



Technology Innovator  
**Puya**

---

# PY32T020-B Datasheet

32-bit ARM® Cortex®-M0+ Microcontroller



**Puya Semiconductor (Shanghai) Co., Ltd.**

## Features

- Core
  - 32-bit ARM® Cortex®-M0+
  - Frequency up to 48 MHz
- Memories
  - Up to 32 KB Flash memory
  - Up to 4 KB SRAM
- Clock management
  - 24/48 MHz High-speed internal RC oscillator (HSI)
  - 32.768 kHz Low-speed internal RC oscillator (LSI)
  - 4 to 8 MHz High-speed external crystal oscillator (HSE)
  - 32.768 kHz Low-speed external crystal oscillator (LSE)
  - External clock input
- Power management and reset
  - Operating voltage: 1.8 to 5.5 V
  - Low-power mode: Sleep/Stop
  - Power-on/power-down reset (POR/PDR)
  - Brown-out reset (BOR)
- General-purpose input and output (I/O)
  - Up to 26 I/Os, all available as external interrupts
  - 5 GPIOs supporting high sink current (configurable as 80mA/60mA/40mA/20mA) for driving common-cathode LED digital tubes
  - 8 GPIOs as LED SEG with constant-current drive
  - All GPIOs can serve as LCD COM with 1/2 Bias
- Touch key
  - High-sensitivity for non-contact touch
  - 10 V dynamic CS test-passed anti-interference mode
  - 26 touch channels with derived functions
  - Low-power touch mode with multi-touch wake-up capability (<8 µA system current consumption)
- 1 x 12-bit ADC
  - Up to 10 external channels and 3 internal channels
  - Voltage reference options: embedded 0.6 V/1.5 V/2.048 V/2.5 V and V<sub>CC</sub>
- Timers
  - 1 x 16-bit advanced-control timer (TIM1)
  - 1 x 16-bit general-purpose timer (TIM14)
  - 1 x independent watchdog timer (IWDG)
  - 1 x SysTick timer
- RTC
- Communication interfaces
  - 1 x serial peripheral interface (SPI)
  - 3 x universal asynchronous receiver/transmitters (UARTs)
  - 1 x I<sup>2</sup>C interface, supporting Standard mode (100 kHz), Fast mode (400 kHz) and Fast mode plus (1 MHz)
- Hardware CRC-32 module
- 2 x comparators
- Unique UID
- Serial wire debug (SWD)
- Operating temperature: -40 to 105 °C
- Packages: TSSOP28, SOP28, TSSOP20, SOP20, QFN20, SOP16 and SOP8

## Content

<b>Features .....</b>	<b>2</b>
<b>1. Introduction .....</b>	<b>5</b>
<b>2. Functional overview .....</b>	<b>9</b>
2.1. Arm® Cortex®-M0+ core .....	9
2.2. Memories .....	9
2.3. Boot modes .....	9
2.4. Clock management .....	10
2.5. Power management .....	11
2.5.1. Power block diagram .....	11
2.5.2. Power monitoring .....	11
2.5.3. Voltage regulator .....	12
2.5.4. Low-power mode .....	12
2.6. Reset .....	12
2.6.1. Power reset .....	12
2.6.2. System reset .....	12
2.7. General-purpose inputs and outputs (GPIOs) .....	13
2.8. Interrupts and events .....	13
2.8.1. Nested vectored interrupt controller (NVIC) .....	13
2.8.2. Extended interrupt/event controller (EXTI) .....	13
2.9. Analog-to-digital converter (ADC) .....	14
2.10. Touch key .....	14
2.11. Comparators (COMP) .....	14
2.11.1. COMP features .....	14
2.12. Timers .....	15
2.12.1. Advanced-control timer (TIM1) .....	15
2.12.2. General-purpose timer .....	15
2.12.3. Independent watchdog (IWDG) .....	15
2.12.4. SysTick timer .....	16
2.13. Real-time clock (RTC) .....	16
2.14. Inter-integrated circuit interface (I²C) .....	16
2.15. Universal asynchronous receivers/transmitter (UART) .....	17
2.16. Serial peripheral interface (SPI) .....	17
2.17. Serial wire debug (SWD) .....	18
<b>3. Pinouts and pin descriptions .....</b>	<b>19</b>
3.1. Alternate functions selected through GPIOA_AFR registers for port A .....	30
3.2. Alternate functions selected through GPIOB_AFR registers for port B .....	30
3.3. Alternate functions selected through GPIOF_AFR registers for port F .....	30
<b>4. Memory mapping .....</b>	<b>31</b>
<b>5. Electrical characteristics .....</b>	<b>34</b>

5.1.	Parameter conditions .....	34
5.1.1.	Minimum and maximum values.....	34
5.1.2.	Typical values.....	34
5.1.3.	Power supply scheme .....	34
5.2.	Absolute maximum ratings.....	35
5.3.	Operating conditions .....	35
5.3.1.	General operating conditions .....	35
5.3.2.	Operating conditions at power-on / power-down.....	35
5.3.3.	Embedded reset .....	36
5.3.4.	Supply current characteristics .....	36
5.3.5.	Wake-up time from low-power mode.....	37
5.3.6.	External clock source characteristics .....	38
5.3.7.	High-speed internal (HSI) RC oscillator .....	40
5.3.8.	Low-speed internal (LSI) RC oscillator.....	40
5.3.9.	Memory characteristics .....	41
5.3.10.	EFT characteristics.....	41
5.3.11.	ESD & LU characteristics .....	41
5.3.12.	Port characteristics .....	41
5.3.13.	Constant current LED SEG driver characteristics .....	42
5.3.14.	ADC characteristics .....	43
5.3.15.	Comparator characteristics .....	44
5.3.16.	Temperature sensor characteristics .....	45
5.3.17.	Embedded internal voltage reference characteristics .....	45
5.3.18.	Internal voltage reference buffer characteristics .....	45
5.3.19.	COMP internal reference buffer characteristics .....	45
5.3.20.	Timer characteristics .....	46
5.3.21.	Communication port characteristics .....	46
6.	<b>Package information .....</b>	<b>49</b>
6.1.	TSSOP28 package size.....	49
6.2.	SOP28 package size.....	50
6.3.	TSSOP20 package size.....	51
6.4.	SOP20 package size.....	52
6.5.	QFN20 (3*3*0.5) package size .....	53
6.6.	SOP16 package size.....	54
6.7.	SOP8 package size.....	55
7.	<b>Ordering information.....</b>	<b>56</b>
8.	<b>Version history.....</b>	<b>57</b>

## 1. Introduction

The PY32T020-B series are based on a 32-bit ARM® Cortex®-M0+ core and operates at up to 48 MHz with a wide voltage range. It integrates up to 32 KB Flash and 4 KB SRAM, available in multiple package options.

The PY32T020-B series integrate I<sup>2</sup>C, SPI, UART and other communication peripherals. It has one 12-bit ADC, two 16-bit timers, two comparators and 26-channel low-power dual-mode capacitive touch circuit (in Stop mode).

The PY32T020-B microcontrollers operate across a temperature range of -40 to 105 °C and a standard voltage range of 1.8 to 5.5 V. provides Sleep and Stop low power operating modes, which can meet different low-power applications.

The PY32T020-B series feature excellent touch key controller. Coupled with its outstanding anti-interference performance, it can be adapted in various solutions. Its applications span smart appliances, controllers, handheld equipment, PC peripherals, gaming, GPS platforms, and industrial systems.

Table 1-1 PY32T020-B TSSOP28 / SOP28 series product features and peripheral counts

Peripherals	PY32T020G16P 7-B	PY32T020G46 P7-B	PY32T020G16 S7-B	PY32T020G15 S7-B	PY32T020G26 S7-B	PY32T020G25S 7-B	PY32T020G36S 7-B	PY32T020G35S 7-B	PY32T020G46 S7-B
Flash (KB)	32	32	32	20	32	20	32	20	32
SRAM (KB)	4	4	4	2	4	2	4	2	4
Timers	Advanced-control					1			
	General-purpose					1			
	SysTick					1			
	Watchdog					1			
Comm. Interfaces	SPI					1			
	I <sup>2</sup> C					1			
	UARTs					3			
RTC						Yes			
GPIOs	26	25	26	26	26	26	26	26	25
Touch CHs	26	25	26	26	26	26	26	26	25
ADC channels (external + internal)	10+3	9+3	10+3	10+3	10+3	10+3	10+3	10+3	9+3
LED COM						5			
LED SEG						8			
LCD COM	26	25	26	26	26	26	26	26	25
Comparators						2			
Max. CPU frequency <sup>(1)</sup>	48 MHz	48 MHz	48 MHz	24 MHz	48 MHz	24 MHz	48 MHz	24 MHz	48 MHz
Operating voltage						1.8 to 5.5 V			
Operating temperature						-40 to 105 °C			
Packages	TSSOP28					SOP28			

Table 1-2 PY32T020-B TSSOP20 / SOP20 / QFN20 /SOP16 / SOP8 series product features and peripheral counts

Peripherals		PY32T020F15P7-B	PY32T020F16S7-B	PY32T020F25S7-B	PY32T020F45U7-B	PY32T020W25S7-B	PY32T020L15S7-B
Flash (KB)	20	32	20	20	20	20	20
SRAM (KB)	2	4	2	2	2	2	2
Timers	Advanced-control				1		
	General-purpose				1		
	SysTick				1		
	Watchdog				1		
Comm. interfaces	SPI				1		
	I <sup>2</sup> C				1		
	UARTs				3		
RTC					Yes		
GPIOs	18	18	18	19	14	6	
Touch CHs	18	18	18	19	14	6	
ADC channels (external + internal)	6+3	6+3	10+3	8+3	6+3	3+3	
LED COM				5		-	
LED SEG				5		1	
LCD COM	18	18	18	19	14	6	
Comparators	2	2	2	2	2	1	
Max. CPU frequency <sup>(1)</sup>	24 MHz	48 MHz			24 MHz		
Operating voltage				1.8 to 5.5 V			
Operating temperature				-40 to 105 °C			
Packages	TSSOP20	SOP20	SOP20	QFN20	SOP16	SOP8	

1. Products with 20 KB Flash support up to 24 MHz CPU frequency.

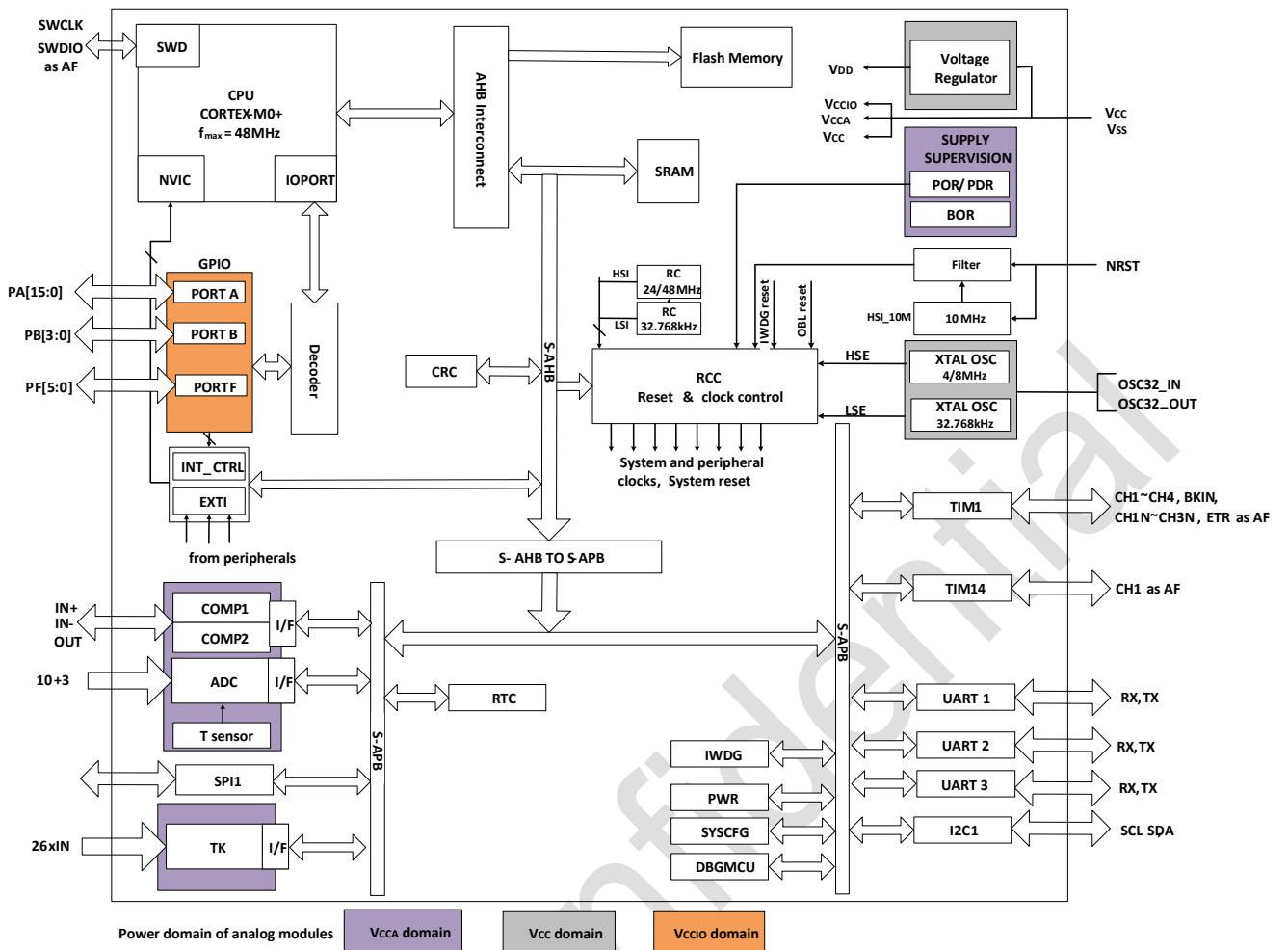


Figure 1-1 System block diagram

## 2. Functional overview

### 2.1. Arm® Cortex®-M0+ core

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

- Simple architecture for easy learning and programming
- Ultra-low power consumption for energy-efficient operation
- Reduced code density

The Arm® Cortex®-M0+ processor is a 32-bit core optimized for area and power consumption and is a 2-stage pipeline Von Neumann architecture. It delivers high performance through a streamlined instruction set and hardware enhancements like a single-cycle multiplier. Outperforms 8/16-bit MCUs in code efficiency.

The Arm® Cortex®-M0+ is tightly coupled with a nested vectored interrupt controller (NVIC).

### 2.2. Memories

Embedded SRAM is accessed by Bytes (8 bits), Half-word (16 bits) or Word (32 bits).

The Flash memory is composed of two distinct physical areas:

- The Main flash area consists of application and user data, with up to 4 KB configurable as a User Bootloader through customer settings.
- 768 Bytes of Information area:
  - Option bytes
  - UID bytes
  - Factory configuration bytes
  - USER OTP memory

The protection of Main flash area includes the following mechanisms:

- Read protection (RDP) blocks external access
- Write protection (WRP) prevents unintended writes (caused by confusion of program). The minimum protection unit for write protection is 4 KB.
- Option byte write protection is a special design for unlock.
- SDK protection

### 2.3. Boot modes

At startup, the nBOOT0 pin and nBOOT1 (stored in option bytes) are used to select one of the three-boot options in the following table:

Table 2-1 Boot mode configuration

Boot mode configuration		Mode	
nBOOT1 bit	nBOOT0 bit	Boot memory size ==0	Boot memory size !=0
X	0	Boot from Main flash	Boot from Main flash
0	1	Boot from SRAM	Boot from SRAM
1	1	N/A	Boot from Load flash <sup>(1)</sup>

1. Products with 20 KB Flash cannot be boot from Load flash.

## 2.4. Clock management

System clock selection is performed on startup, however the internal RC 24 MHz oscillator is selected as default CPU clock on reset. After the program is operating the system clock frequency and system clock source can be reconfigured. The frequency clocks that can be selected are:

- A 24/48 MHz internal high precision HSI clock
- A 32.768 kHz configurable internal LSI clock
- A 4 to 8 MHz HSE clock, and used to 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.
- A 32.768 kHz LSE clock.

The AHB clock can be divided based on the system clock, and the APB clock can be divided based on the AHB clock. The maximum frequency of the AHB and the APB domains is 48 MHz.

