOE	7.6	6.2	4.9	6.2	
	GPIOF	7.7	6.3	5.0	6.3	
	GPIOG	8.4	7.0	5.4	7.0	
	GPIOH	1.8	1.3	1.1	1.3	
	CRC	0.8	0.6	0.4	0.6	
	AES	5	4	3	4	
	FLASH	26.3	19.3	18.3	-(3)	
	DMA1	19.0	16.0	12.8	16.0	
	DMA2	17.0	14.5	11.5	14.5	
All enabled		315	250	220	230.7	

Table 25. High-speed external user clock characteristics(1) (continued)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{HSEH}	OSC_IN input pin high level voltage	-	$0.7V_{DD}$	-	V_{DD}	V
V_{HSEL}	OSC_IN input pin low level voltage		V_{SS}	-	$0.3V_{DD}$	
$t_{w(HSEH)}$ $t_{w(HSEL)}$	OSC_IN high or low time		12	-	-	ns
$t_{r(HSE)}$ $t_{f(HSE)}$	OSC_IN rise or fall time		-	-	20	
$C_{in(HSE)}$	OSC_IN input capacitance		-	2.6	-	pF

1. Guaranteed by design.

Figure 14. High-speed external clock source AC timing diagram

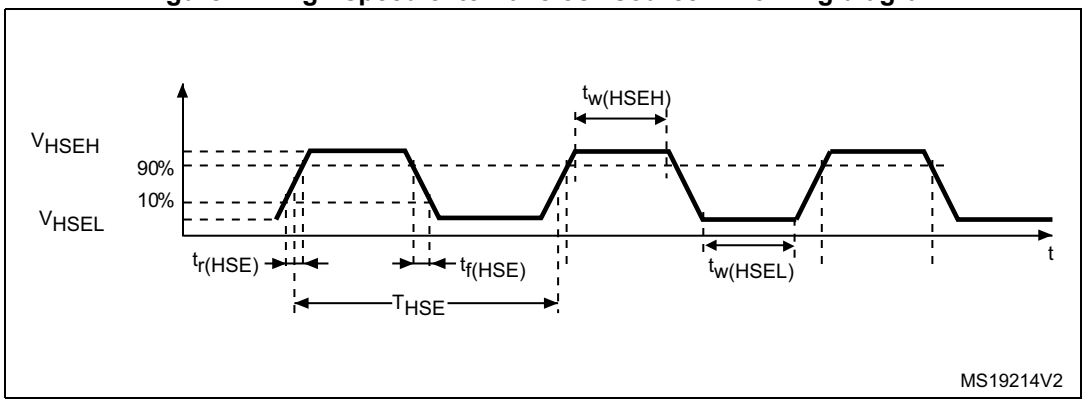


Table 27. HSE oscillator characteristics(1)(2)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
f_{OSC_IN}	Oscillator frequency	-	1		24	MHz
R_F	Feedback resistor	-	-	200	-	kΩ
C	Recommended load capacitance versus equivalent serial resistance of the crystal (R_S)(3)	R_S = 30 Ω	-	20	-	pF
I_{HSE}	HSE driving current	V_{DD}= 3.3 V, V_{IN} = V_{SS} with 30 pF load	-	-	3	mA
$I_{DD(HSE)}$	HSE oscillator power consumption	C = 20 pF f_{OSC} = 16 MHz	-	-	2.5 (startup) 0.7 (stabilized)	mA
		C = 10 pF f_{OSC} = 16 MHz	-	-	2.5 (startup) 0.46 (stabilized)	
g_m	Oscillator transconductance	Startup	3.5	-	-	mA /V
$t_{SU(HSE)}$(4)	Startup time	V_{DD} is stabilized	-	1	-	ms

1. Resonator characteristics given by the crystal/ceramic resonator manufacturer.
2. Guaranteed by characterization results.
3. The relatively low value of the RF resistor offers a good protection against issues resulting from use in a humid environment, due to the induced leakage and the bias condition change. However, it is recommended to take this point into account if the MCU is used in tough humidity conditions.
4. $t_{SU(HSE)}$ is the startup time measured from the moment it is enabled (by software) to a stabilized 8 MHz oscillation is reached. This value is measured for a standard crystal resonator and it can vary significantly with the crystal manufacturer.

