PY32F002A Datasheet

32-bit ARM® Cortex®-M0+ Microcontroller

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PUYA

PY32F002A Series

32-bit ARM ® Cortex ® -M0+ microcontroller

Features

- Core
  - — 32-bit ARM® Cortex® - M0+ CPU
  - — Up to 24 MHz operating frequency
- Memories
  - — Maximum 20 Kbytes of flash memory
  - — Up to 3 Kbytes SRAM
- Clock system
  - — Internal 8/ 24 MHz RC Oscillator (HSI)
  - — Internal 32.768 KHz RC oscillator (LSI)
  - — 4 to 24 MHz crystal oscillator (HSE)
- Power management and reset
  - — Operating voltage: 1.7V to 5.5V
  - — Low power modes: Sleep and Stop
  - — Power-on/Power-down reset (POR/PDR)
  - — Brownout Detect Reset (BOR)
- General purpose input and output (I/O)
  - — Up to 18 I/Os, all available as external interrupts
  - — Driver current 8mA
- 1 x 12-bit ADC
  - — Supports up to 9 external input channels
  - — Input voltage conversion range: 0 ~ VCC
- Timer
  - — A 16bit advanced control timer (TIM1)
  - — 1 general purpose 16-bit timers (TIM16)
  - — A low-power timer (LPTIM), supports wake-up from stop mode
  - — An Independent Watchdog Timer (IWDT)
  - — A SysTick timer
- Communication Interface
  - — A Serial Peripheral Interface (SPI)
  - — 1 Universal Synchronous / Asynchronous Transceivers (USARTs) with automatic baud-rate detection
  - — A I2C interface , supports standard mode (100 kHz) , Fast mode (400 kHz) , supports 7-bit addressing mode
- Hardware CRC-32 module
- Two comparators
- Unique UID
- Serial wire debug (SWD)
- Working temperature: -40 to 85℃

Package:

SOP8, SOP16,

ESSOP10,TSSOP20,QFN16,QFN20,MSOP10

Content

1. Introduction

PY32F002A series microcontrollers are MCUs with high performance 32 - bit ARM® Cortex® -M0 + core, wide voltage operating range. It has embedded up to 20 Kbytes flash and 3 Kbytes SRAM memory, a maximum operating frequency of 24 MHz, and contains various products in different package types. The chip integrates multi-channel I2C, SPI, USART and other communication peripherals, one channel 12bit ADC, two16bit timers, and two-channel comparators.

PY32F002A series microcontrollers are -40 ℃ ~ 85 ℃, and the operating voltage range is 1.7V ~ 5.5V. The chip provides sleep and stop low-power operating modes from meeting different low-power applications.

The PY32F002A series of microcontrollers are suitable for various application scenarios, such as controllers, portable devices, PC peripherals, gaming and GPS platforms, industrial applications.

Table 1-1 PY32F002A series product features and peripheral counts

Peripherals		PY32F002AL15S	PY32F002AW15S	PY32F002AA15M	PY32F002AA15N	PY32F002AF15P	PY32F002AW15U	PY32F002AF15U
Flash memory (Kbyte)		20	20	20	20	20	20	20
SRAM (Kbyte)		3	3	3	3	3	3	3
Timer	Advanced Timer	1 (16-bit)						
	General purpose timer	1 (16-bit)						
	low power timer	1						
	SysTick	1						
	Watchdog	1						
Communication Port	SPI	1						
	I2C	1						
	USART	1						
Universal port		6	14	8	8	18	15	19
Number of ADC		4+2	7+2	5+2	4+2	8+2	9+2	9+2

Periph-erals	PY32F002 AL15S	PY32F002 AW15S	PY32F002 AA15M	PY32F002 AA15N	PY32F002 AF15P	PY32F002 AW15U	PY32F002 AF15U
channels (external + internal)							
Highest frequency							
Operating Voltage	24 MHz						
Package	1.7 ~ 5.5 V						
Universal port	SOP8	SOP16	ESSOP10	MSOP10	TSSOP20	QFN16	QFN20

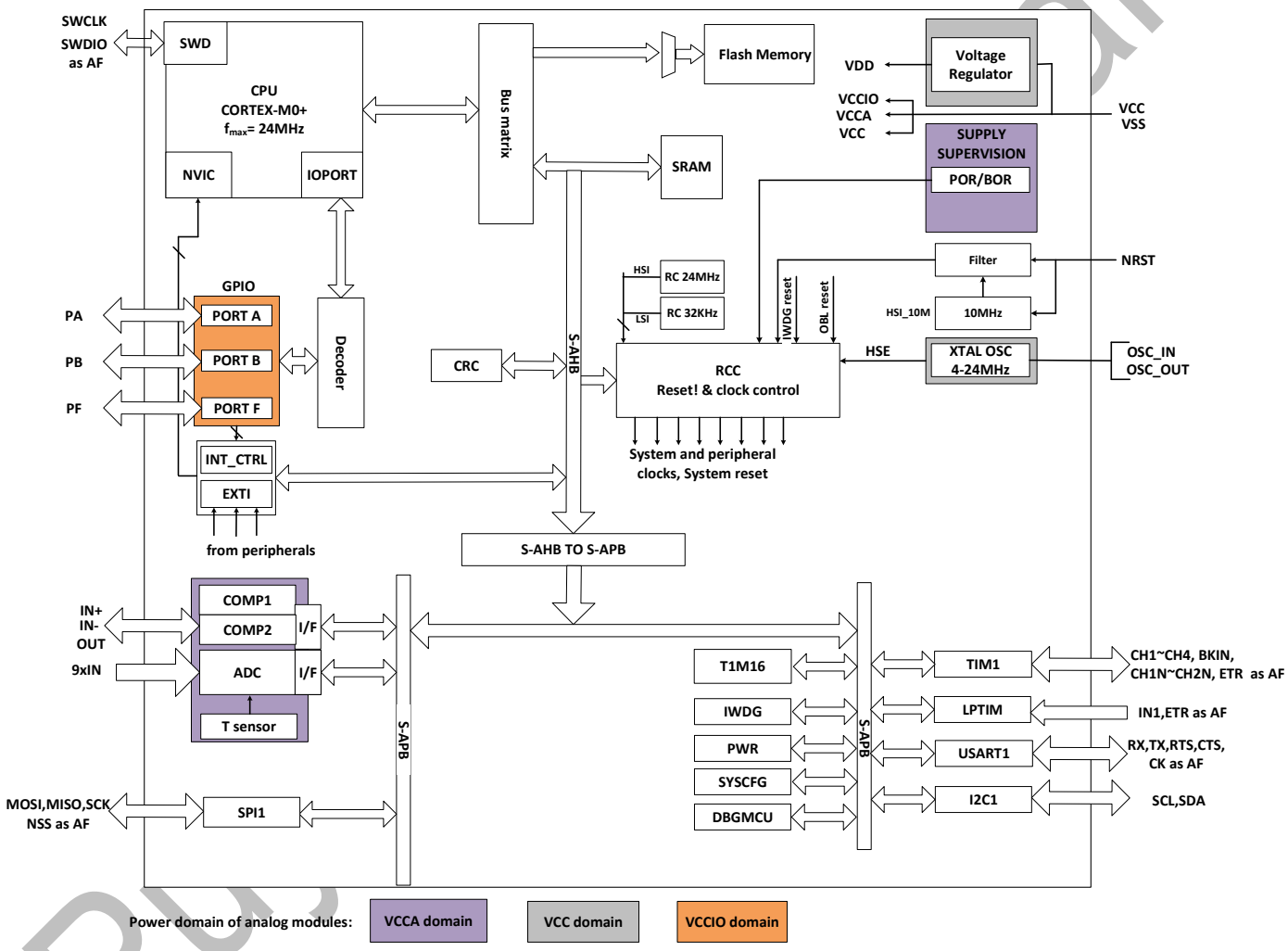


Figure 1-1 Functional Module

2. Functional overview

2.1. Arm®Cortex®-M0+ core

Arm ® The Cortex ® - M0+ is an entry-level 32-bit Arm Cortex processor designed for a wide range of embedded applications. It provides developers with significant benefits, including:

- Simple structure, easy to learn and program
- Ultra-low power consumption, energy-saving operation
- Reduced code density and more

Cortex-M0+ processor is a 32-bit core optimized for area and power consumption and is a 2-stage pipeline Von Neumann architecture. The processor offers high-end processing hardware, including single-cycle multipliers, through a streamlined but powerful instruction set and an extensively optimized design. Moreover, it delivers the superior performance expected from a 32-bit architecture computer, with a higher coding density than other 8 and 16-bit microcontrollers.

The Cortex-M0+ is tightly coupled with a Nested Vectored Interrupt Controller (NVIC).

2.2. Memories

The on-chip integrated SRAM is accessed by bytes (8 bits), half-word (16bits) or word (32bits).

The on-chip integrated Flash consists of two different physical areas:

- Main flash area, which contains application and user data
- The information area has 2.7KBytes, and it includes the following parts:
  - Option bytes
  - UID bytes
  - System memory

The protection of Flash main memory includes the following mechanisms:

- Read protection(RDP) prevents access from outside.
- Write protection (WRP) control prevents unwanted writes (confuse by program memory pointer from PC). The minimum protection unit for write protection is 4K bytes.
- Option byte write protection, special unlocking design.

2.3. Boot mode

Through BOOT0 pin and boot configuration bit nBOOT1 (stored in Option bytes), three different boot modes can be selected, as shown in the following table:

Table 2-1Boot configuration

Boot mode configuration		Mode
nBOOT1 bit	BOOT0 pin	
X	0	Select Main flash as the boot area
1	1	Select System memory as the boot area
0	1	Select SRAM as the boot area

The Boot loader program is stored in the System memory and used to download the Flash program through the USART interface.

2.4. Clock System

After the CPU starts, the default system clock frequency is HSI 8 MHz, and the system clock frequency and system clock source can be reconfigured after the program runs. The high frequency clocks that can be selected are:

- A 8 / 24 MHz configurable internal high precision HSI clock.
- A 32.768 KHz configurable internal LSI clock.
- 4 ~ 24 MHz HSE clock can enable the CSS function to detect HSE. If CSS fails, the hardware will automatically convert the system clock to HSI, and software configures the HSI frequency. Simultaneously, CPU NMI interrupt is generated.

The AHB clock can be divided based on the system clock, and the APB clock can be divided based on the AHB clock. AHB and APB clock frequencies up to 24 MHz.