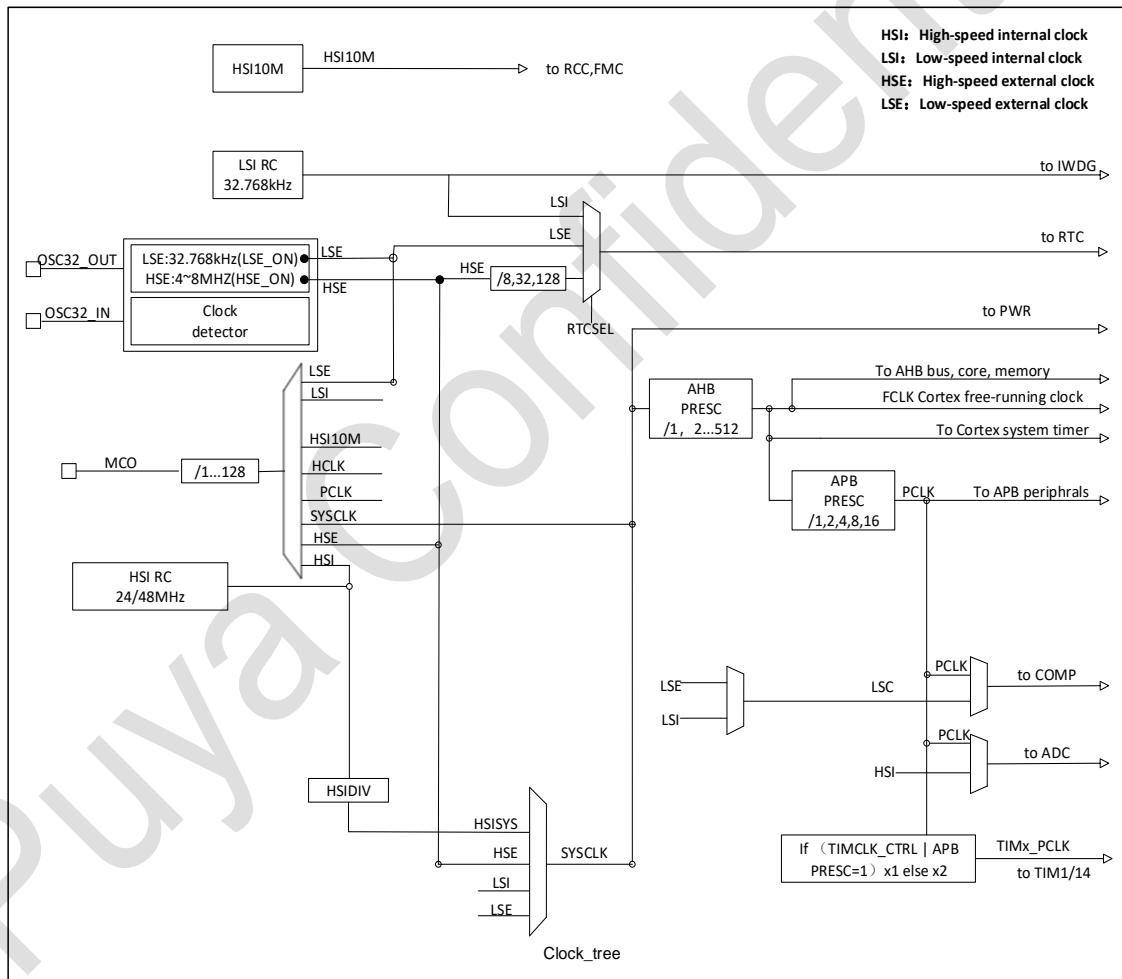


Figure 2-1 System clock structure diagram

## 2.5. Power management

### 2.5.1. Power block diagram

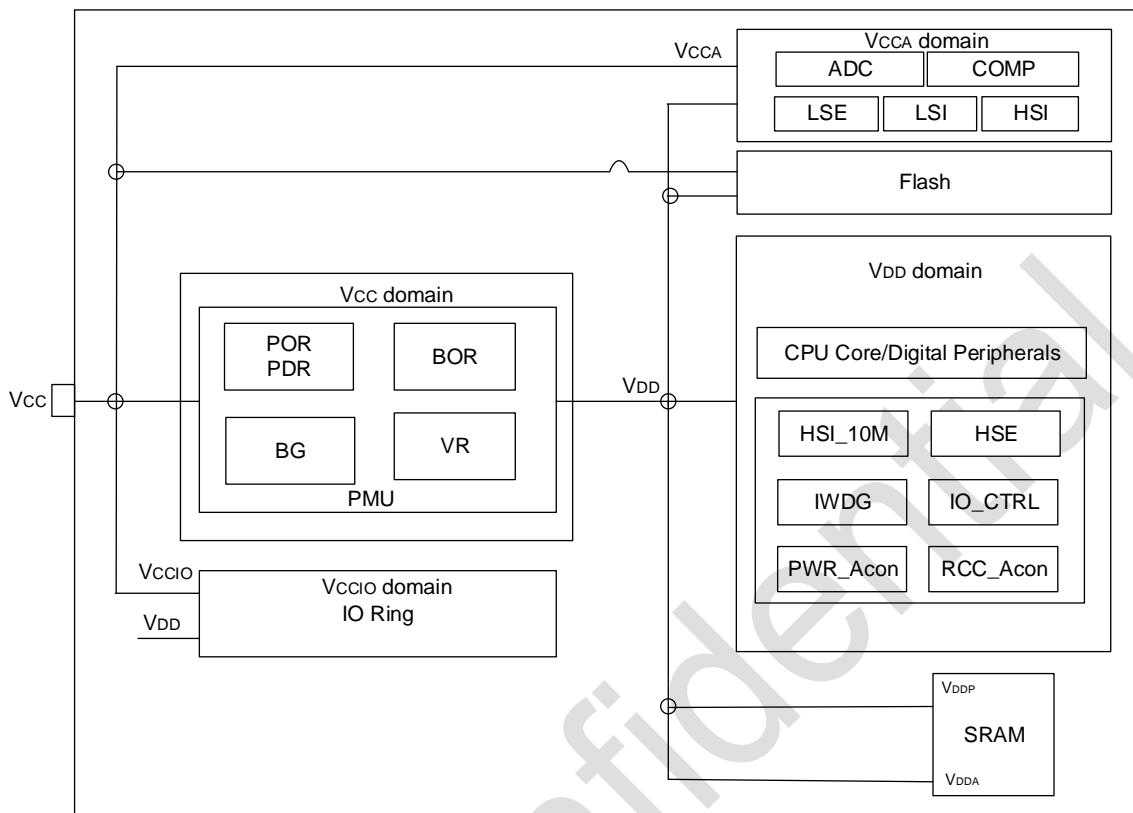


Figure 2-2 Power block diagram

Table 2-2 Power block diagram

No.	Power supply	Power value	Descriptions
1	V <sub>CC</sub>	1.8 to 5.5 V	The power is supplied to the chip through the power pins, with the power supply module comprising: partial analog circuits
2	V <sub>CCA</sub>	1.8 to 5.5 V	Powers for most analog modules, sourced from the V <sub>CC</sub> PAD (a dedicated power PAD can also be designed separately).
3	V <sub>CCIO</sub>	1.8 to 5.5 V	Power to IO from V <sub>CC</sub> PAD

### 2.5.2. Power monitoring

#### 2.5.2.1. Power-on/power-down reset (POR/PDR)

The Power-on reset (POR) and Power-down reset (PDR) module is designed in the chip to provide 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 individually configured.

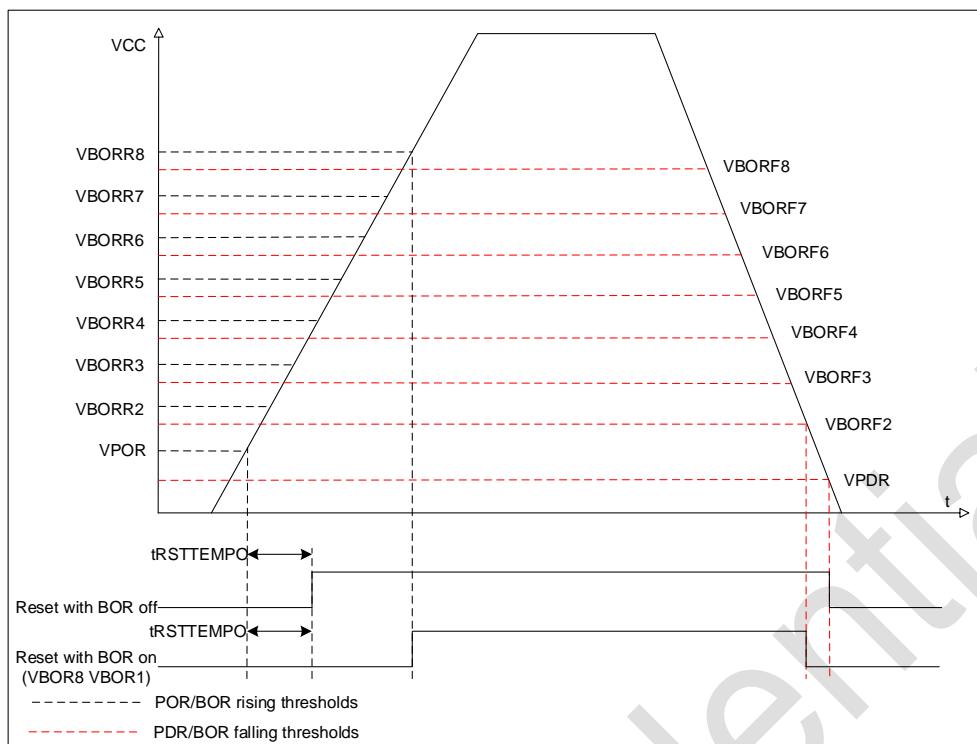


Figure 2-3 POR/PDR/BOR threshold

### 2.5.3. Voltage regulator

The regulator has two operating modes:

- MR (Main regulator) is used in normal operating mode (Run).
- LPR (Low power regulator) provides an option for even lower power consumption in low power mode.

### 2.5.4. Low-power mode

In addition to the normal operating mode, the chip has two 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:** LDO enters low-power mode SRAM and register contents are retained. HSI and HSE are turned off and most module clocks in the  $V_{DD}$  domain are disabled.

## 2.6. Reset

Two resets are designed in the chip: power reset 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 (OBL) reset

## 2.7. General-purpose inputs and outputs (GPIOs)

Each of the GPIO pins can be configured by software as output (push-pull or open-drain), as input (floating, pull-up or pull-down and analog) or as peripheral alternate function. The I/O configuration can be locked and LCD 1/2 Bias output is also supported.

## 2.8. Interrupts and events

The PY32T020-B handles exceptions through the Cortex-M0+ processor's embedded a nested vectored interrupt controller (NVIC) and an extended interrupt/event controller (EXTI).

### 2.8.1. Nested vectored interrupt controller (NVIC)

The 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 higher-priority interrupt event occurs and a lower-priority interrupt event is just waiting to be serviced, the later-arriving higher-priority interrupt event will be serviced first. Another optimization is called tail-chaining. When returning from a higher-priority ISR and then starting a pending lower-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
- Support up to 16 maskable external interrupts
- Support 6 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)

The 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 up to 26 GPIOs multiplexed using 16 EXTI lines, two 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.

- 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 PY32T020-B has a 12-bit SAR-ADC. The module has a total of up to 13 channels to be measured, including 10 external and 3 internal channels.

The ADC internal voltage reference:  $V_{REFBUF}$  (0.6V, 1.5 V, 2.048 V, 2.5 V) or the power supply voltage  $V_{CC}$ .

The internal channels are:  $T_{S\_VIN}$ ,  $V_{REFINT}$ ,  $V_{CC}/3$ .

A/D conversion of the various channels can be performed in single, continuous, scan or discontinuous mode. The result of the ADC is stored in a left-aligned or right-aligned 16-bit data register.

The analog watchdog feature allows the application to detect if the input voltage goes outside the user-defined higher or lower thresholds.

An efficient low-power mode is implemented to allow very low consumption at low frequency.

Interrupt requests are triggered by the following events: end of sampling, conversion, continuous conversion and Analog watchdog threshold violation (converted voltage exceeds preset limits)

## 2.10. Touch key

The PY32T020-B integrates a 26 channel capacitive touch circuit:

- Optional internal/external CMOD capacitor, no external capacitor needed for internal use
- High-sensitivity design enables non-contact touch sensing
- 10 V dynamic CS test-passed anti-interference mode
- Support the frequency hopping function
- Support the waterproof compensation function
- Support multi-channel parallel connection
- Support Low-power Modes: Touch operation in low-power mode maintains total chip power consumption <8  $\mu A$

## 2.11. Comparators (COMP)

The PY32T020-B integrates two general-purpose comparators (COMP). Comparators can be used as:

- Triggered by analog signal to wake-up function from low-power mode
- Analog signal conditioning
- Cycle by cycle current control loop when comparators are connected with PWM output from timer.

### 2.11.1. COMP features

- Each comparator has configurable positive or negative input for flexible voltage selection:
  - Multiple I/O pins
  - Power supply  $V_{CC}$  and 64 sub-multiple values (1/64, 2/64 ... 64/64) provided by voltage divider 64/64)
  - Internal reference voltage is 0.6 V, 1.5 V, 2.048 V or 2.5 V, and 64 sub-multiple values (1/64, 2/64 ... 64/64) provided by voltage divider
- The output can be triggered by a connection to the I/O or timer input
  - OCREF\_CLR event (cycle-by-cycle current control)
  - Brakes for fast PWM shutdown
- Each COMP has interrupt generation capability and is used to wake up the chip from low power mode (Sleep/Stop) (via EXTI)

## 2.12. Timers

The different timers feature as blow:

Table 2-3 Timer characteristics

Timer type	Timers	Counter resolution	Counter type	Prescaler	Capture/compare channels	Complementary outputs
Advanced-control	TIM1	16-bit	up,down, up/down	1 - 65536	4	3
General-purpose	TIM14	16-bit	up	1 - 65536	1	-

### 2.12.1. Advanced-control timer (TIM1)

The advanced-control timer (TIM1) is consist of a 16-bit auto-reload counter driven by a 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).

The four independent channels can be used for:

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

If configured as a standard 16-bit timer, it has the same features as the TIMx timer. If configured as the 16-bit PWM generator, it has full modulation capability (0 to 100 %).

The counter can be frozen in debug mode.

Many features are shared with those of the standard timers which have the same architecture. The advanced control timer can therefore work together with the other timers by the Timer Link feature for synchronization or event chaining.

### 2.12.2. General-purpose timer

The general-purpose timer TIM14 is consist of a 16-bit auto-reload counter driven by a programmable prescaler.

TIM14 features one single channel for input capture/output compare, PWM or one-pulse mode output.

The counter can be frozen in debug mode.

### 2.12.3. Independent watchdog (IWDG)

The 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.

The counter can be frozen in debug mode.

#### 2.12.4. SysTick timer

This timer is dedicated to real-time operating systems (RTOS), but could also be used as a standard down counter.

SysTick features:

- A 24-bit down counter
- Auto-reload capability
- Maskable system interrupt generation when the counter reaches 0

#### 2.13. Real-time clock (RTC)

The RTC is an independent counter. It has a set of continuous counting counters, which can provide a clock calendar function under the corresponding software configuration. Modifying the value of the counter can reset the current time and date of the system.

- RTC is a 32-bit programmable counter with a prescaler factor of up to  $2^{20}$  bits.
- The RTC counter clock source can be LSE, LSI, HSE/128,HSE/32,HSE/8,can be the Stop wake-up source.
- RTC can generate alarm interrupt, second interrupt and overflow interrupt (maskable).
- RTC supports clock calibration.
- RTC can be frozen in debug mode.

#### 2.14. Inter-integrated circuit interface ( $I^2C$ )

The  $I^2C$  (Inter-integrated circuit) bus interface handles communications between the microcontroller and the serial  $I^2C$  bus. It provides multimaster capability, and controls all  $I^2C$  bus-specific sequencing, protocol, arbitration and timing. Standard mode (Sm), Fast mode (Fm) and Fast mode plus (Fm+) are supported.

$I^2C$  features:

- Multimaster capability : can be Master or Slave
- Support different communication speeds
  - Standard mode (Sm): up to 100 kHz
  - Fast mode (Fm): up to 400 kHz
  - Fast mode plus (Fm+): up to 1 MHz
- As Master
  - Generate clock
  - Generation of start and stop
- As Slave
  - Programmable  $I^2C$  address detection
  - Discovery of the STOP bit
- 7-bit addressing mode
- General call
- Status flag
  - Transmit/receive mode flags
  - Byte transfer complete flag
  - $I^2C$  busy flag bit
- Error flag
  - Master arbitration loss

- ACK failure after address/data transfer
- Start/stop error
- Overrun/Underrun (clock stretching function disable)
- Optional clock stretching
- Software reset
- Analog noise filter function
- Low-power address matching wake-up

## 2.15. Universal asynchronous receivers/transmitter (UART)

The UARTs provide a flexible method for full-duplex data exchange with external devices using the industry-standard NRZ asynchronous serial data format. The UART utilizes a fractional baud rate generator to provide a wide range of baud rate options.

Automatic baud rate detection is supported.

UART features:

- Support 5/6/7/8/9 bits serial data
- Support 1 or 2 STOP bit (1/1.5 STOP bit for 5 bits data)
- Support sending address/data
- Support fixed parity check
- Support break frames
- Detect start bit errors
- Support programmable fractional baud rates.
  - Calculation method is as follows: Baud rate = (Serial clock frequency) / (16 \* Divisor)
- Support SWAP function
- Support MSBFIRST endianness switching

## 2.16. Serial peripheral interface (SPI)

The SPIs allow 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 serial 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 half-duplex synchronous transmission (with bidirectional data line)
- 8-bit or 16-bit transmission frame selection
- Support multi-master mode
- 8 Master mode baud rate prescalers (Max 24 MHz)
- Slave mode frequency (Max 24 MHz)
- 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 or overloads
- Two 32-bit Rx and Tx FIFOs

## 2.17. Serial wire debug (SWD)

An ARM SWD interface allows serial debugging tools to be connected to the PY32T020-B.

### 3. Pinouts and pin descriptions

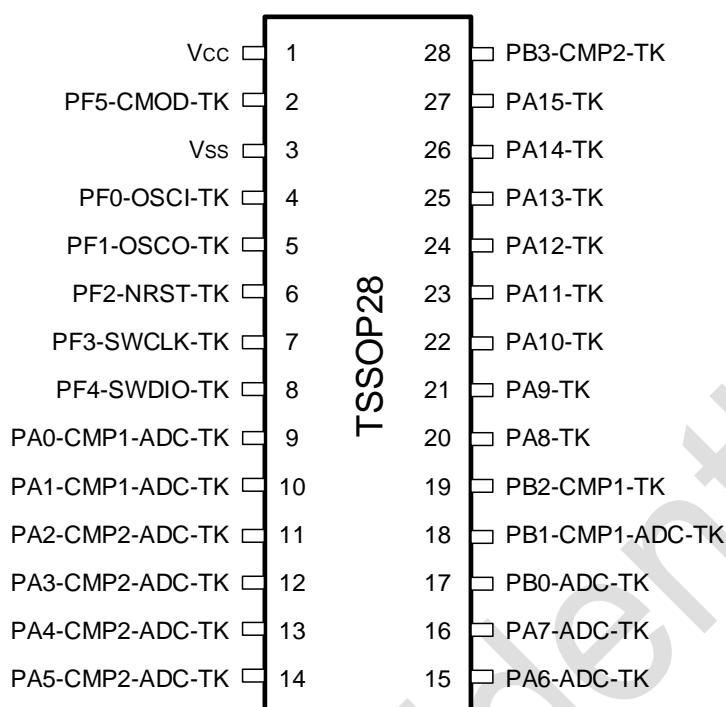


Figure 3-1 TSSOP28 Pinout1 PY32T020G1xP7 (Top view)

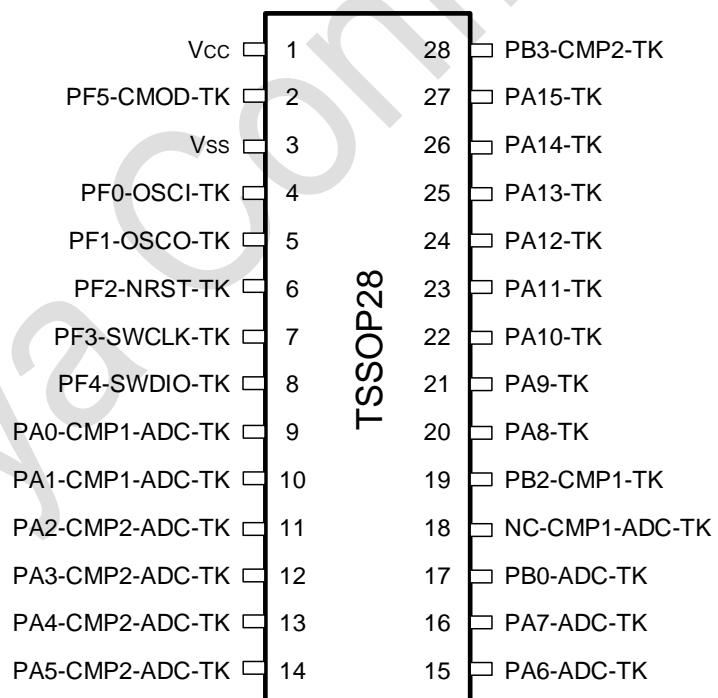


Figure 3-2 TSSOP28 Pinout4 PY32T020G4xP7-B (Top view)

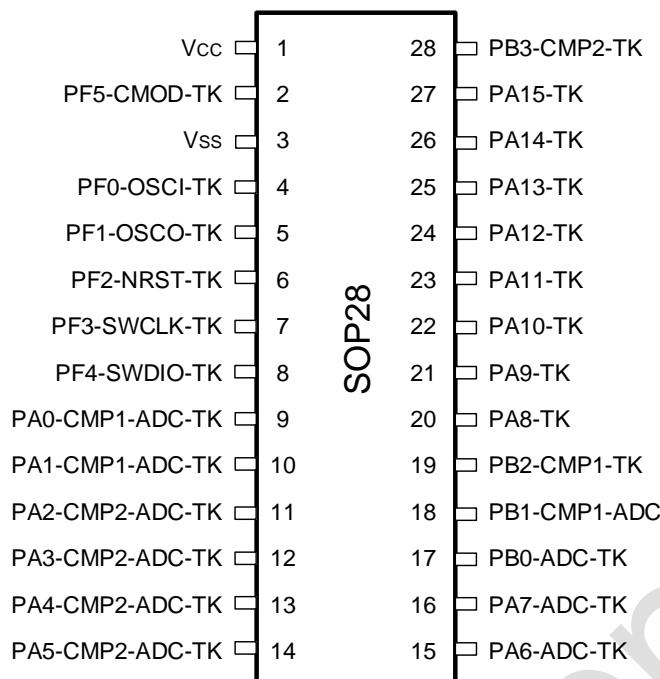


Figure 3-3 TSSOP28 Pinout1 PY32T020G1xP7 (Top view)

