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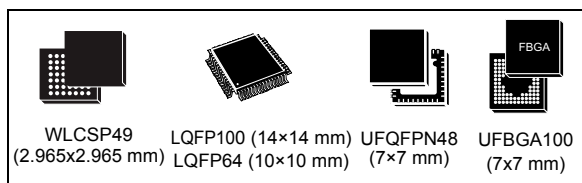


ARM[®] Cortex[®]-M4 32b MCU+FPU, 105 DMIPS, 256KB Flash/64KB RAM, 11 TIMs, 1 ADC, 11 comm. interfaces

Datasheet - production data

Features

- Dynamic Efficiency Line with BAM (Batch Acquisition Mode)
 - 1.7 V to 3.6 V power supply
 - -40 °C to 85/105 °C temperature range
- Core: ARM[®] 32-bit Cortex[®]-M4 CPU with FPU, Adaptive real-time accelerator (ART Accelerator™) allowing 0-wait state execution from Flash memory, frequency up to 84 MHz, memory protection unit, 105 DMIPS/1.25 DMIPS/MHz (Dhrystone 2.1), and DSP instructions
- Memories
 - Up to 256 Kbytes of Flash memory
 - 512 bytes of OTP memory
 - Up to 64 Kbytes of SRAM
- Clock, reset and supply management
 - 1.7 V to 3.6 V application supply and I/Os
 - POR, PDR, PVD and BOR
 - 4-to-26 MHz crystal oscillator
 - Internal 16 MHz factory-trimmed RC
 - 32 kHz oscillator for RTC with calibration
 - Internal 32 kHz RC with calibration
- Power consumption
 - Run: 128 µA/MHz (peripheral off)
 - Stop (Flash in Stop mode, fast wakeup time): 42 µA typ @ 25 °C; 65 µA max @25 °C
 - Stop (Flash in Deep power down mode, slow wakeup time): down to 10 µA typ@ 25 °C; 28 µA max @25 °C
 - Standby: 2.4 µA @25 °C / 1.7 V without RTC; 12 µA @85 °C @1.7 V
 - V_{BAT} supply for RTC: 1 µA @25 °C
- 1×12-bit, 2.4 MSPS A/D converter: up to 16 channels
- General-purpose DMA: 16-stream DMA controllers with FIFOs and burst support
- Up to 11 timers: up to six 16-bit, two 32-bit timers up to 84 MHz, each with up to



- 4 IC/OC/PWM or pulse counter and quadrature (incremental) encoder input, two watchdog timers (independent and window) and a SysTick timer
- Debug mode
 - Serial wire debug (SWD) & JTAG interfaces
 - Cortex-M4 Embedded Trace Macrocell™
- Up to 81 I/O ports with interrupt capability
 - All IO ports 5 V tolerant
 - Up to 78 fast I/Os up to 42 MHz
- Up to 11 communication interfaces
 - Up to 3 × I²C interfaces (1Mbit/s, SMBus/PMBus)
 - Up to 3 USARTs (2 x 10.5 Mbit/s, 1 x 5.25 Mbit/s), ISO 7816 interface, LIN, IrDA, modem control)
 - Up to 4 SPIs (up to 42 Mbits/s at f_{CPU} = 84 MHz), SPI2 and SPI3 with muxed full-duplex I²S to achieve audio class accuracy via internal audio PLL or external clock
 - SDIO interface
- Advanced connectivity
 - USB 2.0 full-speed device/host/OTG controller with on-chip PHY
- CRC calculation unit
- 96-bit unique ID
- RTC: subsecond accuracy, hardware calendar
- All packages are ECOPACK[®]2

Table 1. Device summary

Reference	Part number
STM32F401xB	STM32F401CB, STM32F401RB, STM32F401VB
STM32F401xC	STM32F401CC, STM32F401RC, STM32F401VC

Contents

1	Introduction	9
2	Description	10
2.1	Compatibility with STM32F4 series	12
3	Functional overview	15
3.1	ARM® Cortex®-M4 with FPU core with embedded Flash and SRAM ...	15
3.2	Adaptive real-time memory accelerator (ART Accelerator™)	15
3.3	Memory protection unit	15
3.4	Embedded Flash memory	16
3.5	CRC (cyclic redundancy check) calculation unit	16
3.6	Embedded SRAM	16
3.7	Multi-AHB bus matrix	16
3.8	DMA controller (DMA)	17
3.9	Nested vectored interrupt controller (NVIC)	17
3.10	External interrupt/event controller (EXTI)	17
3.11	Clocks and startup	18
3.12	Boot modes	18
3.13	Power supply schemes	18
3.14	Power supply supervisor	19
3.14.1	Internal reset ON	19
3.14.2	Internal reset OFF	19
3.15	Voltage regulator	20
3.15.1	Regulator ON	21
3.15.2	Regulator OFF	21
3.15.3	Regulator ON/OFF and internal power supply supervisor availability ..	24
3.16	Real-time clock (RTC) and backup registers	24
3.17	Low-power modes	25
3.18	V _{BAT} operation	25
3.19	Timers and watchdogs	26
3.19.1	Advanced-control timers (TIM1)	26
3.19.2	General-purpose timers (TIMx)	27

3.19.3	Independent watchdog	27
3.19.4	Window watchdog	27
3.19.5	SysTick timer	28
3.20	Inter-integrated circuit interface (I2C)	28
3.21	Universal synchronous/asynchronous receiver transmitters (USART)	28
3.22	Serial peripheral interface (SPI)	29
3.23	Inter-integrated sound (I ² S)	29
3.24	Audio PLL (PLL12S)	29
3.25	Secure digital input/output interface (SDIO)	30
3.26	Universal serial bus on-the-go full-speed (OTG_FS)	30
3.27	General-purpose input/outputs (GPIOs)	30
3.28	Analog-to-digital converter (ADC)	30
3.29	Temperature sensor	31
3.30	Serial wire JTAG debug port (SWJ-DP)	31
3.31	Embedded Trace Macrocell™	31
4	Pinouts and pin description	32
5	Memory mapping	50
6	Electrical characteristics	54
6.1	Parameter conditions	54
6.1.1	Minimum and maximum values	54
6.1.2	Typical values	54
6.1.3	Typical curves	54
6.1.4	Loading capacitor	54
6.1.5	Pin input voltage	55
6.1.6	Power supply scheme	56
6.1.7	Current consumption measurement	57
6.2	Absolute maximum ratings	57
6.3	Operating conditions	59
6.3.1	General operating conditions	59
6.3.2	VCAP_1/VCAP_2 external capacitors	61
6.3.3	Operating conditions at power-up/power-down (regulator ON)	61
6.3.4	Operating conditions at power-up / power-down (regulator OFF)	62
6.3.5	Embedded reset and power control block characteristics	62

6.3.6	Supply current characteristics	63
6.3.7	Wakeup time from low-power modes	73
6.3.8	External clock source characteristics	74
6.3.9	Internal clock source characteristics	78
6.3.10	PLL characteristics	80
6.3.11	PLL spread spectrum clock generation (SSCG) characteristics	82
6.3.12	Memory characteristics	83
6.3.13	EMC characteristics	85
6.3.14	Absolute maximum ratings (electrical sensitivity)	87
6.3.15	I/O current injection characteristics	88
6.3.16	I/O port characteristics	89
6.3.17	NRST pin characteristics	94
6.3.18	TIM timer characteristics	95
6.3.19	Communications interfaces	96
6.3.20	12-bit ADC characteristics	104
6.3.21	Temperature sensor characteristics	110
6.3.22	V _{BAT} monitoring characteristics	111
6.3.23	Embedded reference voltage	111
6.3.24	SD/SDIO MMC card host interface (SDIO) characteristics	111
6.3.25	RTC characteristics	113
7	Package information	114
7.1	WLCSP49 2.965x2.965 mm package information	114
7.2	UFQFPN48 package information	117
7.3	LQFP64 package information	120
7.4	LQFP100 package information	123
7.5	UFPGA100 package information	126
7.6	Thermal characteristics	129
7.6.1	Reference document	129
8	Part numbering	130
9	Revision history	131