For C_{L1} and C_{L2}, it is recommended to use high-quality external ceramic capacitors in the 5 pF to 25 pF range (typ.), designed for high-frequency applications, and selected to match the requirements of the crystal or resonator (see *Figure 16*). C_{L1} and C_{L2} are usually the same size. The crystal manufacturer typically specifies a load capacitance which is the series combination of C_{L1} and C_{L2}. PCB and MCU pin capacitance must be included (10 pF can be used as a rough estimate of the combined pin and board capacitance) when sizing C_{L1} and C_{L2}. Refer to the application note AN2867 “Oscillator design guide for ST microcontrollers” available from the ST website *www.st.com*.

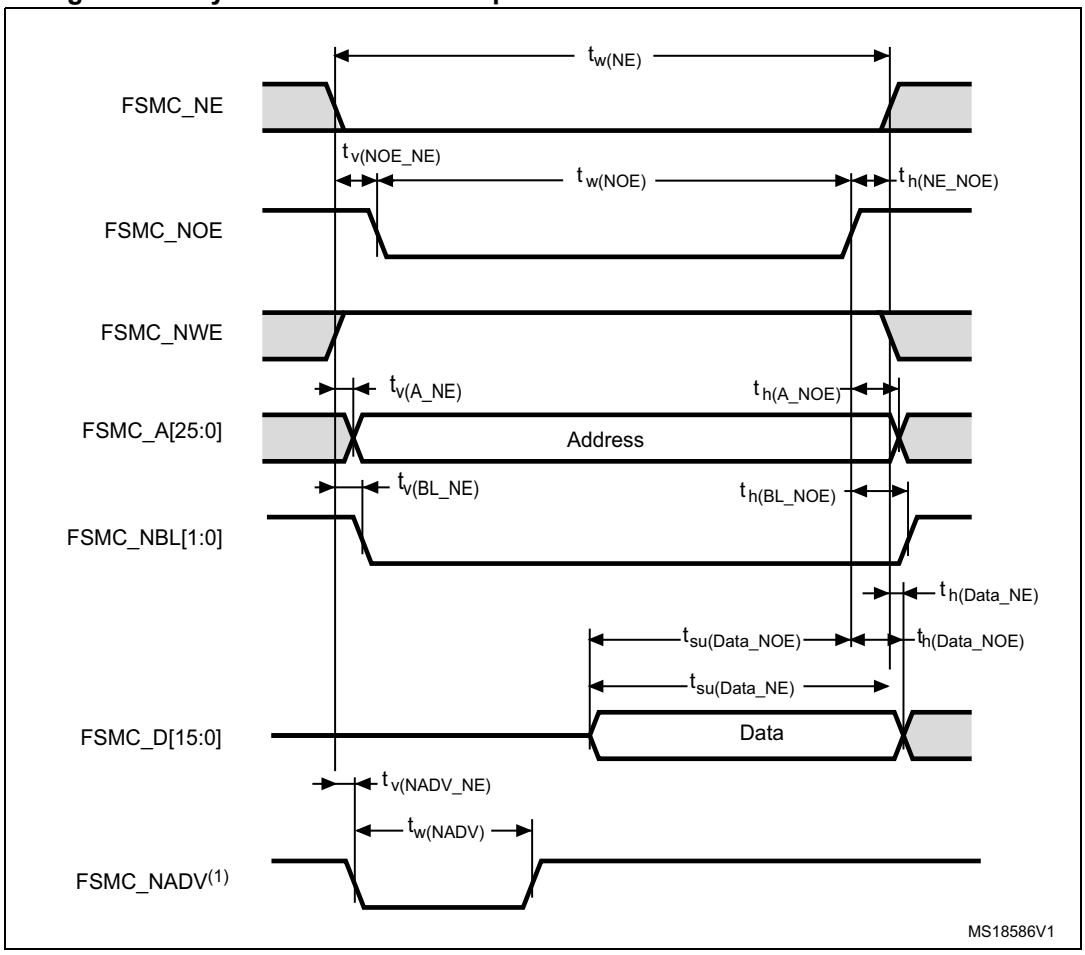
6.3.10 FSMC characteristics

Asynchronous waveforms and timings

Figure 18 through *Figure 21* represent asynchronous waveforms and *Table 36* through *Table 39* provide the corresponding timings. The results shown in these tables are obtained with the following FSMC configuration:

- AddressSetupTime = 0 (AddressSetupTime = 1, for asynchronous multiplexed modes)
- AddressHoldTime = 1
- DataSetupTime = 1