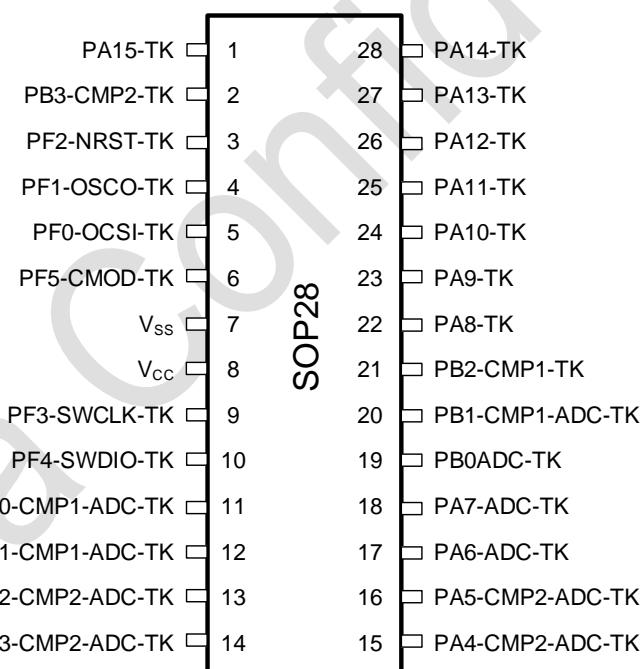


Figure 3-4 SOP28 Pinout2 PY32T020G2xS7 (Top view)

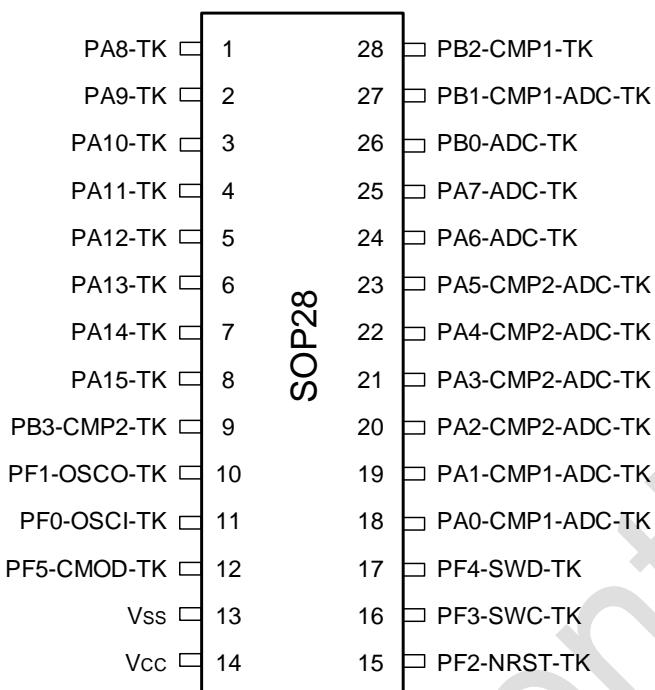


Figure 3-5 SOP28 Pinout3 PY32T020G3xS7 (Top view)

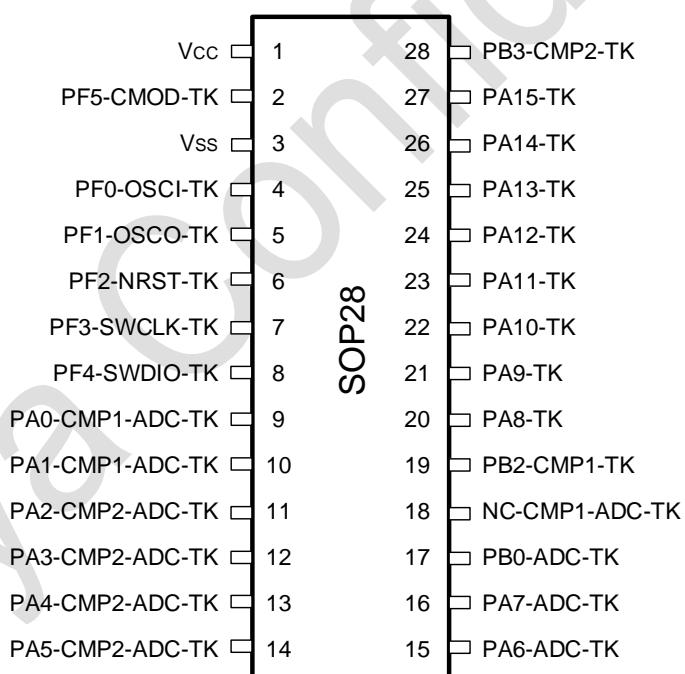


Figure 3-6 SOP28 Pinout4 PY32T020G4xS7-B (Top view)

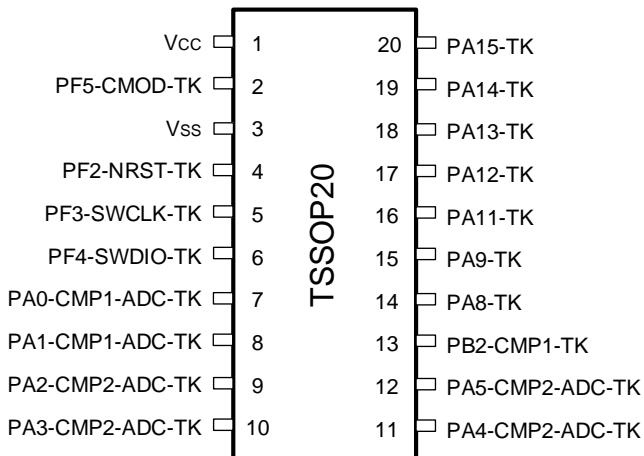


Figure 3-7 TSSOP28 Pinout1 PY32T020G1xP7 (Top view)

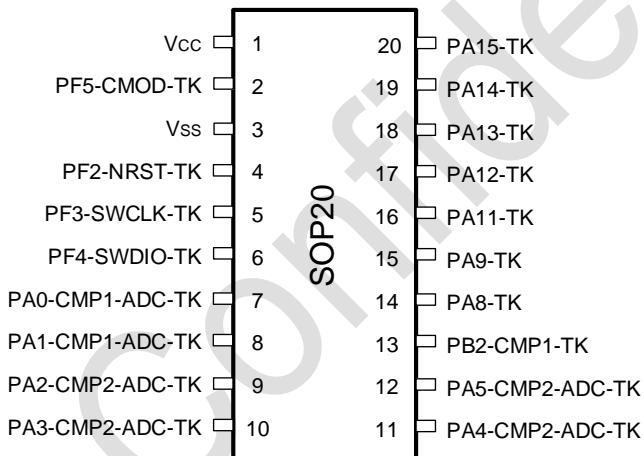


Figure 3-8 TSSOP28 Pinout1 PY32T020G1xP7 (Top view)

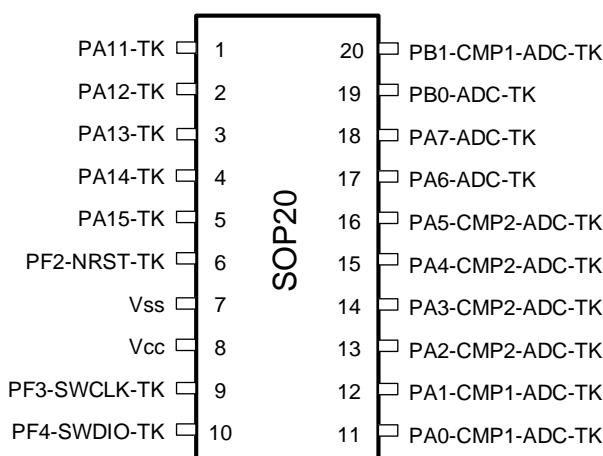


Figure 3-9 SOP28 Pinout2 PY32T020G2xS7 (Top view)

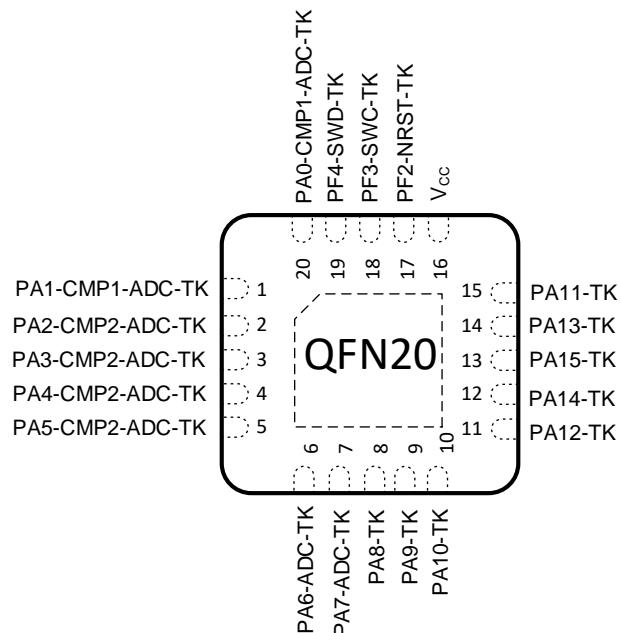


Figure 3-10 QFN20 Pinout4 PY32T020F4xU7-B(Top view)

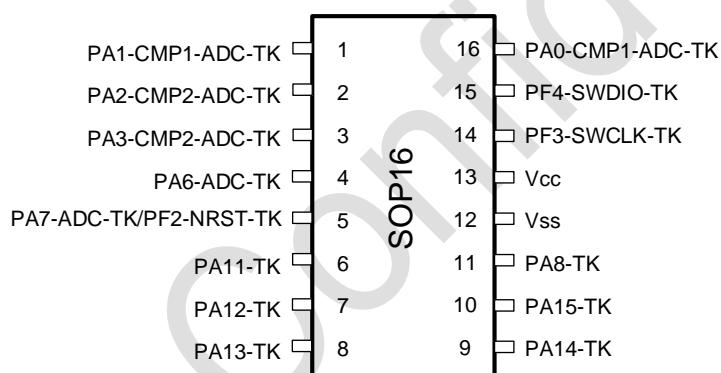


Figure 3-11 SOP28 Pinout2 PY32T020G2xS7 (Top view)

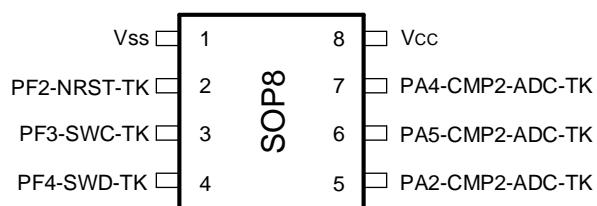


Figure 3-12 TSSOP28 Pinout1 PY32T020G1xP7 (Top view)

Table 3-1 Legend/abbreviations used in the pinout table

Timer type	Symbol	Definition
Pin type	S	Supply pin
	G	Ground
	I/O	Input / output pin
	NC	No internal connection
I/O structure	COM	Standard 5 V I/O, with analog switch function
	NRST	Bidirectional reset pin with embedded weak pull-up resistor, no analog switch function
	_L	LED COM port supports 80 mA sink current and analog input/output functions
	_C	LED SEG port supports constant - current drive and analog input/output functions
	_F	I/O, I <sup>2</sup> C SCL SDA capable with analog input and output function
	_P	Support 2.7 V/20 mA, 5 V/30 mA source current, analog input and output functions
Notes	-	Unless otherwise specified, all ports are used as analog inputs between and after reset All I/Os support Touch Key Cap sense ports and analog input/output functions. All I/Os support LCD 1/2 Bias output function.
Pin functions	Alternate functions	- Function selected through GPIOx_AFR register
	Additional functions	- Functions directly selected/enabled through peripheral registers

Table 3-2 Pin definitions<sup>(5)</sup>

Packages										Reset	Pin type	I/O structure	Port function <sup>(8)</sup>						
TSSOP28 G1 SOP28 G1	TSSOP28 G4 SOP28 G4	SOP28 G2	SOP28 G3	TSSOP20 F1 SOP20 F1	SOP20 F2	QFN20 F4	SOP16 W2	SOP8 L1	Multiplexed function <sup>(6)</sup>				Multiplexed function <sup>(6)</sup>	Additional functions					
1	1	8	14	1	8	16	13	8	Power Supply										
2	2	6	12	2	-	-	-	-	PF5-CMOD		I/O	COM	TK_CMOD TK_IN25						
3	3	7	13	3	7	-	12	1	Ground										
4	4	5	11	-	-	-	-	-	PF0-OSCI		I/O	COM	TIM14_CH1 OSCIN <sup>(9)</sup> TK_IN24						
5	5	4	10	-	-	-	-	-	PF1-OSCO		I/O	COM	TIM14_CH1 OSCOUT <sup>(9)</sup> TK_IN23						
6	6	3	15	4	6	17	5	2	PF2-NRST <sup>(4)</sup>		I/O	NRST COM_F	I2C_SCL	NRST TK_IN22					
7	7	9	16	5	9	18	14	3	PF3-SWCLK <sup>(1)(2)(3)(7)</sup>		I/O	COM_F	I2C_SDA						
8	8	10	17	6	10	19	15	4	PF4-SWDIO <sup>(1)(2)(3)(7)</sup>		I/O		I2C_SCL						
									UART1_RX				TK_IN21						
									I2C_SDA										
									I2C_SCL										
									TIM1_ETR										
									TIM14_CH1										
									SWCLK										
									UART1_RX										
									I2C_SCL										
									I2C_SDA										
									TIM1_ETR										
									TIM14_CH1										
									SWDIO										

Packages										Reset	Pin type	I/O structure	Port function <sup>(8)</sup>	
TSOP28 G1 SOP28 G1	TSOP28 G4 SOP28 G4	SOP28 G2	SOP28 G3	TSOP20 F1 SOP20 F1	SOP20 F2	QFN20 F4	SOP16 W2	SOP8 L1					Multiplexed function <sup>(6)</sup>	Additional functions
9	9	11	18	7	11	20	16	-	PA0	I/O	COM_C	SPI_NSS	CMP1_INM ADC_IN0 TK_IN19	
												UART2_TX		
												TIM1_CH1N		
												TIM1_CH3		
												CMP1_OUT		
10	10	12	19	8	12	1	1	-	PA1	I/O	COM_C	SPI_SCK	CMP1_INP ADC_IN1 TK_IN18	
												UART2_RX		
												TIM1_CH2N		
												TIM1_CH4		
												EVENTOUT		
												MCO		
11	11	13	20	9	13	2	2	5	PA2	I/O	COM_P	SPI_MOSI	CMP2_INM ADC_IN2 TK_IN17	
												UART3_TX		
												TIM14_CH1		
12	12	14	21	10	14	3	3	-				SPI_MISO	CMP2_INP ADC_IN3 TK_IN16	
									PA3	I/O	COM	UART3_RX		
												TIM1_CH1		
												EVENTOUT		
13	13	15	22	11	15	4	-	7	PA4	I/O	COM	SPI_NSS	CMP2_INP ADC_IN4 TK_IN15	
												UART2_TX		
												TIM1_CH3		
												RTC_OUT		
14	14	16	23	12	16	5	-	6	PA5	I/O	COM_C	SPI_SCK	CMP2_INP ADC_IN5 TK_IN14	
												UART2_RX		
												TIM1_CH2		

Packages										Reset	Pin type	I/O structure	Port function <sup>(8)</sup>	
TSOP28 G1 SOP28 G1	TSOP28 G4 SOP28 G4	SOP28 G2	SOP28 G3	TSOP20 F1 SOP20 F1	SOP20 F2	QFN20 F4	SOP16 W2	SOP8 L1					Multiplexed function <sup>(6)</sup>	Additional functions
15	15	17	24	-	17	6	4	-	PA6	I/O	COM_C	MCO	ADC_IN6 TK_IN13	
												SPI_MISO		
												UART1_TX		
												TIM1_BKIN		
												TIM1_CH1		
16	16	18	25	-	18	7	5	-	PA7	I/O	COM_C COM_P	CMP1_OUT	ADC_IN7 TK_IN12	
												SPI_MOSI		
												UART1_RX		
												TIM1_CH1N		
												RTC_OUT		
												CMP2_OUT		
17	17	19	26	-	19	-	-	-	PB0	I/O	COM	EVENTOUT	ADC_IN8 TK_IN11	
												SPI_NSS		
												UART2_TX		
												TIM1_CH2N		
18	NC	20	27	-	20	-	-	-	PB1	I/O	COM	CMP1_INM	CMP1_INP TK_IN9	
												ADC_IN9		
												TK_IN10		
19	19	21	28	13	-	-	-	-	PB2	I/O	COM_C	SPI_MISO	CMP1_INP TK_IN9	
												UART3_RX		
												TIM14_CH1		
20	20	22	1	14	-	8	11	-	PA8	I/O	COM_C COM_F	SPI_MOSI	TK_IN8	
												UART3_TX		
												I2C_SDA		

Packages										Reset	Pin type	I/O structure	Port function <sup>(8)</sup>	
TSOP28 G1 SOP28 G1	TSOP28 G4 SOP28 G4	SOP28 G2	SOP28 G3	TSOP20 F1 SOP20 F1	SOP20 F2	QFN20 F4	SOP16 W2	SOP8 L1					Multiplexed function <sup>(6)</sup>	Additional functions
21	21	23	2	15	-	9	-	-	PA9	I/O	COM	TIM1_CH1	TK_IN7	
												MCO		
												UART2_TX		
												TIM1_ETR		
												TIM1_BKIN		
22	22	24	3	-	-	10	-	-	PA10	I/O	COM	TIM14_CH1	TK_IN6	
												EVENTOUT		
												UART2_RX		
23	23	25	4	16	1	15	6	-	PA11	I/O	COM_F COM_L	TIM1_CH3	TK_IN5	
												I2C_SCL		
												SPI_SCK		
												UART1_TX		
24	24	26	5	17	2	11	7	-	PA12	I/O	COM_L	TIM1_CH4	TK_IN4	
												SPI_MOSI		
												UART1_RX		
												TIM1_ETR		
												TIM14_CH1		
25	25	27	6	18	3	14	8	-	PA13(SWDIO) <sup>(1)(2)(3)</sup>	I/O	COM_L	EVENTOUT	TK_IN3	
												SWDIO		
												UART2_TX		
												TIM1_CH3N		
26	26	28	7	19	4	12	9	-	PA14(SWCLK) <sup>(1)(2)(3)</sup>	I/O	COM_L	MCO	TK_IN2	
												SWCLK		
												UART3_TX		

Packages									Reset	Pin type	I/O structure	Port function <sup>(8)</sup>	
TSOP28 G1 SOP28 G1	TSOP28 G4 SOP28 G4	SOP28 G2	SOP28 G3	TSOP20 F1 SOP20 F1	SOP20 F2	QFN20 F4	SOP16 W2	SOP8 L1				Multiplexed function <sup>(6)</sup>	Additional functions
									PA15	I/O	COM_L	TIM1_CH2N	TK_IN1
27	27	1	8	20	5	13	10	-				EVENTOUT	
												SPI_NSS	
												UART3_RX	
									PB3	I/O	COM_C	TIM1_CH1N	TK_IN0
28	28	2	9	-	-	-	-	-				TIM1_CH4	
												SPI_SCK	CMP2_INM TK_IN0
												UART2_RX	
												TIM1_CH2	

1. PA3, PA4, PA13, and PA14 can be configured via options to select GPIO functionality or SWC/SWD functionality.

option[1:0]	PF3	PF4	PA13	PA14
0/0 (default)	SWCLK	SWDIO	GPIO	GPIO
0/1	GPIO	GPIO	SWDIO	SWCLK
1/0	GPIO	SWDIO	GPIO	SWCLK
1/1	SWCLK	GPIO	SWDIO	GPIO

2. After reset, when the option byte is configured to 0/0 (default state), PA5 and PA4 are configured as SWCLK and SWDIO.
3. The internal pull-up resistor is activated when configured as SWDIO and the internal pull-down resistor is activated when configured as SWCLK.
4. Configured by option bytes to chooseGPIO or NRST.
5. All IOs support pull-up, pull-down valid at the same time, output 1/2 V<sub>cc</sub> level.
6. The RX/TX of UART1, UART2, and UART3 can be set to be interchangeable within the IP.
7. When used as a closed I<sup>2</sup>C EEPROM, an internal pull-up resistor of 4.7 kΩ can be configured.
8. TK function and GPIO digital function cannot be turned on at the same time.
9. When HSE\_ON is enabled, the crystal oscillator is used for HSE. When LSE\_ON is enabled, the crystal oscillator is used for LSE. HSE\_ON and LSE\_ON cannot be enabled simultaneously.