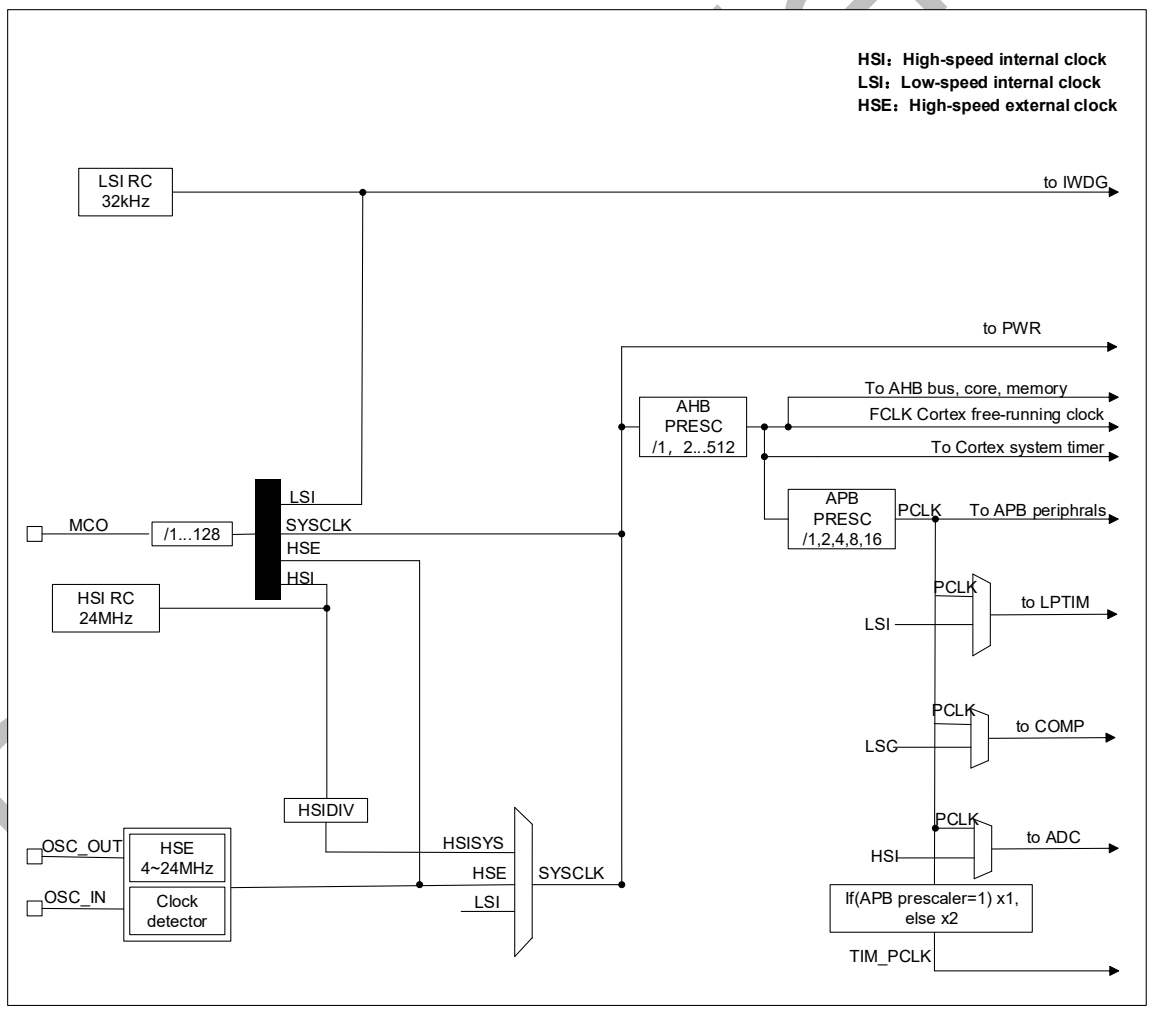


Figure 2-1 System Clock Structure Diagram

2.5. Power management

2.5.1. Power block diagram

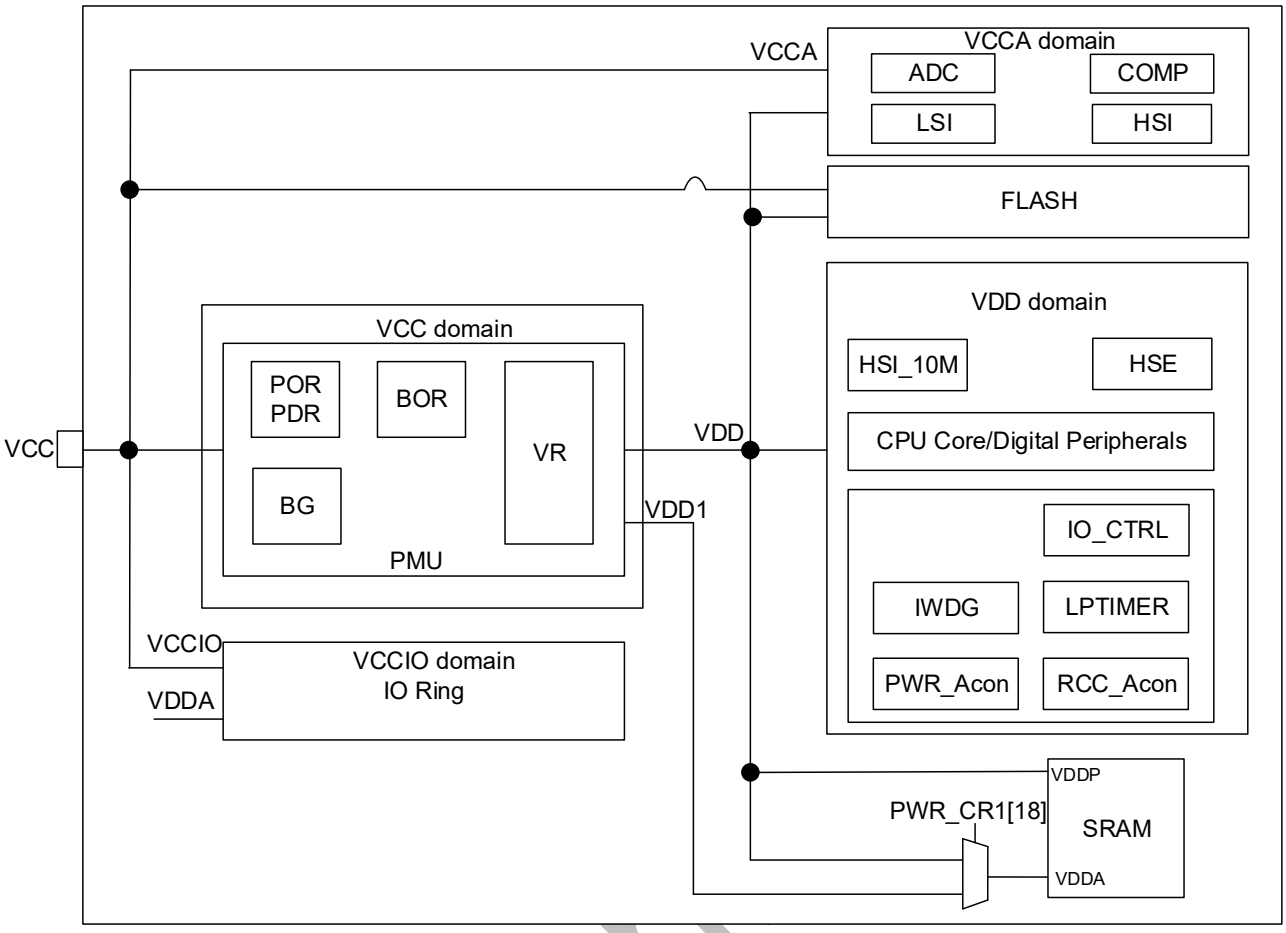


Figure 2-2 Power Block Diagram

Table 2-2 Power Block Diagram

Serial number	Power supply	Power value	Describe
1	VCC	1.7v ~ 5.5v	The chip is supplied with power through the power pins, and its power supply module is part of the analogue circuit.
2	VCCA	1.7v ~ 5.5v	Power to most analogue modules from VCC PAD (a separate power supply PAD can also be designed).
3	VCCIO	1.7v ~ 5.5v	Power supply to IO, from VCC PAD
4	VDD	1.2v/1.0v ± 10 %	VR supplies power to the main logic circuits and SRAM inside the chip. When the MR is powered, it outputs 1.2v. According to the software configuration, entering the stop mode can be powered by MR or LPR, and the LPR output is determined to be 1.2v or 1.0v.

2.5.2. Power monitoring

2.5.2.1. Power on reset (POR/PDR)

The Power on reset (POR)/Power down reset (PDR) module is designed to provide power-on and power-off reset for the chip. The module keeps working in all modes.

2.5.2.2. Brown-out reset (BOR)

In addition to POR/ PDR, BOR (brown-out reset) is also implemented. BOR can only be enabled and disabled through the option byte.

When the BOR is turned on, the BOR threshold can be selected by the Option byte, and both the rising and falling detection points can be configured individually.

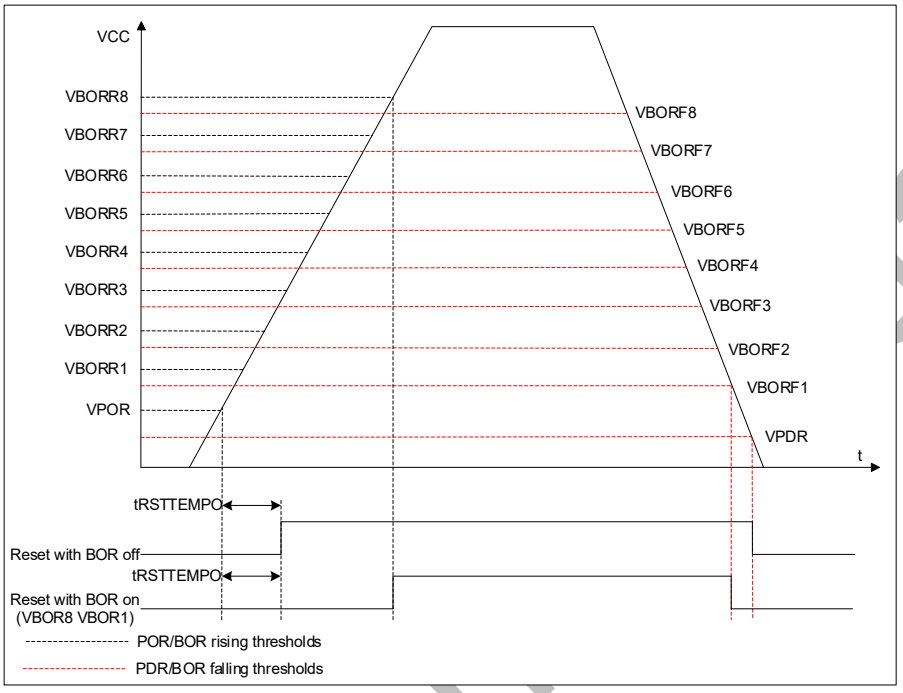


Figure 2-3 POR/PDR/BOR threshold

2.5.3. Voltage regulator

The chip designs two voltage regulators:

- MR (Main regulator) keeps working when the chip is in normal operating state.
- LPR (Low power regulator) provides a lower power consumption option in stop mode.

2.5.4. Low power mode

In addition to the normal operating mode, the chip has 2 low-power modes:

- **Sleep mode**: Peripherals can be configured to keep working when the CPU clock is off (NVIC, SysTick, etc.). It is recommended only to enable the modules that must work, and close the module after the module works.
- **Stop mode**: In this mode, the contents of SRAM and registers are maintained, HSI and HSE are turned off, and most modules of clocks in the VDD domain are stopped. GPIO, COMP output and LPTIM can wake up stop mode.

2.6. Reset

Two resets are designed in the chip: power and system reset.

2.6.1. Power reset

A power reset occurs in the following situations:

- Power on reset (POR/PDR)
- Brown-out reset (BOR)

2.6.2. System reset

A system reset occurs when the following events occur:

- Reset of NRST pin
- Independent Watchdog Reset (IWDG)
- SYSRESETREQ software reset
- Option byte load reset (OBL)
- Power reset (POR/PDR , BOR)

2.7. General-purpose input and output (GPIOs)

The software configures each GPIO as output (push-pull or open-drain), input (floating, pull-up/down, analog), peripheral multiplexing function, and locking mechanism freeze I/O port configuration function.

2.8. Interrupt

The PY32F002A handles exceptions through the Cortex-M0+ processor's embedded Vectored Interrupt Controller (NVIC) and an Extended Interrupt/Event Controller (EXTI).

2.8.1. Interrupt controller NVIC

NVIC is a tightly coupled IP inside the Cortex-M0+ processor. The NVIC can handle NMI (Non-Maskable Interrupts) and maskable external interrupts from outside the processor and Cortex-M0+ internal exceptions. NVIC provides flexible priority management.

The tight coupling of the processor core to the NVIC greatly reduces the delay between an interrupt event and the initiation of the corresponding interrupt service routine (ISR). The ISR vectors are listed in a vector table, stored at a base address of the NVIC. The vector table base address determines the vector address of the ISR to execute, and the ISR is used as the offset composed of serial numbers.

If a high-priority interrupt event occurs and a low-priority interrupt event is just waiting to be serviced, the later-arriving high-priority interrupt event will be serviced first. Another optimization is called tail-chaining. When returning from a high-priority ISR and then starting a pending low-priority ISR, unnecessary pushes and pops of processor contexts will be skipped. This reduces latency and improves power efficiency.

NVIC features:

- Low latency interrupt handling
- Level 4 Interrupt Priority
- Supports one NMI interrupt
- Supports 32 maskable external interrupts
- Supports 10 Cortex-M0+ exceptions
- High-priority interrupts can interrupt low-priority interrupt responses
- Support tail-chaining optimization

- Hardware Interrupt Vector Retrieval

2.8.2. Extended interrupt/event controller (EXTI)

EXTI adds flexibility to handle physical wire events and generates wake-up events when the processor wakes up from stop mode.

The EXTI controller has multiple channels, including a maximum of 16 GPIOs, 2 COMP outputs and LPTIM wake-up signals. GPIO and COMP can be configured to be triggered by a rising edge, falling edge or double edge. Any GPIO signal can be configured as EXTI0 ~ 15 channel through the select signal.

Each EXTI line can be independently masked through registers.

The EXTI controller can capture pulses shorter than the internal clock period.

Registers in the EXTI controller latch each event. Even in stop mode, after the processor wakes up from stop mode, it can identify the wake-up source or identify the GPIO and event that caused the interrupt.

2.9. Analog to digital converter (ADC)

The chip has a 12-bit SARADC. The module has up to 11 channels to be measured, including 9 external channels and 2 internal channels.

The conversion mode of each channel can be set to single, continuous, sweep, discontinuous mode. Conversion results are stored in left or right-aligned 16-bit data registers.

An analogue watchdog allows the application to detect if the input voltage exceeds a user-defined high or low threshold.

The ADC has been implemented to operate at a low frequency, resulting in lower power consumption.

At the end of sampling, conversion, and continuous conversion, an interrupt request is generated when the conversion voltage exceeds the threshold when simulating the watchdog.

2.10. Comparator(COMP)

The on-chip general purpose comparators (COMP) are integrated and can also be used in combination with timers. Comparators can be used as follows:

- It is triggered by analog signal to generate low power mode wake-up function
- Analog signal regulation
- A current control loop that cycles by cycle when connected to a PWM output from a timer

2.10.1. Main features of comparator

- Each comparator has configurable positive or negative inputs for flexible voltage selection
  - Multiple I/O pin
  - Power supply VCC
  - Output of temperature sensor
  - Internal reference voltage and 3 fractional values provided by partial voltage (1/4, 1/2, 3/4)
- The hysteresis function is configurable
- Programmable speed and power consumption

- The output can be triggered by a connection to the input of an I/O or timer
  - OCREF_CLR event (Current control for cycle by cycle)
  - Brakes for fast PWM shutdown

Each COMP has interrupt generation capability and is used to wake up the chip from low power modes (sleep and stop modes) (via EXTI)

2.11. Timer

The characteristics of different timers of PY32F002A are shown in the following table:

Table 2-3 Timer Features

Types	Timer	Bit Width	Counting Direction	Prescaler	Capture /compare channel	Comple-mentary output
Advanced Timer	TIM1	16 bit	superior, Down, center aligned	1 ~ 65536	4	3
General purpose timer	TIM16	16-bit	superior	1 ~ 65536	-	-

2.11.1. Advanced timer

The advanced timer (TIM1) consists of a 16-bit auto-reload counter driven by a 16-bit programmable prescaler. It can be used in various scenarios, including pulse length measurement of input signals (input capture) or generating output waveforms (output compare, output PWM, complementary PWM with dead-time insertion).

TIM1 includes 4 independent channels:

- Input capture
- Output comparison
- PWM generation (edge or center-aligned mode)
- Single pulse mode output

If TIM1 is configured as a standard 16-bit timer, it has the same characteristics as the TIMx timer. Full modulation capability (0-100%) if configured as a 16-bit PWM generator.

In the MCU debug mode, TIM1 can freeze counting.

The timer feature with the same architecture is shared so that the TIM1 can work with other timers for synchro-nization or event chaining through the timer chaining function.

2.11.2. General-purpose timer

2.11.2.1. TIM16

The general-purpose timer TIM16 consists of a 16-bit auto-reload counter driven by a 16-bit programmable prescaler.

In the MCU debug mode, TIM 16 can freeze counting.

2.11.3. Low power timer (LPTIM)

LPTIM is a 16 -bit up counter with a 3-bit prescaler and only support a single count.

LPTIM can be configured as a stop mode wakeup source.