Figure 18. Asynchronous non-multiplexed SRAM/PSRAM/NOR read waveforms



1. Mode 2/B, C and D only. In Mode 1, FSMC_NADV is not used.

Table 38. Asynchronous multiplexed PSRAM/NOR read timings(1)

Symbol	Parameter	Min	Max	Unit
$t_{w(NE)}$	FSMC_NE low time	$3*T_{HCLK} - 1.5$	$3*T_{HCLK} + 1$	ns
$t_{v(NOE\_NE)}$	FSMC_NEx low to FSMC_NOE low	$2*T_{HCLK} - 1$	$2*T_{HCLK}$	ns
$t_{w(NOE)}$	FSMC_NOE low time	$T_{HCLK} - 0.5$	$T_{HCLK} + 0.5$	ns
$t_{h(NE\_NOE)}$	FSMC_NOE high to FSMC_NE high hold time	0	-	ns
$t_{v(A\_NE)}$	FSMC_NEx low to FSMC_A valid	-	5	ns
$t_{v(NADV\_NE)}$	FSMC_NEx low to FSMC_NADV low	1.5	2	ns
$t_{w(NADV)}$	FSMC_NADV low time	$T_{HCLK} - 0.5$	T_{HCLK}	ns
$t_{h(AD\_NADV)}$	FSMC_AD(address) valid hold time after FSMC_NADV high	$T_{HCLK} - 6$	-	ns
$t_{h(A\_NOE)}$	Address hold time after FSMC_NOE high	$2*T_{HCLK} - 1$	-	ns
$t_{h(BL\_NOE)}$	FSMC_BL time after FSMC_NOE high	1.5	-	ns
$t_{v(BL\_NE)}$	FSMC_NEx low to FSMC_BL valid	-	0	ns
$t_{su(Data\_NE)}$	Data to FSMC_NEx high setup time	T_{HCLK}	-	ns
$t_{su(Data\_NOE)}$	Data to FSMC_NOE high setup time	T_{HCLK}	-	ns
$t_{h(Data\_NE)}$	Data hold time after FSMC_NEx high	0	-	ns
$t_{h(Data\_NOE)}$	Data hold time after FSMC_NOE high	0	-	ns