### 3.1. Alternate functions selected through GPIOA\_AFR registers for port A

Table 3-3 Port A alternate functions mapping

Port A	AF0	AF1	AF2	AF3	AF4	AF5	AF6	AF7
PA0	SPI_NSS	-	TIM1_CH3	UART2_TX	-	TIM1_CH1N	CMP1_OUT	-
PA1	SPI_SCK	-	TIM1_CH4	UART2_RX	-	TIM1_CH2N	MCO	EVENTOUT
PA2	SPI_MOSI	UART3_TX		-	-	TIM14_CH1	-	-
PA3	SPI_MISO	UART3_RX	TIM1_CH1	-	-	-	-	EVENTOUT
PA4	SPI_NSS	-	TIM1_CH3	UART2_TX	RTC_OUT	-	-	-
PA5	SPI_SCK	-	TIM1_CH2	UART2_RX	-		MCO	-
PA6	SPI_MISO	UART1_TX	TIM1_CH1	-	-	TIM1_BKIN	CMP1_OUT	-
PA7	SPI_MOSI	UART1_RX	TIM1_CH1N	-	RTC_OUT	TIM1_CH1	CMP2_OUT	EVENTOUT
PA8	SPI_MOSI	UART3_TX	TIM1_CH1	-	I2C_SDA	-	MCO	-
PA9	-	-	TIM1_ETR	UART2_TX	-	TIM1_BKIN	TIM14_CH1	EVENTOUT
PA10	-	-	TIM1_CH3	UART2_RX	-	TIM14_CH1	-	-
PA11	SPI_SCK	UART1_TX	TIM1_CH4	-	I2C_SCL	-	-	-
PA12	SPI_MOSI	UART1_RX	TIM1_ETR	-	-	TIM14_CH1	-	EVENTOUT
PA13	SWDIO	-	TIM1_CH3N	UART2_TX	-	-	MCO	-
PA14	SWCLK	UART3_TX	TIM1_CH2N	-	-	-	-	EVENTOUT
PA15	SPI_NSS	UART3_RX	TIM1_CH1N	-	-	TIM1_CH4	-	-

### 3.2. Alternate functions selected through GPIOB\_AFR registers for port B

Table 3-4 Port B alternate functions mapping

Port B	AF0	AF1	AF2	AF3	AF4	AF5	AF6	AF7
PB0	SPI_NSS	-	TIM1_CH2N	UART2_TX	-	TIM1_CH2	CMP1_OUT	-
PB1	-	-	TIM1_CH3N	UART2_RX	-	-	-	EVENTOUT
PB2	SPI_MISO	UART3_RX	-	-	-	TIM14_CH1	-	-
PB3	SPI_SCK	-	TIM1_CH2	UART2_RX	-	-	-	-

### 3.3. Alternate functions selected through GPIOF\_AFR registers for port F

Table 3-5 Port F alternate functions mapping

Port F	AF0	AF1	AF2	AF3	AF4	AF5	AF6	AF7
PF0	-	-	-	-	-	TIM14_CH1	-	-
PF1	-	-	-	-	-	TIM14_CH1	-	-
PF2	-	-	-	-	I2C_SCL	TIM14_CH1	MCO	-
PF3	SWCLK	UART1_TX	TIM1_ETR	I2C_SCL	I2C_SDA	TIM14_CH1	-	-
PF4	SWDIO	UART1_RX	TIM1_ETR	I2C_SCL	I2C_SDA	TIM14_CH1	-	-
PF5	-	-	-	-	-	-	-	-

## 4. Memory mapping

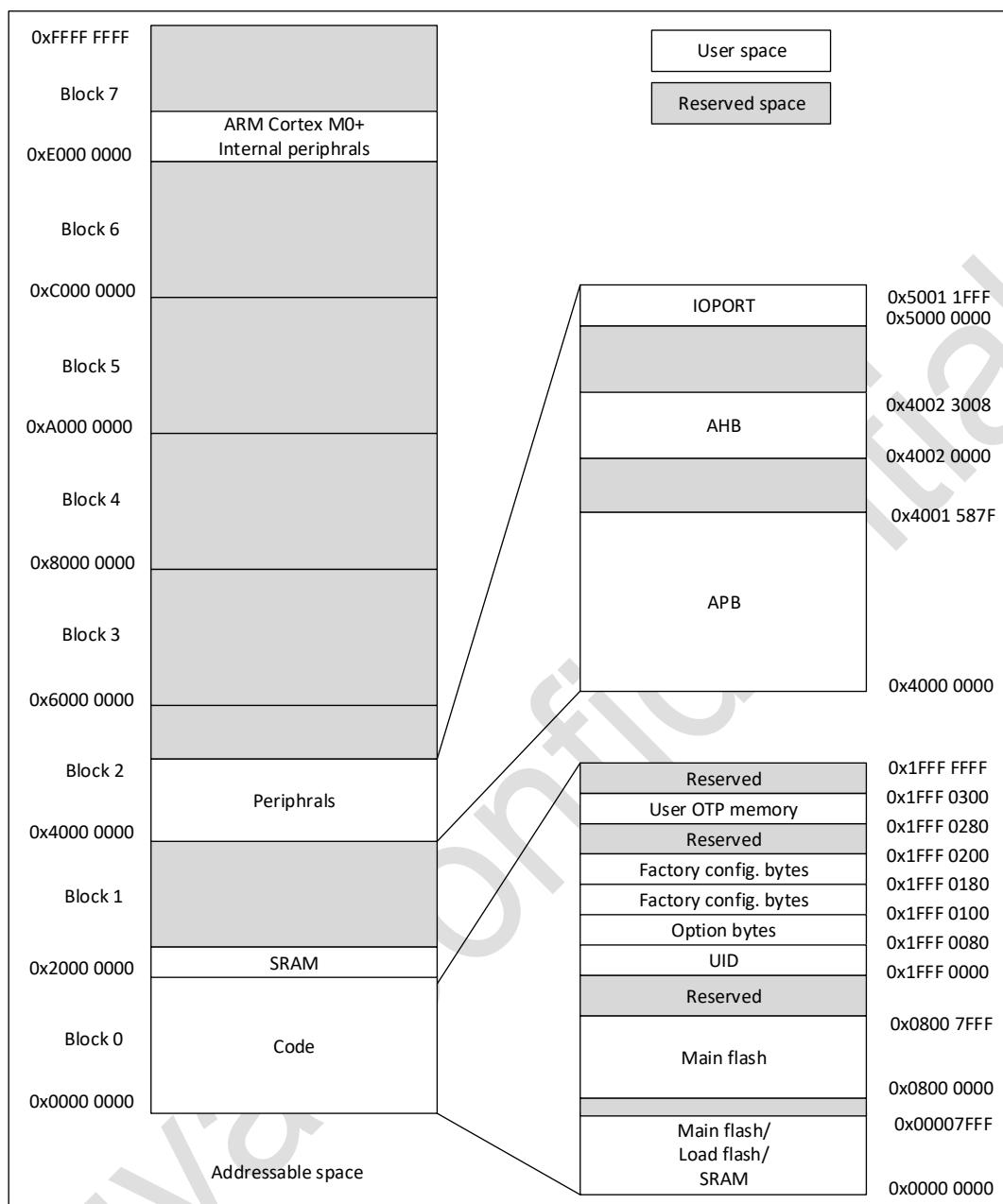


Figure 4-1 Memory map

Table 4-1 Memory boundary address

Type	Boundary address	Size	Memory area
SRAM	0x2000 1000-0x3FFF FFFF	-	Reserved <sup>(1)</sup>
	0x2000 0000-0x2000 0FFF	4 KB	SRAM
Code	0x1FFF 0300-0x1FFF FFFF	-	Reserved
	0x1FFF 0280-0x1FFF 02FF	128 Bytes	USER OTP memory
	0x1FFF 0180-0x1FFF 01FF	128 Bytes	Factory config. bytes
	0x1FFF 0100-0x1FFF 017F	128 Bytes	Factory config. bytes
	0x1FFF 0080-0x1FFF 00FF	128 Bytes	Option bytes
	0x1FFF 0000-0x1FFF 007F	128 Bytes	UID
	0x0800 8000-0x1FFE FFFF	-	Reserved
	0x0800 0000-0x0800 7FFF	32 KB	Main flash memory
	0x0000 8000-0x07FF FFFF	-	Reserved
	0x0000 0000-0x0000 7FFF	32 KB	Selection based on Boot configuration: 1. Main flash memory 2. Load flash 3. SRAM

1. The address is marked as Reserved , which cannot be written , read as 0 , and a response error is generated .

Table 4-2 Peripheral register address

Bus	Boundary address	Size	Peripheral
	0xE000 0000-0xE00F FFFF	1 MB	M0+
IOPORT	0x5000 1800-0x5FFF FFFF	-	Reserved <sup>(1)</sup>
	0x5000 1400-0x5000 17FF	1 KB	GPIOF
	0x5000 0800-0x5000 13FF	-	Reserved <sup>(1)</sup>
	0x5000 0400-0x5000 07FF	1 KB	GPIOB
	0x5000 0000-0x5000 03FF	1 KB	GPIOA
AHB	0x4002 3400-0x4FFF FFFF	-	Reserved
	0x4002 3010-0x4002 33FF	1 KB	Reserved
	0x4002 3000-0x4002 300F		CRC
	0x4002 2400-0x4002 2FFF	-	Reserved
	0x4002 2000-0x4002 23FF	1 KB	Flash FMC
	0x4002 1C00-0x4002 1FFF	-	Reserved
	0x4002 1900-0x4002 1BFF	1 KB	Reserved
	0x4002 1800-0x4002 18FF		EXTI <sup>(2)</sup>
	0x4002 1400-0x4002 17FF	-	Reserved
	0x4002 1080-0x4002 13FF	1 KB	Reserved
	0x4002 1000-0x4002 107F		RCC <sup>(2)</sup>
APB	0x4002 0000-0x4002 0FFF	-	Reserved
	0x4001 5C00-0x4001 FFFF	-	Reserved
	0x4001 5880-0x4001 5BFF	1 KB	Reserved
	0x4001 5800-0x4001 587F		DBG
	0x4001 4800-0x4001 57FF	-	Reserved

Bus	Boundary address	Size	Peripheral
	0x4001 4480-0x4001 47FF	1 KB	Reserved
	0x4001 4400-0x4001 447F		UART2
	0x4001 3C00-0x4001 43FF	-	Reserved
	0x4001 3880-0x4001 3BFF	1 KB	Reserved
	0x4001 3800-0x4001 387F		UART3
	0x4001 3400-0x4001 37FF	-	Reserved
	0x4001 3080-0x4001 33FF	1 KB	Reserved
	0x4001 3000-0x4001 307F		SPI
	0x4001 2C80-0x4001 2FFF	1 KB	Reserved
	0x4001 2C00-0x4001 2C7F		TIM1
	0x4001 2800-0x4001 2BFF	-	Reserved
	0x4001 2400-0x4001 27FF	1 KB	ADC
	0x4001 0400-0x4001 23FF	-	Reserved
	0x4001 0220-0x4001 03FF	1 KB	Reserved
	0x4001 0200-0x4001 021F		CMP1/2
	0x4001 0000-0x4001 01FF		SYSCFG
	0x4000 7400-0x4000 FFFF	-	Reserved
	0x4000 7080-0x4000 73FF	1 KB	Reserved
	0x4000 7000-0x4000 707F		PWR <sup>(3)</sup>
	0x4000 5800-0x4000 6FFF	-	Reserved
	0x4000 5480-0x4000 57FF	1 KB	Reserved
	0x4000 5400-0x4000 547F		I <sup>2</sup> C
	0x4000 4800-0x4000 53FF	-	Reserved
	0x4000 4480-0x4000 47FF	1 KB	Reserved
	0x4000 4400-0x4000 447F		UART1
	0x4000 3C00-0x4000 43FF	-	Reserved
	0x4000 3880-0x4000 3BFF	1 KB	Reserved
	0x4000 3800-0x4000 387F		TK
	0x4000 3400-0x4000 37FF	-	Reserved
	0x4000 3080-0x4000 33FF	1 KB	Reserved
	0x4000 3000-0x4000 307F		IWDG
	0x4000 2C00-0x4000 2FFF	-	Reserved
	0x4000 2880-0x4000 2BFF	1 KB	Reserved
	0x4000 2800-0x4000 287F		RTC
	0x4000 2400-0x4000 27FF	-	Reserved
	0x4000 2080-0x4000 23FF	1 KB	Reserved
	0x4000 2000-0x4000 207F		TIM14
	0x4000 0000-0x4000 1FFF	-	Reserved

- In the above table, the reserved address cannot be written, read back is 0, and a HardFault is generated.
- Not only supports 32-bit word access, but also supports half-word and byte access.
- Not only supports 32-bit word access, but also supports half-word access.

## 5. Electrical characteristics

### 5.1. Parameter conditions

Unless otherwise specified, all voltages are referenced to V<sub>SS</sub>.

#### 5.1.1. Minimum and maximum values

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

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

#### 5.1.2. Typical values

Unless otherwise specified, typical data is based on T<sub>A</sub> = 25 °C and V<sub>CC</sub> = 3.3 V. These data are for design guidance only and have not been tested.

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

#### 5.1.3. Power supply scheme

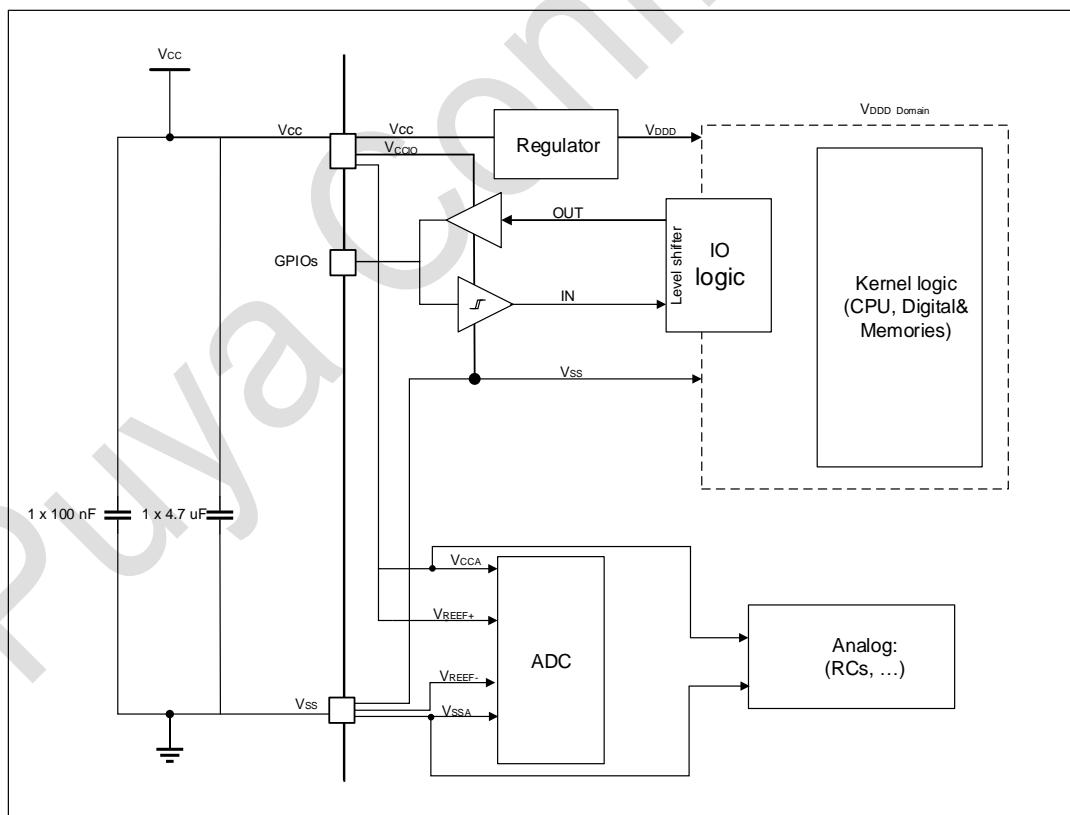


Figure 5-1 Power supply scheme

## 5.2. Absolute maximum ratings

Stresses above the absolute maximum ratings listed in following tables may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these conditions is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.

Table 5-1 Voltage characteristics<sup>(1)</sup>

Symbol	Ratings	Min	Max	Unit
V <sub>CC</sub> - V <sub>SS</sub>	External main power supply <sup>(1)</sup>	-0.3	6.25	V
V <sub>IN</sub> <sup>(2)</sup>	Input voltage on any other pins	V <sub>SS</sub> -0.3	V <sub>CC</sub> +0.3	

1. Main power V<sub>CC</sub> and ground V<sub>SS</sub> pins must always be connected to the external power supply, in the permitted range.
2. Maximum V<sub>IN</sub> must always follow allowable maximum injection current limits as per the table.

Table 5-2 Current characteristics

Symbol	Ratings	Max	Unit
ΣI <sub>VCC</sub>	Total current into sum of all V <sub>CC</sub> power lines (source) <sup>(1)</sup>	170	mA
ΣI <sub>VSS</sub>	Total current out of sum of all V <sub>SS</sub> ground lines (sink) <sup>(1)</sup>	-170	mA
I <sub>O(PIN)</sub> <sup>(2)</sup>	Output current sunk by any I/O and control pin except COM_L I/O	80	mA
	Output current sunk by any COM_L I/O	100	
	Output current source by any I/O and control pin except COM_P I/O	-25	
	Output current source by any COM_P I/O	-40	
ΣI <sub>O(PIN)</sub> <sup>(2)</sup>	Total output current sunk by sum of all I/Os and control pins	160	mA
	Total output current sourced by sum of all I/Os and control pins	-150	

1. Main power V<sub>CC</sub> and ground V<sub>SS</sub> pins must always be connected to the external power supply, in the permitted range.
2. These I/O types refer to the terms and symbols defined by pins.