In the MCU debug mode, LPTIM can freeze the count value.

2.11.4. IWDG

Independent watchdog (IWDG) is integrated in the chip, and this module has the characteristics of high-security level, accurate timing and flexible use. IWDG finds and resolves functional confusion due to software failure and triggers a system reset when the counter reaches the specified timeout value.

The IWDG is clocked by LSI, so even if the main clock fails, it can keep working.

IWDG is the best suited for applications that require the watchdog as a standalone process outside of the main application and do not have high timing accuracy constraints.

Controlling of option byte can enable IWDG hardware mode.

IWDG is the wake-up source of stop mode, which wakes up stop mode by reset.

In the MCU debug mode, IWDG can freeze the count value.

2.11.5. SysTick timer

SysTick counters are specifically for real-time operating systems (RTOS) also can use as standard down counters.

SysTick Features:

- 24-bit count down
- Self-loading capability
- An interrupt can be generated when the counter reaches 0 (maskable)

2.12. I2C interface

I2C (inter-integrated circuit) bus interface connects the microcontroller and the serial I2C bus. It provides multi-master capability and controls all I2C bus specific sequences, protocols, arbitration and timing. Standard (Sm) and fast (Fm) are supported.

I2C Features:

- Slave and master mode
- Multi-host function: can be master or slave
- Support different communication speeds
  - Standard Mode (Sm): Up to 100 kHz
  - Fast Mode (Fm): up to 400 kHz
- As master
  - Generate Clock
  - Generation of Start and Stop

- As slave
  - Programmable I2C address detection
  - Discovery of the Stop bit
- 7-bit addressing mode
- General call
- Status flag
  - Transmit/receive mode flags
  - Byte transfer complete flag
  - I2C busy flag bit
- Error flag
  - Master a rbitration loss
  - ACK failure after address/data transfer
  - Start/Stop error
  - Overrun/Underrun (clock stretching function disable)
- Optional Clock Stretching
- Software reset
- Analogue noise filter function

2.13. Universal synchronous asynchronous recevicer/ transmitter (USART)

PY32F002A contains 2 USARTs with precisely the same functions.

The Universal Synchronous Asynchronous Transceiver (USART) provides a flexible method for full-duplex data exchange with external devices using the industry-standard NRZ asynchronous serial data format. The USART utilizes a fractional baudrate generator to provide a wide range of baudrate options.

It supports simultaneous one-way communication and half-duplex single-wire communication, and it also allows multi-processor communication.

Automatic baudrate detection is supported.

USART features:

- Full-duplex asynchronous communication
- NRZ standard format
- Configurable 16 times or 8 times oversampling for increased flexibility in speed and clock tolerance
- Programmable baudrate shared by transmit and receive, up to 4.5Mbit/s
- Automatic baudrate detection
- Programmable data length of 8 or 9 bits
- Configurable stop bits (1 or 2 bits)
- Synchronous mode and clock output function for synchronous communication
- Single-wire half-duplex communication
- Independent transmit and receive enable bits
- Hardware flow control

- Detection flag
  - Receive full buffer
  - Send empty buffer
  - End of transmission
- Parity Control
  - Send check digit
  - Check the received data
- Flagged interrupt sources
  - CTS change
  - Send empty register
  - Send completed
  - Receive full data register
  - Bus idle detected
  - Overflow error
  - Frame error
  - Noise operation
  - Error detection
- Multiprocessor communication
  - If the address does not match, enter silent mode
- Wake-up from silent mode: by idle detection and address flag detection

2.14. Serial peripheral interface (SPI)

PY32F002A contains one SPI.

Serial Peripheral Interface (SPI) allows the chip to communicate with external devices in half-duplex, full-duplex, and simplex synchronous serial communication. This interface can be configured in master mode and provides the communication clock (SCK) for external slave devices. The interface can also work in a multi-master configuration.

The SPI features are as follows:

- Master or slave mode
- 3 -wire full-duplex simultaneous transmission
- 2-wire half-duplex synchronous transmission (with bidirectional data line)
- 2-wire simplex synchronous transmission (no bidirectional data line)
- 8-bit or 16-bit transmission frame selection
- Support multi-master mode
- 8 master mode baudrate prescaler factors (max fPCLK/ 4)
- Slave mode frequency (max fPCLK/4)
- Both master and slave modes can be managed by software or hardware NSS: dynamic change of master/slave operating mode
- Programmable clock polarity and phase
- Programmable data order, MSB first or LSB first

- Dedicated transmit and receive flags that can trigger interrupts
- SPI bus busy status flag
- Motorola mode
- Interrupt-causing master mode faults, overloads

2.15. SWD

The ARM SWD interface allows serial debugging tools to be connected to the PY32F002A.

3. Pin configuration

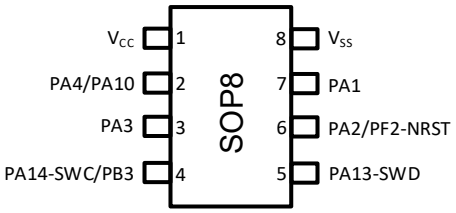


Figure 3-1 SOP8 Pinout1 PY32F002AL15S

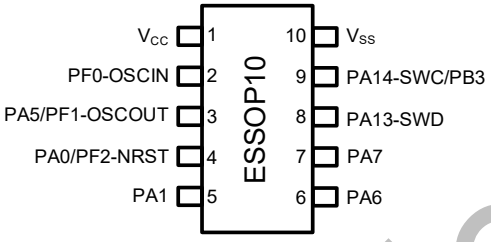


Figure 3-2 ESSOP10 Pinout1 PY32F002AA15M

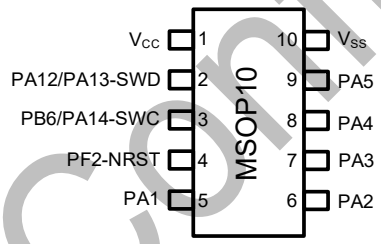


Figure 3-3 MSOP10 Pinout1 PY32F002AA15N

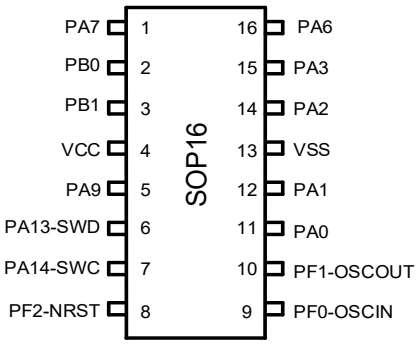


Figure 3-4 SOP16 Pinout1 PY32F002AW15S

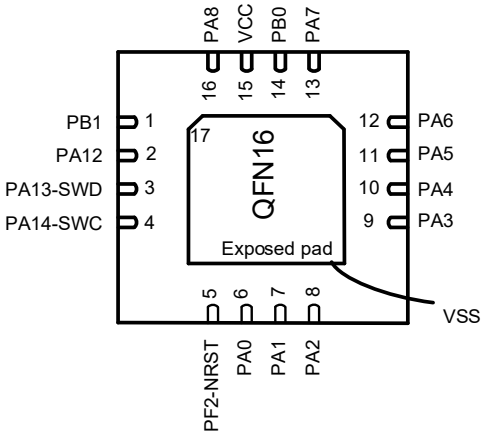


Figure 3-5 QFN16 Pinout1 PY32F002AW15U

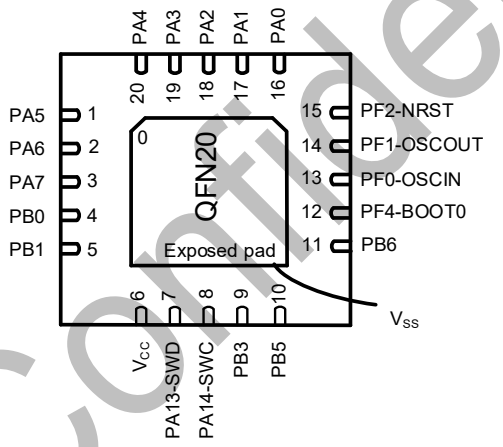


Figure 3-6 QFN20 Pinout1 PY32F002AF15U

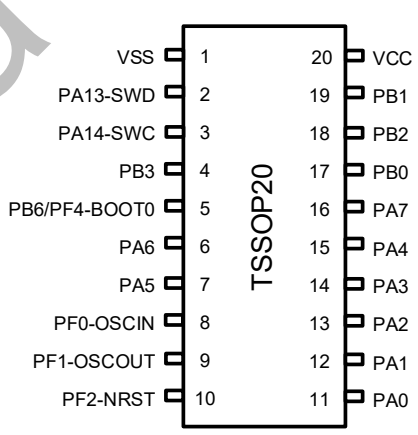


Figure 3-7 TSSOP20 Pinout1 PY32F002AF15P

Table 3-1 Pin definition terminology and symbols

Types		Symbol	Definition
Port type		S	Supply pin
		G	Ground p in
		I/O	Input/output pin
		NC	Undefined
Port structure		COM	5V port, support analogue input and output function
		RST	Reset port, with internal weak pull-up resistor, does not support analog input and output function
Notes			Unless other specified, all ports are used as floating inputs between and after reset
Port function	Multiplexing function		Function selected by GPIOx_AFR register
	Additional features		Directly selected or enabled through peripheral registers

Table 3-2 pin definition

Package type											Note Port function	
SOP8 L1	SOP16 W1	ESSOP10 A1	MSOP10N1	TSSOP20 F1	QFN16 W1	QFN20 F1	Reset	Port type	Port structure	Notes	Multiplexing function	Additional features
-	9	2	-	8	-	13	PF0-OSC_IN-(PF0)	I/O	COM		USART1_RX I²C_SDA	OSC_IN
-	10	3	-	9	-	14	PF1-OSC_OUT-(PF1)	I/O	COM		USART1_TX I²C_SCL SP1_NSS	OSC_OUT
6	8	4	4	10	5	15	PF2-NRST	I/O	RST	(1)	MCO	NRST
-	11	4	-	11	6	16	PA0	I/O	COM		USART1_CTS TIM1_CH3 TIM1_CH1N COMP1_OUT SPI1_MISO	ADC_IN0 COMP1_INM
7	12	5	5	12	7	17	PA1	I/O	COM		SPI1_SCK USART1_RTS EVENTOUT SPI1_MOSI TIM1_CH4 TIM1_CH2N MCO	COMP1_INP ADC_IN1
6	14	-	6	13	8	18	PA2	I/O	COM		SPI1_MOSI USART1_TX SPI1_SCK COMP2_OUT I²C_SDA	COMP2_INM ADC_IN2

Package type											Note Port function	
SOP8 L1	SOP16 W1	ESSOP10 A1	MSOP10N1	TSSOP20 F1	QFN16 W1	QFN20 F1	Reset	Port type	Port struc-ture	Notes	Multiplexing function	Additional features
3	15	-	7	14	9	19	PA3	I/O	COM		USART1_RX EVENTOUT SPI1_MOSI TIM1_CH1 I²C_SCL	COMP2_INP ADC_IN3
2	-	-	8	15	10	20	PA4	I/O	COM		SPI1_NSS USART1_CK ENENTOUT	ADC_IN4
-	-	3	9	7	11	1	PA5	I/O	COM		SPI1_SCK LPTIM_ETR EVENTOUT MCO	ADC_IN5
-	16	6	-	6	12	2	PA6	I/O	COM		SPI1_MISO TIM1_BKIN EVENTOUT COMP1_OUT USART1_CK	ADC_IN6
-	1	7	-	16	13	3	PA7	I/O	COM		SPI1_MOSI TIM1_CH1N EVENTOUT USART1_TX I²C_SDA COMP2_OUT SPI1_MISO	ADC_IN7
-	2	-	-	17	14	4	PB0	I/O	COM		SPI1_NSS TIM1_CH2N COMP1_OUT EVENTOUT	-
-	3	-	-	19	1	5	PB1	I/O	COM		TIM1_CH3N EVENTOUT	COMP1_INM ADC_IN9
8	13	10	10	1	17	-	V_{SS}	S			Ground	
-			-	18	-	-	PB2	I/O	COM		USART1_RX	COMP1_INP
1	4	1	1	20	15	6	V_{CC}	S			Digital power supply	
-	-	-	-	-	16	-	PA8	I/O	COM		USART1_CK TIM1_CH1 MCO EVENTOUT USART1_RX SPI1_MOSI I²C_SCL	-
-	5	-	-	-	-	-	PA9	I/O	COM		USART1_TX	-

Package type											Note Port function	
SOP8 L1	SOP16 W1	ESSOP10 A1	MSOP10N1	TSSOP20 F1	QFN16 W1	QFN20 F1	Reset	Port type	Port struc-ture	Notes	Multiplexing function	Additional features
											TIM1_CH2	
											MCO	
											I²C_SCL	
											EVENTOUT	
											I²C_SDA	
											TIM1_BK	
											SPI1_SCK	
											USART1_RX	
2	-	-	-	-	-	-	PA10	I/O	COM		USART1_RX	-
											TIM1_CH3	
											I²C_SDA	
											EVENTOUT	
											I²C_SCL	
											SPI1_NSS	
											USART1_TX	
-	-	-	2	-	2	-	PA12	I/O	COM		SPI1_MOSI	-
											USART1_RTS	
											TIM1_ETR	
											COMP2_OUT	
											EVENTOUT	
											I²C_SDA	
5	6	8	2	2	3	7	PA13(SWDIO)	I/O	COM	(2)	SWDIO	-
											EVENTOUT	
											SPI1_MISO	
											TIM1_CH2	
											USART1_RX	
											MCO	
4	7	9	3	3	4	8	PA14(SWCLK)	I/O	COM	(2)	SWCLK	-
											USART1_TX	
											EVENTOUT	
											MCO	
4	-	-	-	4	-	9	PB3	I/O	COM		SPI1_SCK	COMP2_INM
											TIM1_CH2	
											USART1_RTS	
											EVENTOUT	
-	-	-	-	-	-	10	PB5	I/O	COM		SPI1_MOSI	-
											USART1_CK	
											LPTIM_IN1	
											COMP1_OUT	
-	-	-	3	5	-	11	PB6	I/O	COM		USART1_TX	COMP2_INP
											TIM1_CH3	

Package type											Note Port function	
SOP8 L1	SOP16 W1	ESSOP10 A1	MSOP10N1	TSSOP20 F1	QFN16 W1	QFN20 F1	Reset	Port type	Port struc-ture	Notes	Multiplexing function	Additional features
											I²C_SCL	
											LPTIM_ETR	
											EVENTOUT	
-	-	-	-	5	-	12	PF4-BOOT0	I/O	COM	(3)	-	BOOT0

Note :

(1) Selecting PF2 or NRST is configured through option bytes .