1. C_L = 30 pF.

Figure 21. Asynchronous multiplexed PSRAM/NOR write waveforms

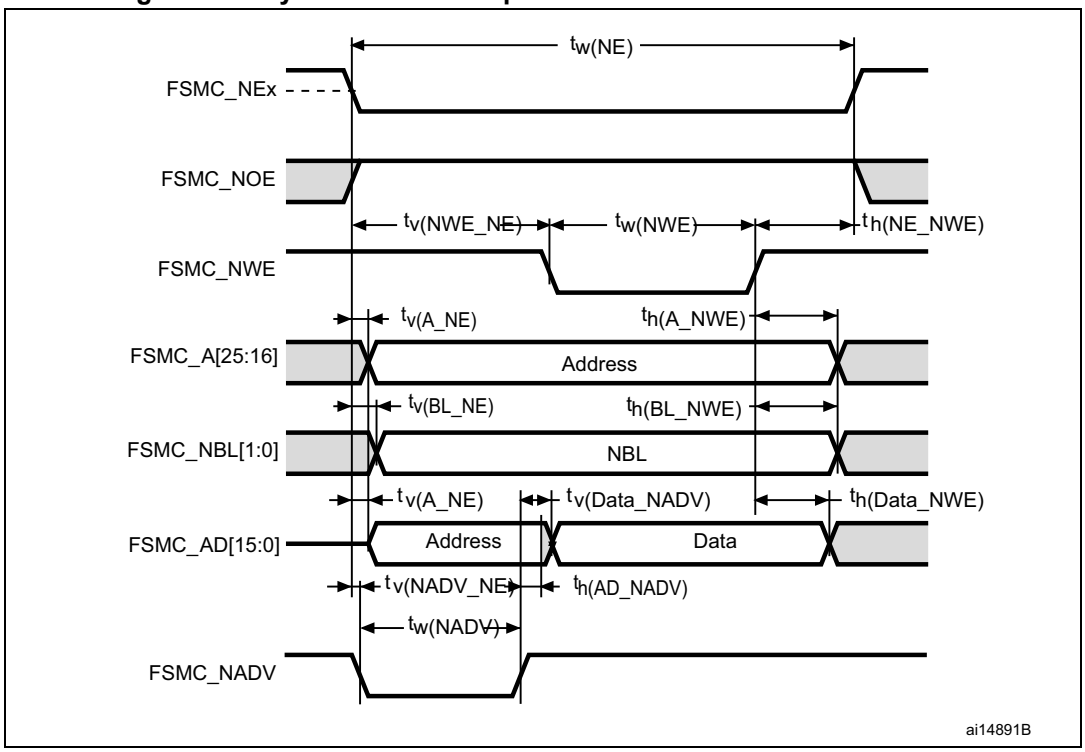


Table 39. Asynchronous multiplexed PSRAM/NOR write timings(1)

Symbol	Parameter	Min	Max	Unit
$t_{w(NE)}$	FSMC_NE low time	$4*T_{HCLK} - 3$	$4*T_{HCLK} + 2$	ns
$t_{v(NWE\_NE)}$	FSMC_NEx low to FSMC_NWE low	T_{HCLK}	$T_{HCLK} + 1$	ns
$t_{w(NWE)}$	FSMC_NWE low time	$2*T_{HCLK} - 2$	$2*T_{HCLK} + 4$	ns
$t_{h(NE\_NWE)}$	FSMC_NWE high to FSMC_NE high hold time	$T_{HCLK} - 2.5$	-	ns
$t_{v(A\_NE)}$	FSMC_NEx low to FSMC_A valid	-	6	ns
$t_{v(NADV\_NE)}$	FSMC_NEx low to FSMC_NADV low	1.5	2	ns
$t_{w(NADV)}$	FSMC_NADV low time	$T_{HCLK} - 4$	$T_{HCLK} + 4$	ns
$t_{h(AD\_NADV)}$	FSMC_AD (address) valid hold time after FSMC_NADV high	$T_{HCLK} - 5$	-	ns
$t_{h(A\_NWE)}$	Address hold time after FSMC_NWE high	$T_{HCLK} - 2.5$	-	ns
$t_{h(BL\_NWE)}$	FSMC_BL hold time after FSMC_NWE high	$T_{HCLK} - 3$	-	ns
$t_{v(BL\_NE)}$	FSMC_NEx low to FSMC_BL valid	-	0.5	ns
$t_{v(Data\_NADV)}$	FSMC_NADV high to Data valid	-	$T_{HCLK} + 6$	ns
$t_{h(Data\_NWE)}$	Data hold time after FSMC_NWE high	$T_{HCLK} - 2.5$	-	ns