Table 5-3 Thermal characteristics

Symbol	Ratings	Value	Unit
T <sub>STG</sub>	Storage temperature range	-65 to +150	°C
T <sub>O</sub>	Operating temperature range	-40 to +105	°C

## 5.3. Operating conditions

### 5.3.1. General operating conditions

Table 5-4 General operating conditions

Symbol	Parameter	Conditions	Min	Max	Unit
f <sub>HCLK</sub>	Internal AHB clock frequency	-	0	48	MHz
f <sub>PCLK</sub>	Internal APB clock frequency	-	0	48	MHz
V <sub>CC</sub>	Standard operating voltage	-	1.8	5.5	V
V <sub>IN</sub>	I/O input voltage	-	-0.3	V <sub>CC</sub> +0.3	V
T <sub>A</sub>	Ambient temperature	-	-40	105	°C
T <sub>J</sub>	Junction temperature	-	-40	110	°C

### 5.3.2. Operating conditions at power-on / power-down

Table 5-5 Operating conditions at power-on / power-down

Symbol	Parameter	Conditions	Min	Max	Unit
t <sub>VCC</sub>	V <sub>CC</sub> rise time rate	-	0	∞	μs/V
	V <sub>CC</sub> fall time rate	-	20	∞	

### 5.3.3. Embedded reset

Table 5-6 Embedded reset characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
t_RSTTEMPO <sup>(1)</sup>	Reset temporization	-	-	4.00	7.50	ms
V <sub>POR/PDR</sub>	POR/PDR reset threshold	Rising edge	1.60 <sup>(2)</sup>	1.70	1.80	V
		Falling edge	1.57	1.67	1.77 <sup>(2)</sup>	
V <sub>BOR2</sub>	BOR2 threshold	Rising edge	1.89 <sup>(2)</sup>	1.99	2.09	V
		Falling edge	1.78	1.88	1.98 <sup>(2)</sup>	
V <sub>BOR3</sub>	BOR3 threshold	Rising edge	2.09 <sup>(2)</sup>	2.19	2.29	V
		Falling edge	2.00	2.10	2.20 <sup>(2)</sup>	
V <sub>BOR4</sub>	BOR4 threshold	Rising edge	2.29 <sup>(2)</sup>	2.39	2.49	V
		Falling edge	2.20	2.30	2.40 <sup>(2)</sup>	
V <sub>BOR5</sub>	BOR5 threshold	Rising edge	2.66 <sup>(2)</sup>	2.78	2.89	V
		Falling edge	2.58	2.69	2.79 <sup>(2)</sup>	
V <sub>BOR6</sub>	BOR6 threshold	Rising edge	2.94 <sup>(2)</sup>	3.08	3.18	V
		Falling edge	2.88	2.99	3.11 <sup>(2)</sup>	
V <sub>BOR7</sub>	BOR7 threshold	Rising edge	3.53 <sup>(2)</sup>	3.68	3.83	V
		Falling edge	3.44	3.58	3.72 <sup>(2)</sup>	
V <sub>BOR8</sub>	BOR8 threshold	Rising edge	4.03 <sup>(2)</sup>	4.20	4.36	V
		Falling edge	3.91	4.08	4.24 <sup>(2)</sup>	
V <sub>POR_PDR_hyst</sub> <sup>(1)</sup>	POR/PDR hysteresis	-	-	30	-	mV
V <sub>BOR_hyst</sub> <sup>(1)</sup>	BOR threshold	-	-	100	-	mV
I <sub>cc(BOR)</sub>	BOR consumption	-	-	0.6	-	µA

1. Guaranteed by design, not tested in production.

2. Data based on characterization results, not tested in production.

### 5.3.4. Supply current characteristics

Table 5-7 Current consumption in Run mode

Symbol	Conditions						Typ <sup>(1)</sup>	Max		Unit		
	System clock	Frequency	Code	Run	Peripheral clock	Flash sleep		T <sub>A</sub> = 85 °C	T <sub>A</sub> = 105 °C			
I <sub>cc</sub> (Run)	HSI	48 MHz	While(1)	Flash	ON	DISABLE	2.6	2.8	3.0	mA		
					OFF	DISABLE	1.9	2.0	2.1			
					ON	DISABLE	1.7	1.9	2.0			
					OFF	DISABLE	1.4	1.6	1.7			
	LSI	32.768 kHz			ON	DISABLE	165	281.1	355	µA		
					OFF	DISABLE	164	281.1	354.4			
		32.768 kHz			ON	ENABLE	92	219.3	293			
					OFF	ENABLE	91.5	219	293			

1. Data based on characterization results, not tested in production.

Table 5-8 Current consumption in Sleep mode

Symbol	Conditions				Typ <sup>(1)</sup>	Max		Unit
	System clock	Frequency	Peripheral clock	Flash sleep		T <sub>A</sub> = 85 °C	T <sub>A</sub> = 105 °C	
I <sub>CC</sub> (Sleep)	HSI	48 MHz	ON	DISABLE	1.7	1.8	1.9	mA
			OFF	DISABLE	0.9	1.0	1.1	
		24 MHz	ON	DISABLE	1.0	1.0	1.1	
			OFF	DISABLE	0.6	0.7	0.8	
	LSI	32.768 kHz	ON	DISABLE	161	280.4	354	μA
			OFF	DISABLE	160	279.1	353.1	
		32.768 kHz	ON	ENABLE	81.3	185	266	
			OFF	ENABLE	81.0	185	266	

1. Data based on characterization results, not tested in production.

Table 5-9 Current consumption in Stop mode

Symbol	Conditions				Typ <sup>(1)</sup>	Max		Unit
	V <sub>CC</sub>	LDO	LSI	Peripheral clock		T <sub>A</sub> = 85 °C	T <sub>A</sub> = 105 °C	
I <sub>CC</sub> (Stop)	1.8 to 5.5 V	Regulator in MR mode (LPR = 00)	-	-	75.2	181	266	μA
				IWDG+RTC	3.9	44.1	84	
		Regulator in LPR mode (LPR = 01)	ON	IWDG	3.9	44.1	84	
				RTC	3.9	44.1	84	
			OFF	No	3.5	44	83.3	

1. Data based on characterization results, not tested in production.

### 5.3.5. Wake-up time from low-power mode

Table 5-10 Wake-up time from low-power mode

Symbol	Parameter <sup>(1)</sup>	Conditions			Typ <sup>(2)</sup>	Max	Unit
t <sub>WUSLEEP</sub>	Wake-up from Sleep mode to Run mode	-			10	-	CPU cycles
t <sub>WUSTOP</sub>	Wake-up from Stop mode to Run mode in Flash	Regulator in MR mode (LPR = 00)	HSI (24 MHz) as system clock FLS_SLPTIME [1:0] = 00		6.6	-	μs
			HSI (48 MHz) as system clock FLS_SLPTIME [1:0] = 00		6.1		
		Regulator in LPR mode (LPR = 01)	HSI (24 MHz) as system clock FLS_SLPTIME [1:0] = 00		10.2	-	μs
			HSI (48 MHz) as system clock FLS_SLPTIME [1:0] = 00		9.8		

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

2. Data based on characterization results, not tested in production.

### 5.3.6. External clock source characteristics

#### 5.3.6.1. High-speed external clock generated from an external source

In HSE bypass mode (HSEON of RCC\_CR is set), the corresponding IO acts as an external clock input port.

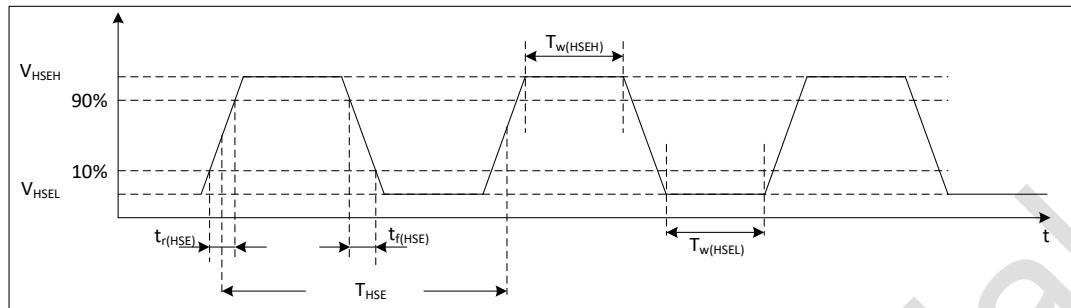


Figure 5-2 Low-speed external clock timing diagram

Table 5-11 High-speed external clock characteristics

Symbol	Parameter	Min	Typ	Max	Unit
$f_{HSE\_ext}$	External clock source frequency	1	8	32	MHz
$V_{HSEH}$	Input pin high level voltage	$0.7*V_{CC}$	-	$V_{CC}$	V
$V_{HSEL}$	Input pin low level voltage	$V_{SS}$	-	$0.3*V_{CC}$	V
$t_w(HSEH)$ $t_w(HSEL)$	High or low time	$15^{(1)}$	-	-	ns
$t_r(HSE)$ $t_f(HSE)$	Rise or fall time	-	-	$20^{(1)}$	ns

1. Guaranteed by design, not tested in production.

#### 5.3.6.2. Low-speed external clock generated from an external source

In the bypass mode of LSE (the LSEBYP of RCC\_BDCR is set), the low-speed start-up circuit in the chip stops working, and the corresponding I/O is used as a standard GPIO.

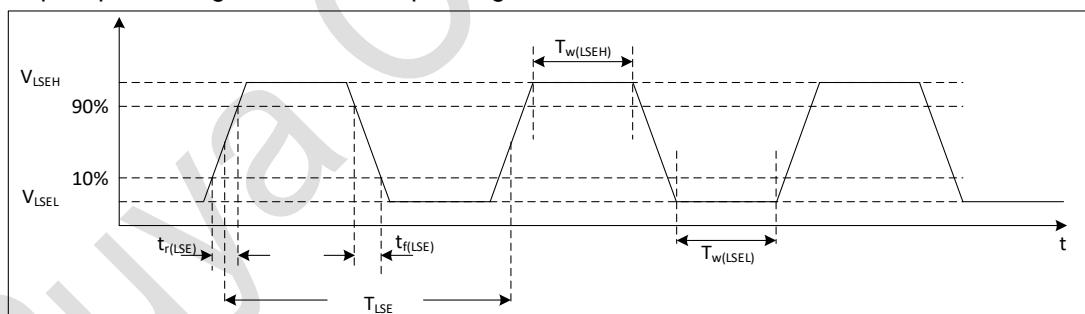


Figure 5-3 Low-speed external clock timing diagram

Table 5-12 Low-speed external clock characteristics

Symbol	Parameter	Min	Typ	Max	Unit
$f_{LSE\_ext}$	External clock source frequency	-	32.768	1000	kHz
$V_{LSEH}$	Input pin high level voltage	$0.7*V_{CC}$	-	-	V
$V_{LSEL}$	Input pin low level voltage	-	-	$0.3*V_{CC}$	V
$t_w(LSEH)$ $t_w(LSEL)$	High or low time	$450^{(1)}$	-	-	ns
$t_r(LSE)$ $t_f(LSE)$	Rise or fall time	-	-	$50^{(1)}$	ns

1. Guaranteed by design, not tested in production.

### 5.3.6.3. High-speed external clock generated from a crystal/ceramic resonator

The high-speed external (HSE) clock can be supplied with 4 to 8 MHz crystal/ceramic resonator oscillator. In the application, the resonator and the load capacitors have to be placed as close as possible to the oscillator pins in order to minimize output distortion and startup stabilization time.

Table 5-13 HSE oscillator characteristics<sup>(1)</sup>

Symbol	Parameter	Conditions	Min <sup>(2)</sup>	Typ	Max <sup>(2)</sup>	Unit
fosc_IN	Oscillator frequency	-	4	-	8	MHz
Vcc	HSE supply voltage	-	2.5	3.3	5.5	V
Icc <sup>(4)</sup>	HSE current consumption	Startup time	-	-	5.5	mA
		V <sub>CC</sub> = 3.3 V, R <sub>m</sub> = 35 Ω , C <sub>L</sub> = 15 pF@8 MHz HSE_DRV = 1	-	0.7	-	
		V <sub>CC</sub> = 3.3 V, R <sub>m</sub> = 35 Ω , C <sub>L</sub> = 15 pF@4 MHz HSE_DRV = 0	-	0.6	-	
tsu(HSE) <sup>(3)(4)</sup>	Startup time	fosc_IN = 8 MHz R <sub>m</sub> = 35 Ω , C <sub>L</sub> = 15 pF@8 MHz HSE_STARTUP [1:0] = 00 HSE_DRV = 1	-	2.5	-	ms
		fosc_IN = 4 MHz R <sub>m</sub> = 35 Ω , C <sub>L</sub> = 15 pF@4 MHz HSE_STARTUP [1:0] = 00 HSE_DRV = 1	-	4.0	-	
		fosc_IN = 4 MHz R <sub>m</sub> = 35 Ω , C <sub>L</sub> = 15 pF@4 MHz HSE_STARTUP [1:0] = 00 HSE_DRV = 0	-	5.0	-	

1. Crystal/ceramic resonator characteristics are based on the manufacturer's datasheet.
2. Guaranteed by design, not tested in production.
3. tsu(HSE) is the startup time from enable (by software) to when the clock oscillation reaches a stable state, measured for a standard crystal/resonator, which can vary considerably from one crystal/resonator to another.
4. Data based on characterization results, not tested in production.

### 5.3.6.4. Low-speed external clock generated from a crystal resonator

The low-speed external (LSE) clock can be supplied with a 32.768 kHz crystal resonator oscillator. In the application, the resonator and the load capacitors have to be placed as close as possible to the oscillator pins in order to minimize output distortion and startup stabilization time.

Table 5-14 LSE oscillator characteristics<sup>(1)</sup>

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Icc <sup>(3)</sup>	LSE current consumption	LSE_DRIVER [1:0] = 00	-	0.4	-	μA
		LSE_DRIVER [1:0] = 01	-	0.5	-	
		LSE_DRIVER [1:0] = 10	-	0.7	-	
		LSE_DRIVER [1:0] = 11	-	1.2	-	
tsu(LSE) <sup>(2)(3)</sup>	Startup time	fosc_IN = 32.768 kHz, C <sub>L</sub> = 6 pF LSE_STARTUP [1:0] = 00 LSE_DRIVER [1:0] = 00	-	2.60	-	s
		fosc_IN = 32.768 kHz, C <sub>L</sub> = 6 pF LSE_STARTUP [1:0] = 00 LSE_DRIVER [1:0] = 01	-	1.20	-	
		fosc_IN = 32.768 kHz, C <sub>L</sub> = 12 pF	-	0.85	-	

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
		LSE_STARTUP [1:0] = 00 LSE_DRIVER [1:0] = 10				
		fosc_IN = 32.768 kHz, CL = 12 pF LSE_STARTUP [1:0] = 00 LSE_DRIVER [1:0] = 11	-	0.50	-	

1. Crystal/ceramic resonator characteristics are based on the manufacturer's datasheet.
2.  $t_{SU(HSE)}$  is the startup time from enable (by software) to when the clock oscillation reaches a stable state, measured for a standard crystal/resonator, which can vary considerably from one crystal/resonator to another.
3. Data based on characterization results, not tested in production.

### 5.3.7. High-speed internal (HSI) RC oscillator

Table 5-15 HSI oscillator characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$f_{HSI}$	HSI frequency	$T_A = 25^\circ C, V_{CC} = 3.3 V$	23.83 <sup>(2)</sup>	24	24.17 <sup>(2)</sup>	MHz
			47.66 <sup>(2)</sup>	48	48.34 <sup>(2)</sup>	
ACC <sub>(HSI)</sub>	HSI accuracy	V <sub>CC</sub> = 2.0 to 5.5 V $T_A = -40 \sim 105^\circ C$	-2 <sup>(2)</sup>	-	2 <sup>(2)</sup>	%
		V <sub>CC</sub> = 1.8 to 5.5 V $T_A = 0 \text{ to } 105^\circ C$	-2 <sup>(2)</sup>	-	2 <sup>(2)</sup>	
		V <sub>CC</sub> = 1.8 to 5.5 V $T_A = -40 \text{ to } 105^\circ C$	-3 <sup>(2)</sup>	-	3 <sup>(2)</sup>	
$f_{TRIM}$ <sup>(1)</sup>	HSI trimming accuracy	-	-	0.1	-	%
D <sub>HSI</sub> <sup>(1)</sup>	Duty cycle	-	45	-	55	%
t <sub>Stab(HSI)</sub>	HSI stabilization time	-	-	2	4 <sup>(1)</sup>	μs
I <sub>CC(HSI)</sub> <sup>(2)</sup>	HSI power consumption	48 MHz	-	300	-	μA
		24 MHz	-	220	-	

1. Guaranteed by design, not tested in production.
2. Data based on characterization results, not tested in production.

### 5.3.8. Low-speed internal (LSI) RC oscillator

Table 5-16 LSI oscillator characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$f_{LSI}$	LSI frequency	$T_A = 25^\circ C, V_{CC} = 3.3 V$	31.6	32.768	33.6	kHz
ACC <sub>(LSI)</sub>	LSI accuracy	V <sub>CC</sub> = 1.8 to 5.5 V $T_A = 0 \text{ to } 105^\circ C$	-8 <sup>(2)</sup>	-	8 <sup>(2)</sup>	%
		V <sub>CC</sub> = 1.8 to 5.5 V $T_A = -40 \text{ to } 105^\circ C$	-10 <sup>(2)</sup>	-	10 <sup>(2)</sup>	
$f_{TRIM}$ <sup>(1)</sup>	LSI trimming accuracy	-	-	0.2	-	%
t <sub>Stab(LSI)</sub> <sup>(1)</sup>	LSI stabilization time	-	-	150	-	μs
I <sub>CC(LSI)</sub> <sup>(1)</sup>	LSI power consumption	-	-	210	-	nA

1. Guaranteed by design, not tested in production.
2. Data based on characterization results, not tested in production.

### 5.3.9. Memory characteristics

Table 5-17 Memory characteristics

Symbol	Parameter	Conditions	Typ	Max <sup>(2)</sup>	Unit
t <sub>prog</sub>	Page programming time	-	1.5	2.0	ms
t <sub>ERASE</sub>	Page/sector/mass erase time	-	3.5	4.5	ms
I <sub>CC</sub>	Page programming supply current	-	2.1	2.9	mA
	Page/sector/mass erase time	-	2.1	2.9	

1. Guaranteed by design, not tested in production.

Table 5-18 Memory endurance and data retention

Symbol	Parameter	Conditions	Min <sup>(2)</sup>	Unit
N <sub>END</sub>	Endurance	T <sub>A</sub> = -40 to 85 °C	100	kcycle
		T <sub>A</sub> = 85 to 105 °C	10	
t <sub>RET</sub>	Data retention	10 kcycle T <sub>A</sub> = 55 °C	20	Year

1. Data based on characterization results, not tested in production.

### 5.3.10. EFT characteristics

Table 5-19 EFT characteristics

Symbol	Parameter	Conditions	Grade
EFT to power	-	IEC61000-4-4	4A

### 5.3.11. ESD & LU characteristics

Table 5-20 ESD &amp; LU characteristics

Symbol	Parameter	Conditions	Typ	Unit
V <sub>ESD(HBM)</sub>	Static discharge voltage (human body model)	ESDA/JEDEC JS-001-2017	8	kV
V <sub>ESD(CDM)</sub>	Static discharge voltage (charged device model)	ESDA/JEDEC JS-002-2018	2	kV
LU	Static latch-up	JESD78E	200	mA