List of tables

Table 1.	Device summary	1
Table 2.	STM32F401xB/C features and peripheral counts.	11
Table 3.	Regulator ON/OFF and internal power supply supervisor availability.	24
Table 4.	Timer feature comparison.	26
Table 5.	Comparison of I2C analog and digital filters.	28
Table 6.	USART feature comparison	29
Table 7.	Legend/abbreviations used in the pinout table	37
Table 8.	STM32F401xB/STM32F401xC pin definitions	37
Table 9.	Alternate function mapping	44
Table 10.	STM32F401xB/STM32F401xC register boundary addresses	51
Table 11.	Voltage characteristics	57
Table 12.	Current characteristics	58
Table 13.	Thermal characteristics.	58
Table 14.	General operating conditions	59
Table 15.	Features depending on the operating power supply range	60
Table 16.	VCAP_1/VCAP_2 operating conditions	61
Table 17.	Operating conditions at power-up / power-down (regulator ON)	61
Table 18.	Operating conditions at power-up / power-down (regulator OFF).	62
Table 19.	Embedded reset and power control block characteristics.	62
Table 20.	Typical and maximum current consumption, code with data processing (ART accelerator disabled) running from SRAM - $V_{DD} = 1.8V$	64
Table 21.	Typical and maximum current consumption, code with data processing (ART accelerator disabled) running from SRAM	65
Table 22.	Typical and maximum current consumption in run mode, code with data processing (ART accelerator enabled except prefetch) running from Flash memory- $V_{DD} = 1.8 V$	65
Table 23.	Typical and maximum current consumption in run mode, code with data processing (ART accelerator enabled except prefetch) running from Flash memory - $V_{DD} = 3.3 V$	66
Table 24.	Typical and maximum current consumption in run mode, code with data processing (ART accelerator disabled) running from Flash memory	66
Table 25.	Typical and maximum current consumption in run mode, code with data processing (ART accelerator enabled with prefetch) running from Flash memory	67
Table 26.	Typical and maximum current consumption in Sleep mode	67
Table 27.	Typical and maximum current consumptions in Stop mode - $V_{DD}=1.8 V$	68
Table 28.	Typical and maximum current consumption in Stop mode - $V_{DD}=3.3 V$	68
Table 29.	Typical and maximum current consumption in Standby mode - $V_{DD}=1.8 V$	68
Table 30.	Typical and maximum current consumption in Standby mode - $V_{DD}=3.3 V$	69
Table 31.	Typical and maximum current consumptions in V_{BAT} mode.	69
Table 32.	Switching output I/O current consumption	71
Table 33.	Peripheral current consumption	72
Table 34.	Low-power mode wakeup timings ⁽¹⁾	73
Table 35.	High-speed external user clock characteristics.	74
Table 36.	Low-speed external user clock characteristics	75
Table 37.	HSE 4-26 MHz oscillator characteristics.	76
Table 38.	LSE oscillator characteristics ($f_{LSE} = 32.768 \text{ kHz}$)	77
Table 39.	HSI oscillator characteristics	78
Table 40.	LSI oscillator characteristics	79
Table 41.	Main PLL characteristics.	80

Table 42.	PLLI2S (audio PLL) characteristics	81
Table 43.	SSCG parameters constraint	82
Table 44.	Flash memory characteristics	83
Table 45.	Flash memory programming	84
Table 46.	Flash memory programming with V_{PP} voltage	84
Table 47.	Flash memory endurance and data retention	85
Table 48.	EMS characteristics for LQFP100 package	86
Table 49.	EMI characteristics for WLCSP49	87
Table 50.	EMI characteristics for LQFP100	87
Table 51.	ESD absolute maximum ratings	88
Table 52.	Electrical sensitivities	88
Table 53.	I/O current injection susceptibility	89
Table 54.	I/O static characteristics	89
Table 55.	Output voltage characteristics	92
Table 56.	I/O AC characteristics	92
Table 57.	NRST pin characteristics	94
Table 58.	TIMx characteristics	95
Table 59.	I ² C characteristics	96
Table 60.	SCL frequency ($f_{PCLK1} = 42$ MHz, $V_{DD} = V_{DD_I2C} = 3.3$ V)	97
Table 61.	SPI dynamic characteristics	98
Table 62.	I ² S dynamic characteristics	101
Table 63.	USB OTG FS startup time	103
Table 64.	USB OTG FS DC electrical characteristics	103
Table 65.	USB OTG FS electrical characteristics	104
Table 66.	ADC characteristics	104
Table 67.	ADC accuracy at $f_{ADC} = 18$ MHz	106
Table 68.	ADC accuracy at $f_{ADC} = 30$ MHz	106
Table 69.	ADC accuracy at $f_{ADC} = 36$ MHz	106
Table 70.	ADC dynamic accuracy at $f_{ADC} = 18$ MHz - limited test conditions	107
Table 71.	ADC dynamic accuracy at $f_{ADC} = 36$ MHz - limited test conditions	107
Table 72.	Temperature sensor characteristics	110
Table 73.	Temperature sensor calibration values	110
Table 74.	V_{BAT} monitoring characteristics	111
Table 75.	Embedded internal reference voltage	111
Table 76.	Internal reference voltage calibration values	111
Table 77.	Dynamic characteristics: SD / MMC characteristics	112
Table 78.	RTC characteristics	113
Table 79.	WLCSP49 - 49-ball, 2.965 x 2.965 mm, 0.4 mm pitch wafer level chip scale package mechanical data	115
Table 80.	WLCSP49 recommended PCB design rules (0.4 mm pitch)	116
Table 81.	UFQFPN48 - 48-lead, 7 x 7 mm, 0.5 mm pitch, ultra thin fine pitch quad flat package mechanical data	117
Table 82.	LQFP64 - 64-pin, 10 x 10 mm, 64-pin low-profile quad flat package mechanical data	121
Table 83.	LQPF100- 100-pin, 14 x 14 mm, 100-pin low-profile quad flat package mechanical data	124
Table 84.	UFBGA100 - 100-ball, 7 x 7 mm, 0.50 mm pitch, ultra fine pitch ball grid array package mechanical data	126
Table 85.	UFBGA100 recommended PCB design rules (0.5 mm pitch BGA)	127
Table 86.	Package thermal characteristics	129
Table 87.	Ordering information scheme	130
Table 88.	Document revision history	131