(2) After reset, the two pins of PA13 and PA14 are configured as SWDIO and SWCLK AF function, the former internal pull-up resistor, the latter internal pull-down resistor is activated.

(3) PF4 -BOOT0 is the default digital input mode, and the pull-down is enabled.

3.1. Port A multiplexing function mapping

Table 3-3 Port A multiplexing function mapping

Port	AF0	AF1	AF2	AF3	AF4	AF5	AF6	AF7
PA0	-	USART1_CTS	-	-	-	-	-	COMP1_OUT
	AF8	**AF9**	**AF10**	**AF11**	**AF12**	**AF13**	**AF14**	**AF15**
	-		SPI1_MISO	-	-	TIM1_CH3	TIM1_CH1N	
PA1	**AF0**	**AF1**	**AF2**	**AF3**	**AF4**	**AF5**	**AF6**	**AF7**
	SPI1_SCK	USART1_RTS	-	-		-	-	EVENTOUT
	AF8	**AF9**	**AF10**	**AF11**	**AF12**	**AF13**	**AF14**	**AF15**
	-		SPI1_MOSI	-	-	TIM1_CH4	TIM1_CH2N	MCO
PA2	**AF0**	**AF1**	**AF2**	**AF3**	**AF4**	**AF5**	**AF6**	**AF7**
	SPI1_MOSI	USART1_TX	-	-		-	-	COMP2_OUT
	AF8	**AF9**	**AF10**	**AF11**	**AF12**	**AF13**	**AF14**	**AF15**
	-	-	SPI1_SCK	-	I2C_SDA		-	-
PA3	**AF0**	**AF1**	**AF2**	**AF3**	**AF4**	**AF5**	**AF6**	**AF7**
	-	USART1_RX	-	-		-	-	EVENTOUT
	AF8	**AF9**	**AF10**	**AF11**	**AF12**	**AF13**	**AF14**	**AF15**
	-	-	SPI1_MOSI	-	I2C_SCL	TIM1_CH1	-	-
PA4	**AF0**	**AF1**	**AF2**	**AF3**	**AF4**	**AF5**	**AF6**	**AF7**
	SPI1_NSS	USART1_CK	-	-			-	EVENTOUT
	AF8	**AF9**	**AF10**	**AF11**	**AF12**	**AF13**	**AF14**	**AF15**
	-		-	-	-		-	
PA5	**AF0**	**AF1**	**AF2**	**AF3**	**AF4**	**AF5**	**AF6**	**AF7**
	SPI1_SCK	-	-		-	LPTIM1_ETR	-	EVENTOUT
	AF8	**AF9**	**AF10**	**AF11**	**AF12**	**AF13**	**AF14**	**AF15**
	-		-	-	-		-	MCO
PA6	**AF0**	**AF1**	**AF2**	**AF3**	**AF4**	**AF5**	**AF6**	**AF7**
	SPI1_MISO		TIM1_BKIN		-		-	COMP1_OUT
	AF8	**AF9**	**AF10**	**AF11**	**AF12**	**AF13**	**AF14**	**AF15**
	USART1_CK	-	-	-	-	-	-	
PA7	**AF0**	**AF1**	**AF2**	**AF3**	**AF4**	**AF5**	**AF6**	**AF7**
	SPI1_MOSI		TIM1_CH1N	-			EVENTOUT	COMP2_OUT
	AF8	**AF9**	**AF10**	**AF11**	**AF12**	**AF13**	**AF14**	**AF15**
	USART1_TX		SPI1_MISO	-	I2C_SDA	-	-	-
PA8	**AF0**	**AF1**	**AF2**	**AF3**	**AF4**	**AF5**	**AF6**	**AF7**
		USART1_CK	TIM1_CH1	-		MCO	-	EVENTOUT
	AF8	**AF9**	**AF10**	**AF11**	**AF12**	**AF13**	**AF14**	**AF15**

	USART1_RX		SPI1_MOSI	-	I2C_SCL	-	-	-
PA9	**AF0**	**AF1**	**AF2**	**AF3**	**AF4**	**AF5**	**AF6**	**AF7**
		USART1_TX	TIM1_CH2	-		MCO	I2C_SCL	EVENTOUT
	AF8	**AF9**	**AF10**	**AF11**	**AF12**	**AF13**	**AF14**	**AF15**
	USART1_RX	-	SPI1_SCK	-	I2C_SDA	TIM1_BKIN	-	-
PA10	**AF0**	**AF1**	**AF2**	**AF3**	**AF4**	**AF5**	**AF6**	**AF7**
		USART1_RX	TIM1_CH3	-			I2C_SDA	EVENTOUT
	AF8	**AF9**	**AF10**	**AF11**	**AF12**	**AF13**	**AF14**	**AF15**
	USART1_TX	-	SPI1_NSS	-	I2C_SCL	-	-	-
PA12	**AF0**	**AF1**	**AF2**	**AF3**	**AF4**	**AF5**	**AF6**	**AF7**
	SPI1_MOSI	USART1_RTS	TIM1_ETR	-		EVENTOUT	I2C_SDA	COMP2_OUT
PA13	**AF0**	**AF1**	**AF2**	**AF3**	**AF4**	**AF5**	**AF6**	**AF7**
	SWDIO		-	-	-	-	-	EVENTOUT
	AF8	**AF9**	**AF10**	**AF11**	**AF12**	**AF13**	**AF14**	**AF15**
	USART1_RX	-	SPI1_MISO	-	-	TIM1_CH2	-	MCO
PA14	**AF0**	**AF1**	**AF2**	**AF3**	**AF4**	**AF5**	**AF6**	**AF7**
	SWCLK	USART1_TX	-	-		-	-	EVENTOUT
	AF8	**AF9**	**AF10**	**AF11**	**AF12**	**AF13**	**AF14**	**AF15**
	-	-	-	-	-	-	-	MCO

3.2. Port B multiplexing function mapping

Table 3-4 Port B multiplexing function mapping

Port	AF0	AF1	AF2	AF3	AF4	AF5	AF6	AF7
PB0	SPI1_NSS		TIM1_CH2N	-	-	EVENTOUT	-	COMP1_OUT
PB1	**AF0**	**AF1**	**AF2**	**AF3**	**AF4**	**AF5**	**AF6**	**AF7**
			TIM1_CH3N	-	-	-	-	EVENTOUT
PB2	**AF0**	**AF1**	**AF2**	**AF3**	**AF4**	**AF5**	**AF6**	**AF7**
	USART1_RX		-		-	-	-	-
PB3	**AF0**	**AF1**	**AF2**	**AF3**	**AF4**	**AF5**	**AF6**	**AF7**
	SPI1_SCK	TIM1_CH2	-	USART1_RTS		-		-
PB5	**AF0**	**AF1**	**AF2**	**AF3**	**AF4**	**AF5**	**AF6**	**AF7**
	SPI1_MOSI			USART1_CK		LPTIM_IN1	-	COMP1_OUT
PB6	**AF0**	**AF1**	**AF2**	**AF3**	**AF4**	**AF5**	**AF6**	**AF7**
	USART1_TX	TIM1_CH3		-		LPTIM_ETR	I2C_SCL	EVENTOUT
PB7	**AF0**	**AF1**	**AF2**	**AF3**	**AF4**	**AF5**	**AF6**	**AF7**
	USART1_RX	-		-		-	I2C_SDA	EVENTOUT

3.3. Port F multiplexing function mapping

Table 3-5 Port F multiplexing function mapping

Port	AF0	AF1	AF2	AF3	AF4	AF5	AF6	AF7
PF0-OSC_IN	-	-		-		-	-	-
	AF8	**AF9**	**AF10**	**AF11**	**AF12**	**AF13**	**AF14**	**AF15**
	USART1_RX		-	-	I2C_SDA	-	-	-
PF1_OSC_OUT	**AF0**	**AF1**	**AF2**	**AF3**	**AF4**	**AF5**	**AF6**	**AF7**
	-	-	-	-		-	-	-
	AF8	**AF9**	**AF10**	**AF11**	**AF12**	**AF13**	**AF14**	**AF15**
	USART1_TX		SPI1_NSS	-	I2C_SCL		-	-
PF2-NRST	**AF0**	**AF1**	**AF2**	**AF3**	**AF4**	**AF5**	**AF6**	**AF7**
	-	-	-	-		-	MCO	-
PF4-BOOT0	**AF0**	**AF1**	**AF2**	**AF3**	**AF4**	**AF5**	**AF6**	**AF7**
	-	-	-	-	-	-	-	-

4. Memory Map

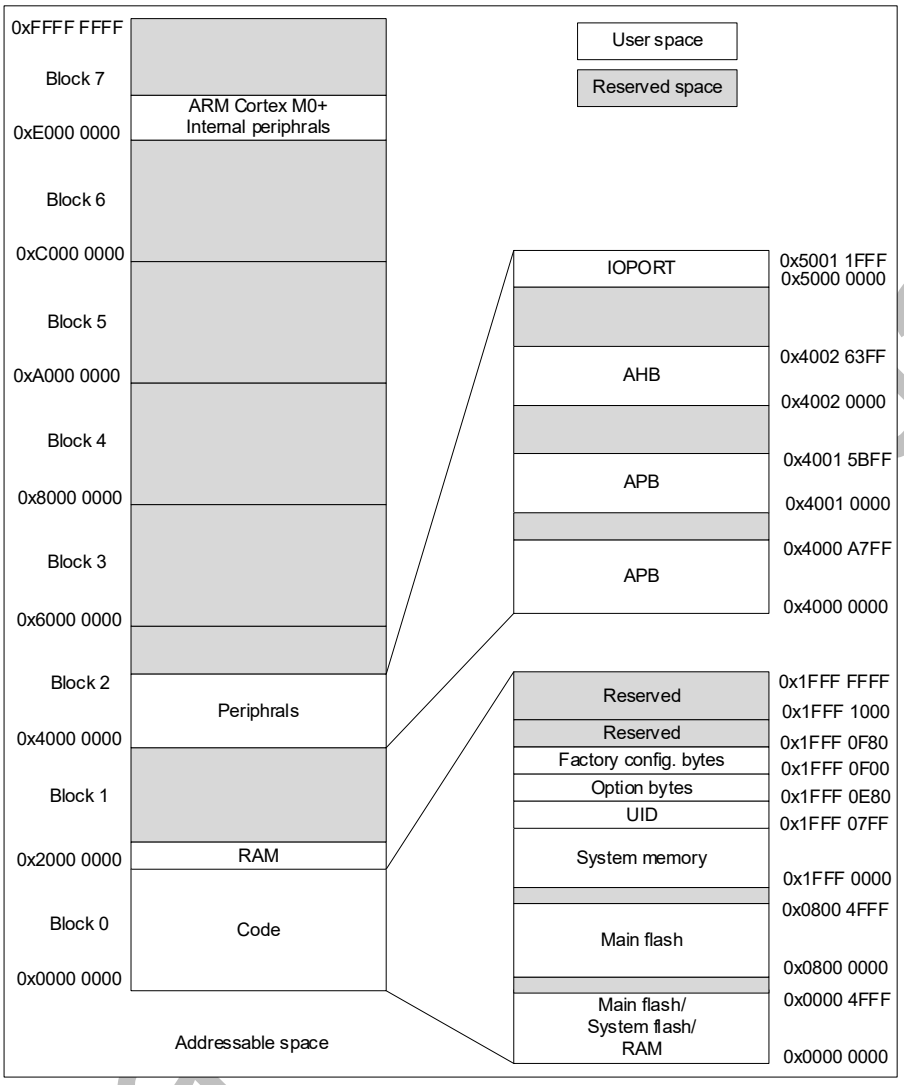


Figure 4-1 Memory map

Table 4-1 Memory address

Type	Boundary Address	Size	Memory Area	Description
SRAM	0x2000 0C00-0x3FFF FFFF	512 MBytes	Reserved	-
	0x2000 0000-0x2000 0BFF	3 KBytes	SRAM	SRAM up to 3 kBytes depending on hardware
Code	0x1FFF 1000-0x1FFF FFFF	4 KBytes	Reserved	-
	0x1FFF 0F80-0x1FFF 0FFF	128 Bytes	Reserved	-
	0x1FFF 0F00-0x1FFF 0F7F	128 Bytes	Factory config	Storing HSI trimming data
	0x1FFF 0E80-0x1FFF 0EFF	128 Bytes	Option bytes	Option bytes
	0x1FFF 0E00-0x1FFF 0E7F	128 Bytes	UID	Unique ID
	0x1FFF 0000-0x1FFF 07FF	2 KBytes	System memory	Boot loader
	0x0800 8000-0x1FFE FFFF	384 MBytes	Reserved	-
	0x0800 0000-0x0800 4FFF	20 KBytes	Main flash memory	-
	0x0000 5000-0x07FF FFFF	8 MBytes	Reserved	-

Type	Boundary Address	Size	Memory Area	Description
	0x0000 0000-0x0000 4FFF	20 KBytes	Selected based on Boot configuration: 1) Main flash memory 2) System memory 3) SRAM	-

Note:

Except for 0x1FFF 0E00-0x1FFF 0E7F, the above spaces are marked as reserved spaces, which cannot be written and read as 0 with response error.