### 5.3.12. Port characteristics

Table 5-21 Port static characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V <sub>IH</sub>	Input high level voltage	V <sub>CC</sub> = 1.8 to 5.5 V	0.7*V <sub>CC</sub>	-	-	V
V <sub>IL</sub>	Input low level voltage	V <sub>CC</sub> = 1.8 to 5.5 V	-	-	0.3*V <sub>CC</sub>	V
V <sub>hys</sub> <sup>(1)</sup>	Schmitt trigger hysteresis	-	-	150	-	mV
I <sub>Ik</sub>	Input leakage current	-	-	-	1	µA
R <sub>PU</sub>	Weak pull-up equivalent resistor	V <sub>IN</sub> = V <sub>SS</sub> , IORP[1:0]=11	24	40	56	kΩ
		V <sub>IN</sub> = V <sub>SS</sub> , IORP[1:0]=10	12	20	28	
		V <sub>IN</sub> = V <sub>SS</sub> , IORP[1:0]=01	6.6	11	15.4	
		V <sub>IN</sub> = V <sub>SS</sub> , IORP[1:0]=00	-	OFF	-	
R <sub>PD</sub>	Weak pull-down equivalent resistor	V <sub>IN</sub> = V <sub>CC</sub> , IORP[1:0]=11	24	40	56	kΩ
		V <sub>IN</sub> = V <sub>CC</sub> , IORP[1:0]=10	12	20	28	
		V <sub>IN</sub> = V <sub>CC</sub> , IORP[1:0]=01	6.6	11	15.4	
		V <sub>IN</sub> = V <sub>CC</sub> , IORP[1:0]=00	-	OFF	-	
R <sub>PUIIC</sub>	I <sup>2</sup> C pull-up resistor	PUPDy[1:0]=01, PF_PU_IIC =1	3.4	4.7	6.0	kΩ

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$C_{IO}^{(1)}$	Pin capacitance	-	-	5	-	pF
$t_{ns(EXTI)}^{(1)}$	Input filter width	ENI=1, ENS=1	3	5	10	ns

1. Guaranteed by design, not tested in production.

Table 5-22 Output voltage characteristics<sup>(1)(4)</sup>

Symbol	Parameter	Conditions <sup>(3)</sup>	Min	Max	Unit
$V_{OL}^{(2)}$	Output low level voltage for an I/O pin(all I/Os except COM_L)		$I_{OL} = 70 \text{ mA}, V_{CC} \geq 5.0 \text{ V}$	-	0.5
			$I_{OL} = 50 \text{ mA}, V_{CC} \geq 3 \text{ V}$	-	0.5
			$I_{OL} = 4 \text{ mA}, V_{CC} = 1.8 \text{ V}$	-	0.5
$V_{OH}^{(2)}$	Output low level voltage for an I/O pin(COM_L)		$I_{OL} = 80 \text{ mA}, V_{CC} \geq 3.3 \text{ V}$	-	0.6
			$I_{OL} = 60 \text{ mA}, V_{CC} \geq 2.7 \text{ V}$	-	0.6
			$I_{OL} = 40 \text{ mA}, V_{CC} \geq 1.8 \text{ V}$	-	0.6
$V_{OH}^{(2)}$	Output low level voltage for an I/O pin(all I/Os except COM_P)		$I_{OH} = 16 \text{ mA}, V_{CC} \geq 5.0 \text{ V}$	$V_{CC}-0.5$	-
			$I_{OH} = 8 \text{ mA}, V_{CC} \geq 2.7 \text{ V}$	$V_{CC}-0.5$	-
			$I_{OH} = 4 \text{ mA}, V_{CC} = 1.8 \text{ V}$	$V_{CC}-0.5$	-
	Output low level voltage for an I/O pin(COM_P)		$I_{OH} = 30 \text{ mA}, V_{CC} \geq 5.0 \text{ V}$	$V_{CC}-0.5$	-
			$I_{OH} = 20 \text{ mA}, V_{CC} \geq 3.3 \text{ V}$	$V_{CC}-0.5$	-
			$I_{OH} = 16 \text{ mA}, V_{CC} \geq 2.7 \text{ V}$	$V_{CC}-0.5$	-
			$I_{OH} = 4 \text{ mA}, V_{CC} = 1.8 \text{ V}$	$V_{CC}-0.5$	-

- The combined maximum current across all output pins (including contributions from both  $V_{OL}$  and  $V_{OH}$  states) must not exceed the  $\Sigma I_{IO(PIN)}$  maximum rating specified in Table 5-2 Current Characteristics.
- These I/O types refer to the terms and symbols defined by pins.
- The test conditions for driving all IOs is that  $GPIOx\_OSPEEDR = 11$ .
- Data based on characterization results, not tested in production.

### 5.3.13. Constant current LED SEG driver characteristics

Table 5-23 Constant current LED SEG driver characteristics<sup>(1)(2)</sup>

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$V_{CC}$	Supply voltage	-	3.3	-	5.5	V
$I_{OH}$	Constant current mode 1 current	$V_{CC} = 3.3 \text{ V}$ $V_{OH} = V_{CC}/3$	-	9.7	-	mA
$I_{OH}$	Constant current mode 2 current	$V_{CC} = 3.3 \text{ V}$ $V_{OH} = V_{CC}/3$	-	7.4	-	mA
$I_{OH}$	Constant current mode 3 current	$V_{CC} = 3.3 \text{ V}$ $V_{OH} = V_{CC}/3$	-	5	-	mA
$I_{OH}$	Constant current mode 4 current	$V_{CC} = 3.3 \text{ V}$ $V_{OH} = V_{CC}/3$	-	2.5	-	mA
$ \Delta I /I$	Current accuracy (unified calibration)	Constant current source outputs 10 mA current: $(I-10)/10$ ( $V_{CC} = 3.3 \text{ V}$ , $T_A = +25^\circ\text{C}$ )	-	-	$\pm 15$	%

- Data based on characterization results, not tested in production.
- When PB2 is used as the LED SEG constant current driver, PA0 must first be enabled as the LED SEG. When PB3 is used as the LED SEG constant current driver, PA1 must first be enabled as the LED SEG.

### 5.3.14. ADC characteristics

Table 5-24 ADC characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V <sub>CC</sub>	ADC supply voltage	-	1.8	-	5.5	V
I <sub>CC(1)</sub>	Consumption	f <sub>S</sub> = 0.75 Msps	-	1	-	mA
C <sub>IN(1)</sub>	Internal sampling and holding capacitor	-	-	5	-	pF
f <sub>ADC</sub>	Conversion clock frequency	V <sub>REF+</sub> = V <sub>CC</sub> = 1.8 to 2.3 V	0.8	4	8 <sup>(2)</sup>	MHz
		V <sub>REF+</sub> = V <sub>CC</sub> = 2.3 to 5.5 V	0.8	8	12 <sup>(2)</sup>	
		V <sub>REF+</sub> = V <sub>REFBUF</sub> , V <sub>CC</sub> = 1.8 to 2.3 V	0.16	0.8	1.6 <sup>(2)</sup>	
		V <sub>REF+</sub> = V <sub>REFBUF</sub> , V <sub>CC</sub> = 2.3 to 5.5 V	0.16	1.6	2.4 <sup>(2)</sup>	
t <sub>samp(1)</sub>	Sampling time	V <sub>CC</sub> = 1.8 to 5.5 V	3.5	-	239.5	1/f ADC
t <sub>samp_setup(1)</sub>	Sampling time for internal channels	-	20	-	-	μs
t <sub>conv(1)</sub>	Total conversion time	-	-	12	-	1/f ADC
t <sub>eoc(1)</sub>	Conversion end time	-	-	0.5	-	1/f ADC

1. Guaranteed by design, not tested in production.

2. Data based on characterization results, not tested in production.

Table 5-25 ADC accuracy (V<sub>REF+</sub> = V<sub>CC</sub>)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
ET	Total unadjusted error	V <sub>CC</sub> = 3.3 V, T <sub>A</sub> = 25 °C f <sub>ADC</sub> = 12 MHz, f <sub>S</sub> = 0.75 Msps	-	±4	±7	LSB
EO	Offset error		-	-2.5	-	
EG	Gain error		-	8.5	11.5	
ED	Differential linearity error		-	+3 -0.9	+4 -1	
EL	Integral Linearity		-	±3.5	±4.5	
ENOB	Effective number of bits		8.9	9.5	-	bit
ET	Total unadjusted error	1.8 V ≤ V <sub>CC</sub> ≤ 5.5 V f <sub>ADC</sub> ≤ 12 MHz, f <sub>S</sub> ≤ 0.75 Msps	-	±4	±10.5	LSB
EO	Offset error		-	-2.5	-	
EG	Gain error		-	8.5	13	
ED	Differential linearity error		-	+3 -0.9	+5 -1	
EL	Integral Linearity		-	±3.5	±6	
ENOB	Effective number of bits		8.8	9.5	-	bit

Table 5-26 ADC accuracy (V<sub>REF+</sub> = V<sub>REFBUF</sub>)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
ET	Total unadjusted error	V <sub>REFBUF</sub> = 1.5 V/2.048 V/2.5 V V <sub>CC</sub> = 3.3 V, T <sub>A</sub> = 25 °C f <sub>ADC</sub> = 12 MHz, f <sub>S</sub> = 0.15 Msps	-	±6	±9	LSB
EO	Offset error		-7	-4	-	
EG	Gain error		-	8	11.5	
ED	Differential linearity error		-	+3.5 -0.9	+4.5 -0.95	
EL	Integral Linearity		-	±4.5	±5	
ENOB	Effective number of bits		8.5	8.8	-	bit
ET	Total unadjusted error	V <sub>REFBUF</sub> = 1.5 V/2.048 V/2.5 V	-	±16.5	±24.5	LSB

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
EO	Offset error	$V_{CC} = 3.3 \text{ V}, T_A = 25^\circ\text{C}$ $f_{ADC} = 12 \text{ MHz}, f_s = 0.15 \text{ Msps}$	-16	-11	-	
EG	Gain error		-	13	18	
ED	Differential linearity error		-	+5.5 -0.9	+9 -0.95	
EL	Integral Linearity		-	$\pm 14$	$\pm 16$	
ENOB	Effective number of bits		7.2	7.3	-	bit
ET	Total unadjusted error	$V_{REFBUF} = 1.5 \text{ V}, 1.8 \text{ V} \leq V_{CC} \leq 5.5 \text{ V}$ $V_{REFBUF} = 2.048 \text{ V}, 2.4 \text{ V} \leq V_{CC} \leq 5.5 \text{ V}$ $V_{REFBUF} = 2.5 \text{ V}, 2.8 \text{ V} \leq V_{CC} \leq 5.5 \text{ V}$ $f_{ADC} \leq 2.4 \text{ MHz}, f_s \leq 0.15 \text{ Msps}$	-	$\pm 6$	$\pm 13$	LSB
EO	Offset error		-11	-4	-	
EG	Gain error		-	8	-	
ED	Differential linearity error		-	+3.5 -0.9	+6.5 -1	
EL	Integral linearity		-	$\pm 4.5$	$\pm 7.5$	
ENOB	Effective number of bits		8.5	8.8	-	bit
ET	Total unadjusted error	$V_{REFBUF} = 0.6 \text{ V}, 1.8 \text{ V} \leq V_{CC} \leq 5.5 \text{ V}$ $f_{ADC} = 12 \text{ MHz}, f_s \leq 0.15 \text{ Msps}$	-	$\pm 16.5$	$\pm 30$	LSB
EO	Offset error		-20.5	-11	-	
EG	Gain error		-	13	-	
ED	Differential linearity error		-	+5.5 -0.9	+11.5 -1	
EL	Integral Linearity		-	$\pm 14$	$\pm 17$	
ENOB	Effective number of bits		7.2	7.3	-	bit

### 5.3.15. Comparator characteristics

Table 5-27 Comparator characteristics

Symbol	Parameter	Conditions		Min	Typ	Max	Unit
$V_{IN}$	Input voltage range	-		0	-	$V_{CC}-1.5$	V
$t_{START}^{(1)}$	Startup time	High-speed mode		-	-	5	$\mu\text{s}$
		Medium-speed mode		-	-	15	
$t_D^{(1)}$	Propagation delay	High-speed mode	200 mV step 100 mV over-drive	-	0.2	-	$\mu\text{s}$
		Medium-speed mode		-	-	1.2	
		High-speed mode	>200 mV step 100 mV over-drive	-	0.2	-	
		Medium-speed mode		-	-	1.2	
$V_{offset}^{(1)}$	Offset voltage	-		-	$\pm 5$	-	mV
$I_{CC}^{(1)}$	$V_{CC}$ consumption	High-speed mode	Static	-	70	-	$\mu\text{A}$
			With 50 kHz and $\pm 100 \text{ mv}$ overdrive square signal	-	70	-	
		Medium-speed mode	Static	-	6	7.5	
			With 50 kHz and $\pm 100 \text{ mv}$ overdrive square signal	-	5	-	
$I_{sleep}^{(1)}$	Sleep power consumption	-	-	-	1	-	nA

1. Guaranteed by design, not tested in production.

### 5.3.16. Temperature sensor characteristics

Table 5-28 Temperature sensor characteristics

Symbol	Parameter	Min	Typ	Max	Unit
T <sub>L</sub> <sup>(1)</sup>	V <sub>TS</sub> linearity with temperature	-	±1	±2	°C
Avg_Slope <sup>(1)</sup>	Average slope	2	2.6	3.2	mV/°C
V <sub>30</sub>	Voltage at 30 °C ( $\pm 5$ °C)	742	760	785	mV
t <sub>samp_setup</sub> <sup>(1)</sup>	ADC sampling time when reading the temperature	20	-	-	μs

1. Guaranteed by design, not tested in production.

### 5.3.17. Embedded internal voltage reference characteristics

Table 5-29 Embedded internal voltage reference (V<sub>REFINT</sub>) characteristics

Symbol	Parameter	Min	Typ	Max	Unit
V <sub>REFINT</sub>	Internal reference voltage	1.17	1.20	1.23	V
t <sub>start_VREFINT</sub>	Start time of V <sub>REFINT</sub>	-	10	15	μs
T <sub>coeff_VREFINT</sub> <sup>(1)</sup>	Temperature coefficient of V <sub>REFINT</sub>	-	-	100 <sup>(1)</sup>	ppm/°C
I <sub>VCC</sub> <sup>(1)</sup>	V <sub>REFINT</sub> current consumption from V <sub>CC</sub>	-	12	20	μA

1. Guaranteed by design, not tested in production.

### 5.3.18. Internal voltage reference buffer characteristics

Table 5-30 Internal voltage reference buffer (V<sub>REFBUF</sub>) characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V <sub>REF25</sub>	2.5 V Internal reference voltage	T <sub>A</sub> = 25 °C, V <sub>CC</sub> = 3.3 V	2.475	2.5	2.525	V
V <sub>REF20</sub>	2.048 V Internal reference voltage	T <sub>A</sub> = 25 °C, V <sub>CC</sub> = 3.3 V	2.028	2.048	2.068	V
V <sub>REF15</sub>	1.5 V Internal reference voltage	T <sub>A</sub> = 25 °C, V <sub>CC</sub> = 3.3 V	1.485	1.5	1.515	V
V <sub>REF06</sub>	0.6 V Internal reference voltage	T <sub>A</sub> = 25 °C, V <sub>CC</sub> = 3.3 V	0.594	0.6	0.606	V
T <sub>coeff_VREFBUF</sub> <sup>(1)</sup>	Temperature coefficient of V <sub>REFBUF</sub>	T <sub>A</sub> = -40 - 105 °C	-	-	120	ppm/°C
t <sub>start_VREFBUF</sub>	Start time of V <sub>REFBUF</sub>	-	-	10	15	

1. Guaranteed by design, not tested in production.

2. V<sub>REFBUF</sub> = 0.6 V.

### 5.3.19. COMP internal reference buffer characteristics

Table 5-31 COMP internal voltage reference buffer(V<sub>REFCMP</sub>)characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
ΔV <sub>abs</sub> <sup>(1)</sup>	Absolute deviation	-	-	-	±0.5	LSB
t <sub>start_VREFCMP</sub>	Start time of V <sub>REFCMP</sub>	-	-	10	15	μs

1. Guaranteed by design, not tested in production.

### 5.3.20. Timer characteristics

Table 5-32 Timer characteristics

Symbol	Parameter	Conditions	Min	Max	Unit
$t_{res(TIM)}$	Timer resolution time	-	1	-	$t_{TIMxCLK}$
		$f_{TIMxCLK} = 48 \text{ MHz}$	20.833	-	ns
$f_{EXT}$	Timer external clock frequency on CH1 to CH4	-	-	$f_{TIMxCLK} / 2$	MHz
		$f_{TIMxCLK} = 48 \text{ MHz}$	-	24	
$Res_{TIM}$	Timer resolution time	TIM1/14	-	16	bit
$t_{COUNTER}$	16-bit counter clock period	-	1	65536	$t_{TIMxCLK}$
		$f_{TIMxCLK} = 48 \text{ MHz}$	0.020833	1365	μs

Table 5-33 IWDG characteristics (timeout period at 32.768 kHz LSI)

Prescaler	PR[2:0]	Min	Max	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	

### 5.3.21. Communication port characteristics

#### 5.3.21.1. I<sup>2</sup>C interface characteristics

I<sup>2</sup>C interface meets the requirements of the I<sup>2</sup>C bus specification and user manual:

- Standard-mode (Sm): 100 kHz
- Fast-mode (400 kHz)
- Fast-mode plus (Fm+): 1 MHz

I<sup>2</sup>C SDA and SCL pins have analog filtering, see table below.

Table 5-34 I<sup>2</sup>C filter characteristics

Symbol	Parameter	Min	Max	Unit
$t_{AF}$	Limiting duration of spikes suppressed by the filter (Spikes shorter than the limiting duration are suppressed)	50	260	ns

#### 5.3.21.2. SPI characteristics

Table 5-35 SPI characteristics

Symbol	Parameter	Conditions	Min	Max	Unit
$f_{SCK}$ $1/t_{c(SCK)}$	SPI clock frequency	Master mode	-	24 <sup>(1)</sup>	MHz
		Slave mode	-	24 <sup>(2)</sup>	
$t_{r(SCK)}$ $t_{f(SCK)}$	SPI clock rise and fall time	Capacitive load: C = 15 pF	-	6	ns
$t_{su(NSS)}$	NSS setup time	Slave mode	$2 T_{pclk}$	-	ns
$t_{h(NSS)}$	NSS hold time	Slave mode	$2 T_{pclk}$	-	ns

Symbol	Parameter	Conditions	Min	Max	Unit
$t_{w(SCKH)}$ $t_{w(SCKL)}$	SCK high and low time	Master mode, presc = 2	$T_{pclk}-2$	$T_{pclk}+1$	ns
$t_{su(MI)}$ $t_{su(SI)}$	Data input setup time	Master mode	1	-	ns
		Slave mode	3	-	
$t_{h(MI)}$ $t_{h(SI)}$	Data input hold time	Master mode	5	-	ns
		Slave mode	2	-	
$t_{a(SO)}$	Data output access time	Slave mode	0	$3 T_{pclk}$	ns
$t_{dis(SO)}$	Data output disable time	Slave mode	$2 T_{pclk}$	-	ns
$t_{v(SO)}$	Data output valid time	Slave mode (after enable edge)	0	20	ns
$t_{v(MO)}$	Data output valid time	Master mode (after enable edge)	-	5	ns
$t_{h(SO)}$ $t_{h(MO)}$	Data output hold time	Slave mode (after enable edge)	2	-	ns
		Master mode (after enable edge)	1	-	
DuCy(SCK)	SPI slave input clock duty cycle	Slave mode	45	55	%

1. The test condition for this parameter is full-duplex mode.
2. Under full-duplex mode, the maximum is 6 MHz, while under single-wire (transmit-only) mode, the maximum is 12 MHz.