1. C_L = 30 pF.

Table 66. DAC characteristics (continued)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
dOffset/dT(1)	Offset error temperature coefficient (code 0x800)	V_{DDA} = 3.3V V_{REF+} = 3.0V T_A = 0 to 50 °C DAC output buffer OFF	-20	-10	0	µV/°C
		V_{DDA} = 3.3V V_{REF+} = 3.0V T_A = 0 to 50 °C DAC output buffer ON	0	20	50	
Gain(1)	Gain error(7)	$C_L \leq 50$ pF, $R_L \geq 5$ kΩ DAC output buffer ON	-	+0.1 / -0.2%	+0.2 / -0.5%	%
		No R_L, $C_L \leq 50$ pF DAC output buffer OFF	-	+0 / -0.2%	+0 / -0.4%	
dGain/dT(1)	Gain error temperature coefficient	V_{DDA} = 3.3V V_{REF+} = 3.0V T_A = 0 to 50 °C DAC output buffer OFF	-10	-2	0	µV/°C
		V_{DDA} = 3.3V V_{REF+} = 3.0V T_A = 0 to 50 °C DAC output buffer ON	-40	-8	0	
TUE(1)	Total unadjusted error	$C_L \leq 50$ pF, $R_L \geq 5$ kΩ DAC output buffer ON	-	12	30	LSB
		No R_L, $C_L \leq 50$ pF DAC output buffer OFF	-	8	12	
$t_{SETTLING}$	Settling time (full scale: for a 12-bit code transition between the lowest and the highest input codes till DAC_OUT reaches final value ±1LSB	$C_L \leq 50$ pF, $R_L \geq 5$ kΩ	-	7	12	µs
Update rate	Max frequency for a correct DAC_OUT change (95% of final value) with 1 LSB variation in the input code	$C_L \leq 50$ pF, $R_L \geq 5$ kΩ	-	-	1	Msps
t_{WAKEUP}	Wakeup time from off state (setting the ENx bit in the DAC Control register)(8)	$C_L \leq 50$ pF, $R_L \geq 5$ kΩ	-	9	15	µs
PSRR+	V_{DDA} supply rejection ratio (static DC measurement)	$C_L \leq 50$ pF, $R_L \geq 5$ kΩ	-	-60	-35	dB

1. Data based on characterization results.
2. Connected between DAC_OUT and V_{SSA}.
3. Difference between two consecutive codes - 1 LSB.

1. Guaranteed by characterization results.
2. The delay is characterized for 100 mV input step with 10 mV overdrive on the inverting input, the non-inverting input set to the reference.
3. Comparator consumption only. Internal reference voltage not included.

Table 71. Comparator 2 characteristics

Symbol	Parameter	Conditions	Min	Typ	Max(1)	Unit
V_{DDA}	Analog supply voltage	-	1.65	-	3.6	V
V_{IN}	Comparator 2 input voltage range	-	0	-	V_{DDA}	V
t_{START}	Comparator startup time	Fast mode	-	15	20	µs
		Slow mode	-	20	25	
$t_{d\ slow}$	Propagation delay(2) in slow mode	1.65 V ≤V_{DDA} ≤2.7 V	-	1.8	3.5	
		2.7 V ≤V_{DDA} ≤3.6 V	-	2.5	6	
$t_{d\ fast}$	Propagation delay(2) in fast mode	1.65 V ≤V_{DDA} ≤2.7 V	-	0.8	2	
		2.7 V ≤V_{DDA} ≤3.6 V	-	1.2	4	
V_{offset}	Comparator offset error		-	±4	±20	mV
dThreshold/ dt	Threshold voltage temperature coefficient	V_{DDA} = 3.3V T_A = 0 to 50 °C V- =V_{REFINT}, 3/4 V_{REFINT}, 1/2 V_{REFINT}, 1/4 V_{REFINT}.	-	15	100	ppm /°C
I_{COMP2}	Current consumption(3)	Fast mode	-	3.5	5	µA
		Slow mode	-	0.5	2	

1. Guaranteed by characterization results.
2. The delay is characterized for 100 mV input step with 10 mV overdrive on the inverting input, the non-inverting input set to the reference.
3. Comparator consumption only. Internal reference voltage (necessary for comparator operation) is not included.