Table 4-2 Peripheral register address

Bus	Boundary Address	Size	Peripheral
	0xE000 0000-0xE00F FFFF	1Mbytes	M0+
IOPORT	0x5000 1800-0x5FFF FFFF	256MBytes	Reserved(1)
	0x5000 1400-0x5000 17FF	1KBytes	GPIOF
	0x5000 1000-0x5000 13FF	1KBytes	Reserved
	0x5000 0C00-0x5000 0FFF	1Kbytes	Reserved
	0x5000 0800-0x5000 0BFF	1Kbytes	Reserved
	0x5000 0400-0x5000 07FF	1Kbytes	GPIOB
	0x5000 0000-0x5000 03FF	1Kbytes	GPIOA
AHB	0x4002 3400-0x4FFF FFFF		Reserved
	0x4002 300C-0x4002 33FF	1Kbytes	Reserved
	0x4002 3000-0x4002 3008		CRC
	0x4002 2400-0x4002 2FFF		Reserved
	0x4002 2124-0x4002 23FF	1KBytes	Reserved
	0x4002 2000-0x4002 2120		Flash
	0x4002 1C00-0x4002 1FFF	3KBytes	Reserved
	0x4002 1888-0x4002 1BFF	1Kbytes	Reserved
	0x4002 1800-0x4002 1884		EXTI (2)
	0x4002 1400-0x4002 17FF	1Kbytes	Reserved
	0x4002 1064-0x4002 13FF	1KBytes	Reserved
	0x4002 1000-0x4002 1060		RCC (2)
	0x4002 0C00-0x4002 0FFF	1KBytes	Reserved
	0x4002 0000-0x4002 03FF	1KBytes	Reserved
APB	0x4001 5C00-0x4001 FFFF	32KBytes	Reserved
	0x4001 5880-0x4001 5BFF	1KBytes	Reserved
	0x4001 5800-0x4001 587F		DBG
	0x4001 4C00-0x4001 57FF	3KBytes	Reserved
	0x4001 4800-0x4001 4BFF	1KBytes	Reserved
	0x4001 4450-0x4001 47FF	1KBytes	Reserved
	0x4001 4400-0x4001 404C		TIM16
	0x4001 3C00-0x4001 43FF	2KBytes	Reserved
	0x4001 381C-0x4001 3BFF	1KBytes	Reserved
	0x4001 3800-0x4001 3018		USART1
	0x4001 3400-0x4001 37FF	1Kbytes	Reserved
	0x4001 3010-0x4001 33FF	1Kbytes	Reserved
	0x4001 3000-0x4001 300C		SPI1

Bus	Boundary Address	Size	Peripheral
	0x4001 2C50-0x4001 2FFF	1Kbytes	Reserved
	0x4001 2C00-0x4001 2C4C		TIM1
	0x4001 2800-0x4001 2BFF	1Kbytes	Reserved
	0x4001 270C-0x4001 27FF	1Kbytes	Reserved
	0x4001 2400-0x4001 2708		ADC
	0x4001 0400-0x4001 23FF	8Kbytes	Reserved
	0x4001 0220-0x4001 03FF	1KBytes	Reserved
	0x4001 0200-0x4001 021F		COMP1 and COMP2
	0x4001 0000-0x4001 01FF		SYSCFG
	0x4000 B400-0x4000 FFFF	19KBytes	Reserved
	0x4000 B000-0x4000 B3FF	1KBytes	Reserved
	0x4000 8400-0x4000 AFFF	11KBytes	Reserved
	0x4000 8000-0x4000 83FF	1KBytes	Reserved
	0x4000 7C28-0x4000 7FFF	1KBytes	Reserved
	0x4000 7C00-0x4000 7C24		LPTIM
	0x4000 7400-0x4000 7BFF	2KBytes	Reserved
	0x4000 7018-0x4000 73FF	1KBytes	Reserved
	0x4000 7000-0x4000 7014		PWR (3)
	0x4000 5800-0x4000 6FFF	6KBytes	Reserved
	0x4000 5434-0x4000 57FF	1KBytes	Reserved
	0x4000 5400-0x4000 5430		I2C
	0x4000 4800-0x4000 53FF	3KBytes	Reserved
	0x4000 4400-0x4000 47FF	1KBytes	Reserved
	0x4000 3C00-0x4000 43FF	1KBytes	Reserved
	0x4000 3800-0x4000 3BFF	1KBytes	Reserved
	0x4000 3400-0x4000 37FF	1KBytes	Reserved
	0x4000 3014-0x4000 33FF	1KBytes	Reserved
	0x4000 3000-0x4000 0010		IWDG
	0x4000 2C00-0x4000 2FFF	1KBytes	Reserved
	0x4000 2800-0x4000 2BFF	1KBytes	Reserved
	0x4000 2400-0x4000 27FF	1KBytes	Reserved
	0x4000 2000-0x4000 23FF	1KBytes	Reserved
	0x4000 1800-0x4000 1FFF	2KBytes	Reserved
	0x4000 1400-0x4000 17FF	1KBytes	Reserved
	0x4000 1000-0x4000 13FF	1KBytes	Reserved
	0x4000 0800-0x4000 0FFF	2KBytes	Reserved
	0x4000 0400-0x4000 07FF	1Kbytes	Reserved
	0x4000 0000-0x4000 03FF	1KBytes	Reserved

Note :

（1） The address space marked as Reserved by AHB in the above table cannot be written, read is 0, and a hardfault is generated. The address space marked as Reserved by APB cannot be written, read back as 0, but no hardfault will be generated.

（2） Not only supports 32 bit word access, but also supports halfword and byte access.

（3） Not only supports 32 bit word access, but also supports half word access.

5. Electrical characteristics

5.1. Test conditions

All voltages are referenced to VSS unless otherwise specified.

5.1.1. Min and Max

Unless otherwise specified, the chip is screened by mass production testing at ambient temperature T_A =25°C and T_A =$T_{A(max)}$, guaranteed to reach the minimum value and maximum value under the worst ambient temperature, supply voltage and clock frequency conditions.

Based on electrical characterization results, design simulations, and/or process parameters noted below the table, not tested in production. Minimum and maximum values are referenced to sample testing and averaged plus or minus three times the standard deviation.

5.1.2. Typical value

Unless otherwise specified, typical data is based on T_A =25°C and VCC = 3.3V. These data are for design guidance only and have not been tested.

Typical ADC accuracy values are obtained by sampling a standard batch, tested under all temperature ranges, and 95% of the chip error is less than or equal to the given value.

5.2. Absolute maximum ratings

If the applied voltage exceeds the absolute maximum value given in the table below, it may cause permanent damage to the chip. Only the strength ratings that can be tolerated are listed here, and it does not imply that the functional operation of the device is correct under these conditions. Operating under maximum conditions for a long time may affect the reliability of the chip.

Table 5-1 Voltage characteristics (1)

Symbol	Describe	Minimum value	Maximum value	Unit
VCC	External mains power supply	-0.3	6.25	V
V_{IN}	Input voltage of other pins	-0.3	VCC+0.3	V

（1） Power supply VCC and ground VSS pins must always be connected to the external power supply within the allowable range.

Table 5-2 Current characteristics

Symbol	Describe	Maximum value	Unit
I_{VCC}	Flowing into VCC pin (supply current) (1)	100	mA
I_{VSS}	Total current flowing out of VSS pin (outflow current) (1)	100	
$I_{IO(PIN)}$	Output sink current of COM IO	20	
	Source current for all IOs	- 20	

（1） Power supply VCC and ground VSS pins must always be connected to the external power supply within the allowable range.

Table 5-3 Temperature characteristics

Symbol	Describe	Value	Unit
T_{STG}	Storage temperature range	-65 ~ +150	℃
T_O	Range of working temperature	- 40 ~ +85	℃

5.3. Operating conditions

5.3.1. General operating conditions

Table 5-4 General operating conditions

Symbol	Parameter	Condition	Minimum	Maximum value	Unit
f_{HCLK}	Internal AHB clock frequency	-	0	24	MHz
f_{PCLK}	Internal APB Clock Frequency	-	0	24	MHz
VCC	Standard working voltage	-	1.7	5.5	V
VIN	IO input voltage	-	-0.3	VCC+0.3	V
T_A	ambient temperature	-	-40	85	℃
T_J	Junction temperature	-	-40	90	℃

5.3.2. Power on and down operating conditions

Table 5-5 Power on and Power down Operating Conditions

Symbol	Parameter	Condition	Minimum	Maximum value	Unit
t_{VCC}	VCC rise rate	-	0	∞	us/V
	V CC fall rate	-	20	∞	

5.3.3. Embedded reset and LVD module features

Table 5-6 Embedded Reset Module Features

Symbol	Parameter	Condition	Minimum	Typical value	Maximum value	Unit
$t_{RSTTEMPO}$(1)	Reset time	-	-	4.0	7.5	ms
$V_{POR/PDR}$	POR/PDR reset thresh-old	rising edge	1.50 (2)	1.6 0	1.70	V
		falling edge	1.45 (1)	1.55	1.65 (2)	V
V_{BOR1}	BOR threshold 1	rising edge	1.70 (2)	1.80	1.90	V
		falling edge	1.60	1.70	1.80 (2)	V
V_{BOR2}	BOR threshold 2	rising edge	1.90 (2)	2.00	2.10	V
		falling edge	1.80	1.90	2.00 (2)	V
V_{BOR3}	BOR threshold 3	rising edge	2.10 (2)	2.20	2.30	V
		falling edge	2.00	2.10	2.20 (2)	V
V_{BOR4}	BOR threshold 4	rising edge	2.30 (2)	2.40	2.50	V
		falling edge	2.20	2.30	2.40 (2)	V
V_{BOR5}	BOR threshold 5	rising edge	2.50 (2)	2.60	2.70	V
		falling edge	2.40	2.50	2.60 (2)	V

Symbol	Parameter	Condition	Minimum	Typical value	Maximum value	Unit
V_{BOR6}	BOR threshold 6	rising edge	2.70 (2)	2.80	2.90	V
		falling edge	2.60	2.70	2.80 (2)	V
V_{BOR7}	BOR threshold 7	rising edge	2.90 (2)	3.00	3.10	V
		falling edge	2.80	2.90	3.00 (2)	V
V_{BOR8}	BOR threshold 8	rising edge	3.10 (2)	3.20	3.30	V
		falling edge	3.00	3.10	3.20 (2)	V
$V_{POR\_PDR\_hyst}$(1)	POR / PDR hysteresis voltage	-		50		mV
$I_{dd(BOR)}$	BOR power consumption			0.6		uA

（1） Guaranteed by design, not tested in production.

（2） Data is based on assessment results and is not tested in production.

5.3.4. Operating current characteristics

Table 5-7 Run mode current

Symbol	Condition						Typical value(1)	Maximum value	Unit
	System clock	Frequency	Code	Run	Peripheral clock	FLASH sleep			
IDD(run)	HSI	24MHz	While(1)	Flash	ON	DISABLE	1.5	-	mA
					OFF	DISABLE	0.9	-	
		8MHz			ON	DISABLE	0.7	-	
					OFF	DISABLE	0.5	-	
	LSI	32.768kHz			ON	DISABLE	170	-	uA
					OFF	DISABLE	170	-	
	LSI	32.768kHz			ON	ENABLE	95	-	uA
					OFF	ENABLE	95	-	

（1） Data is based on assessment results and is not tested in production.

surface 5-8Sleep mode current

Symbol	Condition				Typical value(1)	Maximum value	Unit
	System clock	Frequency	Peripheral clock	FLASH sleep			
IDD(sleep)	HSI	24MHz	ON	DISABLE	1	-	mA
			OFF	DISABLE	0.6	-	mA
		8MHz	ON	DISABLE	0.5	-	mA
			OFF	DISABLE	0.35	-	mA
	LSI	32.768kHz	ON	DISABLE	170	-	uA
			OFF	DISABLE	170	-	uA
	LSI	32.768kHz	ON	ENABLE	95	-	uA
			OFF	ENABLE	96	-	uA

（1） Data is based on assessment results and is not tested in production.

Table 5-9Stop mode current

Symbol	Condition			Unit

	VCC	VDD	MR/LPR	LSI	Peripheral clock	Typical value(1)	Maximum value	
I_{DD}(stop)	1.7~5.5V	1.2V	MR	-	-	70	-	uA
		1.2V	LPR	ON	IWDG+LPTIM	6	-	
					IWDG	6	-	
					LPTIM	6	-	
				OFF	No	6	-	
		1.0V		ON	IWDG+LPTIM	4.5	-	
					IWDG	4.5	-	
					LPTIM	4.5	-	
				OFF	No	4.5	-	

（1） Data is based on assessment results and is not tested in production.

5.3.5. Low power mode wake-up time

Table 5-10 Low power mode wake-up time

Symbol	Parameters(1)		Condition		Typical value (2)	maxi-mum value	unit
$T_{WUSLEEP}$	Wake-up time from sleep		-		1.65		us
T_{WUSTOP}	Wake-up time from stop	Powered by MR	Execute program in Flash, HSI (24 Mhz) as system clock		3.5		us
		Powered by LPR	Execute program in Flash, HSI as system clock	VDD=1.2V	6		us
				VDD=1.0V	6		

（1） The wake-up time is measured from the wake-up time until the first instruction is read by the user program.

（2） Data is based on assessment results and is not tested in production.

5.3.6. External clock source characteristics

5.3.6.1. External high-speed clock

In the bypass mode of HSE (the HSEBYP of RCC_CR is set), when the high-speed start-up circuit in the chip stops working, the corresponding IO is used as a standard GPIO.