List of figures

Figure 1.	Compatible board design for LQFP100 package	12
Figure 2.	Compatible board design for LQFP64 package	13
Figure 3.	STM32F401xB/STM32F401xC block diagram	14
Figure 4.	Multi-AHB matrix	16
Figure 5.	Power supply supervisor interconnection with internal reset OFF	19
Figure 6.	PDR_ON control with internal reset OFF	20
Figure 7.	Regulator OFF	22
Figure 8.	Startup in regulator OFF: slow V_{DD} slope - power-down reset risen after V_{CAP_1}/V_{CAP_2} stabilization.	23
Figure 9.	Startup in regulator OFF mode: fast V_{DD} slope - power-down reset risen before V_{CAP_1}/V_{CAP_2} stabilization	23
Figure 10.	STM32F401xB/STM32F401xC WLCSP49 pinout	32
Figure 11.	STM32F401xB/STM32F401xC UFQFPN48 pinout	33
Figure 12.	STM32F401xB/STM32F401xC LQFP64 pinout	34
Figure 13.	STM32F401xB/STM32F401xC LQFP100 pinout	35
Figure 14.	STM32F401xB/STM32F401xC UFBGA100 pinout	36
Figure 15.	Memory map	50
Figure 16.	Pin loading conditions	54
Figure 17.	Input voltage measurement	55
Figure 18.	Power supply scheme	56
Figure 19.	Current consumption measurement scheme	57
Figure 20.	External capacitor C_{EXT}	61
Figure 21.	Typical V_{BAT} current consumption (LSE and RTC ON)	69
Figure 22.	High-speed external clock source AC timing diagram	75
Figure 23.	Low-speed external clock source AC timing diagram	76
Figure 24.	Typical application with an 8 MHz crystal	77
Figure 25.	Typical application with a 32.768 kHz crystal	78
Figure 26.	ACC_{HSI} versus temperature	79
Figure 27.	ACC_{LSI} versus temperature	80
Figure 28.	PLL output clock waveforms in center spread mode	83
Figure 29.	PLL output clock waveforms in down spread mode	83
Figure 30.	FT I/O input characteristics	91
Figure 31.	I/O AC characteristics definition	94
Figure 32.	Recommended NRST pin protection	95
Figure 33.	I ² C bus AC waveforms and measurement circuit	97
Figure 34.	SPI timing diagram - slave mode and CPHA = 0	99
Figure 35.	SPI timing diagram - slave mode and CPHA = 1 ⁽¹⁾	99
Figure 36.	SPI timing diagram - master mode ⁽¹⁾	100
Figure 37.	I ² S slave timing diagram (Philips protocol) ⁽¹⁾	102
Figure 38.	I ² S master timing diagram (Philips protocol) ⁽¹⁾	102
Figure 39.	USB OTG FS timings: definition of data signal rise and fall time	104
Figure 40.	ADC accuracy characteristics	108
Figure 41.	Typical connection diagram using the ADC	108
Figure 42.	Power supply and reference decoupling (V_{REF+} not connected to V_{DDA})	109
Figure 43.	Power supply and reference decoupling (V_{REF+} connected to V_{DDA})	110
Figure 44.	SDIO high-speed mode	112
Figure 45.	SD default mode	112
Figure 46.	WLCSP49 - 0.4 mm pitch wafer level chip scale package outline	114

Figure 47.	WLCSP49 0.4 mm pitch wafer level chip scale recommended footprint	115
Figure 48.	WLCSP49 marking example (package top view)	116
Figure 49.	UFQFPN48 - 48-lead, 7 x 7 mm, 0.5 mm pitch, ultra thin fine pitch quad flat package outline	117
Figure 50.	UFQFPN48 - 48-lead, 7 x 7 mm, 0.5 mm pitch, ultra thin fine pitch quad flat recommended footprint	118
Figure 51.	UFQFPN48 marking example (top view)	119
Figure 52.	LQFP64 - 64-pin, 10 x 10 mm, 64-pin low-profile quad flat package outline	120
Figure 53.	LQFP64 recommended footprint	121
Figure 54.	LQFP64 marking example (top view)	122
Figure 55.	LQFP100 - 100-pin, 14 x 14 mm, 100-pin low-profile quad flat package outline.	123
Figure 56.	LQFP100 recommended footprint	124
Figure 57.	LQFP100 marking example (top view)	125
Figure 58.	UFBGA100 - 100-ball, 7 x 7 mm, 0.50 mm pitch, ultra fine pitch ball grid array package outline	126
Figure 59.	UFBGA100 - 100-ball, 7 x 7 mm, 0.50 mm pitch, ultra fine pitch ball grid array package recommended footprint	127
Figure 60.	UFBGA100 marking example (top view)	128

1 Introduction

This datasheet provides the description of the STM32F401xB/STM32F401xC line of microcontrollers.

The STM32F401xB/STM32F401xC datasheet should be read in conjunction with RM0368 reference manual which is available from the STMicroelectronics website www.st.com. It includes all information concerning Flash memory programming.

For information on the Cortex[®]-M4 core, please refer to the Cortex[®]-M4 programming manual (PM0214) available from www.st.com.



2 Description

The STM32F401xB/STM32F401xC devices are based on the high-performance ARM[®] Cortex[®]-M4 32-bit RISC core operating at a frequency of up to 84 MHz. The Cortex[®]-M4 core features a Floating point unit (FPU) single precision which supports all ARM single-precision data-processing instructions and data types. It also implements a full set of DSP instructions and a memory protection unit (MPU) which enhances application security.

The STM32F401xB/STM32F401xC incorporate high-speed embedded memories (up to 256 Kbytes of Flash memory, up to 64 Kbytes of SRAM), and an extensive range of enhanced I/Os and peripherals connected to two APB buses, two AHB buses and a 32-bit multi-AHB bus matrix.

All devices offer one 12-bit ADC, a low-power RTC, six general-purpose 16-bit timers including one PWM timer for motor control, two general-purpose 32-bit timers. They also feature standard and advanced communication interfaces.

- Up to three I²Cs
- Up to four SPIs
- Two full duplex I²Ss. To achieve audio class accuracy, the I²S peripherals can be clocked via a dedicated internal audio PLL or via an external clock to allow synchronization.
- Three USARTs
- SDIO interface
- USB 2.0 OTG full speed interface

Refer to [Table 2: STM32F401xB/C features and peripheral counts](#) for the peripherals available for each part number.

The STM32F401xB/STM32F401xC operate in the –40 to +105 °C temperature range from a 1.7 (PDR OFF) to 3.6 V power supply. A comprehensive set of power-saving mode allows the design of low-power applications.

These features make the STM32F401xB/STM32F401xC microcontrollers suitable for a wide range of applications:

- Motor drive and application control
- Medical equipment
- Industrial applications: PLC, inverters, circuit breakers
- Printers, and scanners
- Alarm systems, video intercom, and HVAC
- Home audio appliances
- Mobile phone sensor hub

[Figure 3](#) shows the general block diagram of the devices.

Table 2. STM32F401xB/C features and peripheral counts

Peripherals		STM32F401xB			STM32F401xC		
Flash memory in Kbytes		128			256		
SRAM in Kbytes	System	64					
Timers	General-purpose	7					
	Advanced-control	1					
Communication interfaces	SPI/ I ² S	3/2 (full duplex)		4/2 (full duplex)	3/2 (full duplex)		4/2 (full duplex)
	I ² C	3					
	USART	3					
	SDIO	-	1		-	1	
USB OTG FS		1					
GPIOs		36	50	81	36	50	81
12-bit ADC		1					
Number of channels		10	16		10	16	
Maximum CPU frequency		84 MHz					
Operating voltage		1.7 to 3.6 V					
Operating temperatures		Ambient temperatures: -40 to +85 °C/-40 to +105 °C					
		Junction temperature: -40 to + 125 °C					
Package		WLCSP49 UFQFPN48	LQFP64	UFBGA100 LQFP100	WLCSP49 UFQFPN48	LQFP64	UFBGA100 LQFP100

2.1 Compatibility with STM32F4 series

The STM32F401xB/STM32F401xC are fully software and feature compatible with the STM32F4 series (STM32F42x, STM32F43x, STM32F41x, STM32F405 and STM32F407)

The STM32F401xB/STM32F401xC can be used as drop-in replacement of the other STM32F4 products but some slight changes have to be done on the PCB board.