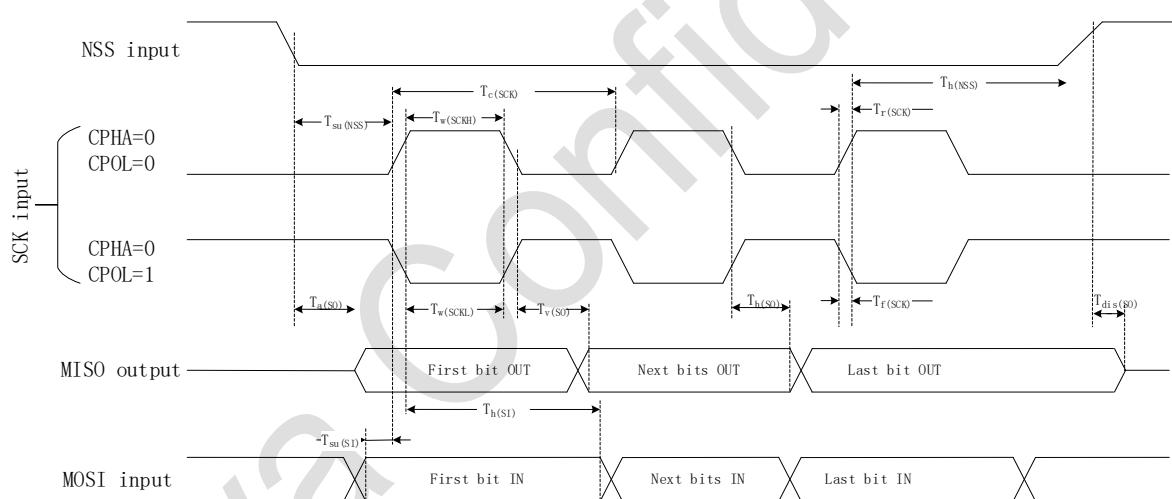


Figure 5-4 SPI timing diagram – Slave mode and CPHA=0

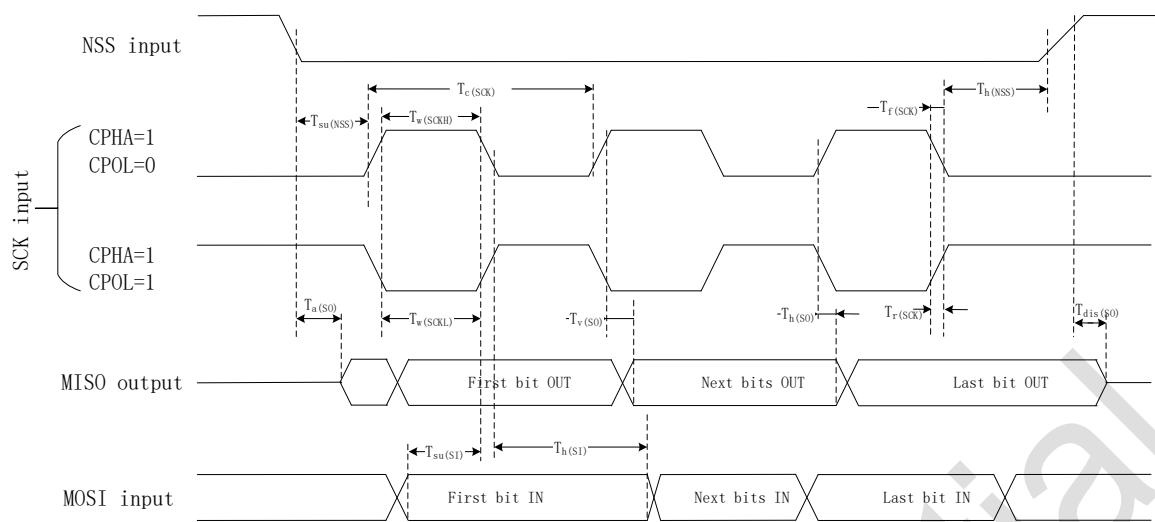


Figure 5-5 SPI timing diagram – Slave mode and CPHA=1

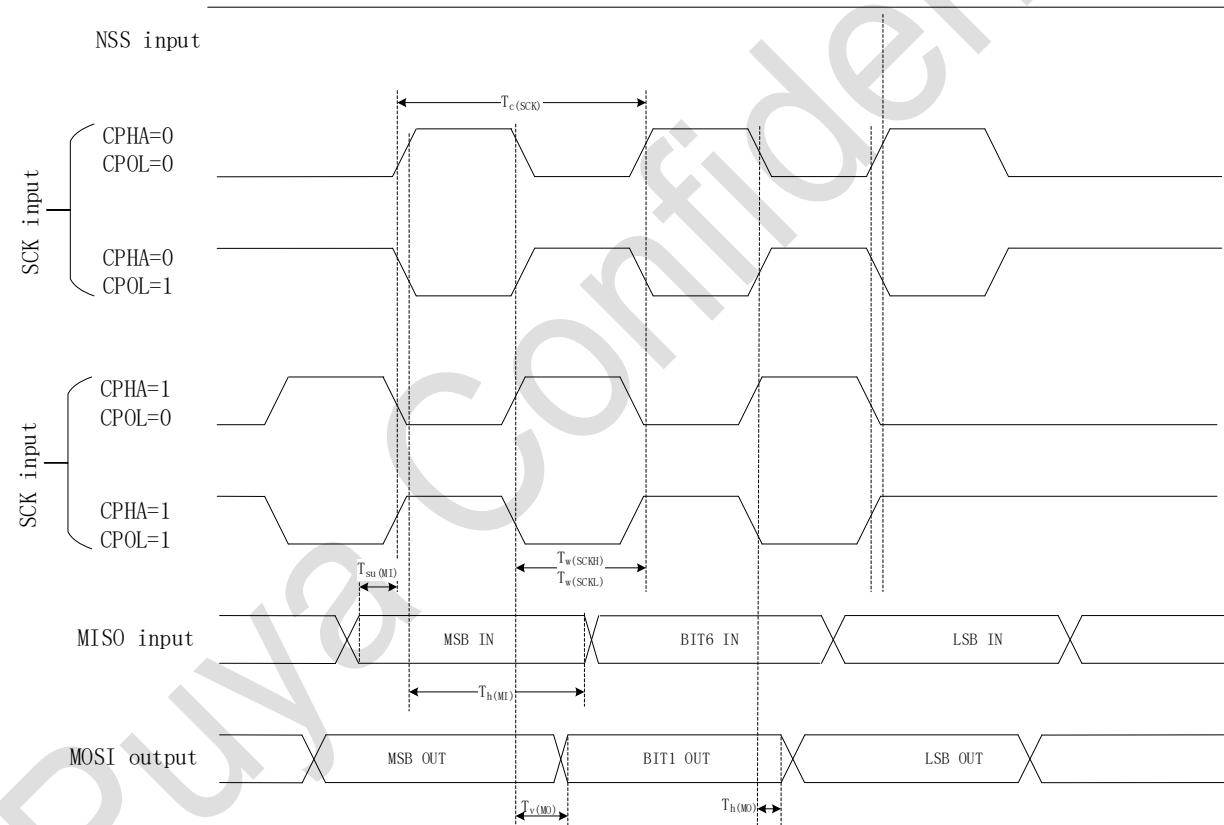
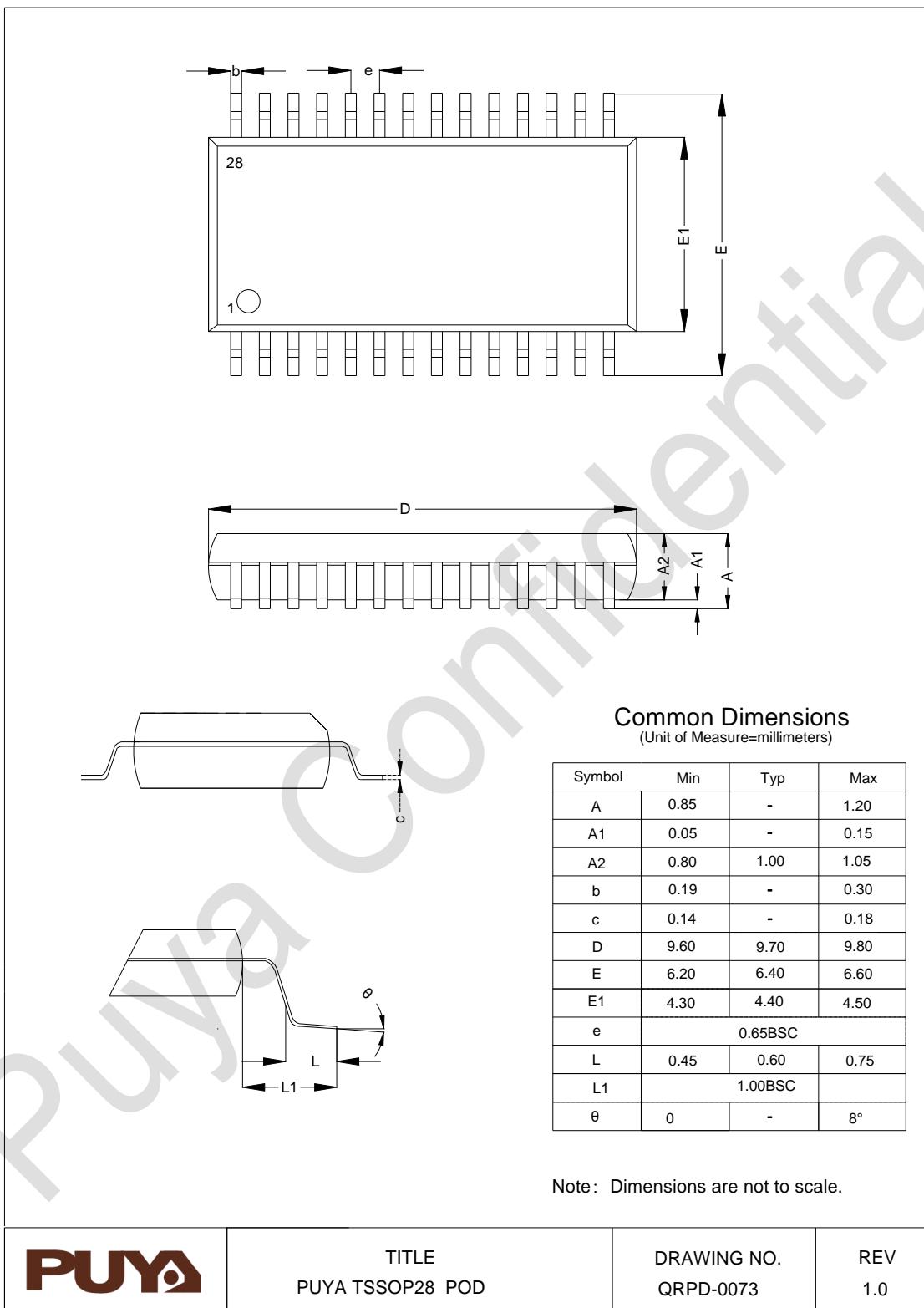


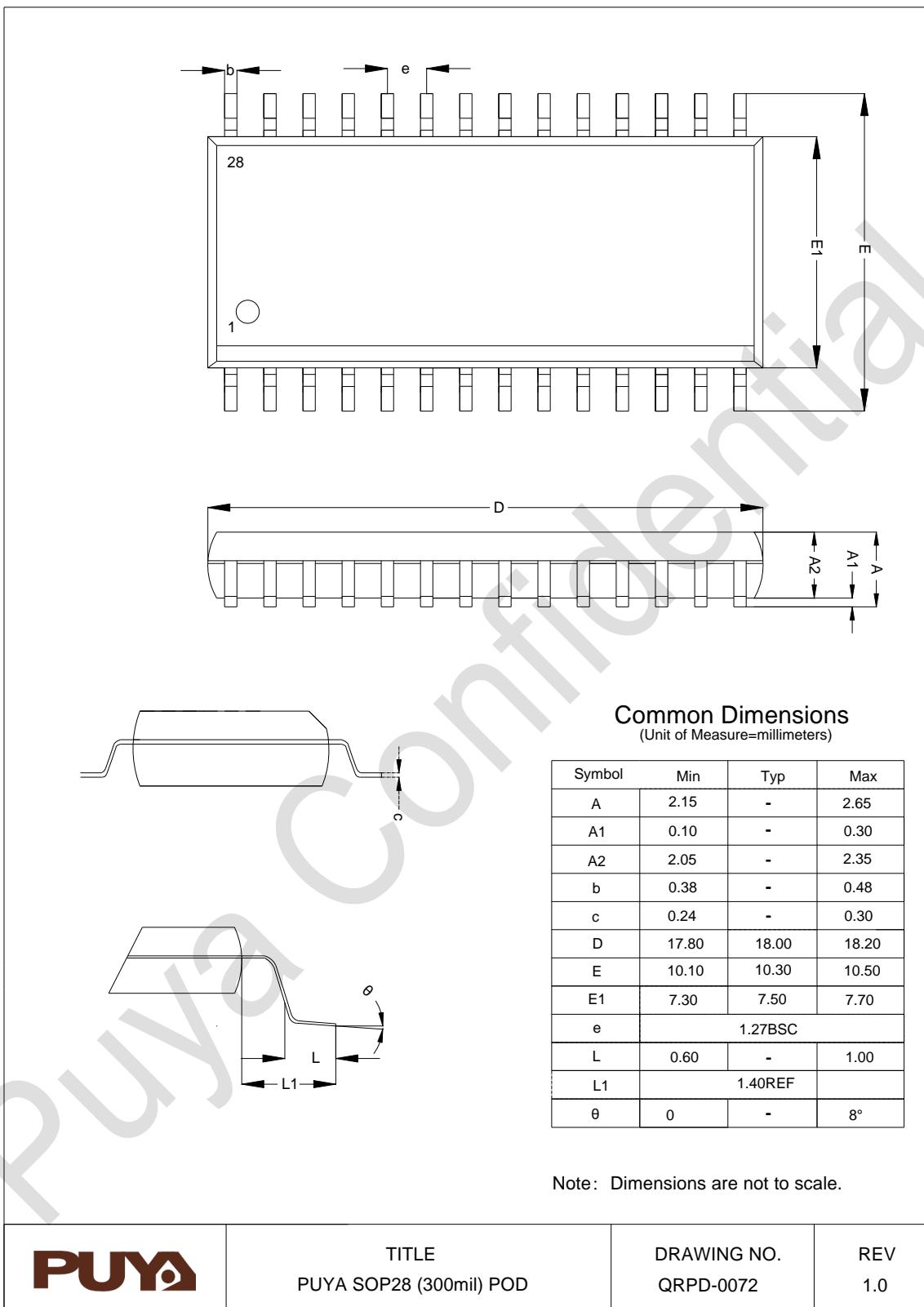
Figure 5-6 SPI timing diagram - Master mode