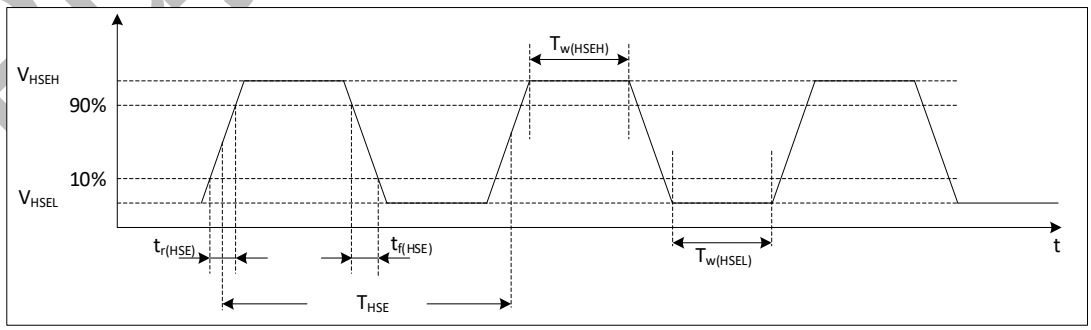


Figure 5-1 External high-speed clock timing diagram

Table 5-11 External high-speed clock features

Symbol	Parameters(1)	Minimum	Typical value	Maximum value	Unit
f_{HSE_ext}	User external clock frequency	0	8	24	MHz
V_{HSEH}	Input pin high level voltage	0.7VCC		VCC	V
V_{HSEL}	Input pin low level voltage	Vss		0.3VCC	
$t_{W(HSEH)}$ $t_{W(HSEL)}$	Enter high or low time	1 5			ns
$t_{r(HSE)}$ $t_{f(HSE)}$	Enter the rise/fall time	-		20	ns

（1） Guaranteed by design, not tested in production.

5.3.6.2. External high-speed crystal

An external 4~32MHz crystal/ceramic resonator. In the application, the crystal and load capacitors should be as close as possible to the pins to minimize output distortion and start-up settling time.

Table 5-12 External high-speed crystal characteristics

Symbol	Parameter	Condition(1)	Mini-mum(2)	Typi-cal value	Maxi-mum(2)	Unit
f_{OSC_IN}	Oscillation fre-quency	-	4		32	MHz
IDD(4)	HSE power con-sumption	During startup			5.5	mA
		VCC=3V, Rm=30Ω, CL=10pF@8MHz		0.58		
		VCC=3V,Rm=45Ω, CL=10pF@8MHz		0.59		
		VCC=3V,Rm=30Ω, CL=5pF@24MHz		0.89		
		VCC=3V,Rm=30Ω, CL=10pF@24MHz		1.10		
		VCC=3V,Rm=30Ω, CL=20pF@24MHz		1.90		
$t_{SU\ (HSE)}$ (3) (4)	Start Time	f_{OSC_IN}=24MHz		3		ms
		f_{OSC_IN}=4MHz		15		ms

（1） Crystal/ceramic resonator characteristics are based on the manufacturer datasheet.

（2） Guaranteed by design, not tested in production.

（3） $t_{SU(HSE)}$ is the start-up time from enable (by software) to the clock oscillation reaches stability, measured for a standard crystal/resonator, which can vary greatly from one crystal/resonator to another .

（4） Data is based on assessment results and is not tested in production.

5.3.7. Internal high frequency clock source HSI characteristics

Table 5-13 Internal high frequency clock source characteristics

Symbol	Parameter	Condition	Mini-mum	Typi-cal value	Maxi-mum	Unit
f_{HSI}	HSI frequency	T_A=25°C,VCC=3.3V	23.83(2)	24	24.17(2)	MHz

Symbol	Parameter	Condition	Mini-mum	Typi-cal value	Maxi-mum	Unit
			7.94(2)	8	8.06(2)	MHz
$\Delta_{Temp(HSI)}$	HSI frequency tempera-ture drift	VCC=1.7V~5.5V, T_J=0C~85C	-2(2)		2(2)	%
		VCC=1.7V~5.5V, T_J=-40C~85C	-4(2)		2(2)	%
f_{TRIM}(1)	HSI fine-tuning accuracy			0.1		%
D_{HSI}(1)	Duty cycle		45(1)		55(1)	%
$t_{Stab(HSI)}$	HSI stabilization time			2	4(1)	us
$I_{DD(HSI)}$ (2)	HSI power consumption	8MHz		105		uA
		24MHz		180		uA

（1） Guaranteed by design, not tested in production.

（2） Data is based on assessment results and is not tested in production.

5.3.8. Internal low frequency clock source LSI characteristics

Table 5-14 Internal low frequency clock characteristics

Symbol	Parameter	Condition	Mini-mum	Typi-cal value	Maxi-mum	Unit
f_{LSI}	LSI frequency	T_A=25°C,VCC=3.3V	-1		+1	%
$\Delta_{Temp(LSI)}$	LSI frequency tempera-ture drift	VCC=1.6V~5.5V T_J=0C~70C	-10(2)		10(2)	%
		VCC=1.6V~5.5V,T_J=-40C~85C	-20(2)		20(2)	%
f_{TRIM}(1)	LSI fine-tuning accu-racy			0.2		%
$t_{Stab(LSI)}$ (1)	LSI stabilization time			150		us
$I_{DD(LSI)}$ (1)	LSI power consumption			210		nA

（1） Guaranteed by design, not tested in production.

（2） Data is based on assessment results and is not tested in production.

5.3.9. Memory characteristics

Table 5-15 Memory characteristics

Symbol	Parameter	Condition	Typical value	Maxi-mum(1)	Unit
t_{prog}	Page program	-	1.0	1.5	ms
t_{ERASE}	Page/sector/mass erase	-	3.0	4.5	ms
I_{DD}	Page programe		2.1	2.9	mA
	Page/sector/mass erase		2.1	2.9	mA

（1） Guaranteed by design, not tested in production.

Table 5-16 Memory erase times and data retention

Symbol	Parameter	Condition	Mini-mum(1)	Unit
N_{END}	Erase and write times	T_A = -40~85℃	100	kcycle
t_{RET}	Data retention period	10 kcycle T_A = 55℃	20	Year

（1） Data is based on assessment results and is not tested in production.

5.3.10. EFT characteristics

Symbol	Parameter	Condition	Grade	Typical value	Unit
EFT to IO		IEC61000-4-4	B	2	KV
EFT to Power		IEC61000-4-4	B	4	KV

5.3.11. ESD & LU Characteristics

Table 5-17ESD & LU characteristics

Symbol	Parameter	Condition	Typical value	Unit
$V_{ESD(HBM)}$	Static Discharge Voltage (human body model)	ESDA/JEDEC JS-001-2017	6	KV
$V_{ESD(CDM)}$	Static Discharge Voltage (charging equipment model)	ESDA/JEDEC JS-002-2018	1	KV
$V_{ESD(MM)}$	Static discharge voltage (machine model)	JESD22-A115C	200	V
LU	Static Latch-Up	JESD78E	200	mA

5.3.12. Port characteristics

Table 5-18IO static characteristics

Sym-bol	Parameter	Condition	Minimum	Typi-cal value	Maximum	Unit
V_{IH}	Input high level voltage	VCC=1.7V~5.5V	0.7VCC			V
V_{IL}	Input low level voltage	VCC=1.7V~5.5V			0.3VCC	V
V_{hys}(1)	Schmitt hysteresis voltage			200		mV
I_{lkg}	Input leakage current				1	uA
R_{PU}	Pull-up resistor		30	50	70	kΩ
R_{PD}	Pull-down resistor		30	50	70	kΩ
C_{IO}(1)	Pin capacitance			5		pF

（1） Guaranteed by design, not tested in production.

Table 5-19 Output Voltage Characteristics

sym-bol	Parameters (1)	condition	minimum	maxi-mum value	unit
V_{OL}	COM IO output low level	IOL = 8 mA, V_{CC} ≥ 2.7 V	-	0.4	V
V_{OL}		IOL = 4 mA, V_{CC} = 1.8 V	-	0.5	V
V_{OH}	COM IO output high level	IOH = 8 mA, V_{CC} ≥ 2.7 V	VCC–0.4	-	V
V_{OH}		IOH = 4 mA, V_{CC} = 1.8 V	VCC–0.5	-	V

（1） IO types can refer to the terms and symbols defined by the pins.

5.3.13. NRST pin characteristics

Table 5-20NRST pin characteristics

Symbol	Parameter	Condition	Minimum	Typical value	Maximum	Unit
V_{IH}	Input high level voltage	VCC=1.7V~5.5V	0.7VCC			V
V_{IL}	Input low level voltage	VCC=1.7V~5.5V			0.2VCC	V
V_{hys}(1)	Schmitt hysteresis voltage			300		mV
I_{lkg}	Input leakage current				1	uA
R_{PU} (1)	Pull-up resistor		30	50	70	kΩ
R_{PD} (1)	Pull-down resistor		30	50	70	kΩ
C_{IO}	Pin capacitance			5		pF

（1） Guaranteed by design, not tested in production.

5.3.14. ADC characteristics

Table 5-21ADC characteristics

Symbol	Parameter	Condition	Minimum	Typical value	Maximum	Unit
I_{DD}	Power consumption	@0.75MSPS		1.0		mA
C_{IN}(1)	Internal sample and hold capacitors			5		pF
F_{ADC}	Convert clock frequency	VCC=1.7~2.3V	1	4	6(2)	MHz
		VCC=2.3~5.5V	1	8	12(2)	MHz
Tsamp(1)		@0.75MSPS		1.0		mA
		VCC=2.3~5.5V	0.1			us
Tconv(1)				12*Tclk		
Teoc(1)				0.5*Tclk		
DNL(2)				±2		LSB
INL(2)				±3		LSB
Offset(2)				±2		LSB

（1） Guaranteed by design, not tested in production.

（2） Data is based on assessment results and is not tested in production.

5.3.15. Comparator characteristics

Table 5-22 Comparator features(1)

Symbol	Parameter	Condition	Minimum	Typical value	Maximum	Unit
VIN	Input voltage range		0		VCC	V
VBG	Scale input voltage		VREFINT			
VSC	Scaler offset voltage			±5	±10	mV

Symbol	Parameter	Condition		Minimum	Typical value	Maximum	Unit
IDD(SCALER)	Scaler static consumption	BRG_EN=1(bridge enable)			0.8	1	uA
tSTART_SCALER	Scaler startup time				100	200	us
tSTART	Startup time to reach propagation delay specification	High-speed mode				5	us
		Medium-speed mode				15	
tD	Propagation delay	200mV step; 100mV overdrive	High-speed mode		40	70	ns
			Medium-speed mode		0.9	2.3	us
		>200mV step;100mV overdrive	High-speed mode			85	ns
			Medium-speed mode			3.4	us
Voffset	Offset error				±5		mV
Vhys	hysteresis	No hysteresis			0		mV
		With hysteresis			20		
IDD	consumption	Medium-speed mode; No deglitcher	Static		5		uA
			With 50kHz and ±100mv overdrive square signal		6		uA
		Medium-speed mode With deglitcher	Static		7		uA
			With 50kHz and ±100mv overdrive square signal		8		uA
		High-speed mode; No deglitcher	Static		250		uA
			With 50kHz and ±100mv overdrive square signal		250		uA

（1） Guaranteed by design, not tested in production.

5.3.16. Temperature sensor characteristics

Table 5-23 Temperature sensor characteristics

Symbol	Parameter	Mini-mum	Typical value	Maxi-mum	Unit
T_L(1)	VTS linearity with temperature		±1	±2	℃
Avg_Slope(1)	Average slope	2.3	2.5	2.7	mV/℃
V_{30}	Voltage at 30℃(±5℃)	0.742	0.76	0.785	V
t_{START}(1)	Start-up time entering in continuous mode		70	120	us
t_{S_temp}(1)	ADC sampling time when reading the temperature	9			us

（1） Guaranteed by design, not tested in production.

（2） Data is based on assessment results and is not tested in production.

5.3.17. Built-in reference voltage feature

Table 5-24 Built-in reference voltage feature

Symbol	Parameter	Mini-mum	Typical value	Maxi-mum	Unit
VREFINT	Internal reference voltage	1.17	1.2	1.23	V
$T_{start\_vrefint}$	Start time of internal reference voltage		10	15	us
T_{coeff}	Temperature coefficient			100(1)	ppm/℃
I_{vcc}	Current consumption from VCC		12	20	uA

(1) Guaranteed by design, not tested in production.

5.3.18. Timer features

Table 5-25LPTIM characteristics (clock selection LSI)

Prescaler	PRESC [2:0]	Minimum overflow value	Maximum overflow value	Unit
/1	0	0.0305	1998.848	ms
/2	1	0.0610	3997.696	
/4	2	0.1221	8001.9456	
/8	3	0.2441	15997.3376	
/16	4	0.4883	32001.2288	
/32	5	0.9766	64002.4576	
/64	6	1.9531	127998.3616	
/128	7	3.9063	256003.2768	

Table 5-26IWDG characteristics (clock selection LSI)

Prescaler	PR[2:0]	Minimum overflow value	Maximum overflow value	Unit
/4	0	0.122	499.712	ms
/8	1	0.244	999.424	
/16	2	0.488	1998.848	

/32	3	0.976	3997.696	
/64	4	1.952	7995.392	
/128	5	3.904	15990.784	
/256	6 or 7	7.808	31981.568	

5.3.19. Communication port characteristics

5.3.19.1. I2C bus interface features

I2C interface meets the requirements of the I2C -bus specification and user manual :

- Standard-mode(Sm): 100kbit/s
- Fast-mode(Fm): 400kbit/s

Timing is guaranteed by design, provided the I2C peripheral is properly configured and the I2C CLK frequency is greater than the minimum required in the table below.

Table 5-27 Minimum I2C CLK frequency

Symbol	Parameter	Condition	Minimum	Unit
$f_{I2CCLK(min)}$	Minimum I2CCLK frequency	Standard-mode	2	MHz
		Fast-mode	9	

I 2 C SDA and SCL pins have analog filtering, see table below.