Figure 1. Compatible board design for LQFP100 package

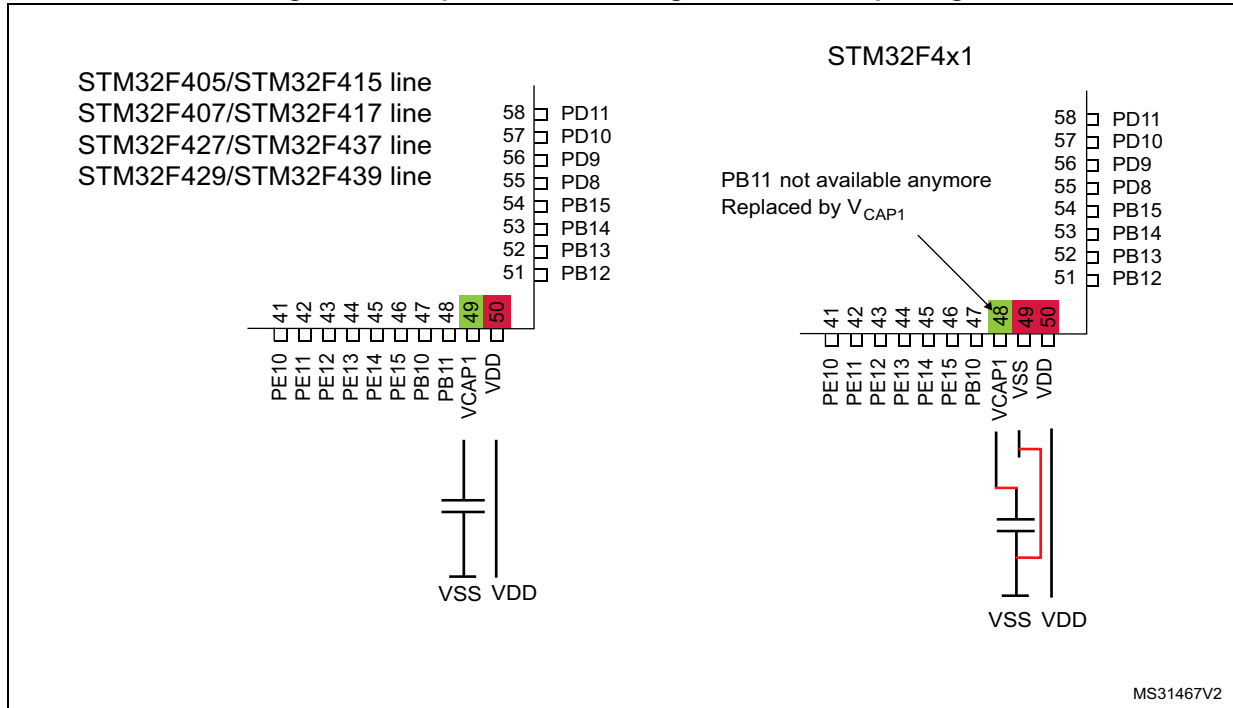


Figure 2. Compatible board design for LQFP64 package

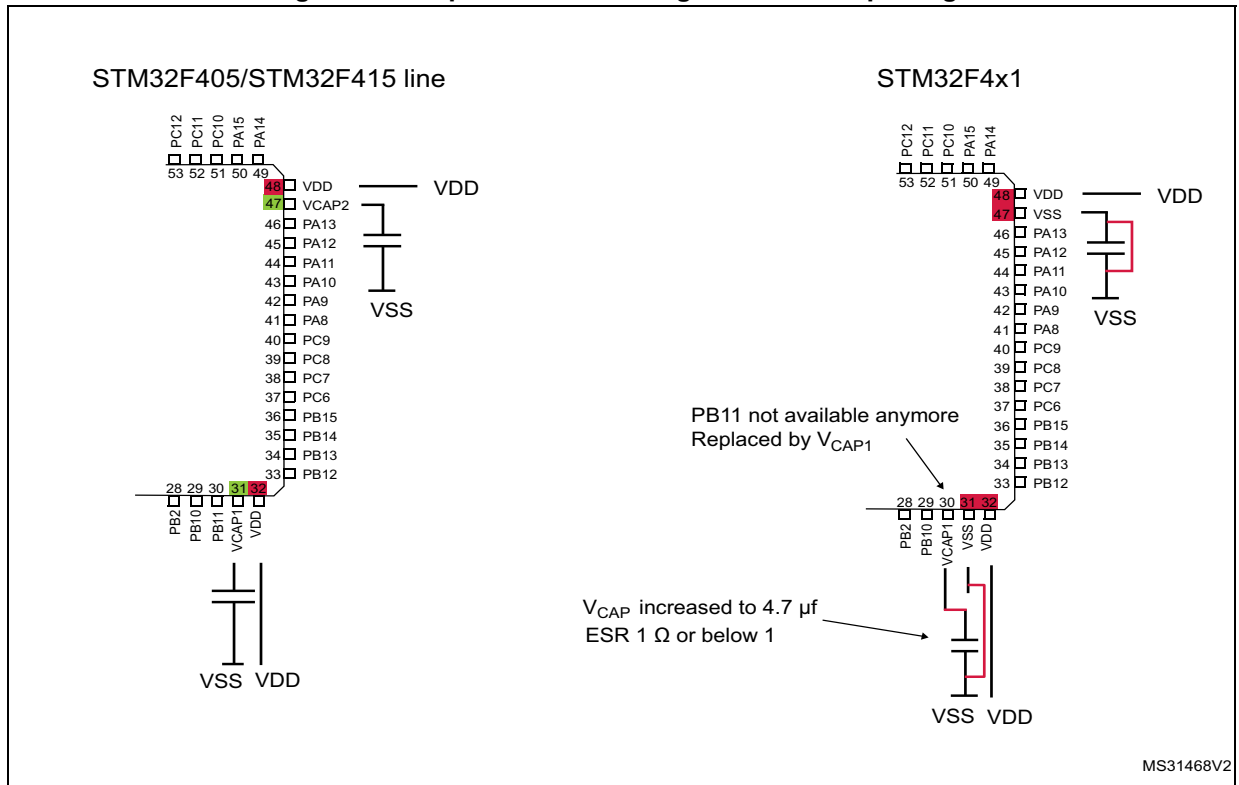
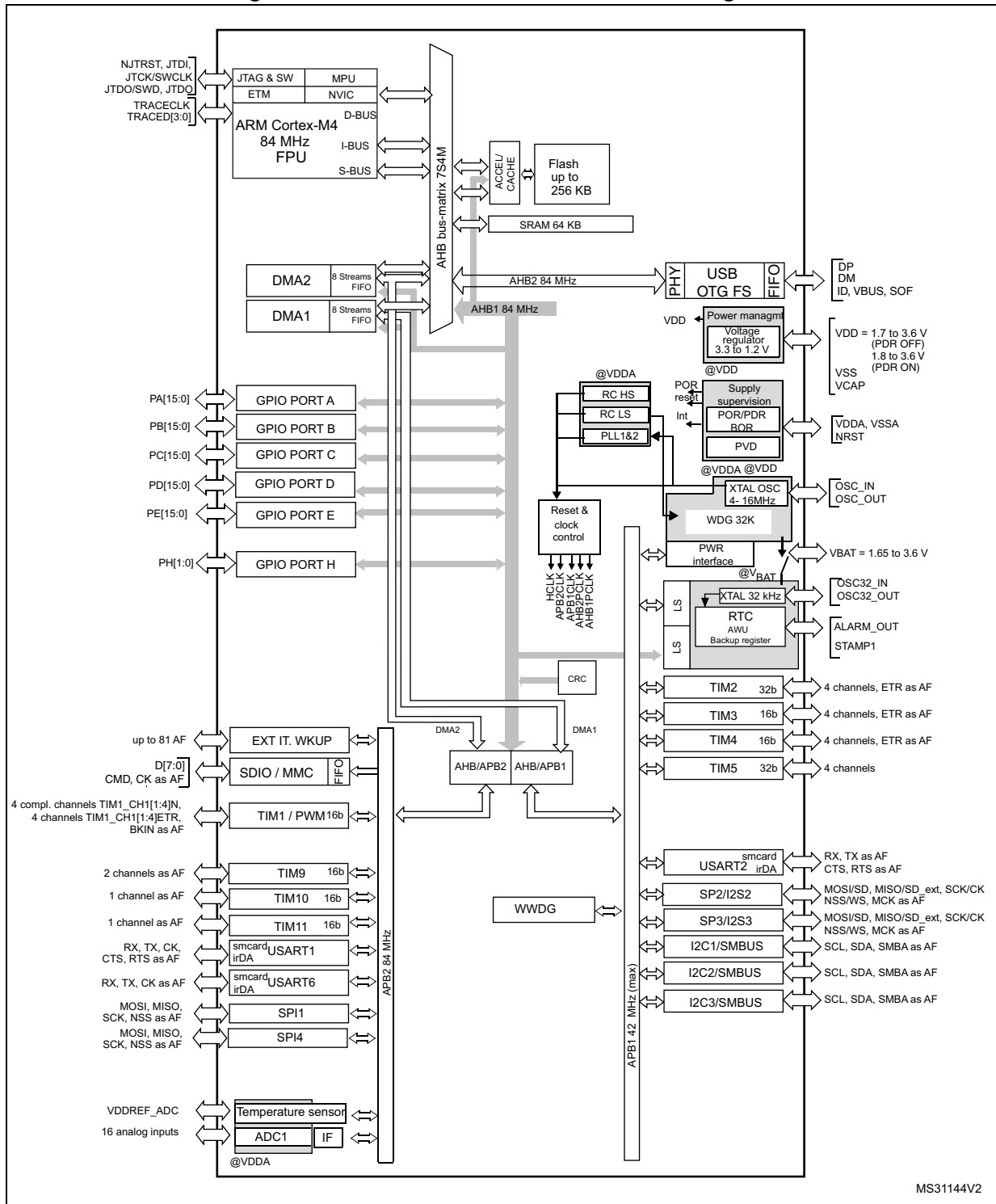