## 6. Package information

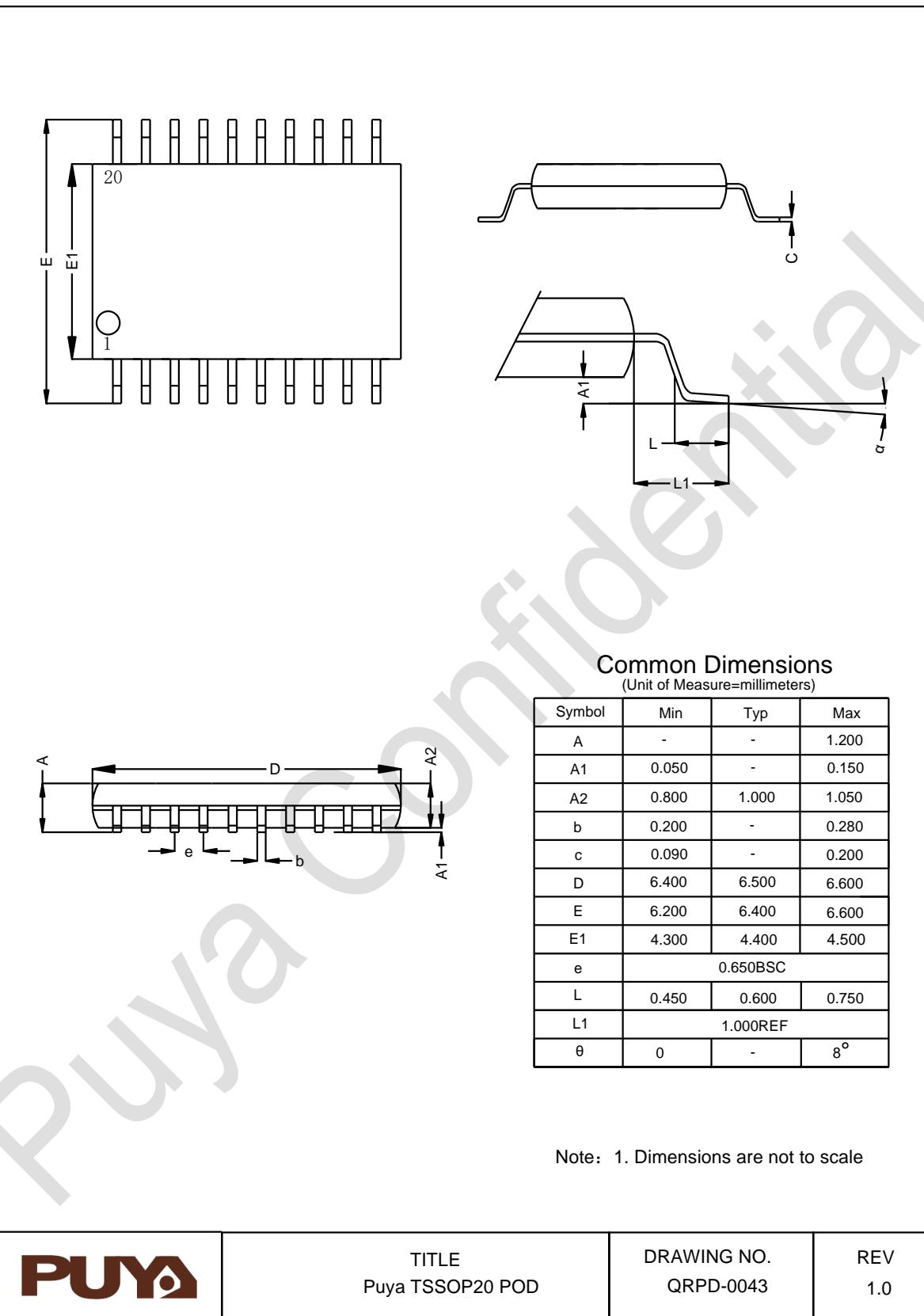
### 6.1. TSSOP28 package size



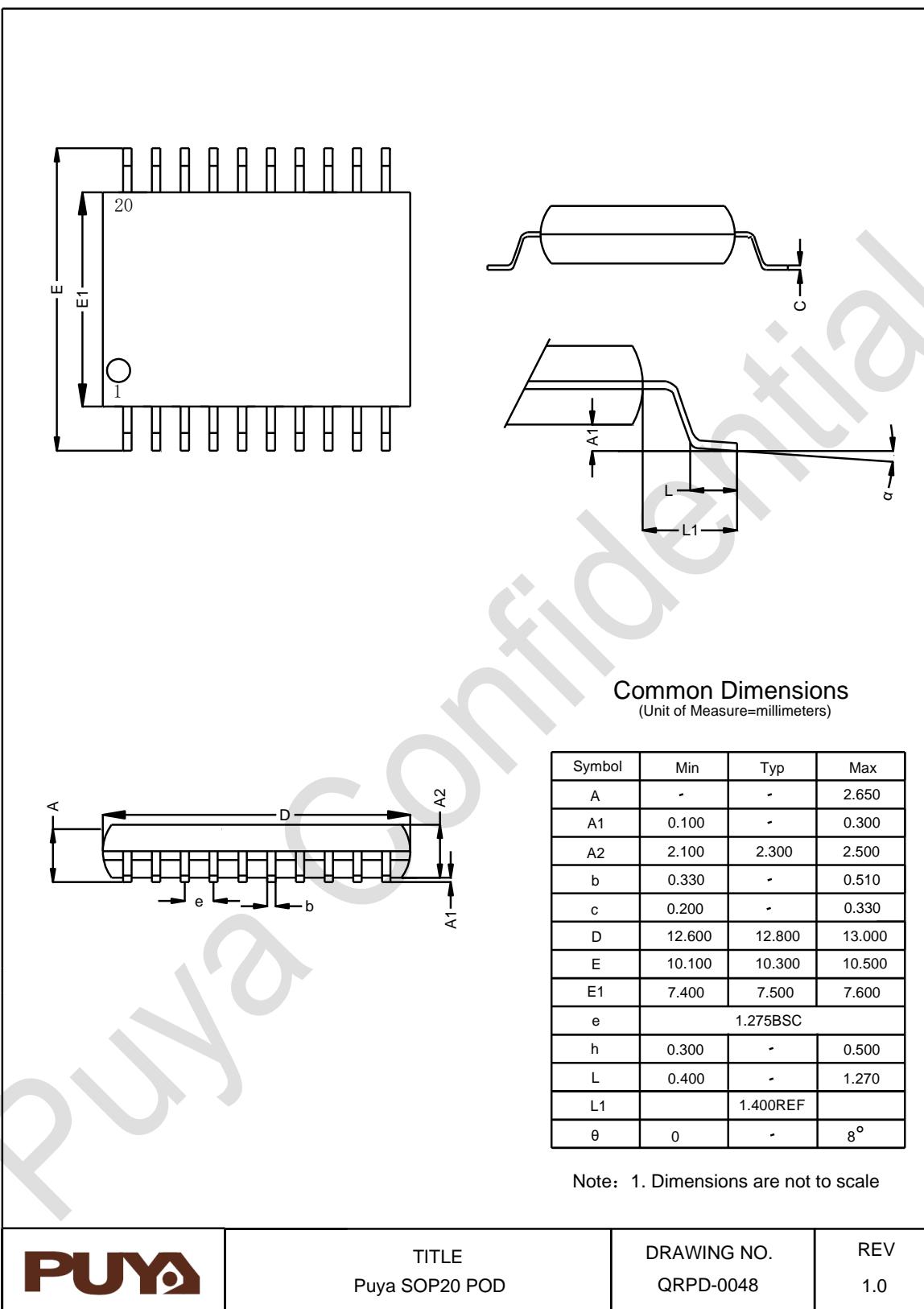
## 6.2. SOP28 package size



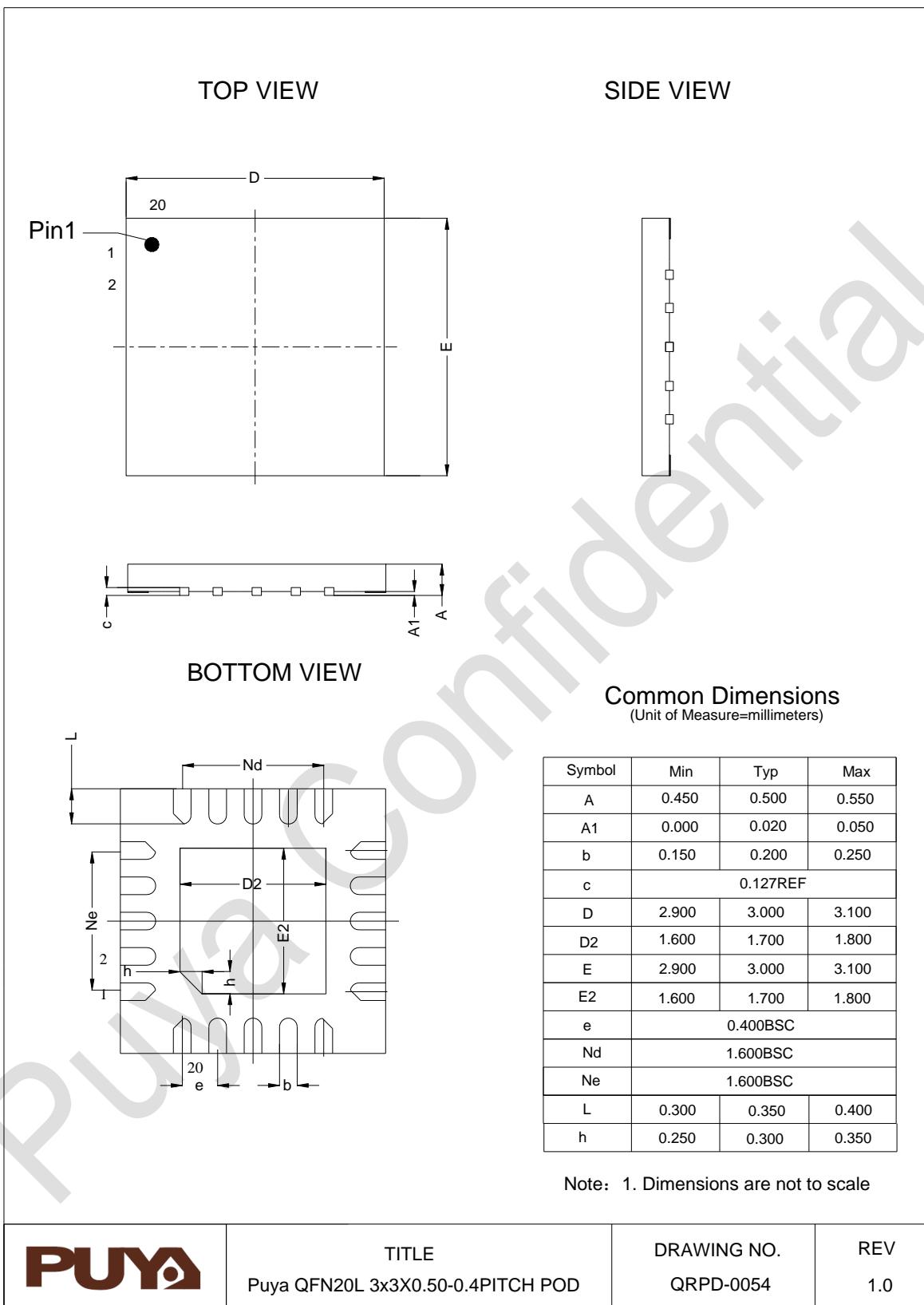
### 6.3. TSSOP20 package size



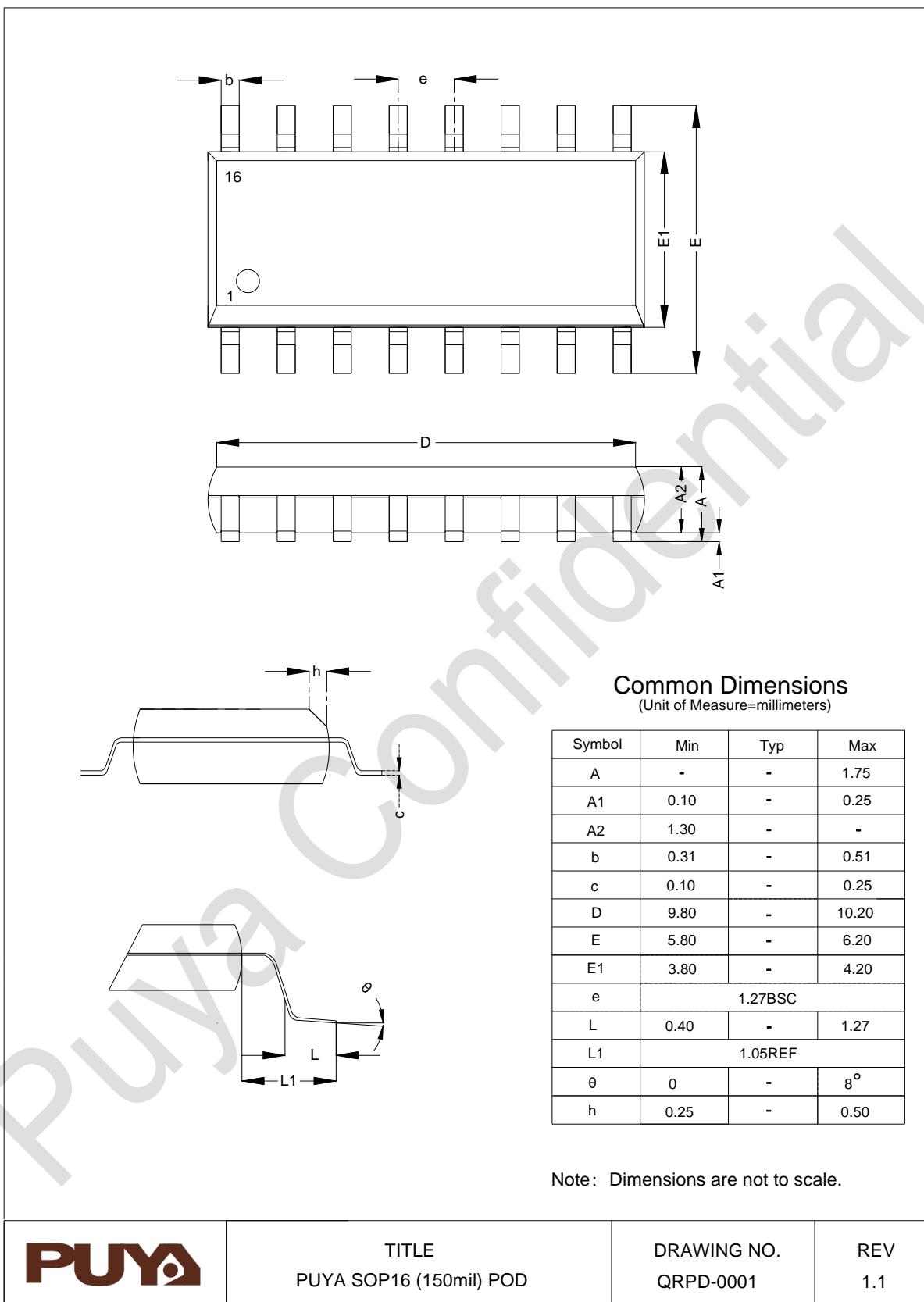
## 6.4. SOP20 package size



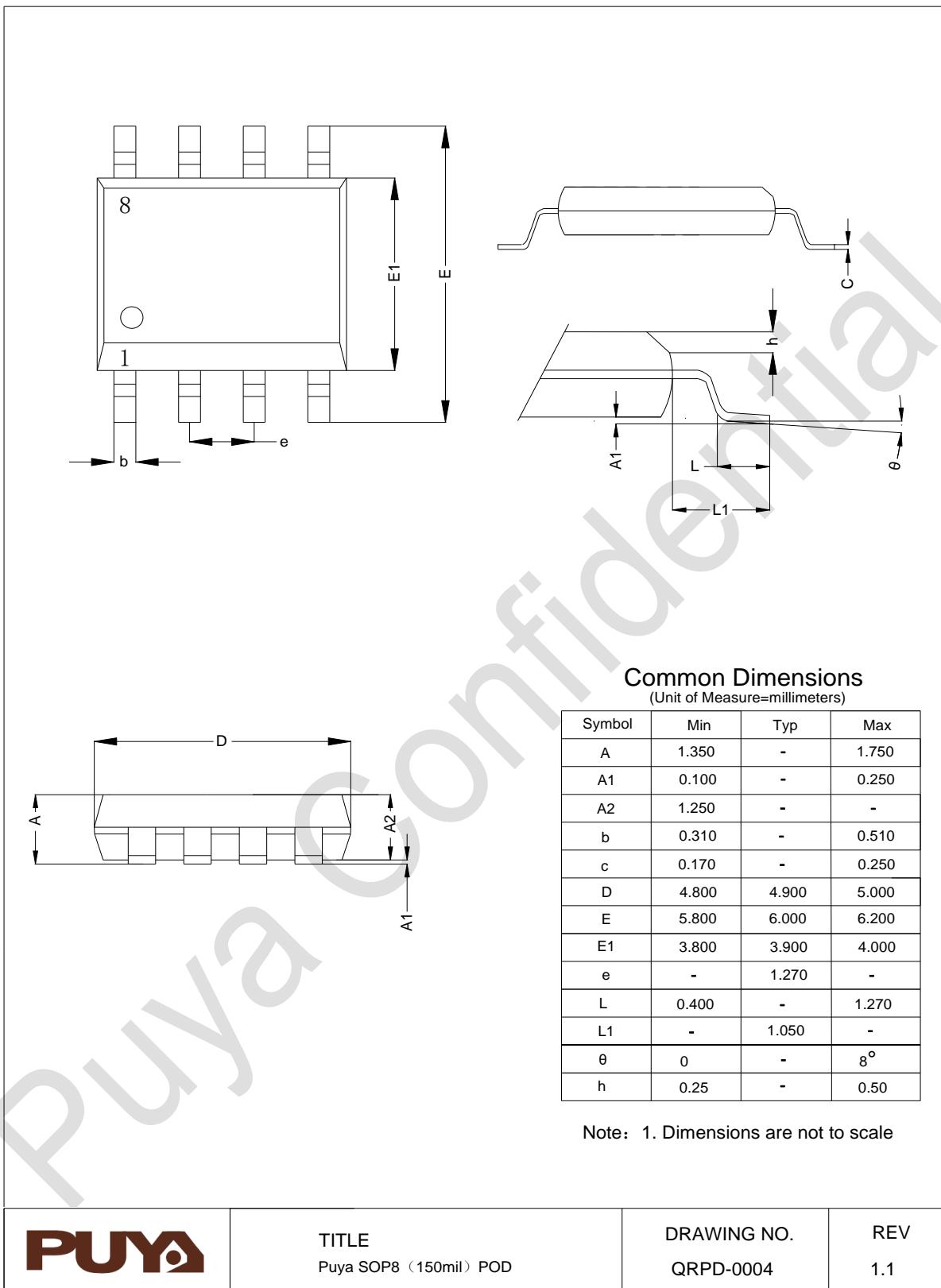
## 6.5. QFN20 (3\*3\*0.5) package size



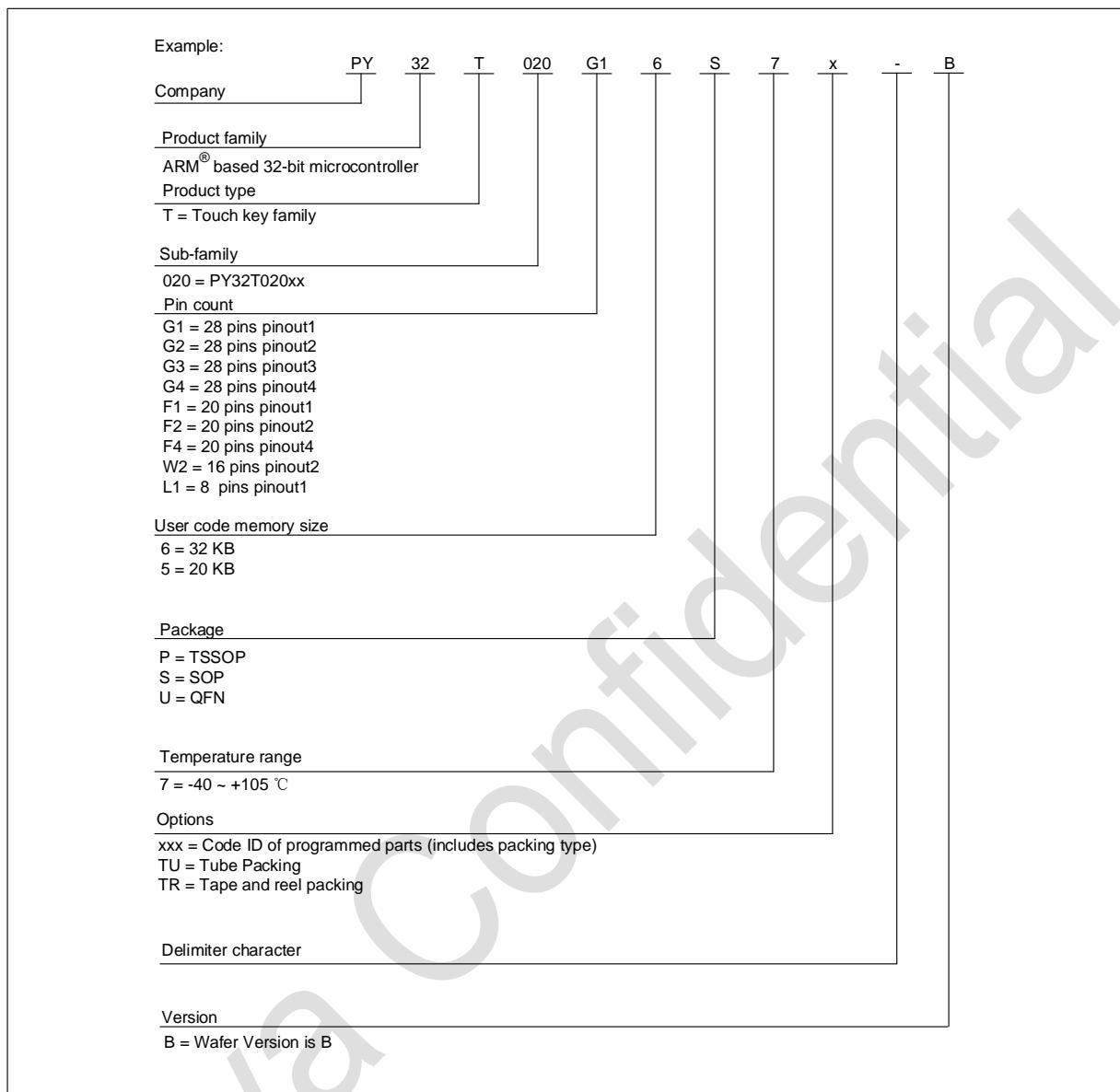
## 6.6. SOP16 package size



## 6.7. SOP8 package size



## 7. Ordering information



## 8. Version history

Version	Date	Changes
V0.2	2024.05.06	Beta version
V0.5	2024.08.27	Beta version
V1.0	2024.04.01	Initial version
V1.1	2024.09.19	Add SOP8 package
V1.2	2025.02.10	Add product PY32T020F25S7-B and PY32T020W25S7-B
V1.3	2025.02.13	Add product PY32T020G16S7-B and PY32T020G26S7-B
V1.4	2025.03.25	Add product PY32T020G25S7-B, PY32T020G35S7-B and PY32T020F15P7-B
V1.5	2025.04.08	1. Consistent with the Chinese version No. 2. Add product PY32T020F45U7-B
V1.6	2025.04.27	Add Table 5-23 Constant current LED SEG driver characteristics
V1.7	2025.05.06	Add product PY32T020G36S7-B
V1.8	2025.06.25	Add the maximum values in supply current characteristic tables
V1.9	2025.07.31	Add product PY32T020G15S7-B
V2.0	2025.08.20	Replacement of the company logo mark



## Puya Semiconductor Co., Ltd.

### IMPORTANT NOTICE

Puya reserve the right to make changes, corrections, enhancements, modifications to Puya products and/or to this document at any time without notice. Purchasers should obtain the latest relevant information of Puya products before placing orders.

Puya products are sold pursuant to terms and conditions of sale in place at the time of order acknowledgement.

Purchasers are solely responsible for the choice and use of Puya products. Puya does not provide service support and assumes no responsibility when products that are used on its own or designated third party products.

Puya hereby disclaims any license to any intellectual property rights, express or implied.

Resale of Puya products with provisions inconsistent with the information set forth herein shall void any warranty granted by Puya.

Any with Puya or Puya logo are trademarks of Puya. All other product or service names are the property of their respective owners.

The information in this document supersedes and replaces the information in the previous version.

Puya Semiconductor Co., Ltd. – All rights reserved