Table 5-28I2C filter characteristics

Symbol	Parameter	Minimum	Maximum	Unit
t_{AF}	Limiting duration of spikes suppressed by the filter (Spikers shorter than the limiting duration are suppressed)	50	260	ns

5.3.19.2. Serial Peripheral Interface SPI Characteristics

Table 5-29SPI characteristics

Symbol	Parameter	Condition	Minimum	Maximum	Unit
f_{SCK} $1/t_{c(SCK)}$	SPI clock frequency	Master mode	-	12	MHz
		Slave mode	-	12	
$t_{r(SCK)}$ $t_{f(SCK)}$	SPI clock rise and fall time	Capacitive load: C = 15 pF	-	6	ns
$t_{su(NSS)}$	NSS setup time	Slave mode	4Tpclk	-	ns
$t_{h(NSS)}$	NSS hold time	Slave mode	2Tpclk + 10	-	ns
$t_{w(SCKH)}$ $t_{w(SCKL)}$	SCK high and low time	Master mode, fPCLK = 36 MHz,presc = 4	Tpclk*2 -2	Tpclk*2 + 1	ns
$t_{su(MI)}$ $t_{su(SI)}$	Data input setup time	Master mode, fPCLK = 48 MHz,presc = 4	Tpclk+5(1)	-	ns
		Slave mode, fPCLK = 48 MHz,presc = 4	5	-	
$t_{h(MI)}$	Data input hold time	Master mode	5	-	ns
$t_{h(SI)}$		Slave mode	Tpclk+5	-	
$t_{a(SO)}$	Data output access time	Slave mode, presc = 4	0	3Tpclk	ns
$t_{dis(SO)}$	Data output disable time	Slave mode	2Tpclk+5	4Tpclk+5	ns

Symbol	Parameter	Condition	Minimum	Maximum	Unit
$t_{v(SO)}$	Data output valid ime	Slave mode (after enable edge), presc = 4	0	1.5Tpclk(2)	ns
$t_{v(MO)}$	Data output valid ime	Master mode (after enable edge)	-	6	ns
$t_{h(SO)}$	Data output hold time	Slave mode, presc = 4	0(3)	-	ns
$t_{h(MO)}$		Master mode	2	-	
DuCy(SCK)	SPI slave input clock duty cycle	Slave mode	45	55	%

（1） The Master generates 1pclk to receive control signal before the receive edge.

（2） Slave has a maximum of 1PCLK based on the sending edge of SCK delay, considering IO delay, etc., define 1.5PCLK.

（3） In the case that the SCK duty cycle sent by the Master is wide between the receiving edge and the sending edge, the Slave updates the data before the sending edge.

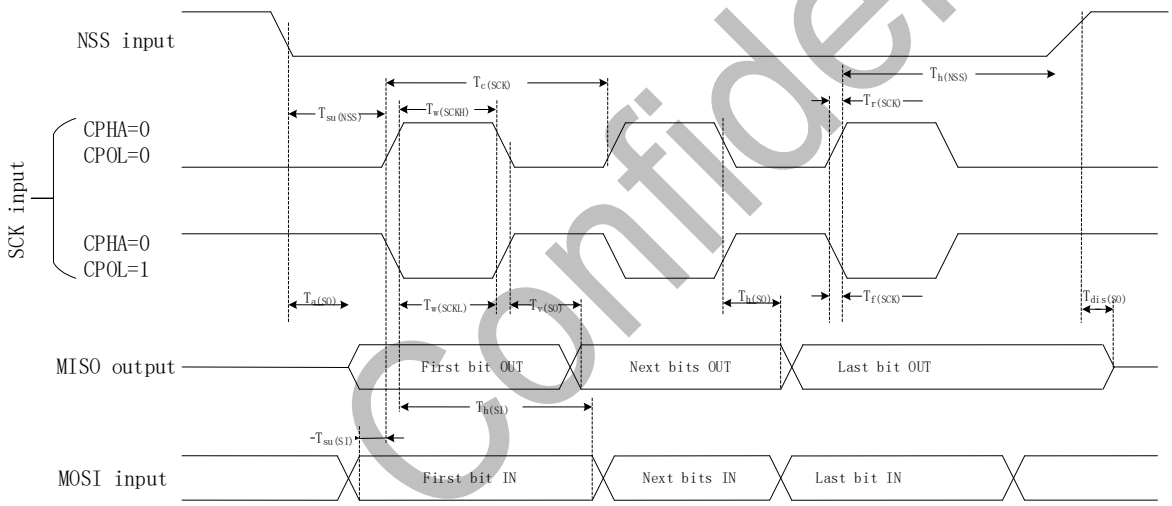


Figure 5-2 SPI timing diagram – slave mode and CPHA=0

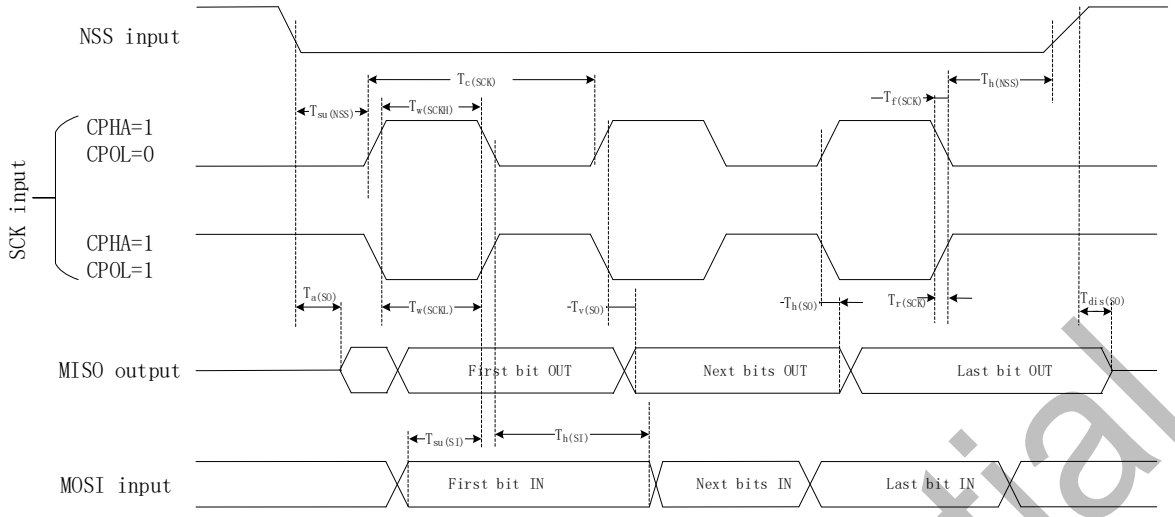


Figure 5-3 SPI timing diagram – slave mode and CPHA=1

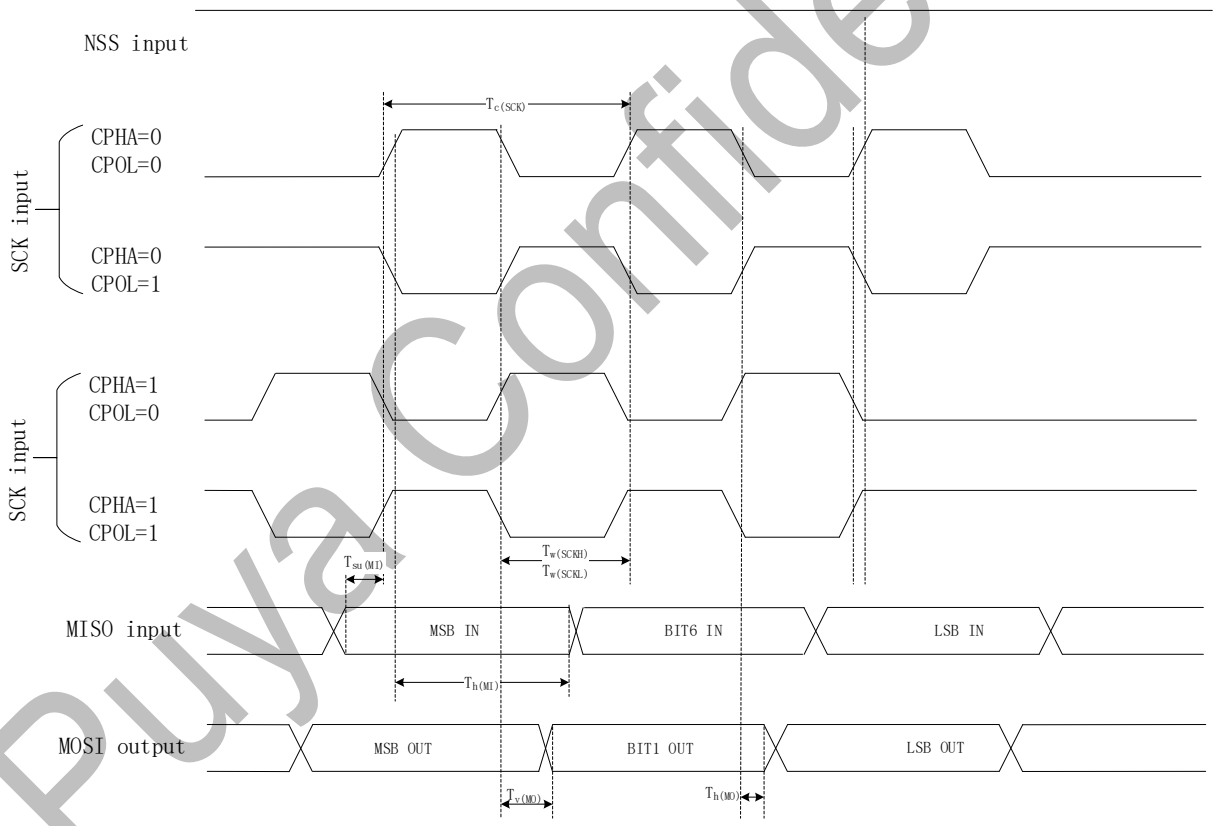
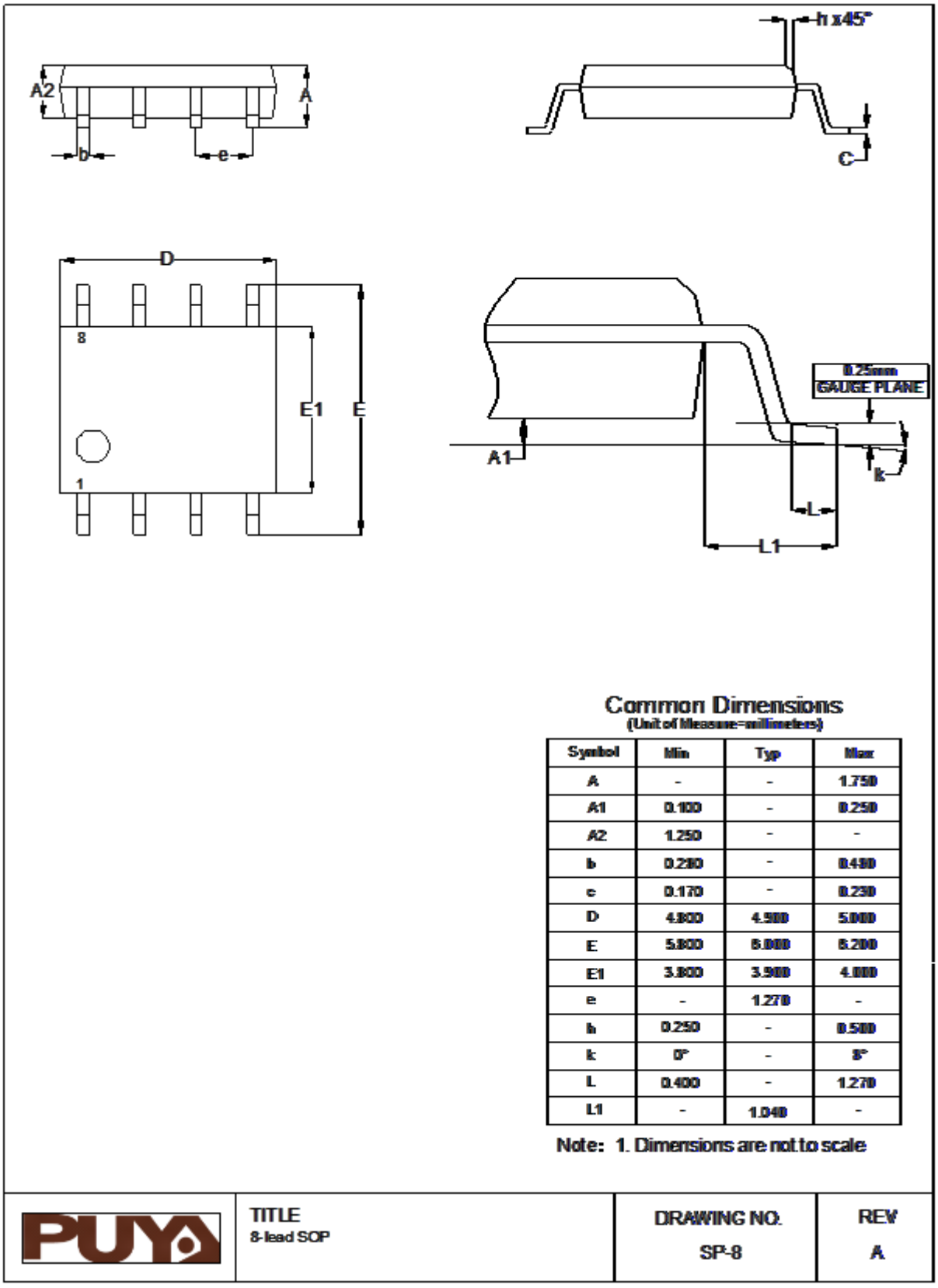


Figure 5-4 SPI timing diagram – master mode

6. Package information

6.1. SOP8 package information



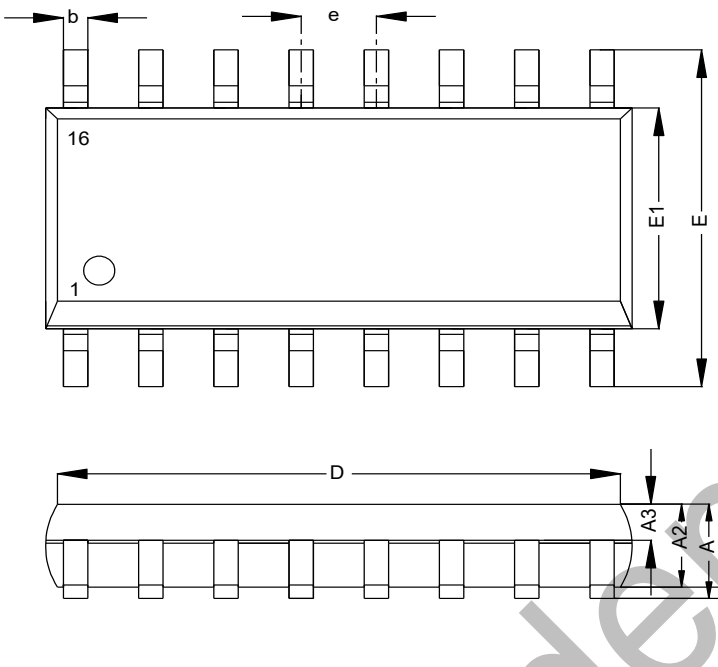
Common Dimensions
(Unit of Measure=millimeters)