Figure 3. STM32F401xB/STM32F401xC block diagram



1. The timers connected to APB2 are clocked from TIMxCLK up to 84 MHz, while the timers connected to APB1 are clocked from TIMxCLK up to 42 MHz.

3 Functional overview

3.1 ARM[®] Cortex[®]-M4 with FPU core with embedded Flash and SRAM

The ARM[®] Cortex[®]-M4 with FPU processor is the latest generation of ARM processors for embedded systems. It was developed to provide a low-cost platform that meets the needs of MCU implementation, with a reduced pin count and low-power consumption, while delivering outstanding computational performance and an advanced response to interrupts.

The ARM[®] Cortex[®]-M4 with FPU 32-bit RISC processor features exceptional code-efficiency, delivering the high-performance expected from an ARM core in the memory size usually associated with 8- and 16-bit devices. The processor supports a set of DSP instructions which allow efficient signal processing and complex algorithm execution. Its single precision FPU (floating point unit) speeds up software development by using metalanguage development tools, while avoiding saturation.

The STM32F401xB/STM32F401xC devices are compatible with all ARM tools and software.

[Figure 3](#) shows the general block diagram of the STM32F401xB/STM32F401xC.

Note: Cortex[®]-M4 with FPU is binary compatible with Cortex[®]-M3.

3.2 Adaptive real-time memory accelerator (ART Accelerator[™])

The ART Accelerator[™] is a memory accelerator which is optimized for STM32 industry-standard ARM[®] Cortex[®]-M4 with FPU processors. It balances the inherent performance advantage of the ARM[®] Cortex[®]-M4 with FPU over Flash memory technologies, which normally requires the processor to wait for the Flash memory at higher frequencies.

To release the processor full 105 DMIPS performance at this frequency, the accelerator implements an instruction prefetch queue and branch cache, which increases program execution speed from the 256-bit Flash memory. Based on CoreMark benchmark, the performance achieved thanks to the ART accelerator is equivalent to 0 wait state program execution from Flash memory at a CPU frequency up to 84 MHz.

3.3 Memory protection unit

The memory protection unit (MPU) is used to manage the CPU accesses to memory to prevent one task to accidentally corrupt the memory or resources used by any other active task. This memory area is organized into up to 8 protected areas that can in turn be divided up into 8 subareas. The protection area sizes are between 32 bytes and the whole 4 gigabytes of addressable memory.

The MPU is especially helpful for applications where some critical or certified code has to be protected against the misbehavior of other tasks. It is usually managed by an RTOS (real-time operating system). If a program accesses a memory location that is prohibited by the MPU, the RTOS can detect it and take action. In an RTOS environment, the kernel can dynamically update the MPU area setting, based on the process to be executed.

The MPU is optional and can be bypassed for applications that do not need it.

3.4 Embedded Flash memory

The devices embed up to 256 Kbytes of Flash memory available for storing programs and data.

3.5 CRC (cyclic redundancy check) calculation unit

The CRC (cyclic redundancy check) calculation unit is used to get a CRC code from a 32-bit data word and a fixed generator polynomial.

Among other applications, CRC-based techniques are used to verify data transmission or storage integrity. In the scope of the EN/IEC 60335-1 standard, they offer a means of verifying the Flash memory integrity. The CRC calculation unit helps compute a software signature during runtime, to be compared with a reference signature generated at link-time and stored at a given memory location.

3.6 Embedded SRAM

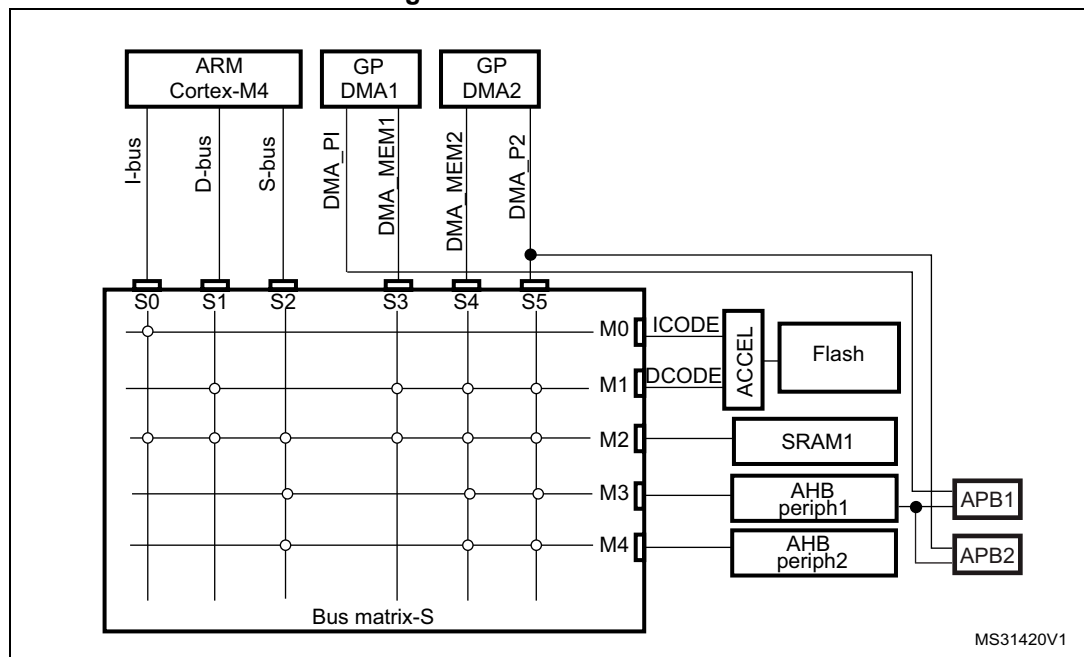
All devices embed:

- Up to 64 Kbytes of system SRAM which can be accessed (read/write) at CPU clock speed with 0 wait states

3.7 Multi-AHB bus matrix

The 32-bit multi-AHB bus matrix interconnects all the masters (CPU, DMAs) and the slaves (Flash memory, RAM, AHB and APB peripherals) and ensures a seamless and efficient operation even when several high-speed peripherals work simultaneously.

Figure 4. Multi-AHB matrix



3.8 DMA controller (DMA)

The devices feature two general-purpose dual-port DMAs (DMA1 and DMA2) with 8 streams each. They are able to manage memory-to-memory, peripheral-to-memory and memory-to-peripheral transfers. They feature dedicated FIFOs for APB/AHB peripherals, support burst transfer and are designed to provide the maximum peripheral bandwidth (AHB/APB).

The two DMA controllers support circular buffer management, so that no specific code is needed when the controller reaches the end of the buffer. The two DMA controllers also have a double buffering feature, which automates the use and switching of two memory buffers without requiring any special code.

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

The DMA can be used with the main peripherals:

- SPI and I²S
- I²C
- USART
- General-purpose, basic and advanced-control timers TIMx
- SD/SDIO/MMC host interface
- ADC

3.9 Nested vectored interrupt controller (NVIC)

The devices embed a nested vectored interrupt controller able to manage 16 priority levels, and handle up to 62 maskable interrupt channels plus the 16 interrupt lines of the Cortex[®]-M4 with FPU.

- Closely coupled NVIC gives low-latency interrupt processing
- Interrupt entry vector table address passed directly to the core
- Allows early processing of interrupts
- Processing of late arriving, higher-priority interrupts
- Support tail chaining
- Processor state automatically saved
- Interrupt entry restored on interrupt exit with no instruction overhead

This hardware block provides flexible interrupt management features with minimum interrupt latency.

3.10 External interrupt/event controller (EXTI)

The external interrupt/event controller consists of 21 edge-detector lines used to generate interrupt/event requests. Each line can be independently configured to select the trigger event (rising edge, falling edge, both) and can be masked independently. A pending register maintains the status of the interrupt requests. The EXTI can detect an external line with a pulse width shorter than the Internal APB2 clock period. Up to 81 GPIOs can be connected to the 16 external interrupt lines.

3.11 Clocks and startup

On reset the 16 MHz internal RC oscillator is selected as the default CPU clock. The 16 MHz internal RC oscillator is factory-trimmed to offer 1% accuracy at 25 °C. The application can then select as system clock either the RC oscillator or an external 4-26 MHz clock source. This clock can be monitored for failure. If a failure is detected, the system automatically switches back to the internal RC oscillator and a software interrupt is generated (if enabled). This clock source is input to a PLL thus allowing to increase the frequency up to 84 MHz. Similarly, full interrupt management of the PLL clock entry is available when necessary (for example if an indirectly used external oscillator fails).

Several prescalers allow the configuration of the two AHB buses, the high-speed APB (APB2) and the low-speed APB (APB1) domains. The maximum frequency of the two AHB buses is 84 MHz while the maximum frequency of the high-speed APB domains is 84 MHz. The maximum allowed frequency of the low-speed APB domain is 42 MHz.

The devices embed a dedicated PLL (PLL12S) which allows to achieve audio class performance. In this case, the I²S master clock can generate all standard sampling frequencies from 8 kHz to 192 kHz.

3.12 Boot modes

At startup, boot pins are used to select one out of three boot options:

- Boot from user Flash
- Boot from system memory
- Boot from embedded SRAM

The bootloader is located in system memory. It is used to reprogram the Flash memory by using either USART1(PA9/10), USART2(PD5/6), USB OTG FS in device mode (PA11/12) through DFU (device firmware upgrade), I2C1(PB6/7), I2C2(PB10/3), I2C3(PA8/PB4), SPI1(PA4/5/6/7), SPI2(PB12/13/14/15) or SPI3(PA15, PC10/11/12).

For more detailed information on the bootloader, refer to Application Note: AN2606, *STM32™ microcontroller system memory boot mode*.

3.13 Power supply schemes

- $V_{DD} = 1.7$ to 3.6 V: external power supply for I/Os with the internal supervisor (POR/PDR) disabled, provided externally through V_{DD} pins. Requires the use of an external power supply supervisor connected to the V_{DD} and PDR_ON pins.
- $V_{DD} = 1.8$ to 3.6 V: external power supply for I/Os and the internal regulator (when enabled), provided externally through V_{DD} pins.
- $V_{SSA}, V_{DDA} = 1.7$ to 3.6 V: external analog power supplies for ADC, Reset blocks, RCs and PLL. V_{DDA} and V_{SSA} must be connected to V_{DD} and V_{SS} , respectively, with decoupling technique.
- $V_{BAT} = 1.65$ to 3.6 V: power supply for RTC, external clock 32 kHz oscillator and backup registers (through power switch) when V_{DD} is not present.

Refer to [Figure 18: Power supply scheme](#) for more details.

3.14 Power supply supervisor

3.14.1 Internal reset ON

This feature is available for V_{DD} operating voltage range 1.8 V to 3.6 V.

The internal power supply supervisor is enabled by holding PDR_ON high.

The devices have an integrated power-on reset (POR) / power-down reset (PDR) circuitry coupled with a Brownout reset (BOR) circuitry. At power-on, POR is always active, and ensures proper operation starting from 1.8 V. After the 1.8 V POR threshold level is reached, the option byte loading process starts, either to confirm or modify default thresholds, or to disable BOR permanently. Three BOR thresholds are available through option bytes.

The devices remain in reset mode when V_{DD} is below a specified threshold, $V_{POR/PDR}$ or V_{BOR} , without the need for an external reset circuit.

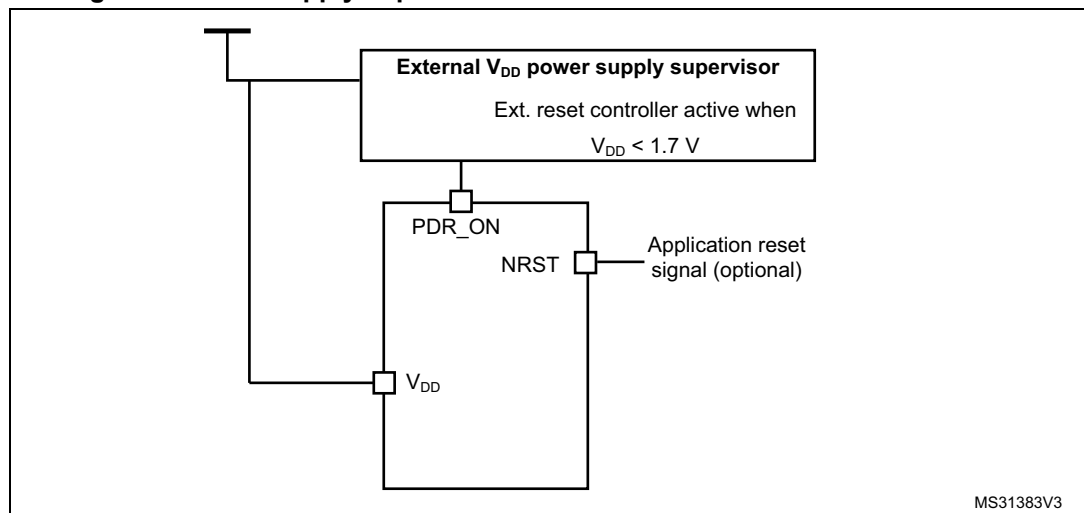
The devices also feature an embedded programmable voltage detector (PVD) that monitors the V_{DD}/V_{DDA} power supply and compares it to the V_{PVD} threshold. An interrupt can be generated when V_{DD}/V_{DDA} drops below the V_{PVD} threshold and/or when V_{DD}/V_{DDA} is higher than the V_{PVD} threshold. The interrupt service routine can then generate a warning message and/or put the MCU into a safe state. The PVD is enabled by software.