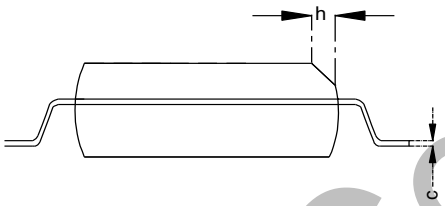
Symbol	Min	Typ	Max
A	-	-	1.750
A1	0.100	-	0.250
A2	1.250	-	-
b	0.280	-	0.480
c	0.170	-	0.230
D	4.800	4.900	5.000
E	5.800	6.000	6.200
E1	3.800	3.900	4.000
e	-	1.270	-
h	0.250	-	0.500
k	0°	-	8°
L	0.400	-	1.270
L1	-	1.040	-

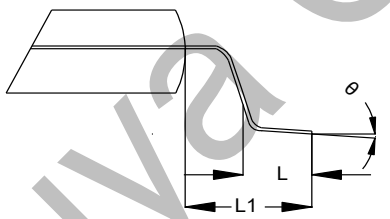
Note: 1. Dimensions are not to scale

	TITLE	DRAWING NO.	REV
PUYA	8-lead SOP	SP-8	A

6.2. SOP16 package information







Common Dimensions

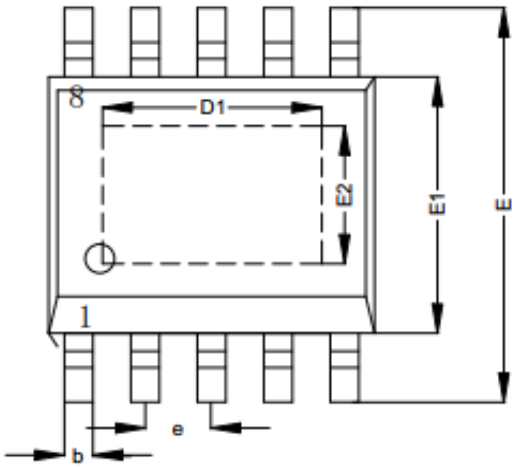
(Unit of Measure=millimeters)

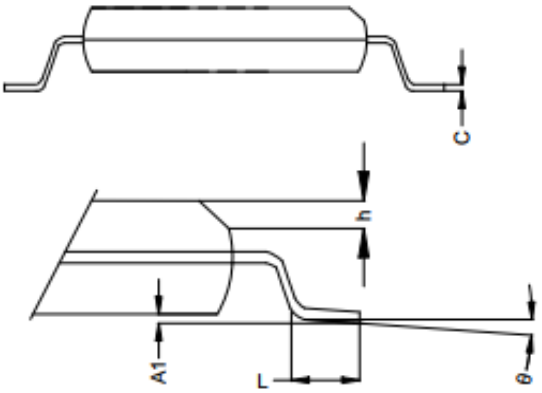
Symbol	Min	Typ	Max
A	-	-	1.75
A1	0.10	-	0.25
A2	1.30	-	-
A3	0.60	-	0.70
b	0.31	-	0.51
c	0.10	-	0.25
D	9.80	-	10.20
E	5.80	-	6.20
E1	3.80	-	4.20
e	1.27BSC		
L	0.40	-	1.27
L1	1.05REF		
θ	0	-	8°
h	0.25	-	0.50

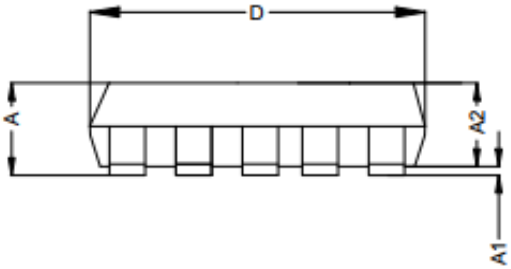
Note: Dimensions are not to scale.

	TITLE	DRAWING NO.	REV
PUYA	PUYA SOP16 (150mil) POD	PY-POD-0001	1.0

6.3. ESSOP10 package information







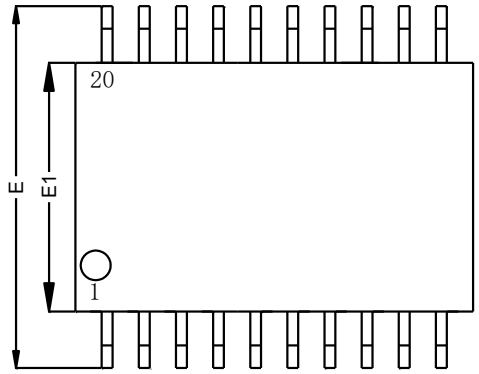
Common Dimensions
(Unit of Measure=millimeters)

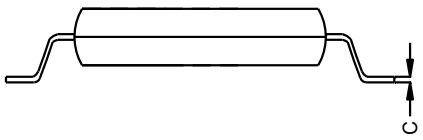
Symbol	Min	Typ	Max
A	1.350	1.600	1.850
A1	0.000	-	0.100
A2	1.350	1.450	1.550
b	0.300	0.400	0.500
c	0.170	-	0.270
D	4.700	4.900	5.100
D1	3.200	3.300	3.400
E	5.750	6.000	6.250
E1	3.800	3.900	4.000
E2	2.000	2.100	2.200
e	1.000BSC		
h	0.300	-	0.500
L	0.450	-	0.850
θ	0°	-	8°

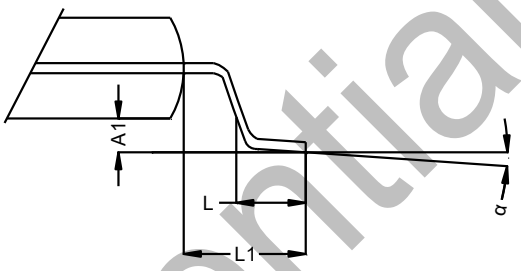
Note：1. Dimensions are not to scale

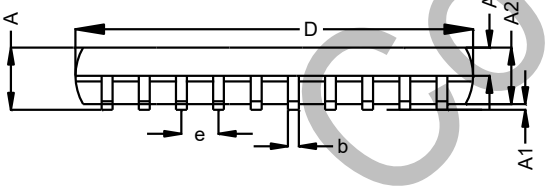
	TITLE	DRAWING NO.	REV
PUYA	Puya ESSOP10 POD	QRPD-0050	1.0

6.4. TSSOP20 package information









Common Dimensions

(Unit of Measure=millimeters)

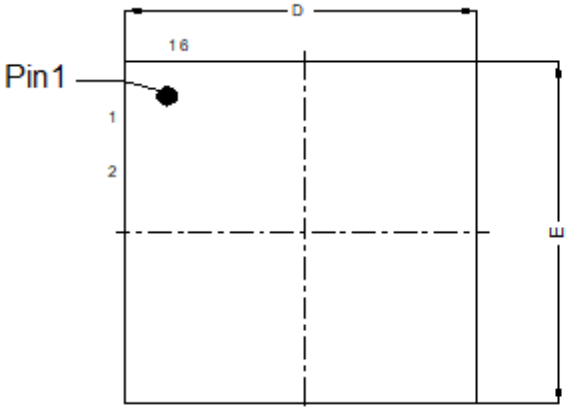
Symbol	Min	Typ	Max
A	-	-	1.200
A1	0.050	-	0.150
A2	0.800	1.000	1.050
A3	0.340	0.440	0.540
b	0.200	-	0.280
c	0.100	-	0.190
D	6.400	6.500	6.600
E	6.200	6.400	6.600
E1	4.300	4.400	4.500
e	0.650BSC		
L	0.450	0.600	0.750
L1	1.000REF		
θ	0	-	8°

Note：1. Dimensions are not to scale

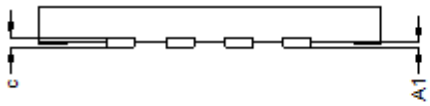
	TITLE	DRAWING NO.	REV
PUYA	TSSOP20	TSSOP-20	B

6.5. QFN16 package information

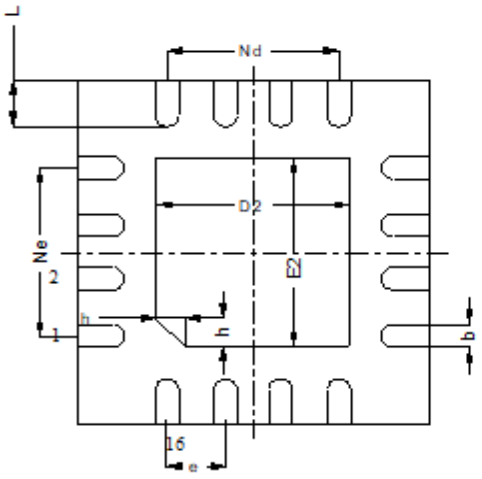
TOP VIEW



SIDE VIEW



BOTTOM VIEW



Common Dimensions

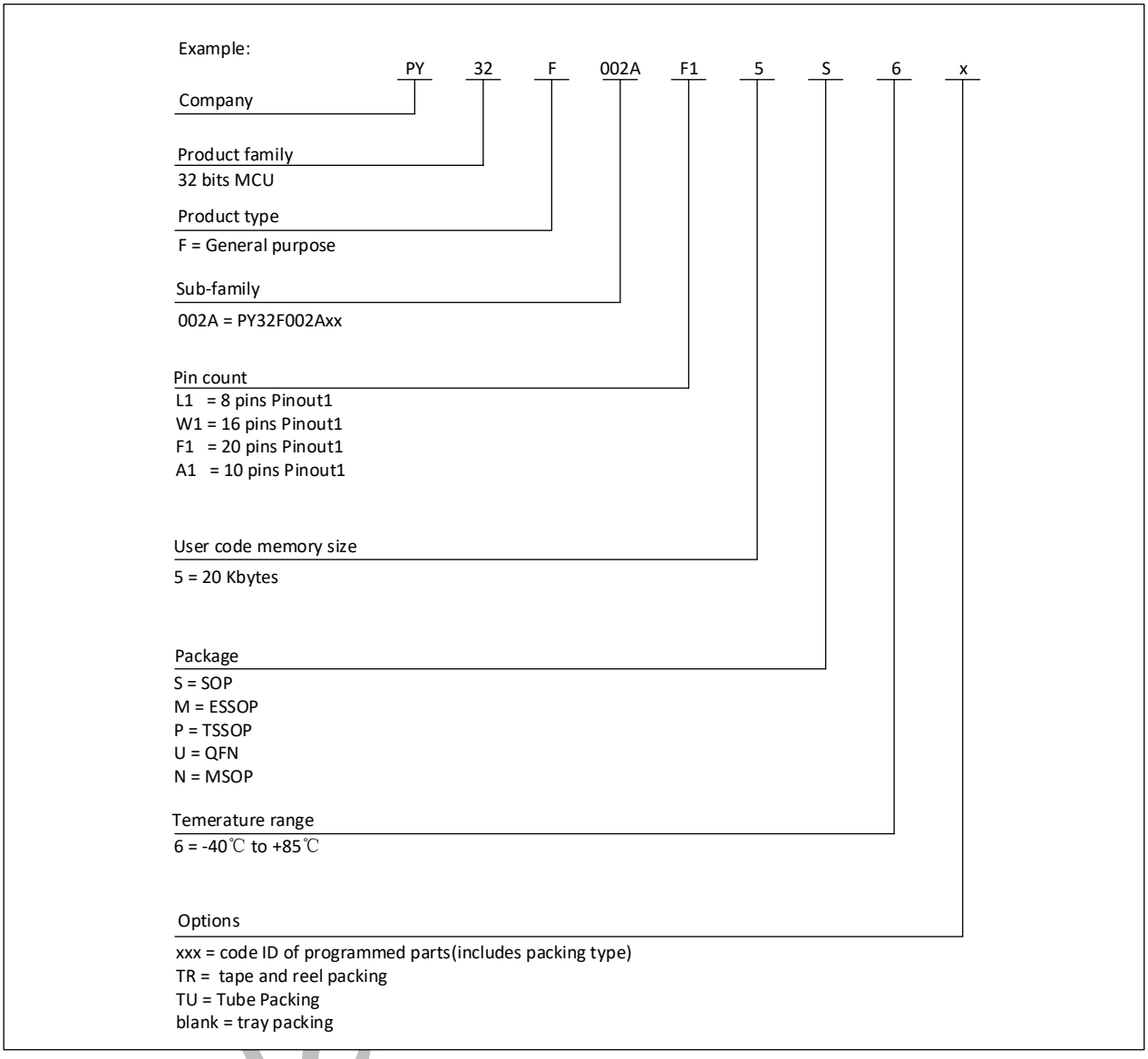
(Unit of Measure=millimeters)

Symbol	Min	Typ	Max
A	0.700	0.750	0.800
A1	0.000	0.020	0.050
b	0.180	0.240	0.300
c		0.203REF	
D	2.900	3.000	3.100
D2	1.600	1.700	1.800
E	2.900	3.000	3.100
E2	1.600	1.700	1.800
e		0.500BSC	
Nd		1.500BSC	
Ne		1.500BSC	
L	0.300	0.400	0.500
h	0.350	0.400	0.450

Note: 1. Dimensions are not to scale

	TITLE	DRAWING NO.	REV
PUYA	Puya QFN16 3x3X0.75-0.5PITCH POD	QRPD-0051	1.0

7. Ordering Information



8. Version history

Version	Date	Updated the record
V0.1	2022.06.15	1. Initial version
V0.2	2023.06.20	1. Updated Table 1-1 2. Updated Table 3-2

Puya Semiconductor Co., Ltd.