3.14.2 Internal reset OFF

This feature is available only on packages featuring the PDR_ON pin. The internal power-on reset (POR) / power-down reset (PDR) circuitry is disabled by setting the PDR_ON pin to low.

An external power supply supervisor should monitor V_{DD} and should maintain the device in reset mode as long as V_{DD} is below a specified threshold. PDR_ON should be connected to this external power supply supervisor. Refer to [Figure 5: Power supply supervisor interconnection with internal reset OFF](#).

Figure 5. Power supply supervisor interconnection with internal reset OFF⁽¹⁾



1. The PRD_ON pin is only available on the WLCSP49 and UFBGA100 packages.

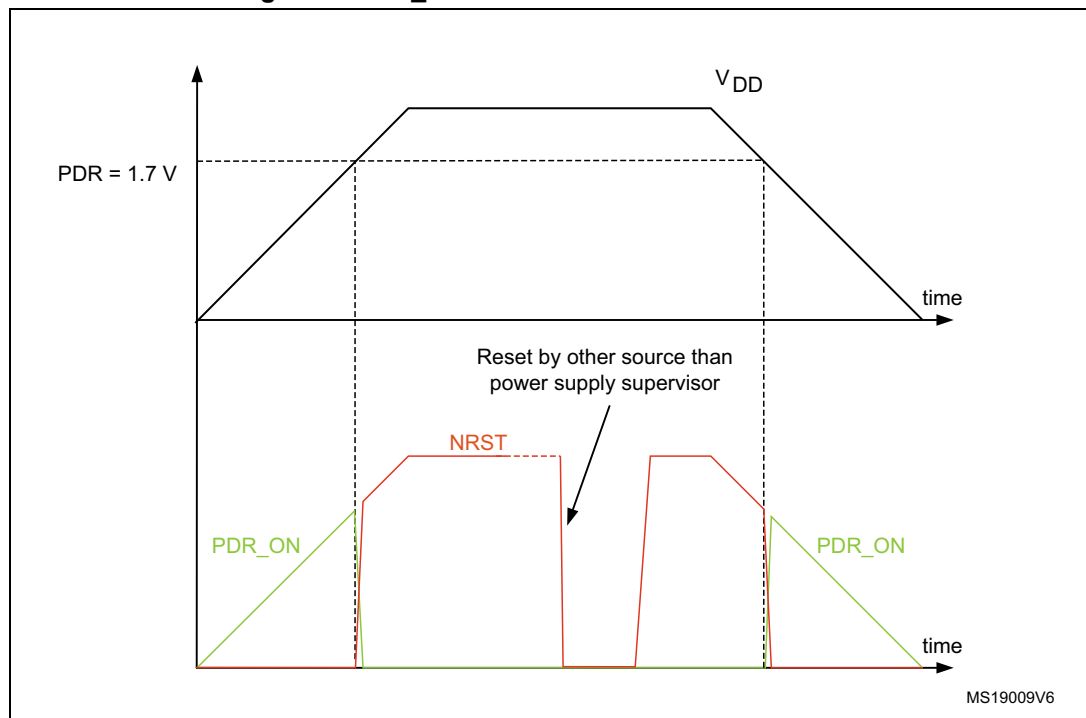
The V_{DD} specified threshold, below which the device must be maintained under reset, is 1.7 V (see [Figure 6](#)).

A comprehensive set of power-saving mode allows to design low-power applications.

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} .

Figure 6. PDR_ON control with internal reset OFF



3.15 Voltage regulator

The regulator has four operating modes:

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

3.15.1 Regulator ON

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

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

- MR is used in the nominal regulation mode (With different voltage scaling in Run)
In Main regulator mode (MR mode), different voltage scaling are provided to reach the best compromise between maximum frequency and dynamic power consumption.
- LPR is used in the Stop modes
The LP regulator mode is configured by software when entering Stop mode.
- Power-down is used in Standby mode.
The Power-down mode is activated only when entering in Standby mode. The regulator output is in high impedance and the kernel circuitry is powered down, inducing zero consumption. The contents of the registers and SRAM are lost.

Depending on the package, one or two external ceramic capacitors should be connected on the V_{CAP_1} and V_{CAP_2} pins. The V_{CAP_2} pin is only available for the LQFP100 and UFBGA100 packages.

All packages have the regulator ON feature.

3.15.2 Regulator OFF

The Regulator OFF is available only on the UFBGA100, which features the BYPASS_REG pin. The regulator is disabled by holding BYPASS_REG high. The regulator OFF mode allows to supply externally a V12 voltage source through V_{CAP_1} and V_{CAP_2} pins.

Since the internal voltage scaling is not managed internally, the external voltage value must be aligned with the targeted maximum frequency. Refer to [Table 14: General operating conditions](#).

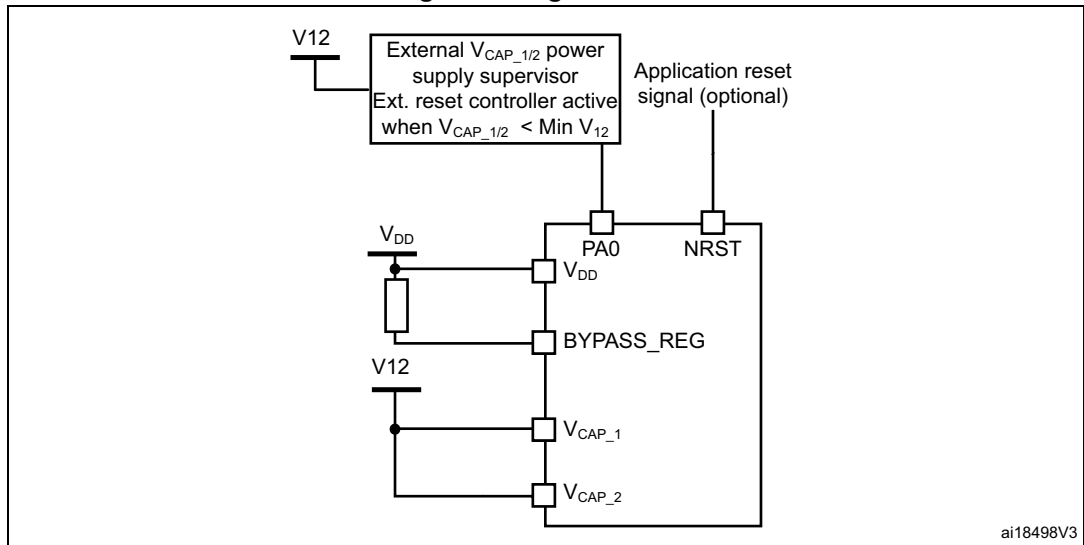
The two 2.2 μF V_{CAP} ceramic capacitors should be replaced by two 100 nF decoupling capacitors. Refer to [Figure 18: Power supply scheme](#).

When the regulator is OFF, there is no more internal monitoring on V12. An external power supply supervisor should be used to monitor the V12 of the logic power domain. PA0 pin should be used for this purpose, and act as power-on reset on V12 power domain.

In regulator OFF mode, the following features are no more supported:

- PA0 cannot be used as a GPIO pin since it allows to reset a part of the V12 logic power domain which is not reset by the NRST pin.
- As long as PA0 is kept low, the debug mode cannot be used under power-on reset. As a consequence, PA0 and NRST pins must be managed separately if the debug connection under reset or pre-reset is required.

Figure 7. Regulator OFF

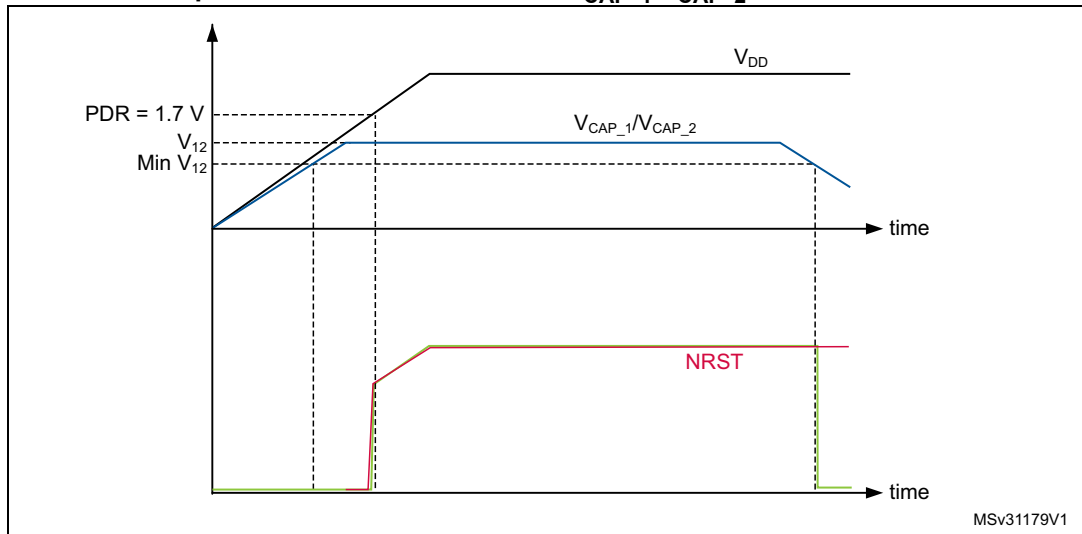


The following conditions must be respected:

- V_{DD} should always be higher than V_{CAP_1} and V_{CAP_2} to avoid current injection between power domains.
- If the time for V_{CAP_1} and V_{CAP_2} to reach V_{12} minimum value is faster than the time for V_{DD} to reach 1.7 V, then PA0 should be kept low to cover both conditions: until V_{CAP_1} and V_{CAP_2} reach V_{12} minimum value and until V_{DD} reaches 1.7 V (see [Figure 8](#)).
- Otherwise, if the time for V_{CAP_1} and V_{CAP_2} to reach V_{12} minimum value is slower than the time for V_{DD} to reach 1.7 V, then PA0 could be asserted low externally (see [Figure 9](#)).
- If V_{CAP_1} and V_{CAP_2} go below V_{12} minimum value and V_{DD} is higher than 1.7 V, then a reset must be asserted on PA0 pin.

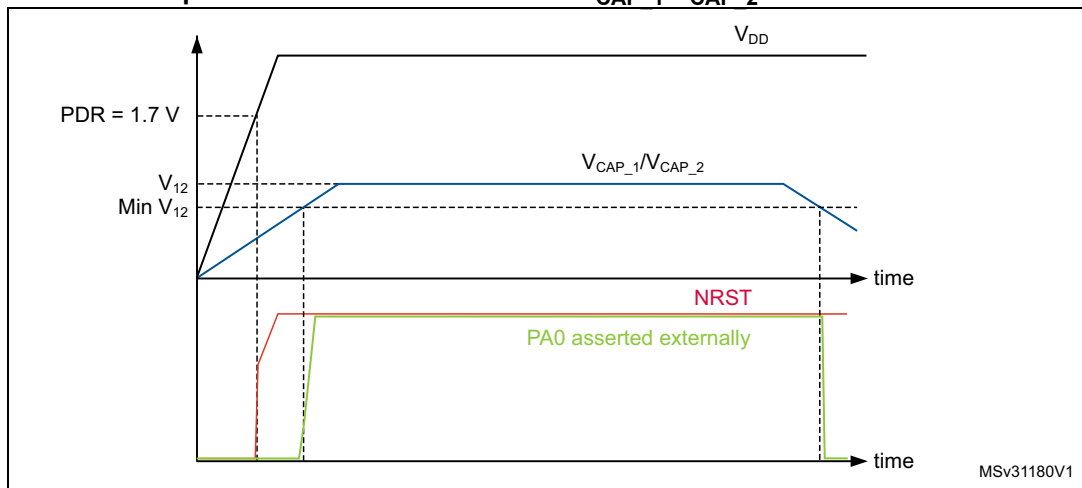
Note: The minimum value of V_{12} depends on the maximum frequency targeted in the application

Figure 8. Startup in regulator OFF: slow V_{DD} slope - power-down reset risen after V_{CAP_1}/V_{CAP_2} stabilization



1. This figure is valid whatever the internal reset mode (ON or OFF).

Figure 9. Startup in regulator OFF mode: fast V_{DD} slope - power-down reset risen before V_{CAP_1}/V_{CAP_2} stabilization



1. This figure is valid whatever the internal reset mode (ON or OFF).

3.15.3 Regulator ON/OFF and internal power supply supervisor availability

Table 3. Regulator ON/OFF and internal power supply supervisor availability

Package	Regulator ON	Regulator OFF	Power supply supervisor ON	Power supply supervisor OFF
UFQFPN48	Yes	No	Yes	No
WLCSP49	Yes	No	Yes PDR_ON set to VDD	Yes PDR_ON external control ⁽¹⁾
LQFP64	Yes	No	Yes	No
LQFP100	Yes	No	Yes	No
UFBGA100	Yes BYPASS_REG set to VSS	Yes BYPASS_REG set to VDD	Yes PDR_ON set to VDD	Yes PDR_ON external control ⁽¹⁾

1. Refer to [Section 3.14: Power supply supervisor](#)

3.16 Real-time clock (RTC) and backup registers

The backup domain includes:

- The real-time clock (RTC)
- 20 backup registers

The real-time clock (RTC) is an independent BCD timer/counter. Dedicated registers contain the second, minute, hour (in 12/24 hour), week day, date, month, year, in BCD (binary-coded decimal) format. Correction for 28, 29 (leap year), 30, and 31 day of the month are performed automatically. The RTC features a reference clock detection, a more precise second source clock (50 or 60 Hz) can be used to enhance the calendar precision. The RTC provides a programmable alarm and programmable periodic interrupts with wakeup from Stop and Standby modes. The sub-seconds value is also available in binary format.

It is clocked by a 32.768 kHz external crystal, resonator or oscillator, the internal low-power RC oscillator or the high-speed external clock divided by 128. The internal low-speed RC has a typical frequency of 32 kHz. The RTC can be calibrated using an external 512 Hz output to compensate for any natural quartz deviation.

Two alarm registers are used to generate an alarm at a specific time and calendar fields can be independently masked for alarm comparison. To generate a periodic interrupt, a 16-bit programmable binary auto-reload downcounter with programmable resolution is available and allows automatic wakeup and periodic alarms from every 120 μ s to every 36 hours.

A 20-bit prescaler is used for the time base clock. It is by default configured to generate a time base of 1 second from a clock at 32.768 kHz.

The backup registers are 32-bit registers used to store 80 bytes of user application data when V_{DD} power is not present. Backup registers are not reset by a system, a power reset, or when the device wakes up from the Standby mode (see [Section 3.17: Low-power modes](#)).

Additional 32-bit registers contain the programmable alarm subseconds, seconds, minutes, hours, day, and date.

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.

3.17 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 also be put either in normal or in low-power mode.

The devices 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).

- **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 when selected.

The devices exit 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.

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

3.18 V_{BAT} operation

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

V_{BAT} operation is activated when V_{DD} is not present.

The V_{BAT} pin supplies the RTC and the backup registers.

Note: When the microcontroller is supplied from V_{BAT} , external interrupts and RTC alarm/events do not exit it from V_{BAT} operation. When PDR_ON pin is not connected to V_{DD} (internal Reset OFF), the V_{BAT} functionality is no more available and V_{BAT} pin should be connected to V_{DD} .